11.3.2. Overall progress in MPI marine biodiversity research

The MPI Biodiversity Research programme has three overarching science goals:

- To describe and characterise the distribution and abundance of fauna and flora, as expressed through measures of biodiversity, and improving understanding about the drivers of the spatial and temporal patterns observed.
- To determine the functional role of different organisms or groups of organisms in marine ecosystems, and assess the role of marine biodiversity in mitigating the impacts of anthropogenic disturbance on healthy ecosystem functioning.
- To identify which components of biodiversity are required to ensure the sustainability of healthy marine ecosystems as well as to meet societal values on biodiversity.

More specific Science Objectives developed below have been modified by BRAG over time and are used to focus the research commissioned:

1. To classify and characterise the biodiversity, including the description and documentation of biota, associated with nearshore and offshore marine habitats in New Zealand.
2. To develop ecosystem-scale understanding of biodiversity in the New Zealand marine environment.
3. To investigate the role of biodiversity in the functional ecology of nearshore and offshore marine communities.
4. To assess developments in all aspects of diversity, including genetic marine biodiversity and identify key topics for research.
5. To determine the effects of climate change and increased ocean acidification on marine biodiversity, as well as effects of incursions of non-indigenous species, and other threats and impacts.
6. To develop appropriate diversity metrics and other indicators of biodiversity that can be used to monitor change.
7. To identify threats and impacts to biodiversity and ecosystem functioning beyond natural environmental variation.

To date, 55 research projects have been commissioned. Early studies focused primarily on Objectives 1 and 2 and resulted in reviews, Identification Guides, habitat and community characterisations, and revised taxonomy for certain groups of organisms. These objectives have also resulted in large collaborative ship-based surveys that have contributed to improved seabed classification in New Zealand waters and the exploration of new habitats in the region and in Antarctic waters. Over time, the complexity and scale of studies has increased with projects on the functional ecology of marine ecosystems from localised experimental manipulation to broad-scale observations across 100s km^2 under Objective 3. Such studies have also pursued the development of improved measures of biodiversity and indicators under Objectives 6 and 7. A study on changes in shelf ecosystems over the past 1000 years is yielding insights into the effects of long-term climate change, land-use effects and fishing on marine ecosystems while more recently, some studies have begun to address the effects of ocean acidification on marine biodiversity under Objective 5. A study underway has reviewed genetic variation in the New Zealand marine environment and is conducting field observations on several species to examine genetic variation across latitudinal gradients. Aspects of the seven Objectives have also been addressed through a range of biodiversity projects in the Ross Sea region including the International Polar Year Census of Antarctic Marine Life project (IPY-CAML). A key to study findings is consideration of biodiversity within the context of the carrying capacity of the system and the natural assemblages of biota supported by that system in the absence of human disturbance.
Progress in the MPI Biodiversity Programme is summarised in Figure 11.5.

Progression of research understanding	***Science objective†***	***Estuarine/ Coastal 0-30 m***	***Shelf 30-200 m***	***Slope 200-1500 m***	***Deep/Abyss >1500 m***	***Antarctica All depths***
1. Review extent of knowledge of biodiversity (desktop)	1-7					
2. Identify & characterise species and habitat diversity (field work, qualitative analysis, taxonomy & systematics)	1					
3. Quantify biodiversity distribution, abundance (replication, purpose designed surveys)	1					
4. Model and predict biodiversity distribution and abundance	1					
5. Assess or measure functional processes in healthy marine ecosystems (experiments, process studies)	2, 3					
6. Assess the role of genetic diversity	4					
7. Assess interactions and connectivity on ecosystem scale, (genetics, modelling)	2, 5					
8. Develop indicators and measures to monitor bio-diversity, ecosystem health	6					
9. Define key risks and threats to biodiversity	5, 7					
10. Define standards for maintaining biodiversity and healthy ecosystem functioning	6					
11. Examine strategies to mitigate remedy or avoid threats to biodiversity	6					
12. Monitor risks and compliance with standards	6					

Figure 11.5. Progress on biodiversity research commissioned by MPI 2000–2010. Dark grey: Significant progress (several projects completed and results emerging from research underway). Light grey: Limited progress (some results emerging, more research needed). White: no substantive research. Diagonal-hatch: progress linked to large whole-of-government projects (e.g. Ocean Survey 2020) and/or other funding outside MPI (e.g. MBIE (MSI) funded Outcome Based Investment projects, DOC Marine Coastal Services, MAFBNZ marine biosecurity research).

† Science objectives are- 1 characterisation and description; 2 ecosystem scale biodiversity; 3 functional role of biodiversity; 4 genetics; 5 ocean climate effects; 6 indicators; 7 threats to biodiversity. The objectives are detailed in MPI Biodiversity Programme: Part 2. Medium Term Research Plan 2011-2014.

The chart depicts a logical flow down the page of increasing conceptual complexity from cataloguing of biodiversity to increasingly complex understanding of environmental drivers and functionality of biodiversity; and ultimately methods to develop standards and protection of biodiversity. Across the

chart, the marine environment is graded from the coastline to offshore regions, and Antarctica. A full list of projects can be obtained from the MPI Biodiversity Medium Term research programme 2010-2014.

Greatest progress has been made in the shallower inshore parts of the marine environment, not least because of cost and ease of access. However, by leveraging from existing offshore projects, significant progress has also been made to depths of 1500 m.

MPI Biodiversity research based in Antarctica lags behind EEZ-based research, simply because of the difficulty in securing additional funding to access and work in such a remote and hostile marine environment. While the top left side of the figure shows the area of greatest progress, it would be a mistake to conclude that biodiversity work is completed here.

11.3.1. Progress on Science Objective 1. Characterisation and Classification of Biodiversity

The characterisation and classification of biodiversity requires an assessment of the abundance and distribution of marine life. Building on earlier research to map fish and squid species (Anderson *et al.* 1998, Bagley *et al.* 2000) and the biodiversity of the New Zealand ecoregion (Arnold 2004), literature reviews, taxonomic studies and habitat mapping surveys have been undertaken.

Reviews and books

The following lists scientific reviews and books on biodiversity that were commissioned by the programme:

ZBD2000-01 A review of current knowledge describing the biodiversity of the Ross Sea region (Bradford-Grieve and Fenwick 2001, 2002; Fenwick and Bradford-Grieve 2002a, 2002b, Varian 2005)
ZBD2000-06 "*The Living Reef: The Ecology of New Zealand's Rocky Reefs"* (eds. Andrew and Francis 2003)
ZBD2000-08 A review of current knowledge describing New Zealand's Deepwater Benthic Biodiversity (Key 2002),
ZBD2000-09 Antarctic fish taxonomy (Roberts and Stewart 2001)
ZBD2001-02 Documentation of New Zealand Seaweed (Nelson *et al.* 2002)
ZBD2001-04 "Deep Sea New Zealand" (Batson 2003)
ZBD2001-05 Crustose coralline algae of New Zealand (Harvey *et al.* 2005, Farr *et al.* 2009, Broom *et al.* 2008)
ZBD2001-06 Biodiversity of New Zealand's soft-sediment communities (Rowden *et al.* 2011)
ZBD2003-09 Macquarie Ridge Complex Research Review (Grayling 2004)
ZBD2008-27 Scoping investigation into New Zealand abyss and trench biodiversity (Lörz *et al.* 2012).

In addition a major work which includes marine species – "The New Zealand Inventory of Biodiversity" (Gordon 2009, Gordon 2010, Gordon 2012), has been completed. Field identification guides have also been published by MPI on deepsea invertebrates (–projects ENV2005-20 and ZBD2010-39, Tracey *et al.* 2005, 2007, 2011), bryozoans (project IPA2009/14 Smith and Gordon 2011) and on fish species (IDG2006-01 MacMillan *et al.* (2011 a, b, c) which further contribute to the accurate monitoring and identification of biodiversity in New Zealand waters.

Projects

Several hundred new species of marine organisms have been discovered, and the known range of species extended, through exploratory surveys such as the NORFANZ project ZBD2002-16 (Clark

and Roberts 2008); MSI's Seamount Programme, mainly commissioned through public-good science, supplemented by MPI projects ZBD2000-04, e.g., Rowden *et al.* 2002 and 2003, ZBD2001-10 (Rowden et. al 2004), ZBD2004-01 (Rowden *et al.* 2010) and MPI projects ENV2005-15, ENV2005-16 (Clark *et al.* 2010, Rowden *et al.* 2008) and the Ocean Survey 20/20 programme (Clark *et al.* 2009); inshore surveys of bryozoans at Tasman Bay ZBD2000-03 (Grange *et al.* 2003); Farewell Spit, ZBD2002-18 (Battley *et al.* 2005), Fiordland, ZBD2003-04 (Wing 2005); coralline algae ZBD2001-05, ZBD2004-07 (Harvey *et al.* 2005, Farr *et al.* 2009); soft sediment environments ZBD2003-08 (Neill *et al.* 2011); rhodolith community study ZBD2009- 03 (Nelson *et al.* 2012); offshore surveys of the Chatham Rise and Challenger Plateau funded through Ocean Survey 20/20 programme, ZBD2006-04 (Nodder 2008) and ZBD2007-01 (Nodder *et al.* 2011; Hewitt *et al.* 2011; Bowden 2011, Bowden and Hewitt 2012; Bowden *et al.* 2011b; Bowden *et al.* in press).

Research in the Ross Sea Region (BioRoss projects) have also generated records of new species including MPI projects ZBD2000-02 (Page *et al.* 2001), ZBD2001-03 (Norkko *et al.* 2002), ZBD2002-02 (Sewell *et al.* 2006, Sewell 2005, 2006), ZBD2003-02 (Cummings *et al.* 2003, 2006), ZBD2003-03 (Rowden *et al.* 2012a, Rowden *et al.* in press), ZBD2005-03 (MacDiarmid and Stewart 2012), ZBD2006-03 (Cummings *et al.* 2003, 2006; Norkko *et al.* 2002), ZBD2008-23 (Nelson *et al.* 2010)and IPY2007-01 (Bowden *et al.* 2011a, Clark *et al.* 2010, Eakin *et al.* 2009, Hanchet, *et al.* 2008a Hanchet 2008b, Hanchet 2008c, Hanchet *et al.* 2008d. Hanchet 2009, Hanchet 2010, Koubbi *et al.* in press, Lörz and Coleman 2009, Lörz in press, Lörz *et al.* in press, Mitchell 2008, O'Driscoll *et al.* 2009. O'Driscoll 2009, O'Driscoll, *et al.* 2010, O'Loughlin *et al.* 2010)

Habitat diversity, classification and characterisation

The development of the Marine Environment Classification or "MEC" (Snelder *et al.* 2006) was an important step in the delineation of areas with similar environmental attributes in the offshore environment. However, significant environmental drivers of variability in marine biodiversity, such as substrate type for seafloor organisms, were absent from the classification. In 2005, DOC and MPI jointly commissioned a project to optimise the MEC using fish distribution data. This project (ZBD2005-02) demonstrated a substantial improvement in the MEC classification for offshore habitats (Leathwick *et al.* 2006a, b, c). In 2006, three projects to map coastal biodiversity were completed in the Coromandel scallop, Foveaux Strait oyster and southern blue whiting fisheries as part of fishery plan development for these fisheries (ZBD2005-04, ZBD2005-15, ZBD2005-16). These projects found that the biological distribution of organisms and their habitats were not well predicted by the MEC. MPI project (BEN2006-01) aimed to further optimise the MEC by producing a methodology for a Benthic Optimised MEC (Leathwick *et al.* 2009).MPI Ecological studies to improve habitat classification and vulnerability indices have also been completed through MPI AEWG projects on seamounts (ENV2005-15, ENV2005-16) (e.g., Clark *et al.* 2010), and to supplement other studies funded by MPI, and MSI (e.g. ZBD2004-01, ZBD2001-10, ZBD2000-04, and CO1X0508).

Distribution maps providing indicative abundance and characterisation of biodiversity are now emerging and have been produced through projects using predictive modelling tools e.g., Compton *et al.* 2012; the fish optimised MEC in project ZBD2005-02 (Leathwick *et al.* 2006a, 2006b, 2006c), the benthic optimised MEC (Leathwick *et al.* 2009) and Chatham-Challenger project ZBD2007-01 (Hewitt *et al.* 2011, Bowden *et al.* 2012, Compton *et al.* in press).

Progress has advanced considerably in recent years with the introduction of the whole-of-government Ocean Survey 20/20 Programme and Biosecurity New Zealand mapping projects (Beaumont *et al.* 2008, 2010) In addition, MPI implemented spatial management tools (Benthic Protection Areas[53]) implemented on the basis of the Marine Environment Classification[54 55] to address broader statutory responsibilities on the environmental effects of fishing on biodiversity.

[53] www.fish.govt.nz/en-nz/Environmental/Seabed+Protection+and+Research/Benthic+Protection+Areas.htm
[54] Marine Environmental Classification. (2005). Can be viewed online at http://www.mfe.govt.nz/publications/ser/marine-environment-classification-jun05/index.html

ZBD2007-01 Chatham-Challenger seabed habitats-post voyage analyses.

This large project has been completed. Progress for each objective is as follows:

1. To count, measure, and identify to species level (where possible, otherwise to genus) all macro invertebrates (>2 mm) and fish collected during Oceans Survey 20/20 voyages. Completed (Figure 6, Bowden 2011).
2. To count, measure and identify to species-level (where possible, otherwise to genus or family) all meiofauna (>45µm to <500 µm) from multicore samples collected during the Oceans Survey 20/20 voyages. [Collaborative venture MBIE-Otago University]. Completed (Leduc *et al.* 2012)
3. To count, measure and identify to species- level (where possible, otherwise to genus or family) all fauna collected by hyper-benthic sled during the Oceans Survey 20/20 voyages. Completed. (Lorz 2011, Bowden 2011).
4. To count, measure, and identify to species-level (where possible, otherwise to genus or family) all macrofauna observed on DTIS images collected during the Oceans Survey 20/20 voyages. The number of biogenic features (burrows/mounds) and habitat (spatial) complexity should also be estimated. Completed. (Bowden 2011, Compton *et al.* 2012).
5. To count, measure, and identify to species-level (where possible, otherwise to genus or family) all macrofauna observed on DTIS video footage collected during the Oceans Survey 20/20 voyages. Completed. (Bowden 2011, Compton *et al.* 2012).
6. To calculate and compare the performance of a suite of diversity measures (species and taxonomic based) at varying levels of resolution. Completed. (Hewitt *et al* 2011a).
7. To estimate particle size composition and organic content of sediment samples. Sediment samples should be aggregated over the top 5 cm of sediment. Completed. (Nodder et al 2011).
8. To measure the bacterial biomass (top 2 cm) of the sediment and in the sediment surface water samples, collected during the Oceans Survey 20/20 voyages. Completed. (Nodder *et al.* 2011.
9. To elucidate the relationships, patterns and contrasts in species composition, assemblages, habitats, biodiversity and biomass (abundance) both within and between stations, strata and areas. Completed. (Floerl *et al.* 2012.
10. To define habitats (biotic) encountered during the survey and assess their relative sensitivity to modification by physical disturbance, their recoverability and their importance to ecosystem function / production. Completed (Hewitt *et al.* 2011b).
11. *To quantify the productivity, energy flow (trophic networks) and the energetic coupling (bentho pelagic or otherwise) of the area surveyed areas at various levels of resolution. Objective withdrawn*
12. To assess the extent to which patterns of species distributions and communities can be predicted using environmental data (including fishing) collected during the Ocean 20/20 voyages or held in other databases. Modelling approaches as well as standard statistical procedures are anticipated. (Compton *et al.* 2012).
13. To provide an interactive, high resolution mapping facility for displaying and plotting all data collected and derived indices. This would include environmental data, the abundance of individual species, indices of biomass or diversity, and statistically derived groupings. Completed in conjunction with Bay of Islands Ocean Survey 20/20 Portal[56].
14. To assess the extent to which acoustic, environmental, or other remote-sensed data can provide cost-effective, reliable means of assessing biodiversity at the scale of the Oceans

[55] http://seafoodindustry.co.nz/bpa and use of MEC (2005)
[56] http://www.os2020.org.nz/

Survey 20/20 samples. Completed. (Bowden *et al.*in press, Bowden *et al* 2011b, Compton *et al* 2012).

15. To assess the extent to which the 2005 MEC and subsequent variants can provide cost-effective, reliable means of assessing biodiversity at the scale of the Oceans 20/20 surveys. Completed. (Bowden *et al.* 2011b).
16. Collating all information and analysis from all objectives, devise a series of statistically supported recommendations for surveying marine biodiversity in the future. This should include, but may not be limited to, statistical analyses and modelling. Bowden and Hewitt 2011).

ZBD2008-05 Macroalgal diversity associated with soft sediment habitats.

Although macroalgae normally require hard substrata for attachment and occur less frequently in soft sediment environments they contribute to biodiversity in a range of soft sediment environments providing structural complexity, modifying flow and sediment regimes, and contributing to productivity. Soft sediment habitats where macroalgae are found are physically highly diverse, ranging from harbours and estuaries (with varying sediment types and sizes, freshwater influence, tidal flushing, current flows), to coarse stabilised sediments (shell fragments, cobbles, coarse gravels), and biogenic habitats such as worm tubes, horse mussel beds, brachiopod beds, mangrove forests, rhodolith (maerl) beds and seagrass meadows.

The state of knowledge of macroalgal diversity, distribution and abundance is poor, and there are few examples of targeted collecting programmes for macroalgal assemblages, particularly in soft sediment habitats. This research conducted (a) a targeted collection programme across diverse soft sediment environments to develop a permanent reference collection of representative macroalgae, and (b) examined algal distribution in soft sediment habitats in relation to selected environmental variables.

Macroalgal sampling trips to Kaipara (1), Whangarei (3) and Otago (4) Harbours were completed. Further sampling trips were planned for 2010, however, no further collections will be made in Kaipara Harbour. Approximately 2400 collections of algae were made from soft sediments in these harbours. In Whangarei and Otago Harbours, collections were made from a range of soft sediment habitats including mud, sand, shell gravel, sea grass, scallop, pipi and horse mussel beds. At each site algae were collected opportunistically, quantitatively (i.e. by quadrats), or by both methods. Standard ecological methods (e.g. species area curves, count frequencies) were used to assess the appropriateness of the methods.

A database was developed for information about specimens and collection sites. Information was gathered on environmental variables within the target harbours. Identified algal distributions were analysed relative to these environmental variables.

Collections were made from three harbours with the primary focus on Whangarei and Otago Harbours where seasonal sampling programmes were conducted in spring and in autumn. In the Kaipara Harbour sampling was conducted only in spring. Two hundred and forty four taxa sampled from intertidal and subtidal sites and a range of habitats: 146 (112 spring, 102 autumn) from Whangarei, 43 Kaipara, 150 (107 spring, 115 autumn) from Otago. Diversity indices indicate that the collecting was not saturated and predict that there is higher diversity of macroalgae in these harbours than found in the samples obtained.

The flora composition in the harbours was found to differ markedly e.g., only 67 taxa (45%) of the Whangarei flora were found to be in common with Otago Harbour collections; 17 taxa (39%) of the Kaipara flora was in common with the Otahgo flora, in common (39% of K found in O); 27 taxa (63%) of the Kaipara flora was also found in Whangarei.19 non-indigenous species were found in the harbours, including two new records for the New

Zealand algal flora (confirmed by sequence data), *Hypnea cornuta* and *Polysiphonia morrowii*. In Whangarei Harbour 8 non-indigenous species were found (4 new records for harbour including *Hypnea*), in Kaipara Harbour 4 species were found including 2 new records for the harbour, and in Otago Harbour 11 non-indigenous species were found including 1 new record as well as *P. morrowii*. More taxa were collected in the subtidal (107) in Whangarei Harbour than in the intertidal (84), compared with Otago where numbers of intertidal taxa (120) exceeded the subtidal taxa collected (83).

Two methods were employed to enable high resolution sampling and these provided differing outcomes in the two main harbours sampled, clearly indicating that there was value in collecting by both methods in order to adequately sample the diversity: Whangarei Harbour 90 taxa were collected in quadrat sampling compared with 118 taxa via opportunistic collections, and in the Otago Harbour 107 taxa were collected in quadrat sampling and 118 taxa via opportunistic collections.

ZBD2008-27 Review of deep-sea benthic biodiversity associated with trench, canyon and abyssal habitats below 1500 m depth in New Zealand waters

The state of knowledge of benthic biodiversity and ecosystem functioning in deep-sea abyssal, canyon and trench habitats in the New Zealand Exclusive Economic Zone and the Ross Sea region, was summarised and recommendations for future deep-sea research in depths exceeding 1500 m were made. All biological information in scientific papers and reports from New Zealand below 1500 m was reviewed and an exhaustive search of multiple data sources was conducted.

The area of the deep seafloor below 1500 m covers more than 65% of New Zealand‘s Exclusive Economic Zone. A total of 1489 benthic gear deployments have been conducted by New Zealand-based sampling initiatives since 1955, most of which were focused on obtaining geological samples. Less than 0.002 % of New Zealand‘s deep-sea environment (i.e. in terms of seabed area) below 1500 m has been sampled. All taxonomy-based studies of all taxa reported in New Zealand waters below 1500 m have been reviewed. To date, 8 species of Bacteria, 293 species of Protozoa, 785 species of invertebrates, and 56 fish species have been recorded from water depths greater than 1500 m.

More than 8000 images are known to have been taken of the seafloor below 1500 m in the New Zealand region, covering an area of approximately 0.016 km2. Over 4000 of the images held at NIWA exist either as paper prints or negatives and ideally should be digitised for future storage and access for analyses. Analysis of these photographic images should yield considerable information about deep-sea biodiversity and ecosystem function in the New Zealand region and could be used to answer a number of research questions (especially around deep-sea benthic biodiversity).

Recommendations on how to potentially further analyse existing data from images, databases and actual specimens were provided. The technical challenges, including gear requirements to sample deep-sea New Zealand benthos and potential future investments, were summarised. (see Coleman and Lörz 2010; Lörz 2011a, 2011b; Lörz *et al.* 2012a, 2012b).

ZBD2008-50 Chatham Rise biodiversity hotspots.

This survey covered the “Graveyard Seamount Complex” and “Andes Seamount Complex” on the Chatham Rise. Objectives were to monitor changes over time on Graveyard hills subject to differing management regimes (some open to fishing, some closed), as well as to compare seamount biodiversity between different regions of the Rise. It was linked to the CoML CenSeam programme, and the former FRST Seamounts research, now under the MBIE Vulnerable Deep-sea Communities project. The data from that survey are being

worked up under the latter project (see Clark *et al.* 2009).). Analyses comparing the 3 surveys of the Graveyard complex between 2001 and 2009 indicate there are changes in some taxa following cessation of fishing operations on one of the features in 2001, but little sign of any recovery of stony coral species and associated benthic communities . Preliminary results were presented at the 2012 Deep Sea Biology Symposium (Clark *et al.* 2012).

ZBD2009-03 The vulnerability of rhodoliths to environmental stressors and characterisation of associated biodiversity.

Rhodoliths are free-living calcified red algae. They occur worldwide, forming structurally and functionally complex benthic marine habitats. Rhodolith beds form a unique ecosystem with a high benthic biodiversity supporting many species, including some that are rare and unusual. Recent international studies show that these fragile algae are at risk from the impacts of a range of human activities e.g., physical disruption, reduction in water quality, alterations to water movement, and aquaculture installations. Impacts of fragmentation may be critical in terms of biodiversity and abundance associated with rhodolith beds.

The focus of this programme was to improve knowledge about the location, extent or ecosystem functioning of rhodolith beds in New Zealand. The ecology of subtidal rhodolith beds was been investigated for the first time in New Zealand, characterising two rhodolith species, *Lithothamnion crispatum* and *Sporolithon durum*, examining the structure and physical characteristics of beds at two locations and documenting their associated biodiversity. In addition the responses of these rhodolith species to environmental stressors were investigated for the first time.

This study documented high biodiversity in two subtidal rhodolith beds sited in relatively close proximity in the coastal zone, with significant differences in biotic composition. The rhodolith beds studied (located in the Bay of Islands) differed significantly in terms of water motion, sediment characteristics and light levels. Biodiversity of the rhodolith beds was investigated sampling (1) invertebrates at three levels of association (epifauna, infauna, cryptofauna), (2) macroalgae, (3) fishes, as well as recording the biogenic and non-biogenic substrates:

- a number of undescribed taxa were discovered as well as new records for the New Zealand region, and range extensions of species known elsewhere,
- more than double the number of invertebrate taxa were present in the rhodolith beds than found outside the beds,
- both rhodolith beds harboured high diversity of associated macroalgae and invertebrates but with markedly different species composition,
- the floral and faunal composition differed significantly between sites.

Both species of rhodolith were found to be vulnerable to the impacts of increasing temperature and decreasing pH. There was a significant difference between the effects of treatments on the two species and further statistical analysis showed significant interaction between temperature and pH level on growth. Overall the greatest effect on growth rate came with the combination of high temperature (25° C) and low pH (7.65) on *Lithothamnion crispatum* which showed negative growth, indicating probable dissolution. In experiments investigating other environmental stressors, temperature was found to be more important for the survival and growth of the rhodolith species examined than the effects of burial, light and fragmentation.

The extent of rhodolith beds in other parts of the New Zealand region remain to be documented, including those in coastal areas (including intertidal beds) and subtidal beds on the shelf.

ZBD2010-40 Predictive modelling of the distribution of vulnerable marine ecosystems in the South Pacific Ocean region.

In January 2010 New Zealand and the United States held their second Joint Commission meeting (JCM) on Scientific and Technological Cooperation. The meeting was to share knowledge about common interests and capabilities and identify areas for future collaboration. The JCM consisted of six workshops held simultaneously around the North Island and an officials meeting held in Wellington. One of the six workshops, ocean and marine sciences, identified an area of interest in a joint project in the South Pacific Regional Fisheries Management Organisation (SPRFMO) area to map and groundtruth vulnerable marine ecosystem (VME) distribution.

The 3rd New Zealand and United States Joint Commission on Science and Technology Cooperation (JCM) met on 19 and 20 September 2012 in Washington. Building on several recommendations from the previous JCM (held in January 2010), and on the Marine Conservation Think Tank VME Workshop report 3: Science requirements for effective High Seas governance, held on 2-5 December 2011 (Lundquist et al 2012) 1, Topic 1 for the Oceans and Marine Workshop and the 3rd JCM meeting was again Vulnerable Marine Ecosystems (VMEs). Several actions were developed at the workshop and these included: 'Increase in situ deep-sea exploration and VME studies in regions of common interest by exploring options for NOAA/WHOI participation (including use of ROV/AUV technologies) in New Zealand funded initiative and voyage to explore and ground-truth VMEs in the South Pacific' and 'Facilitate U.S. researcher involvement in NIWA Louisville Ridge Exploration.'

There are relatively few data available on the distribution of VME species or taxa in the South Pacific Ocean (Parker *et al.* 2009) although studies have been conducted in Antarctica (Tracey *et al.* 2010, Parker *et al.* 2009) to use for the objective planning of spatial protection measures to protect those taxa, particularly in the SPRFMO Area. It is therefore becoming increasingly important to develop robust predictions of where VMEs are likely to occur, using habitat prediction and species distribution models. Such models have recently been developed and/or are in the process of being refined for certain VME taxa on a global scale (e.g. Actinaria, Guinotte *et al.* 2006; Scleractinia, Tittensor *et al.* 2009). However, the spatial resolution of existing models is coarse (larger than the scale of the topographic features typically targeted during demersal high seas fishing), and the level of uncertainty around the predictions is variable or still unknown.

Phase 1 a project to use modelling to predict the location of VMEs in the SPRFMO area was initiated between the US and New Zealand (ZBD2010-40) and has now been completed. The objectives of the project were to:

1. To develop and test spatial habitat modelling approaches for predicting distribution patterns of vulnerable marine ecosystems in the Convention Area of the South Pacific Regional Fisheries Management Organisation with agreed international partners.

2. To collate data sets and evaluate modelling approaches which are likely to be useful to predict the distribution of vulnerable marine ecosystems in the South Pacific Ocean region.

Data for ten Vulnerable Marine Ecosystems (VME) taxa were compiled from different data sources to produce a single groomed dataset for VME indicator taxa in the New Zealand region. Regional-tuned environmental data layers and global environmental data layers were obtained from available data sources. Using these data, three types of predictive models were made for each VME indicator taxon. Two models were made using regional-tuned environmental data layers, using maximum entropy analysis (MaxEnt) and boosted regression tree (BRT) techniques to provide a comparison of the different model approaches. The third type of model made used the MaxEnt approach, but using globally available environmental

data layers. Having a third model meant that model performance could be compared based on the use of different environmental data layers. Three model types for all VME taxa have been completed and the performance of the different modelling approaches and usefulness of the environmental data sets described.

The next phases of the project will be undertaken as part of a MBIE-funded project that will revise models that predict the sites of Vulnerable Marine Ecosystems from existing data by conducting a ground truthing survey of benthic biodiversity on the Lewisville Ridge in 2013/14 (Ministry of Business Innovation and Employment project code C01X1229). This will be used to inform New Zealand and South Pacific Regional Fisheries Management Organisation initiatives on spatial management in the South Pacific region, and potentially the New Zealand EEZ.

Other research relevant or specifically linked to the projects above, is listed in Table 11.1.

Table 11.1: Other research linked to Objective 1 habitat classification and characterisation.

MPI	HAB2007-01 Biogenic habitats as areas of particular significance for fisheries management ZBD2006-02 NABIS ongoing development Useful data related to defining potential VMEs are collected by MPI scientific fisheries observers working on NZ authorised fishing vessels that operate on the high seas in the South Pacific.
CRI core purpose funding	C01X501 Coasts & oceans Centre (NIWA) ecosystem based management, habitat model development with Auckland Regional Council C01X0907 Coastal Conservation Management (fish habitat classification) (NIWA)C01X502 Biodiversity & Biosecurity (NIWA) C01X0508 Seamount fisheries (linking acoustic backscatter to habitat type and biota) (NIWA) CO1X0906 Vulnerable deep-sea communities (mapping and sampling a range of deep-sea habitats (seamounts, slope, canyons, seeps, vents) (NIWA) CO1X0702 Kermadec Arc minerals (mapping and sampling the biodiversity of several Kermadec Arc seamounts) (NIWA)
DOC	MEC development and application to MPAs, Regional surveys
OTHER	University studies, Regional Council studies
ZBD2010-40	Mapping VMEs in the SPRFMO area Part 1. Predictive modelling desktop study
EMERGING ISSUES	
What portion of a given habitat type should remain intact to support sustainable ecosystems? What are the most effective predictive tools for predicting biodiversity in areas as yet unsampled? Can ecological mapping used in OS20/20 projects to date be extended to other areas of New Zealand?	

11.3.2. Progress on Science Objective 2. Ecosystem-scale research

Marine ecosystems influence, and are influenced by, a wide array of oceanic, climatic, and ecological processes across a broad range of spatial and temporal scales. Marine communities are generally dynamic, can occur over large areas and have strong links to other communities through processes such as migration and long-distance physical transport (e.g. of larvae, nutrients, and biomass). Patterns observed on a small scale can interact with larger and longer-scale processes that in turn result in large scale patterns. Marine food webs are usually complex and dynamic over time (Link 1999). To distinguish useful descriptors of long-term ecosystem change from short-term fluctuations requires innovative approaches to integrate broad-scale correlative studies from smaller scale manipulative experiments (Hewitt *et al.* 1998, 2007).

Recent theoretical and technical advances show great promise toward the goal of understanding the role of biodiversity in ecosystems. Technologies for remote sensing and deepwater surveying, combined with powerful integrative and interpretive tools such as GIS, climate modelling, qualitative ecosystem modelling, and trophic ecosystem modelling, will contribute to the development of an

ecosystem-based approach to management (Thrush *et al.* 1997, 2000), with potential benefits for marine conservation and management. Ecosystem modelling of species distribution (and habitats) with respect to known and projected environmental parameters will improve predictability for both broad and fine-scale biodiversity distribution. This has already resulted in improved definition of environmental classifications addressing biodiversity assessment. It is also important to make progress in establishing the links between biodiversity and the long-term viability of fish stocks under various harvesting strategies. It is also important that modellers consider processes from all ecosystem function perspectives i.e., top-down effects such as predation (e.g. trophic modelling), bottom-up effects such as the environment (e.g., habitat classification based on environmental variable), and wasp-waisted systems where there are major effects in both directions.

Projects

ZBD2002-06A: Impacts of terrestrial run-off on the biodiversity of rocky reefs Completed.
(Schwarz *et al.* 2006).

ZBD2004-02: Ecosystem scale trophic relationships of fish on the Chatham Rise. Completed.
(Connell *et al.* 2010, Dunn 2009, Dunn *et al.* in press, Dunn *et al.* 2010a, b, c, Eakin *et al.* 2009, Forman and Dunn 2010, Horn *et al.* 2010, Stevens and Dunn 2010. Follow-up research on isotope signatures to improve the trophic data from ZBD2004-02 has been incorporated into the NIWA's Coast and Ocean programme and trophic modelling is underway in this programme.

ZBD2004-08 Sea-grass meadows as biodiversity and connectivity hotspots.

This contract links closely with the MBIE project Coastal Conservation Management (CO1X0907). National scale sampling across North and South Island seagrass meadows in a range of estuarine and coastal settings has shown that seagrass meadows overall consistently supported higher species richness, biomass, and productivity of invertebrates (infaunal and epifaunal). Associated sampling of small fish assemblages found that while seagrass meadows provided a nursery function to a number of species, this function was most pronounced in northern New Zealand systems, where relatively high numbers of juvenile snapper, trevally, spotties, parore, and garfish/piper were caught. However, there was strongly spatial variation across different estuary and coast settings ***(***MBIE91B).

ZBD2004-19 Ecological function and critical trophic linkages in New Zealand softsediment habitats. Project completed. (see Lohrer *et al.* 2010.)

ZBD2005-05 Effects of climate variation and human impacts on the structure and functioning of New Zealand shelf ecosystems.

The project is a multidisciplinary study to utilise archeological, paleoecological, and historical data to retrospectively model ecosystem states during different historical and prehistoric time periods. The project is collaborating with the international History of Marine Animal Populations (HMAP) project, itself a part of the Census of Marine Life (CoML) programme. The data have been used as inputs to a mass balance model of the shelf ecosystem starting with the present day Hauraki Gulf. A short video about the NZ Taking Stock project was made by HMAP staff and is currently available on the HMAP website http://hmapcoml.org/projects/nz/. Several presentations have been made at NZ and international conferences as results have emerged.

ZBD2008-01 Inshore biogenic habitats.

Existing knowledge on biogenic habitat-formers in the <5 – 200 m depth zone of New Zealand's continental shelf, from sources including structured fisher interviews ("Local Ecological Knowledge" LEK), primary and grey literature, and other sources have been integrated to generate maps of key biogenic habitats in New Zealand coastal waters.

Over 600 targets of interest were identified and marked on marine charts, with more than 200 of these targets being biogenic in nature. Fieldwork has been completed to verify and quantify biodiversity in biogenic habitats using Ocean Survey 20/20 vessel days on Tangaroa and a new MSI project to extend the survey potential of the project. New biogenic habitats have been identified, including extensive worm tube 'meadows' off the east coast of the South Island ("the Hay Paddock" and "Wire-weed"), with associated relatively high epi-faunal invertebrate diversity compared to adjacent bare sediments. Over 60 new species were also collected (dominated by sponges), along with range extensions of many other species. Analyses are underway for key selected areas included in the Tangaroa voyages, including offshore North Taranaki Bight, Ranfurly Bank, the polychaete meadows mentioned above, and the Otago Peninsula bryozoan fields.

IPA2009-11. Trophic Review.

This project publishes a report prepared on the feeding habits of New Zealand fishes 1960 to 2000 (Stevens *et al.* 2011)

Other research relevant or specifically linked to the projects above, is listed in Table 11.2.

Table 11.2: Other research linked to ecosystem scale understanding of biodiversity in the marine environment.

MPI	ENV2006-04 Ecosystem indicators for New Zealand fisheries ENV2007-04 Climate and oceanographic trends relevant to New Zealand fisheries ENV2007-06 Trophic relationships of commercial middle depth species on the Chatham Rise
CRI Core purposes	C01X501 coasts & oceans productivity plankton-mesopelagic fish trophic relations Chatham Rise IO 2. Second Fisheries Oceanography voyage to Chatham Rise: mesopelagics and hyperbenthics
OTHER	AUT deepsea and subtidal food web dynamics; offshore & coastal biodiversity post graduate studies

11.3.3. Progress on Science Objective 3. The role of biodiversity in the functional ecology of nearshore and offshore communities.

An identified outcome of the Biodiversity Strategy is that by 2020 "*New Zealand's natural marine habitats and ecosystems are maintained in a healthy functioning state. Degraded marine habitats are recovering.*" Sustaining ecosystem integrity in marine habitats requires a thorough understanding of the ecological and anthropogenic drivers affecting biodiversity and ecosystem function, and the ability to manage human impacts in marine environments.

Near-shore environments range from wetlands to estuaries, coasts and continental shelf ecosystems, they contain a variety of habitats and often contain species that are particularly important, either for cultural, recreational, and commercial reasons, or because the species exerts disproportionate influence on community structure and ecosystem function. Near-shore ecosystems are the multi-use ecosystems most subjected to multiple stressors. Due to ocean-coast and land-coast interactions these ecosystems will be subjected to the greatest range of stresses associated with global warming. Near-shore environments may also contain habitats that are particularly important for biodiversity in other environments, for instance by providing larval/juvenile nursery areas or by exporting nutrients. The MPI Biodiversity Programme has directed funds into research examining the implications of environmental and human impacts on the functional ecology of these key species and habitats.

Near-shore ecosystems are complex and changes in diversity and community composition may be driven by multiple variables. Interactions between variables are likely to be non-linear, with disturbance thresholds and the potential for multiple stable states. As a consequence, it is often difficult to distinguish 'natural' from 'anthropogenic' impacts affecting ecosystem dynamics. MPI

BioInfo research seeks to help disentangle this complexity, recognising that there will be contributions to this from both biodiversity research and Fisheries Services research.

Regional Councils and universities support some research projects and survey programmes in coastal and estuarine waters by investigating the effects of sedimentation, pollution, ocean outfalls, sand dredge spoils, sand mining and nutrient enrichment on the marine ecosystem[57]. Although this workstream applies to offshore areas as well as near-shore, research to date has focussed on the near-shore.

Projects

ZBD2005-09 Rocky reef ecosystems - how do they function?

The draft report for this project has been submitted and reviewed (Beaumont *et al.* In press).
The Hauraki Gulf in north-eastern New Zealand offers one of the best opportunities to investigate how rocky reef ecosystems function and what impact fishing and other human activities may have on them. This study took advantage of these circumstances to first review the extensive literature to set the parameters of a model of how north-eastern New Zealand reef ecosystems function. The study used the model to identify key species and interactions, and explore the impacts of fishing. Field work was then undertaken across the range of reefs within the Hauraki Gulf to test the model predictions, describe spatial variation in patterns of abundance of key species, determine trophic relationships and investigate the linkages of reefs to other habitats.

A qualitative model of northeast New Zealand rocky reef ecosystems was developed to explore the complexity of interactions amongst New Zealand rocky reef species and the impacts of exploitation. This model was developed on the basis of a review and summary of interactions among reef components. A key modelling outcome was the highly predictive but opposite responses by small lobsters and large predatory invertebrates to changes in the abundance of a range of other groups. This suggests that these two groups are ideal candidates as variables for monitoring reef ecosystem responses to perturbations. The modelling agreed with a well-documented example of responses to a perturbation in fishing pressure in the Leigh Marine Reserve. However, the predictability was low for all responses. This implies, for example, that the reduction of kina in the Leigh Marine Reserve and the subsequent increase in macro-algae consequent to an increase in lobster abundance may not necessarily occur in another area.

Field sampling at ten rocky reef sites across the Hauraki Gulf revealed differences among sites in community structure of macroalgae and invertebrates within all habitat strata. Of the environmental factors available, depth followed by a measure of water clarity (mean secchi) explained the most variation in the dependent variables (invertebrate taxa) from the quadrat data. Fish abundance data showed a similar, though weaker, trend across sites with depth, distance across the Gulf, and water clarity being the most important factors. The strong association between depth and water clarity and abundances of key taxa was expected and is similar to that found in earlier studies. With the exception of crayfish, there was no apparent overall relationship between invertebrate and fish abundances and marine reserve status of study sites, though the baited underwater video data showed snapper to be significantly larger within marine reserve sites than at fished sites.

Stable isotope analysis of tissue samples collected from key species from all study sites allowed insight into the functional relationships among species as well as dietary sources of carbon. Many of the study taxa, from the primary producers through to the predators, had the most depleted $\delta^{13}C$ values at the furthest inshore and offshore sites (e.g. Poor Knights and Long Bay)

[57] See MFish Biodiversity Research Programme 2010: Part 4. Reference Materials and Other research

and the highest $\delta^{13}C$ values at the coastal sites (e.g. Leigh, Tawharanui and Kawau). Without direct modelling of end point source signatures we cannot definitively determine the percentage contribution of each carbon source. However, we suggest that the depleted $\delta^{13}C$ of taxa from offshore sites is the result of a pelagic source of C and the enriched $\delta^{13}C$ at coastal sites is the result of a more benthic input of C than at offshore sites, with sources including kelp detritus. Taxa at the inner gulf sites are also likely to be subjected to a proportion of benthicaly-derived enriched $\delta^{13}C$. There were no obvious effects of marine reserve status on the isotopic signatures of study taxa with the exception of slightly enriched $\delta^{13}C$ of kina and snapper at Leigh, and of kina at Tawharanui.

Otolith microchemistry results for parore and snapper indicate strong connectivity between reef and non-reef systems within the wider Hauraki Gulf ecosystem. The majority of fishes sampled (both species) were likely to have originated as juveniles from lower salinity water environments such as estuaries fringing the Gulf. For snapper, our data suggest that only a small percentage of juveniles derive from reefs themselves. However, greater sampling replication is now required across a range of reef sites to better define the ratio of reef- versus estuary-derived juveniles, given the low percentage of reef-derived snapper.

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ZBD2008-07 Carbonate Sediments: The positive and negative effects of land-coast interactions on functional diversity (complete):

Land-coast interactions can profoundly influence coastal biodiversity and ecosystem function. Estuarine primary productivity derived from phytoplankton, resuspended phytobenthos, aquatic vegetation and fringing habitat plant material is exported to the adjacent coast on outgoing tides and contributes to secondary production in the vicinity of the estuary mouth. However, land-derived sediments and contaminants that are discharged from estuaries can also stress open coastal populations. The balance of these competing processes was evaluated using a combination of laboratory and field investigations. A survey of two coastal locations (outside Whangapoua and Tairua harbours on the Coromandel Peninsula, New Zealand) quantified shifts in community structure in mollusc-dominated habitats and demonstrated that both distance from the mouth of the estuary and the size and density of large shellfish living in the sediments affect the composition and functionality seafloor communities. Tracing the importance of different estuary-derived food resources (seagrass, mangrove, estuarine phytoplankton and phytobenthos) using stable isotopes emphasized the importance of estuarine productivity to coastal bivalve. The work in the field has been supplemented with laboratory feeding trials, with the goal of verifying isotopic uptake rates in bivalve body tissues in a carefully controlled experimental setting. Trophic connections have important effects on coastal biodiversity. Understanding ecosystem processes and dynamics and their implications for functional biodiversity emphasises the importance of shifting the management focus from exploitation to resilience. Enhancing or maintaining this biodiversity will require more integrative ecosystem-based management focused on maintaining the resilience of coastal ecosystems.

Other research relevant or specifically linked to the projects above, are listed in Table 11.3.

Table 11.3: Other research linked to investigation of the role of biodiversity in the functional ecology of nearshore and offshore marine communities.

MPI	ZBD2005-04 Information on benthic impacts in support of the Foveaux Strait Oyster Fishery Plan ZBD2005-15 Information on benthic impacts in support of the Coromandel Scallops Fishery Plan ENV2005-23 Monitoring recovery of the benthic community between North Cape and Cape Reinga BEN2007-01 Assessing the effects of fishing on soft sediment habitat, fauna, and processes HAB2007-01 Biogenic habitats as areas of particular significance for fisheries management
CRI Core purpose	C01X1005— Management Of Cumulative Effects Of Stressors On Aquatic Ecosystems ; CO1X0907 Coastal Conservation Management, Freshwater and Estuaries and Coasts and Oceans
DOC	Conservancy surveys
BNZ	Biosecurity surveys
OTHER	Universities
EMERGING ISSUES	
Cumulative footprint of human activities; understanding cumulative impacts and risks; marine spatial planning	
Land-base effects on marine biodiversity and inshore/offshore habitats; pollution in offshore	
Ecosystem-based management and integrative governance	
Defining marine ecosystem services, linking them to ecosystem function and societal values	

11.3.4. Progress on Science Objective 4. Marine genetic biodiversity

Genetic biodiversity can be measured directly by measurement made at the genes and chromosomes scale or indirectly by measuring physical features at the organism scale (assuming they have a genetic basis).

Genetic diversity is fundamental to the long-term survival, stability and success of a species. Central to this is the "metapopulation" concept where populations are sufficiently genetically distinct from each other to be identifiable as individual units. A low level of recruitment between populations counters the effects of random genetic drift and inbreeding depression of genetic diversity.

Human activities can profoundly affect genetic diversity both within populations and between populations. For example, shipping activity (movement across the globe) and aquaculture practices (transfer of organisms to different areas) can increase population connectivity such that genetic biodiversity may decrease between populations. In extreme cases, populations can become the same genetically (homogeneous) although considerable within population diversity may remain. In the event of increased genetic connectivity, a species may become more susceptible to extinction through biological or catastrophic stochasticity. That is, in the absence of between population diversity there is insufficient genetic variance to adapt to the effects of climate change, disease epidemics and so on.

In contrast, under the much more common scenario of habitat fragmentation caused by human activities (fishing, pollution), decreased connectivity between populations will result in greater between-population diversity, but a reduction of within-population diversity. This also results in a decrease in a species survival (fitness) because fragmented or isolated populations may become extinct through environmental and genetic stochasticity or localised depletion. Periodic fluctuations in annual temperature for example can lead to small scale population extinction, which in the absence of recruitment between populations will result, over time, in the demise of all populations.

To reduce the risk of species loss information about the genetic diversity both within populations (population isolation) and between populations (population connectivity) is needed. Without such information, the effects of perturbation on a species persistence and survival cannot be predicted. Furthermore, the links between genetic diversity, the dispersal capacity (mode of reproduction and life history development) of a species and the minimum viable population (MVP) size required in the marine environment to ensure population persistence, are little understood. For example, the MVP size for a species with a large dispersal capacity is likely to be quite different from that of a species with a relatively restricted dispersal capacity. Examining the connectivity between populations in the marine environment is fundamental to resolving some of the central challenges in ecology and has almost been ignored in the management of New Zealand fisheries or protection of biodiversity.

Projects

ZBD2002-12 Molecular identification of cryptogenic/invasive marine species – gobies.

Project complete. (Lavery *et al.* 2006.)

ZBD2009/10 Multi-species analysis of coastal marine connectivity.

An extensive literature review of published and unpublished information about connectivity of New Zealand coastal biota has been completed. Reviews were made of 58 studies of 42 taxa to identify the taxon or taxa studied, the habitat where each study took place, and geographic location of sampling sites used by each study. From these data, gaps in knowledge about taxa, habitats and spatial coverage of sampling were identified. Recommendations about four species to be studied, habitats that they should be collected from, and location of sampling sites were made. Recommendations included a standardised collecting protocol and

for the development and application of microsatellite markers to quantify the population genetic structure and the coastal connectivity of these taxa (Gardner *et al.* 2010).

Two PhD students are carrying out field work, genetic analyses, and writing up (in the form of two theses) of this research. Both studies are underway. Fieldwork has begun on two flatfish species and two species of shellfish. The project been extended to incorporate a subtidal species of shellfish. A new component of the coastal connectivity project has been added to include work on the New Zealand scallop, Pecten novaezelandiae. This work focuses on population genetic structure and genetic connectivity at two different spatial scales and uses microsatellite markers (consistent with the use of microsatellite markers for the 4 species already under investigation in the original ZBD2009-10 project). First, the extension work focusses on scallops in the Hauraki Gulf and Coromandel Peninsula region. Scallops have been collected from several populations in this region and further samples will be added in the next two years. Second, the extension work focuses on scallops across New Zealand (the full range of this species' distribution). Samples have been sourced from several regions including the fiords, the far north, and central New Zealand. In both cases, genetic connectivity will be assessed to determine linkages among populations at the two different spatial scales. The smaller spatial scale information will be of particular relevance to the scallop fishery in the Hauraki Gulf and Coromandel Peninsula region, whereas the larger scale work will complement ongoing studies of coastal connectivity at the national scale already under examination as part of the project. A PhD student has been recruited for this work and a suite of microsatellite markers has been developed for the New Zealand scallop and testing of population genetic variation is underway

Other research relevant or specifically linked to the projects above, are listed in Table 11.4.

Table 11.4: Other research linked to marine genetic biodiversity.

MPI	ENH2007-01 Stock enhancement of blackfoot paua GEN2007-01 Genetic population profile of blackfoot paua ENH2007-02 Outbreeding depression in invertebrate populations IPY2007-01 Objective 11. Barcode of life
MBIE	C01X0502 Biodiversity& Biosecurity
MPI	Base line surveys for non-indigenous species
OTHER	Universities **[?]**
BRAG PROJECTS FOR 2011-12	
Extension to ZBD2009-10 to include subtidal shellfish	
EMERGING ISSUES	
Can genetics combined with hydrographic models usefully contribute to the identification of biodiversity hot-spots and/or to source-sink relationships within ecosystems?	

11.3.5. Progress on Science Objective 5. Effects of climate change and variability on marine biodiversity

Cyclical changes or trends in climate and oceanography and associated effects such as increased ocean acidification and how they affect the marine ecosystem as a whole have long-term implications for trophic interactions and biodiversity, as well as functional aspects of the system e.g. biogeochemical processes. With significant improvement in remote sensing tools and global monitoring of climate change, new patterns are emerging indicating that there are long-term cycles. Examples include the Interdecadal Pacific Oscillation as well as shorter periods of change in relation to the El Niño Southern Oscillation that affect ocean ecosystems. Further, physical phenomena such as the deep subtropical gyre 'spin-up' in the South Pacific which resulted in a warmer ocean around New Zealand from 1996–2002, can have flow-on effects on ecosystem functioning.

A new report was launched in 2010 by the United Nations on ocean acidification[58] Among other findings, the study shows that increasing ocean acidification will mean that by 2100 some 70% of cold water corals, (a key refuge and feeding ground for some commercial fish species), will be exposed to corrosive waters (see also Tracey *et al.* 2011). In addition, given the current greenhouse gas emission rates, it is predicted that the surface water of the highly productive Arctic Ocean will become under-saturated with respect to essential carbonate minerals by the year 2032, and the Southern Ocean by 2050 with disruptions to large components of the marine food source, in particular those calcifying species, such as foraminifera, pteropods, coccolithophores, which rely on calcium carbonate.

Emerging research suggests that many of the effects of ocean acidification on marine organisms and ecosystems will be variable and complex and will affect different species in different ways. Evidence from naturally acidified locations confirms, however, that although some species may benefit, biological communities in acidified seawater conditions are less diverse and calcifying (calcium-reliant) species are absent whereas algae tend to dominate.

Many questions remain regarding the biological and biogeochemical consequences of ocean acidification for marine biodiversity and ecosystems, and the impacts of these changes on ecosystems and the services they provide, for example, in fisheries, coastal protection, tourism, carbon sequestration and climate regulation.

Studies to predict changes in biodiversity in relation to climate change in more than a rudimentary way are beyond the state of current knowledge in New Zealand. Nevertheless, surveys of biodiversity that have occurred or are planned will provide a snapshot against which future research results or trends can be compared.

Meeting the challenges of climate change and identifying crucial issues for marine biodiversity is an area of high political interest internationally[59] and has been identified as a gap in biodiversity research in New Zealand[60]

Projects

ZBD2005-05 Long-term effects of climate variation and human impacts on the structure and functioning of New Zealand shelf ecosystems.

This is a large scale project to investigate changes in shelf ecosystems over a 1000 year time-scale to provide context and perspective on issues of natural variation versus human impacts on marine biodiversity.

The project is a multidisciplinary study to collate and sythesise paleoecological, archaeological, historical, and contemporary data relating to changes in the structure and functioning of New Zealand shelf ecosystems since human arrival about 750 years ago. The data have been used to model present and four past states of the Hauraki Gulf ecosystem over the last 1000 years.

The project is collaborating with the international History of Marine Animal Populations (HMAP) project, itself a part of the Census of Marine Life (CoML) programme. A short video about the NZ Taking Stock project was made by HMAP staff and is currently available on the HMAP website http://hmapcoml.org/projects/nz/.

[58] http://www.un.org/apps/news/story.asp?NewsID=36941&Cr=emissions&Cr1 Downloadable Report The Environmental Consequences of Ocean Acidification

[59] http://biodiversity-l.iisd.org/news/ungas-second-committee-considers-biodiversity-and-sustainable-development/

[60] Green, W.; Clarkson, B. (2006). Review of the New Zealand Biodiversity Strategy Themes

Fifteen reports stemming from this project have been submitted to the Ministry and are at various stages of review, acceptance and publication. Four reports are still to be delivered. The report most relevant to this section is Pinkerton (In press). Other reports published to date are Carroll *et al.* (In press); Jackson *et al.* (In Press); Lalas *et al.* (In Press) a; b; Lalas & MacDiarmid (In Press); Lorrey *et al. (*In Press); MacDiarmid *et al.* (In Press a; b); Maxwell & MacDiarmid (In Press); Neil *et al.* (In Press); Paul (2012); Parsons *et al.* (In Press); Smith (2011).

ZBD2008-11 Predicting plankton biodiversity & productivity with ocean acidification.

This multi-year project is inter-linked with the Coasts and Oceans OBI and has the following objectives:

1. To document the spatial and inter-annual variability of coccolithophore abundance and biomass, and assess in terms of the phytoplankton abundance, biomass and community composition in sub-tropical and sub-Antarctic water.
2. To document the seasonal and inter-annual variability of foraminifera and pteropod abundance and biomass at fixed locations in sub-tropical and sub-Antarctic water by analysis of sediment trap material from time-series data collection.
3. To document the spatial and seasonal distribution of the key coccolithophore species, *Emiliana huxleyi*, using both archived and ongoing ingestion of satellite images of Ocean Colour, and ground-truth the reflectance algorithm for *E huxleyi* for future application in New Zealand waters
4. To determine the sensitivity of, and response of *E. huxleyi* and other EEZ coccolithophores to pH under a range of realistic atmospheric CO_2 concentrations in perturbation experiments, using monocultures and mixed populations from in situ sampling.
5. To document the spatial variability of diazotrophs (nitrogen-fixing organisms) and associated nitrogen fixation rate, and assess in terms of phytoplankton abundance, biomass and community composition in sub-tropical waters north of New Zealand.
6. To determine the sensitivity of diazotrophs to ocean acidification composition in sub-tropical waters north of New Zealand.

The project is proceeding according to plan and is still primarily in the sample collection phase with some data analysis but limited interpretation to date. The biodiversity record of coccolithophore species in New Zealand waters has been extended, with a transect across the Tasman Sea and a number of transects across the Chatham Rise. A bloom of the coccolithophore *Emiliana huxleyi* on the Chatham Rise was extensively characterised in terms of surface water biogeochemistry, and subsequently successfully cultured in the lab. Seasonal and interannual variability of *E. huxleyi* blooms were further characterised by extending the true colour satellite image analysis of presence/absence of coccolithophore blooms in the New Zealand EEZ. This was augmented by sample collection for ground-truthing of published calcite algorithms (for satellite detection of coccolithophore blooms) and application of a published calcite algorithm to New Zealand waters for 2002-3. Coccolithophore acidification sensitivity experiments were run in the Tasman Sea and the Chatham Rise region, with preliminary analysis indicating a decline in coccolithophore abundance under high CO_2, but not when accompanied by elevated temperature as predicted under future climate change scenarios. Analysis of sediment trap samples for pteropod and foraminifera identification and abundance was completed for 2000-2010, with significant interannual variability noted in both, but also some indication of a recent decline in pteropod abundance in Sub-Antarctic water. Sample analysis from the 2010 Tasman Sea voyage identified the presence of nitrogen-fixing unicellular cyanobacteria and significant nitrogen fixation south of the Tasman Front, in contrast to previous observations. In acidification sensitivity experiments on this voyage nitrogen fixation did not change or decreased under high CO_2 concentrations, in contrast to published data. Outputs to date include Boyd *et al.* (in press).

ZBD2009-13 Ocean acidification impact on key NZ molluscs.

Ocean acidification associated with increased atmospheric CO_2 levels is a pressing threat to coastal and oceanic ecosystems. The chemical reaction which occurs when this CO_2 is dissolved in seawater results in a well documented decrease in seawater pH (and an increase in seawater

acidity), which may physically dissolve $CaCO_3$ shells and/or skeletons and affect the shell/skeleton generation, as well as influencing many other physiological processes. Flow on effects to the viability of populations and the economic benefit that can be derived from commercially important species are likely. There is very little information on how key NZ calcifying species will respond to this change.

This project is using laboratory experiments to quantify responses of key New Zealand mollusc species (paua, *Haliotus iris*, cockles, *Austrovenus stutchburyi*, and oysters *Tiostrea chiliensis*) to levels of ocean CO_2 saturation predicted to occur in NZ waters over the following decades. Results will be combined with information on the role of these key species in influencing ecosystem structure and function, to assess local and ecosystem-scale implications of acidification of NZ coastal waters expected in the following decades.

ZBD2010-41. Potential effects of ocean acidification on habitat forming deep-sea corals in the New Zealand region.

Specific Objectives of this research were to 1. Determine the carbonate mineralogy of selected deep-sea corals found in the New Zealand region, 2. Assess the distribution of deep-sea coral species in the region relative to improved knowledge of current and predicted aragonite (ASH) and calcite saturation horizons (CSH), and 3. Assess potential locations vulnerable to deepwater upwelling and areas of key deep-water fishery habitat. Through a literature search and analysis, the project aimed to determine the most appropriate tools to age corals and measure the effects of ocean acidification on deep-sea habitat-forming corals, and recommend the best approach for future assessments of the direct effects of declining ocean pH on these key fauna.

Under Objective 1, new results of investigations into the carbonate mineralogy of selected deep-sea corals found in the New Zealand region were presented, and previous work on coral mineralogy summarised. The mineralogy and trace element concentration (Sr and Mg) of the five branching stony coral species (Order: Scleractinia) *Goniocorella dumosa*, *Solenosmilia variabilis*, *Enallopsammia rostrata*, *Madrepora oculata*, and the endemic *Oculina virgosa*, and for the key habitat forming gorgonian coral species (Order: Alcyonacea) *Keratoisis* spp., *Lepidisis* spp., *Paragorgia* spp. and *Primnoa sp*., was ascertained. Stony branching corals are all aragonitic with high Sr and low Mg while most of the gorgonian corals are made of high Mg and low Sr, with high Mg calcite (>8 mol% Mg). The gorgonian sea fan, *Primnoa sp*., is aragonitic.

Under Specific Objective 2, up to date position and depth data were used to produce distribution maps for the study species. Data compare well with previous publications from biodiversity research, research trawl, and observer sampling effort on wide regional distribution, but individual species display variations within the region. The peak depth distributions are unimodal at about 800-1000 m for most of the above species, but *G. dumoas*, *E. rostrata*, and *Lepidisis* spp. show bi-modal distributions and *O. virgosa* occurs primarily in shallow depths. In the second year of the project these distribution data will be compared with existing and predicted aragonite and calcite saturation horizons, particularly in areas of key deepwater fishery habitat.

Also under Specific Objective 2, on-going opportunistic water sampling analyses are being carried out to determine alkalinity and dissolved inorganic carbon (DIC), and modelling to determine aragonite (ASH) and calcite saturation horizon (CSH) data is in progress. The aim is to compare water carbonate chemistry with regional biogeochemistry models and future scenarios to identify areas potentially at risk from ocean acidification.

Under Specific Objective 3, at-sea sampling of live corals for aquarium studies has been carried out to investigate the feasibility of keeping the corals alive for growth and ocean acidification experiments. The corals collected in April, 2012 are still alive in the laboratory and include one small colony of *S. variabilis*. A literature search and analysis to determine the most appropriate tools to age and measure the effects of ocean acidification on deep-sea habitat-forming corals is

in progress. From these trials and reviews, recommendations on the best approach for future assessments of the direct effects of changes in ocean pH on these key fauna will be made.

Other research relevant or specifically linked to the projects above, are listed in Table 11.5.

Table 11.5: Other research linked to effects of climate change and variability on marine biodiversity.

MPI	SAM2005-02 Effects of climate on commercial fish abundance ENV2007-04 Climate and oceanographic trends relevant to New Zealand fisheries
MBIE	C01X502 Coasts & Oceans Centre
DOC	Baseline surveys; protected deepsea corals (Tracey *et al.* 2011; Baird *et al.* 2012)
OTHER	University of Otago-NIWA shelf carbonate geochemistry and bryozoans Geomarine Services-foraminiferal record of human impact Regional Council monitoring programmes
EMERGING ISSUES (this objective)	
What papers can be generated on the effects of climate change on marine biodiversity in NZ in time for 5th IPCC report? How does climate change influence marine microbial diversity, species mix and biogeochemical roles? How will harmful toxic algal blooms be affected by warming seas? (e.g. Chang 2003, Chang *et al.* 2003)	

11.3.6. Progress on Science Objective 6. Biodiversity metrics and other indicators for monitoring change

In the mid 1990s, monitoring of marine biodiversity and the marine environment was a topic of considerable discussion, yielding several reports on developing MfE indicators[61] However, since the publication of MfE's indicators in 2001, a much reduced set of core indicators that relate to the marine environment have been reported on[62]. A new international initiative launched in 2010 "Biodiversity Indicators Partnership[63]" provides guidelines and examples of biodiversity indicators developed around the globe, however, Oceania does not appear to have any partnership identified. The link between this initiative and OECD environmental indicators is unclear.

A serious gap identified by Green and Clarkson (2006)[64] in their review of progress on implementation of the *NZBS* was the lack of development of an integrated national monitoring system (see Biodiversity Research Programme 2010: Part 4). Efforts to respond to this gap within the Biodiversity Programme resulted in the immediate initiation of a 5-year Continuous Plankton Recorder project, and a series of workshops to determine how best to approach monitoring on a national scale (ZBD2008-14). [One objective of monitoring would be to test the effectiveness of management measures.]

[61] Downloadable MfE reports Confirmed indicators for the marine environment 2001, ME398; An analysis of potential indicators for marine biodiversity 1998 TR44; Environmental Performance Indicators: an analysis of potential indicators for fishing impacts 1998 TR43; Environmental Performance Indicators: Summary of Proposed Indicators for the Marine Environment 1998, ME296; Environmental Performance Indicators: Marine environment potential indicators for physical and chemical processes, and human uses and values 1998 TR45; Potential coastal and estuarine indicators - a review of current research and data 1997 TR40; Monitoring and indicators of the coastal and estuarine environment - a literature review 1997 TR39

[62] http://www.mfe.govt.nz/environmental-reporting/about/tools-guidelines/indicators/core-indicators.html

[63] www.bipnational.net/IndicatorInitiatives

[64] Green, W.; Clarkson, B. (2006). Review of the New Zealand Biodiversity Strategy Themes.

Projects

ZBD2004-10 Development of bioindicators in coastal ecosystems.

Project complete (Savage 2009). Agricultural and urban development can increase run-off and lead to excessive nutrient loadings in fragile coastal environments that are nursery grounds for a diverse array of coastal and estuarine species, as well as other resident organisms. This project investigated the development of bioindicators to strengthen the ability of managers to detect and quantify changes in anthropogenic nitrogen inputs to coastal and estuarine ecosystems by comparing six study sites with different levels of development ranging from pristine through to fully urban. The results show a strong positive relationship between the percent agricultural land in surrounding catchments and total nitrogen (TN) loading to nearshore environments.

These results also hint at differences in dissolved and particulate nitrogen source pools, and highlight the importance of using complementary components of food webs and high spatial replication to show linkages between watershed land use and chemical markers in biota. The effects of nutrient enrichment were transmitted up the food web, with growth of secondary consumers, *Notolabrus celidotus* (spotties) and *Grahamina nigripenne* (estuarine triplefins) generally enhanced in nutrient enriched coastal areas. Benthic prey dominated the diets of these fish species, with amphipods and brachyurans being the most important prey items for triplefins and spotties, respectively. However, there were site-specific differences in prey importance and diet diversity. Both triplefins and spotties consumed considerably more diverse prey items at pristine than nutrient-enriched coastal areas. Food web models based on stomach content analyses and dual isotope ratios suggest that there are shifts in the relative importance of the different organic matter sources supporting food structure among the different coastal ecosystems due to nutrient enhancement from land-based activities. [how might these results be used in a biodiversity management context?]

ZBD2008-14 What and where should we monitor to detect long-term marine biodiversity and environmental changes?

Two workshops and a follow up meeting were held with stakeholders in 2008/09 to discuss a marine environmental monitoring programme (MEMP) for New Zealand, to detect long-term changes in the marine environment, building on existing time series and data collection (Livingston 2009). The MEMP was formulated into a developmental project staged over 3 years and submitted to the former Ministry of Research Science and Technology's Cross Departmental Research Pool (CDRP) for funding starting July 2010. Since that time, CDRP funding has been withdrawn. Instead a call for proposals taking a more modest approach to developing MEMP beginning with collation of all potential data series into a metadata database, a scientific evaluation of the existing time series as to their 'fit to purpose' for MEMP was made and tender evaluations are underway.

Monitoring change in the marine environment is the only way we can measure long-term trends, mitigate risk and provide evidence of changes which may require policy or management practice response. DOC has since been developing an integrated approach to monitoring biodiversity particularly on the land but also in marine reserves[65].

ZBD2008-15 Continuous Plankton Recorder Project: implementation and identification.

This project adopts the methods used in a long-term programme that has proved highly relevant to measuring biological changes in the ocean, i.e., the Continuous Plankton Recorder Programme in the North Atlantic (SAHFOS) and more recently the Southern Ocean[66]. This 5-year MPI project aims to map changes in the quantitative distribution of epipelagic plankton, including

[65] The Department of Conservation Biodiversity Monitoring and Reporting System Fact Sheet July 2010
[66] Southern Ocean CPR programme http://data.aad.gov.au/aadc/cpr/

phytoplankton, zooplankton and euphausiid (krill) life stages annually when vessels depart and return from New Zealand on their journey to the Ross Sea toothfish fishery each year in November/December, and February/March traversing key water masses and ocean fronts in New Zealand's EEZ as well as south to the Ross Sea. Four years the transectshave been collected, staff have been trained in plankton ID work and over three years of samples analysed.

ZBD2010-42 Marine Environmental Monitoring Programme.

This project continues from ZBD2008-14. A starting point to the assessment and reporting of broad-scale changes in New Zealand's marine environment is to define basic criteria and locate all existing and past time series of marine environmental data to improve awareness and access to these data. After this, these data can be evaluated as to their fitness-for-purpose for contributing towards a national Marine Environmental Monitoring Programme (MEMP). To date an online catalogue has been designed and a portal to this is available at http:\geodata.govt.nz. Questionnaires were developed to determine what marine environmental time series data were available within New Zealand. Information to date gives us 131 databases, 50% of these are listed as having ongoing funding (although not necessarily for all locations), and another 19% are listed as likely to continue. Over 70% are publically available. Most cover more than one location, although this is dependent on how the databases are constructed, e.g., DOC at present has a separate database for each marine reserve, while regional councils tend to have separate databases for different subjects (e.g., contaminant monitoring, ecological monitoring). Around 95estuaries and harbours are being sampled, which is not surprising given that the majority of the information comes from Regional Councils (Figure 1). There are 78 coastal locations and 33 marine reserves.

The second phase, determining fitness-for-purpose, was begun at a workshop held at NIWA on 11th June (see objective 3). Priority variables for inclusion in a national monitoring programme have been identified from responses to a questionnaire sent to scientific experts and central and regional government departments involved in monitoring and/or reporting. Core reference sites and major gaps in the spatial network are presently being determined and the requirements for spatial and temporal sampling determined. The project is due to be completed by June 2013.

Other research relevant or specifically linked to the projects above, are listed in Table 11.6.

Table 11.6: Other research linked to biodiversity metrics and other indicators for monitoring change.

MPI	ENV2006-15: Database and fishing indicator on seamount habitats (Rowden *et al 2008*) BEN2009-02 (Tuck *et al.* 2010) ENV2006-04: Fisheries indicators from trawl surveys (Tuck 2009) DEE2010-05
MBIE	Core funding for Coasts and Oceans Centre
DOC	Conservancy projects-Hawke's Bay;
OTHER	Regional Councils, Universities
EMERGING ISSUES	
Monitoring coastal waters and New Zealand's oceans to report on a national scale remains a major gap	
There is little longterm commitment to direct monitoring the marine environment	

11.3.7. Scientific Objective 7. Identifying threats and impacts to biodiversity and ecosystem functioning

Many marine ecosystems in New Zealand have been modified in some way through the harvesting of marine biota, the selective reduction of certain species and size/age classes, modification of food webs, including the detrital components and habitat destruction. Benthic communities including seamount communities, volcanic vent communities, bryozoans, corals, hydroids and sponges are

vulnerable to human disturbance. The mechanical disturbance of marine habitats that occurs with some activities such as trawling, dredging, dumping, and oil, gas and mineral exploration and extraction; can substantially change the structure and composition of benthic communities. The invasion of alien species into New Zealand waters is also a real threat, with evidence of nuisance species already well established[67]

A number of inshore marine ecosystems (especially estuaries and other sheltered waters) have been modified by sediment, contaminants and nutrients derived from human land use activities (Morrison *et al.* 2009). Coastal margin development has had a major impact on some inshore marine communities.

A recent project commissioned by the MPI Aquatic Environment Programme, identifies key threats to the marine environment (BEN2007-05) is complete and has listed and ranked the top threats to New Zealand's marine environment, as perceived by expert opinion. Relevant findings are that the highest ranking threats are ocean acidification, increasing sea water temperatures and bottom trawling (across all habitats) and that the most threatened habitats are intertidal reef systems in harbours and estuaries (MacDiarmid *et al.* 2012). Ecological risk assessment (ERA) methods have also been reviewed (under ENV200515, Rowden *et al.* 2008), and a trial Level 2+ assessment completed on Chatham Rise seamounts to estimate the relative risk to seamount benthic habitat from bottom trawling (under ENV200516, Clark *et al.* 2011). An MPI project (DEE2010-04) has resulted in a new ecological risk assessment being developed that is tailored for New Zealand deepwater fisheries (Clark *et al.* in press).

Projects

ZBD2009-25 Predicting impacts of increasing rates of disturbance on functional diversity in marine benthic ecosystems. The objectives of this project are to:

1. Further develop landscape/seascapes ecological model of disturbance/recovery dynamics in marine benthic communities, incorporating habitat connectivity, based on existing model by Lundquist *et al.* (2010).
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.

The baseline model, incorporating connectivity, has been created in Matlab. Objective 2 (predictions for functional biodiversity based on model) is underway. Some progress has been made on objective 3 (quantify functional biodiversity from existing data) through familiarisation of the programmers with the datasets of the Ocean Survey 2020 Chatham/Challenger project (ZBD2007-01) and biodiversity analyses to date for objective 8 of that project. Objective 4 is in process, with the majority of the field test funded by BEN2007-01. Researchers from both projects have met to discuss and modify the draft sampling design in order to best allocate sampling to test the predictions of the functional diversity model. The field testing took place in March-April 2010 in Tasman/Golden Bay.

Other research relevant or specifically linked to the projects above, are listed in Table 11.7.

[67] http://www.biosecurity.govt.nz/biosec/camp-acts/marine
http://www.biosecurity.govt.nz/pests/salt-freshwater/saltwater
http://www.biosecurity.govt.nz/about-us/our-publications/technical-papers

Table 11.7: Other research linked to threats to and impacts on biodiversity.

MPI	BEN2007-05 Assessment of anthropogenic threats to New Zealand marine habitats. MacDiarmid *et al* 2012 DEE2010-04
MBIE	CO1X0906 Vulnerable deep-sea communities (mapping and sampling a range of deep-sea habitats (seamounts, slope, canyons, seeps, vents), and determining relative risk to their benthic communities from human activities
EMERGING ISSUES	
The socio-economic valuation of biodiversity in NZ has not been adequately addressed.	
The cumulative footprint of anthropogenic activities on the NZ marine environment has not been assessed. Potential development of seabed mining makes this a priority in deepwater environments as well as coastal.	

11.3.8. Biodiversity in Antarctica: BioRoss Project Summaries and Progress

The objectives of BioRoss are to improve understanding of the biodiversity and functional ecology of selected marine communities in the Ross Sea. These objectives are being achieved by commissioning directed research on the diversity and function of selected marine communities in the Ross Sea region. BioRoss is committed to linking with ongoing Ross Sea ecosystems research through the Antarctic Working Group, and supporting climate change related research, especially at high latitudes.

Data acquisition from the Antarctic marine environment is logistically difficult and expensive. Nevertheless, the seven biodiversity Science Objectives listed above also drive BioRoss research projects. The BioRoss survey in 2004 and the Latitudinal Gradient Project ICECUBE have provided significant new information on biodiversity, species abundance and distribution that are now facilitating research into functional ecology and longer term monitoring programmes. This research has the potential to lead into other research on genetic diversity, climate variability and the development of indicators. The research results are also being used in the MPI Antarctic Research Programme projects on ecosystem modelling of the Ross Sea.

The MPI Antarctic Research and BioRoss Programmes are also directly involved in supporting the development of protection measures around the Balleny Islands. In 2005 MPI scientists and Ministry of Foreign Affairs and Trade (MFAT) personnel prepared a paper for submission to CCAMLR justifying MPA designation around the islands to protect ecosystem processes occurring there that may be important for the stability and function of the wider Ross Sea regional ecosystem.

To collect data in support of the MPA proposal, MPI BioRoss funded a targeted research voyage to the Balleny Islands in February 2006 (ZBD2005-01), and also provided supplementary funding to carry out opportunistic biological sampling at the Balleny Islands on a voyage to the Ross Sea that was primarily funded by LINZ to do bathymetric mapping.

The field sampling of these projects were successful, both providing important data and specimens from the Balleny Islands area and supplementary information for the Antarctic Working Group Research Programme. The results will inform research planning for subsequent projects. Support for Ross Sea region biodiversity will remain a high priority for future research in the BioRoss Programme.

In addition, BioRoss funded a further ICECUBE project to sample the Antarctic coastline during the summer season of 2006/07 (ZBD2006-03). ICECUBE is a key part of the international Latitudinal

Gradient Project to explore hypotheses about environmental drivers of structure and function in sub-tidal ecosystems along the western Ross Sea coastline (Cummings *et al.* 2008). This project acquired funding for three seasons (2007/08, 08/09, 09/10) as part of the MBIE IPY contestable round (see also Cummings *et al.* 2011 and Thrush and Cummings 2011). Published reports and papers from the MPI Ross Sea coastal projects include Cummings *et al.* 2003, 2006, 2008, 2010, 2011. De Domenico *et al.* 2006, Grotti *et al*, 2008, Guidetti *et al.* 2006, Norkko *et al.* 2002, 2004, 2005, 2007; Pinkerton *et al.* 2006, Schwarz *et al.* 2003, 2005, Sharp *et al.* 2010, Sutherland 2008, Thrush *et al.* 2006, 2010 and in press.

The New Zealand Government provided one-off funding for a Census of Antarctic Marine Life (CAML) survey to the Ross Sea from *R.V. Tangaroa* as part of New Zealand's involvement in the 2007-08 International Polar Year activities. The CAML Voyage was a large cooperative research effort under the banner of Ocean Survey 20/20 with considerable international collaboration, simultaneously utilising a number of different vessels with different strengths and capabilities. Progress on the two projects IPY2007-01 and IPY2007-02, is detailed below.

Projects

ZBD2002-02 Whose larvae is that? Molecular identification of planktonic larvae of the Ross Sea. Completed. (See Sewell *et al.* 2006, Sewell 2005, Sewell 2006.)

ZBD2003-03 Biodiversity of deepwater invertebrates and fish communities of the north western Ross Sea. Completed. Two AEBR reports were produced by Rowden *et al.* (2012a, in press) and a Voyage Report, Mitchell and Clark 2004. A number of papers have also been published in the scientific literature using specimens or data from the 2004 biodiversity survey (e.g. De Domenico *et al.* 2006, Schiaparelli *et al.* 2006, Rehm *et al.* 2007, Kröger & Rowden 2008, Clark *et al.* 2010)

ZBD2005-01 Balleny Islands Ecology Research, Tiama Voyage (2006).

This voyage collected a large amount of new data from the Balleny Islands and surrounding waters using a range of methods, including bird and mammal observations, whale biopsy sampling, shore-based penguin colony surveys, SCUBA dive quadrats and transects, tissue collections for stable isotope analyses, and continuous acoustic/bathymetric data collection (Smith 2006). Some of the specimens and data have been used for other studies.

ZBD2005-03 Opportunistic biological data during 2006 Ross Sea voyage utilising Tangaroa.

This project is complete (MacDiarmid and Stewart 2012).In brief it proved feasible to assess demersal fish abundance using the camera and lights. Because sampling was restricted to areas outside the main fishery, no toothfish were observed. The camera system, (a predecessor to the deep towed imaging system (DTIS)) proved capable of characterizing the demersal fish habitat associations. Sampling using a variety of methods yielded specimens and tissue samples of a wide variety of benthic and pelagic organisms. The acoustic information collected on water column organisms was less useful than desired because of interference from the bottom profiling aspects of the voyage. Marine mammals and seabirds were routinely recorded and automated sampling of the surface waters using a continuous plankton recorder and instruments to record sea surface temperature, salinity and chlorophyll-a concentration was successful.

ZBD2008-23 Macroalgae diversty and benthic community structure at the Balleny Islands.

Project complete**.** As a result of this study, the known macroalgal flora of the Balleny Islands has increased from 13 to 27 species, and there are 2 new records for the Ross Sea in addition to the 3 new records reported by Page *et al.* (2001). The biodiversity however remains poorly known, and detailed comparisons with other parts of the Antarctic region would be premature. A high proportion of the taxa reported here are known from only one collection, with a further group of taxa known from either two or three collections. Many of the taxa cannot be fully documented as there is insufficient mature material available.

The samples collected as part of a benthic survey at Borradaile Island, one of the Balleny Islands group, during the 2006 *Tiama* expedition have been analysed to provide an assessment of benthic community structure. The Borradaile Island sites were located in a high energy environment, sediments had relatively high organic and chlorophyll *a* content, and considerably lower concentrations of degraded plant material (phaeophytin) than noted in previously surveyed southern Ross Sea locations. Borradaile Island macrofaunal diversity was within the range noted for the more southern sites; macrofaunal abundance however, was more variable. Epifaunal diversity was very low, with the seastar *Odontaster validus* the only large epifaunal taxon found. In contrast, the Borradaile Island dive sites had high macroalgal diversity. Although not observed at these dive sites, the *Tiama* voyage researchers noted shallow water areas with high diversities of encrusting organisms. This study has provided the first analysis of shallow water benthic communities of the Balleny Islands. While it has shown some interesting similarities and contrasts in benthic diversity with other coastal Ross Sea locations, this information from Borradaile Island may not be representative of the entire Balleny area, and further surveys from other sites within the Balleny group are recommended (Nelson *et al.* 2010).

ZBD2008-20 Ross Sea Ecosystem function: predicting consequences of shifts in food supply.

Project complete. Detailed information on the uptake and incorporation of different primary food sources to key epibenthic species help predict consequences of potential environmental change. Over a two year period, *in situ* investigations into responses to, and utilisation of, primary food sources by a common ophiuroid, were conducted at two contrasting coastal Ross Sea locations, Granite Harbour and New Harbour. At both locations, benthic net primary production was measured and the contributions of large macrobenthic organisms to ecosystem functions such as organic matter processing and nutrient recycling were quantified. Granite Harbour benthic soft-sediments supplied overlying waters with regenerated ammonium and phosphate, and the ophiuroid significantly increased the rates of nutrient release. Ultimately, the nutrients will be used by microalgae in the water column and under the ice. Detrital algae (phaeophytin) were present in sediments at greater concentrations than fresh microalgal material (chlorophyll a), and appears to be functionally important; it was a significant predictor of dissolved oxygen, phosphate, ammonium and nitrate-plus-nitrite flux. Benthic organisms in predominantly ice covered Ross Sea locations such as Granite Harbour probably feed on degraded detrital algae for much of year, given the limited amount of fresh microalgae available due to the dimly lit environment, and the consequently low rates of in situ benthic primary production. Results of the New Harbour investigations contrast those of Granite Harbour, reflecting the very different ice conditions at these two locations (Cummings *et al.* 2010; Lohrer *et al.* 2012).

IPY2007-01 NZ International Polar Year Census of Antarctic Marine Life

Overall science objectives for the Project were developed by MPI, NIWA and other interested and participatory parties in discussions held through the Ocean Survey 20/20 Science Working Group.

1. To measure and describe the relationships between patterns of marine organisms, their biodiversity and environmental variables between longitudes ~170°E and ~175°W, and depths down to ~3500-4000m in the Ross Sea region.

2. To assess the trophic interrelationships of the major functional groups in the Ross Sea and regional ecosystem, with particular reference to improving inputs to ecosystem modelling.

3. To obtain baseline measures of the marine environment and identify a suite of ecosystem or environmental indicators that could potentially be used to monitor change in response to environmental or anthropogenic forcing in the Ross Sea region

All specific objectives apart from objective 2 have now been completed.

Specific Objective 1: To measure seabed depth and rugosity using the multibeam system (whenever possible) to identify topographic features such as bottom type, iceberg scouring, seamounts etc and

to determine areas for targeted benthic fauna sampling. (not funded in this project). Objective Completed. (Mitchell 2008, Hanchet *et al*. 2008)

Specific Objective 2: To continue the analysis of opportunistic seabird and marine mammal distribution observations from this and previous BioRoss voyages and published records, and in relation to environmental variables. (Draft report completed.)

The distributions of the seabird and marine mammal taxa reported from two RV Tangaroa voyages (TAN200602 and TAN200802) have been mapped. These represent the count data of seabirds recorded during the 2006 Ross Sea voyage and the locations of images of seabird taxa (recorded opportunistically) from the 2008 IPY-CAML voyage and records from observers from the toothfish fishery. The distributions include the presence data of taxa over waters south of about 60° S to the Ross Sea. Additional work to explain the distribution of the most common seabirds in relation to environmental variables has been proposed but has not yet started.

Specific Objective 3: To identify and determine near-surface spatial distribution, diversity and abundance of phytoplankton, and zooplankton, based on Continuous Plankton Recorder samples collected during transit to and from the Ross Sea.

The Continuous Plankton Recorder (CPR) was deployed during the IPY voyage, both during the transit to and from Wellington, and within the Ross Sea itself. CPR silks collected during transit were preserved in formalin and sent to Australian Antarctic Division where they were analyzed for zooplankton species composition and abundance. CPR silks collected within the Ross Sea were preserved in ethanol for the analysis of epipelagic meroplankon. In addition to the zooplankton, sampling, water samples were collected for phytoplankton analysis using the underway water sampling system from a depth of 7 m, corresponding to the approximate depth of CPR sampling. In addition to the work described above, ICOMM (International census of marine microbes) samples collected during the IPY-CAML survey (10 m depth x 4 stations) have been analysed by collaborators in the USA (Ghiglione *et al.* 2012).

Specific Objective 4: To analyse underway and station data collected on salinity, temperature and chlorophyll *a* data, spot optical measurements with the SeaWiFS Profiling Multichannel Radiometer (SPMR), surface samples for chlorophyll *a*, nutrients and particle analysis as well as underway nutrient observations to allow ground-truthing of data collection from satellites and identify water masses (e.g. surface seawater temperature, and chlorophyll concentration).

This objective addressed background physical and surface biological conditions at the time of the IPY-CAML survey. The objective was split into two parts 1. characterisation of the biological environment and bio-optical regime using continuous underway sampling, and 2. identification of thermohaline fronts using discrete and underway sampling of temperature, salinity and nutrient profiles. The combined dataset was used to validate satellite data of temperature and surface chlorophyll distributions, providing a synoptic overview of physical and biological conditions during the survey.

Specific Objective 5: To identify and determine the spatial distribution, abundance (biomass), diversity, and size structure of epipelagic, mesopelagic (and possibly bathypelagic) species using acoustics data, target strength estimation techniques and net sampling.

This objective addressed samples collected using the mesopelagic trawl and acoustic data collected from midwater marks using the ship's echosounders. Results were presented at five conferences: 1) CAML-IPY Symposium in Genoa, Italy, May 2009; 2) CCAMLR SG-ASAM meeting in Genoa, Italy, May 2009; 3) Antarctic New Zealand conference in Auckland, July 2009; New Zealand Marine Sciences' Society conference in Stewart Island, July 2011; and International Polar Year Symposium, Montreal, Canada, April 2012. Results were also presented to the Ross Sea Bioregionalisation workshop in Wellington in June 2009 (see below) and were incorporated in the

bioregionalisation reports prepared for CCAMLR (SC-CAMLR-XXIV-BG-25) and the Antarctic Treaty Consultative Meeting (ATCM). Reports include those by Koubbi *et al.* (2011), O'Driscoll (2009), O'Driscoll *et al.* (2009, 2011), Pinkerton *et al.* (in press), and Hanchet *et al.* (in press).

Specific Objective 6: To identify and measure diversity, distribution and densities of mesozooplankton, macrozooplankton and meroplankton.

This objective addressed the samples taken by Multiple Opening/Closing Net and Environmental Sampling System (MOCNESS) from the sea surface to the sea floor. The samples were quantitatively divided at sea to allow several complementary analyses to be performed. In terms of the mesozooplankton community in the Ross Sea, copepods were the dominant zooplankton collected in most samples, and this was primarily calanoids and cyclopoids (i.e., *Oithona* spp.). However, in certain cases pteropods (*Limacina helacina antarctica*) and salps (*Salpa thompsoni*) made important contributions to mesozooplankton abundance. Total water column mesozooplankton biomass ranged between 0.6-9.1 g C m^{-2} and was usually highest close to the surface. Mesozooplankton biomass in the Ross Sea was generally higher than expected, and can rival that of productive subantarctic regions (e.g., South Georgia). Salps were the main macrozooplankton species recorded in the MOCNESS samples and a paper describing the population ecology and distribution of *Salpa thompsoni* on the continental slope and around the seamounts to the north of the Ross Sea has been published by Pakhamov *et al.* (2011).

Samples were also preserved in ethanol for the analysis of meroplankton species composition and DNA sequencing. Larvae from at least eight phyla were found, with a remarkable dominance of annelids in both abundance and diversity. Overall, larval abundances observed were lower than other Antarctic studies, likely attributable to the late summer sampling, months after Ross Sea's phytoplankton bloom and the main trigger of spawning in many benthic invertebrates. Analysis of variation in meroplankton community composition showed significant differences among geographic regions (Shelf, Slope and waters of the Antarctic Circumpolar Current - ACC), among water masses (Shelf Water, Antarctic Surface Water, and Circumpolar Deep Water), and among depth strata (upper, midwater and bottom). Overall, near surface waters showed greater larval abundances, and these values decreased from the continental shelf to the slope, declining further in the deeper waters of the ACC. Differences between these locations were due not only to the presence or absence of certain taxa, but also a result of changes in OTU abundance.

Specific Objective 7: To determine diversity, distribution and densities of viral, bacterial, phytoplankton and microzooplankton species in the water column.

The full data sets have been completed and loaded into an MPI database and to the South western Pacific OBIS node (Gordon 2000). Phytoplankton and nanoplankton cell counts have revealed that there is a significant difference between shelf and abyssal site water column assemblages, both in terms of cell numbers, diversity and density. These data now have to be integrated with the water column data to help understand what may be driving the changes in these compositions.

Specific Objective 8: To determine the spatial distribution, abundance (biomass), diversity, and size structure of shelf and slope demersal fish species and associated invertebrate species using a demersal survey.

This objective had three key tasks; (i) to identify specimens, update the Ross Sea species list and determine biodiversity, (ii) to identify fish assemblages and relate them to environmental data, and (iii) to compare estimates of fish density and abundance between trawls, visual (video & still images) and acoustic sampling techniques. A fourth key task, to determine density and abundance of demersal fish using a bottom trawl survey, was funded under MPI project ANT2007-02. Results have been published as three scientific journal papers with an additional paper in review, and have been submitted to several CCAMLR working group meetings.

A paper on the distribution and diversity of demersal and pelagic fish species in the Ross Sea region including results from both the BioRoss and IPY surveys and collections from the toothfish fishery will soon be published (Hanchet *et al.* in press). A diverse collection of over 2,500 fish specimens was obtained from the BioRoss and IPY-CAML surveys representing 110 species in 21 families. When combined with previous documented material this gave a total species list of 175, of which 137 were from the Ross Sea shelf and slope (to the 2,000 m isobath). Demersal species richness, diversity and evenness indices all decreased going from the shelf to the slope and the seamounts. In contrast, indices for pelagic species were similar for the slope and seamounts/abyss but were much lower for the shelf.

A paper on the variation of demersal fish assemblages in the western Ross Sea including results from both the BioRoss and IPY surveys has been published (Clark *et al.* 2010). The distribution and abundance of 96 species able to be identified to species level collected in these surveys were examined to determine if demersal fish communities varied throughout the area, and what environmental factors might influence this. Three broad assemblages were identified, in the southern Ross Sea (south of 74ºS), central–northern Ross Sea (between latitudes 71º–74ºS), and the seamounts further north (65º–68ºS) where some species more typical of sub-Antarctic latitudes were observed. Multivariate analyses indicated that environmental factors of seafloor rugosity (roughness), temperature, depth, and current speed were the main variables determining patterns in demersal fish communities.

Acoustic data collected during the demersal survey suggest that there may be potential to use fisheries acoustic methods to obtain estimates of grenadier abundance (O'Driscoll *et al.* in press). The acoustic target strength distribution of single targets close to the bottom was very similar to that predicted based on the measured size range of grenadiers. There are also positive correlations between acoustic backscatter and trawl catches of grenadiers.

Photographic data collected using NIWA's Deep Towed Imaging System (DTIS) suggest that there may be potential to use photographic methods to obtain estimates of community structure and grenadier abundance (Bowden *et al.* in prep.).
Twenty-three sites spanning the continental shelf, northern continental slope, abyssal plain, and two seamounts were sampled using the towed camera and either demersal trawl or beam trawl, allowing direct comparisons between sampling methods. Patterns of species turnover between sites were similar across all methods. Estimates of fish population densities from the towed camera and beam trawl data were also comparable but those from the demersal trawl were consistently lower than for the other methods. *Macrourus* spp. grenadiers were ca. eight times less abundant in the demersal trawl than the video data but more large individuals were sampled by the trawl than the video and biomass estimates were similar.

Specific Objective 9: To determine the diversity, abundance/density, spatial distribution, and physical habitat associations of benthic assemblages across a body size spectrum from megafauna to bacteria, for shelf, slope, seamounts, and abyssal sites in the Ross Sea.

Using cameras, corers, epibenthic sleds, and trawls, benthic bacteria, macro-infauna, macro-hyperbenthic fauna, and mega-epifauna were sampled at sites on the continental shelf and previously unsampled areas on the northern continental slope of the Ross Sea, the abyssal plain, and seamounts to the north. Photographic data from seamounts in the northern Ross Sea region revealed a diverse and abundant fauna. Particularly striking were benthic communities comprised of stalked crinoids and brachiopods on Admiralty Seamount and the flanks of Scott Island which are reminiscent of an archaic fauna that may have survived through the isolation of these seamounts and reduced predator species (Bowden *et al.* 2010).

Taxonomists in New Zealand and around the world identified more than 150,000 individual specimens representing more than 700 species, many undescribed, across sixteen phyla for the

mega-epifauna groups alone (e.g. Lörz 2009, 2010, Eléaume *et al.* 2011). At least three genera and sixty-two species are new to science. All eukaryotic components of the benthic fauna showed similar broad-scale distributional trends across the study region. Total abundances and numbers of taxa were orders of magnitude higher on the continental shelf than on the slope or abyss plain, and shelf, slope, and abyssal samples were distinct from each other in multivariate analyses. Diversity, however, was comparable between shelf and abyssal sites and lowest on the slope. Bacterial diversity was highest in abyssal and slope samples, but abundance, biomass, production, and activity of all enzymes except proteinase, which was highest in the abyss, were significantly higher in shelf samples. Benthic mega-epifaunal community composition was more strongly correlated with depth and seabed current speed than either water column productivity or seasonal ice cover, indicating that local hydrodynamics and their influence on advection of primary production are more important in determining distributions across the shelf than are local variations in production. Fauna on the seamounts were distinct from all other samples and were comprised of both Antarctic and Southern Ocean species, including remarkable populations of a new hyocrinid species on Admiralty seamount (Bowden *et al.* 2011, Eléaume *et al.* 2011).

Published research to date has provided new insights into the distributions of several taxonomic groups (Lörz *et al.* 2009) , raised questions about the history of the northern seamount fauna over evolutionary time (Bowden *et al.* 2011), and contributed to a meta-analysis of the relationship between productivity and diversity in the deep sea (Leduc *et al.* 2012). In combination with molecular phylogenies and existing data from around Antarctica, results from this project represent a major contribution to knowledge of the Antarctic marine ecosystem.

Specific Objective 10: To describe trophic/ecosystem relationships in the Ross Sea ecosystem (pelagic and benthic, fish and invertebrates).
Progress has been made on obtaining data from which to elucidate trophic relationships between organisms in the Ross Sector of Antarctica collected on the IPY-CAML survey in February–March 2008. Two methods have been used. First, 1081 stomachs from 22 species of Antarctic fish were examined and the contents of the full or partially-full stomachs (comprising 776 fish) were identified to 68 prey codes. Index of Relative Importance (IRI) has been calculated from these data and diet overlap between fish species is presented. Second, stable isotope and elemental composition analysis of samples were carried out for carbon and nitrogen. In total, nearly 2000 samples were analysed. Samples include:

- Fish (N=662 muscle, N=377 liver samples, 22 species);
- Cephalopods (N=193);
- Pelagic invertebrates (N=407);
- Benthic sediments (N=36);
- Phytoplankton (N=92);
- Benthic invertebrates (N=200 completed, 95 pending analysis);

Results have already been used to assist in parameterising and validating the quantitative model of the food web of the Ross Sea (paper accepted by CCAMLR Science). Research on the shrinkage of Antarctic silverfish carried out as part of this objective has contributed to a paper presented to the Ministry of Fisheries Antarctic Fisheries Working Group and accepted for submission to the CCAMLR working group on fisheries assessment in September 2010 (Pinkerton *et al.* 2007, 2009a, 2009b).

Specific Objective 11: Assess molecular taxonomy and population genetics of selected Antarctic fauna and flora to estimate evolutionary divergence within and among ocean basins in circumpolar species. Provide DNA barcoding for all fish and multi-cellular invertebrate species by sequencing reference specimens in conjunction with Canadian Barcoding Centre, for specimen identification in gut content, plankton, and in taxonomic and population genetic projects.

DNA data sets generated for selected Ross Sea taxa were combined with parallel data sets generated by other Institutes in order to estimate divergence within and among regions in the Southern Ocean. High levels of divergence, indicative of cryptic speciation, were found in all major groups tested to date. Fishes: DNA sequencing of the COI gene revealed four well supported clades among the three recognized species of *Macrourus* in the Southern Ocean, indicating the presence of an undescribed species (Smith *et al.* 2011). A conclusion subsequently supported by meristic and morphometric examination of specimens with the description of a new species by McMillan *et al.* (2012). DNA barcodes also showed high sequence divergence among specimens of the slender codling *Halargyreus johnsonii* from New Zealand and the Southern Ocean, indicative of a cryptic species in this cosmopolitan species (Smith *et al.* 2011). A study of snailfishes collected during the IPY survey and from the toothfish fishery showed high species diversity with more than 34 Ross Sea liparid species in three genera; 18 of them new to science divergence (Stein 2012).

Invertebrates: A combined NZ-BAS data set on the octopod genus *Pareledone* provided one of the largest barcoding studies on a Southern Ocean genus. Ross Sea specimens provisionally identified as *Pareledone aequipapillae* appeared in a discrete clade to specimens from the Antarctic Peninsula, with a barrier to gene flow to the west of the Antarctic Peninsula (Allcock *et al.* 2010). Large numbers of echinoderms have been tissue sampled and sequenced for COI and include the Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea, and the crinoids (Dettai *et al.* in press). In the Ophiuroidea two dominant patterns emerged: a. widely distributed species showing shallow divergence by location and b. species with deeper divergence associated with location or depth, that represent cryptic species. A similar pattern emerged in the smaller set of Asteroid sequences, with deep divergences within some Ross Sea taxa. Preliminary results for the amphipod genus *Rhacotropis* showed 5 well supported clades, indicative of cryptic taxa; while for the genus *Epimeria* (27 specimens from the Ross Sea) there were two well supported clades for specimens identified as *Epimeria robusta*, and likewise for specimens identified as *E. schiaparelli*, indicative of cryptic taxa (Lörz 2009, 2010, Lörz *et al.* in press). These taxa show shallow morphological differences.

IPY2007-02 NZ IPY-CAML Cephalopoda.

This project will report on the diversity of Antarctic Cephalopoda (Octopus and Squid), including a complete inventory of taxa, and reports on ontogenetic and sexual variation in species, their systematics, diversity, distribution, life histories, and trophic importance. A MAppSc thesis has been completed as part of this project (Garcia 2010).

Other research relevant or specifically linked to the projects above, are listed in Table 11.8.

Table 11.8: Other research linked to MPI Ross Sea Antarctica biodiversity programme.

MPI	ANT2011-01 Stock modelling, fishery effects and ecosystems of the Ross Sea
MBIE	C01X1001 Protecting Ross Sea Ecosystems. Comparative distribution and ecology of *Macrourus caml* and *M. whitsoni* in the Ross Sea region; feeding relationships of fish species in the Ross Sea region; Spatial processes, including spatial marine protection; Ecosystem modelling of the Ross Sea region).(Pinkerton *et al.* 2012a,b; Murphy *et al.* 2012)
DOC	Leigh Torres NIWA/Alison
OTHER	Universities NIWA;Lincoln, Canterbury, Otago, Auckland, Waikato
EMERGING ISSUES	
Coastal research and functional ecology-ongoing need	
Taxonomic issues for fish and invertebrates (from IPY)ANT 2005-02	
Water samples from throughout water column to assess microbial content (from IPY) check with Els	

11.4. *Progress and re-alignment*

Given that the MPI Biodiversity programme has been running for 11+ years, and that a number of new strategic documents and directions are emerging across government, it is time to look both back and forward and review the programme to ensure its alignment with more recent strategic documents.

In 2000, five strategic outcomes were built into the MPI Biodiversity Research Programme:

That by 2010:

i) the MPI Biodiversity programme will have become an integral part of the research effort devoted to understanding New Zealand's marine environment.

ii) research planning will benefit from close cooperative relationships within the Ministry of Fisheries, with other government agencies, and with external stakeholders.

iii) mutually beneficial collaborative research projects will be carried out alongside other New Zealand and international research providers, especially for vessel-based research.

iv) MPI Biodiversity projects will have contributed substantially to an improved understanding of New Zealand's marine biodiversity and its role in marine ecosystem function, yielding scientifically rigorous outputs for a national and international professional audience.

v) results generated by MPI Biodiversity projects will be incorporated into management policy, with clear benefits for the New Zealand marine environment.

The Biodiversity Programme has been highly effective in delivering on the first 4 and part of the 5th of the five outcomes. A missing element is some measure of "*clear benefits for the New Zealand marine environment*". In recent years, significant all-of-government projects have been administered through the programme, and one-off funding applications made jointly with other stakeholders have been successful. The Programme has made a significant contribution to increasing understanding about biodiversity in the marine environment. Achievements in each outcome are addressed below.

i) Has the Biodiversity Research Programme become integrated with New Zealand's research effort to understand the marine environment?

Seven science objectives were developed by multiple stakeholders through the Biodiversity Research Advisory Group. The agreed objectives include ecosystem-scale studies in the New Zealand marine environment, the classification and characterisation of the biodiversity of nearshore and offshore marine habitats, the role of biodiversity in the functional ecology of marine communities, connectivity and genetic marine biodiversity, the assessment of the effects of climate change and increased ocean acidification, identification of indicators of biodiversity that can be used to monitor change, identification of key threats to biodiversity, identification of threats and impacts to biodiversity and ecosystem functioning beyond natural environmental variation.

Projects ranged from localised experiments on seabed communities of shellfish and echinoderms, to integrated studies of rocky reef systems and offshore fishery-scale trophic studies. The effects of ocean climate change (temperature, acidification) are being explored on shellfish, rhodolith communities, plankton productivity and the microbial productivity engines of polar waters. A major project to investigate shelf communities in relation to climate over the past 1000 years has resulted in the development of new methods and insights to past changes and human impact on New Zealand's marine environment.

A total of 55 projects were commissioned and managed within this 10 year period, yielding over 100 final research reports, most of which have been published through MPI Publications (Marine Biosecurity and Biodiversity Reports and Aquatic Environment and Biodiversity Reports), books, Identification Guides and mainstream scientific literature. A number of other publications are still in preparation. In addition, several workshops have been run through the Programme, including qualitative modelling techniques, how to set up a marine monitoring programme and predictive

modelling. A large number of science providers, including NIWA, Cawthron Institute, University of Auckland, Auckland University of Technology, University of Waikato, Victoria University of Wellington, University of Otago, University of Canterbury and Massey University have been directly commissioned or sub-contracted to take part in or conduct research projects through the Programme during the 10-year period. For some, the projects have provided critical synergies with MBIE funded OBIs or projects, while others have provided one-off opportunities for marine biodiversity investigation or opportunistic leveraging for research voyages.

Research into the biodiversity of habitats such as seamounts has been completed and new methods to assess the vulnerability of seabed habitats have been developed. The land-sea interface is being investigated and projects have shown how land use in a given catchment can affect nutrient transfer and the living conditions and impact diversity and functioning of estuarine and coastal organisms. Publication and presentation of the results from these projects has resulted in widespread contribution to the development of Marine Science in New Zealand. Partnership with overseas researchers and presentations to international meetings and conferences has added to the growing global initiatives on marine biodiversity research questions.

Feedback from stakeholders has indicated that the move to a 5 year research planning horizon was welcomed by research providers, but some stakeholders felt that Requests for Proposals should be at a higher level than individual projects to safeguard intellectual property on new ideas and methods.

ii) Does research planning now benefit from close cooperative relationships within the Ministry of Fisheries, with other government agencies, and with external stakeholders?

The Biodiversity Programme is very co-operative. Of 38 projects underway in the last 5 years, 14 have formal collaborative components across government departments, with other stakeholders or multiple research providers and 10 have formal linkages to international research programmes. Within MPI and with other stakeholders (NGOs, industry, other government departments), the Biodiversity Projects have contributed to discussions about Marine Stewardship Council (MSC) certification, to decision papers on aspects of Antarctic management under CAMLR, fulfilling MPI commitments to the NZ Biodiversity Strategy, and to MPI progress towards recognising the role of the ecosystem in underpinning sustainable and healthy fisheries production. There are many other examples, e.g. the programme has towards DOC and MPI decisions on marine protected areas. The interaction at the research and policy advice stages of resource management feeds back into the BRAG planning for future research.

There are close links with the MPI Aquatic Environment research programme, the National Aquatic Biodiversity Information System (NABIS), an MPI web-based interactive data access and mapping tool) and the MPI Antarctic Research programme. These and other links have enabled contributions resulting from progress on land-sea interface research, habitats of significance to fisheries management, trophic studies (MSC Certification), climate change (effects on shellfish) and habitat classification (fish optimised MEC, testing of MEC and BOMEC). The successful involvement of the Biodiversity Programme in major all-of-government projects such as Ocean Survey 20/20 and IPY-CAML, has also raised the profile of MPI and the research it has commissioned both across New Zealand and internationally.

Datasets, voucher specimens and samples from all biodiversity research projects have resulted in a substantial amount of material that has been physically preserved and housed in the Te Papa Fish Collection and NIWA National Invertebrate Collection. All data are held in databases either at MPI, NIWA or Te Papa, and accessibility is being improved. The recent Bay of Islands Ocean Survey 20/20 Portal was very well received and nominated for NZ Govt Open Source awards. It will also incorporate data access from Chatham Challenger and IPY projects. Data from a number of MPI biodiversity projects have also been entered into international biodiversity databases such as OBIS and from there into the Global Biodiversity Information Facility (GBIF).

Biodiversity Research planning receives regular input from DOC, SeaFIC, MfE, Cawthron Institute, NIWA, GNS, LINZ, MAFBNZ, Te Papa, University of Auckland, AUT, University of Otago, MoRST, MFAT, Regional Councils and others. Research planning for 2011-12 and beyond will include a re-alignment of the current research programme to take account of new developments such as Fisheries 2030, MfE's National Monitoring programme, DOC's integrated coastal monitoring programme, Statistic New Zealand's Environmental Domain Plan[68], and international commitments such as the recent CBD COP10 Aichi-Nagoya Agreement.

Feedback and support for projects by external stakeholders has shown that the Programme has been effective in promoting inter-agency collaboration. The Programme has also had close links with Research Data Management and the Observer Programme for certain projects (e.g trophic studies on the Chatham Rise, ZBD2004-02). With the former restructure of MPI and now the merger with MAF, and the move to Fisheries 2030 and Fisheries Plans, it important that the Programme develops strong relationships with the Fisheries Management and Strategy (International) groups within MPI and at MAF.

iii) *Have mutually beneficial collaborative research projects been carried out alongside other New Zealand and international research providers, especially for vessel-based research?*
As discussed above, collaborative research projects across government and among research providers have resulted in many mutually beneficial data and specimen collection, surveys of New Zealand marine biodiversity in NZ territorial seas, the EEZ and the Ross Sea, groundbreaking research into seamount biodiversity and the identification of VMEs, and research for international collaboration, particularly vessel based studies. Large scale vessel dependent oceanic research projects have made significant gains in baseline knowledge about the distribution and abundance of biodiversity in the EEZ/Ross Sea region. Vessel-based projects include: NORFANZ (Norfolk Island-Australia-New Zealand survey of biodiversity on Norfolk Ridge and Lord Howe Rise); BioRoss (MPI-LINZ, first NZ survey of biodiversity in the Ross Sea); Chatham-Challenger (LINZ-MPI-NIWA-DOC first Ocean Survey 20/20 project), NZ IPY-CAML (MPI-LINZ-NIWA (with international and NZ wide collaboration) survey of the Ross Sea as part of International Polar Year; Biodiversity of seamounts (MPI-NIWA-LINZ-MBIE voyages to the Kermadec Arc and on the Chatham Rise). These projects have generated huge geo-referenced datasets and thousands of specimens for Te Papa and National Invertebrate Collections. They have also resulted in the identification of new species, new genera and new families, as well as new records extending the known distribution of species. These surveys have contributed to habitat classification, identified areas of high biodiversity and challenged paradigms on the environmental drivers that determine biodiversity. More recently they have provided new information on the effects of ocean acidification on the productivity of polar seas, and in New Zealand waters.

Vessel dependent coastal projects have also generated significant new understanding about the distribution of inshore biota, and the role they play in maintaining a healthy ecosystem. Experimental field work on the productivity of the seabed has been carried out in NZ waters (Fiordland, Otago, Bay of Islands, Hauraki Gulf, Kaipara and Manukau Harbours), and along the west coast of the Ross Sea. The impact of land practices on the land-sea interface has also highlighted real downstream effects on the productivity of the coastal environment. These projects have provided new insights into the connectivity between different species groups, and data are being used in a number of ways to assist with spatial planning by RMAs.

Feedback from stakeholders has indicated that the collaborative voyages administered through the Programme have successfully created synergy and opportunity for New Zealand scientists as well as facilitating new international collaborations.

[68] http://www.stats.govt.nz/browse_for_stats/environment/natural_resources/environment-domain-plan-stocktake-paper.aspx

iv) *Have MPI [MFish] Biodiversity projects contributed substantially to an improved understanding of New Zealand's marine biodiversity and its role in marine ecosystem function, yielding scientifically rigorous outputs for a national and international professional audience?*

In the early years, the Programme focussed primarily on taxonomy and the description of marine biodiversity. As the Programme matured, projects to address biodiversity roles in ecosystem function were introduced. Some were experimental and on a local scale while others were on a regional scale. Recent projects have addressed patterns of marine biodiversity in relation to environmental drivers with ecosystem function. This enabled modelling to predict the distribution of biodiversity in unsurveyed areas of ocean, and evaluation of the vulnerability of biodiversity to perturbations such as climate change, as well as the modelling of trophic interactions among key fish species. Presentations of research results have been made to numerous overseas and New Zealand science audiences, and publications in the mainstream literature have been encouraged. IPY, Chat chall, Alison s etc CBD-FAO Int seabed authority

v) Have results generated by MPI [MFish] Biodiversity projects been incorporated into management policy, with clear benefits for the New Zealand marine environment?

Examples of incorporation into management policy with clear benefits for the marine environment include the increased awareness of research topics initiated in the biodiversity programme by policy analysts to core Aquatic Environment research projects and Fishery Plans, (land-use effects, climate change in the ocean, habitat classification); links to the Antarctic research programme and uptake into CCAMLR (ecotrophic studies, ecosystem baselines, VME risk assessment, bioregionalisation), spatial management (seamount closures, BPAs, MPAs, RMAs), the need by MfE to report on the marine environment at a national scale (plankton recording programme, Marine Environmental Monitoring Programme). MPI biodiversity advice is frequently requested to contribute to cross-government initiatives including Ocean Survey 20/20, DOC Sub-Antarctic Islands Forum National Monitoring, Stats New Zealand Tier 1 statistic review and Environmental Domain Stocktake, International Year of Biodiversity, OECD and CBD reports, International Oceans Issues, SPRFMO, NRS marine issues paper, the Antarctic Science Framework, Ocean Fertilisation and IPCC Finally, the programme has contributed to New Zealand's efforts in the international Census of Marine Life and an ongoing assessment of New Zealand's progress in Marine Biodiversity has been proposed as a new Tier 1 Environmental Statistic. However, the benefits to the marine environment are more inferred than demonstrated. There is substantially increased awareness within MPI and across government, that the health of fisheries and other valued uses of the sea depend on intact ecosystem services provided by the diversity of organisms, the diversity of habitats and the genetic diversity found in the marine environment. Statements of intent and long-term strategic documents such as Fisheries 2030 and Fish Plans have biodiversity protection and an ecosystem approach to fisheries management objectives explicitly stated. Future research questions will also need to address follow-up of management decisions to assess whether and to what extent the objectives have been achieved.

In 2000, the concept of research on marine biodiversity was hotly debated among stakeholders and the benefit of the research (other than to scientists) was not widely accepted. In 2010, it is clear that much of the research in this biodiversity programme has been about defining and mapping the biological diversity of the sea, its roles in marine ecosystem function, threats to these roles and how best biodiversity and its successful protection can be measured. Huge advances have been made in providing new identification tools for major groups (e.g. Coralline algae …). Much progress has been made, and the programme has successfully raised the profile of biodiversity in coastal and ocean environmental management, in particular fisheries management, and biodiversity research uptake into policy and management decisions within MPI and across government.

11.4.1. Concluding remarks

New Zealand is moving into an era of unprecedented and increasing interest in the utilisation of marine resources. Mineral, petroleum and gas resources are estimated to be worth billions of dollars to the economy (Glasby and Wright 1990), and new environmental legislation has been drafted (the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012). Changes inshore are also taking effect with the Environmental Protection Authority Act passed by Parliament on 11 May 2011. This Act establishes a new Environmental Protection Authority (EPA) as a standalone crown agent from 1 July 2011. The newly released Coastal Policy statement and proposed Policy Statement on Indigenous Biodiversity demonstrates an awareness by Government that much of New Zealand's primary production based economy is dependent on clean "green" policies supporting effective environmental management both on land, freshwater and in the sea.

New Zealand is also a signatory to the CBD Aichi-Nagoya Agreement with a new International Decade for Biodiversity that runs 2011-2020 and New Zealand's contribution to the identification of EBSAs in the SW Pacific, and to GOBI. Progress in our knowledge of the marine biodiversity and ecosystem services provided by the marine environment has clearly been made over the last decade. However, we need a more co-ordinated approach across government to link science to policy needs. For example, there is a compelling need for large-scale projects such as mapping seafloor habitats and establishing long-term nation-wide monitoring and reporting schemes to measure the effects of ocean climate change, regular assessment of the cumulative effects of anthropogenic activities and multiple stressors in the ocean and the effectiveness of their management. Without these, we face the risks that New Zealand's "green" branding will be increasingly challenged, and that tipping points in the health of the aquatic environment may be reached too soon for evasive action to be taken.

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11.6. *Appendix*

Technical rationale for the goals and targets of the strategic plan for the period 2011-2020. UNEP/CBD/COP/10/9 18 July 2010.

Strategic goal A. Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

Strategic actions should be initiated immediately to address, over a longer term, the underlying causes of biodiversity loss. This requires policy coherence and the integration of biodiversity into all national development policies and strategies and economic sectors and at all levels of government. Approaches to achieve this include communication, education and public awareness, appropriate pricing and incentives, and the broader use of planning tools such as strategic environmental assessment. Stakeholders across all sectors of government, society and the economy, including business, will need to be engaged as partners to implement these actions. Consumers and citizens must also be mobilized to contribute to biodiversity conservation and sustainable use, to reduce their ecological footprints and to support action by Governments.

[Note: Targets 1-5 not given here.] Targets 6-11 are directly quoted from the document.

Target 6: By 2020, overfishing is ended, destructive fishing practices are eliminated, and all fisheries are managed sustainably.] or [By 2020, all exploited fish stocks and other living marine and aquatic resources are harvested sustainably [and restored], and the impact of fisheries on threatened species and vulnerable ecosystems are within safe ecological limits.

Overexploitation is the main pressure on marine fisheries globally and the World Bank estimates that overexploitation represents a lost profitability of some $50 billion per year and puts at risk some 27 million jobs and the well-being of more than one billion people. Better fisheries management, which may include a reduction in fishing effort is needed to reduce pressure on ecosystems and to ensure the sustainable use of fish stocks. The specific target should be regarded as a step towards ensuring that all fisheries are sustainable while building upon existing initiatives such as the Code of Conduct for Responsible Fishing. Indicators to measure progress towards this target include the Marine Trophic Index, the proportion of products derived from sustainable sources and trends in abundance and distribution of selected species. Other possible indicators include the proportion of collapsed species, fisheries catch, catch per unit effort, and the proportion of stocks overexploited. Baseline information for several of these indicators is available from the Food and Agriculture Organization of the United Nations.

Target 7: By 2020, areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.

The increasing demand for food, fibre and fuel will lead to increasing losses of biodiversity and ecosystem services if management systems do not become increasingly sustainable with regard to the biodiversity. Criteria for sustainable forest management have been adopted by the forest sector and there are many efforts by Governments, indigenous and local communities, NGOs and the private sector to promote good agricultural, aquaculture and forestry practices. The application of the ecosystem approach would also assist with the implementation of this target. While, as yet, there are no universally agreed sustainability criteria, given the diversity of production systems and environmental conditions, each sector and many initiatives have developed their own criteria which could be used pending the development of a more common approach. Similarly, the use of certification and labelling systems or standards could be promoted as part of this target. Relevant indicators for this target include the area of forest, agricultural and aquaculture ecosystems under sustainable management, the proportion of products derived from sustainable sources and trends in genetic diversity of domesticated animals, cultivated plants and fish species of major socioeconomic importance. Existing sustainability certification schemes could provide baseline information for some ecosystems and sectors. UNEP/CBD/COP/10/9 Page 5 /...

Target 8: By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.
Pollution, including nutrient loading is a major and increasing cause of biodiversity loss and ecosystem dysfunction, particularly in wetland, coastal, marine and dryland areas. Humans have already more than doubled the amount of "reactive nitrogen" in the biosphere, and business-as-usual trends would suggest a further increase of the same magnitude by 2050. The better control of sources of pollution, including efficiency in fertilizer use and the better management of animal wastes, coupled with the use of wetlands as natural water treatment plants where appropriate, can be used to bring nutrient levels below levels that are critical for ecosystem functioning, without curtailing the application of fertilizer in areas where it is necessary to meet soil fertility and food security needs. Similarly, the development and application of national water quality guidelines could help to limit pollution and excess nutrients from entering freshwater and marine ecosystems. Relevant indicators include nitrogen deposition and water quality in freshwater ecosystems. Other possible indicators could be the ecological footprint and related concepts, total nutrient use, nutrient loading in freshwater and marine environments, and the incidence of hypoxic zones and algal blooms. Data which could provide baseline information already exists for several of these indicators, including the global aerial deposition of reactive nitrogen and the incidence of marine dead zones (an example of human-induced ecosystem failure).

Target 9: By 2020, invasive alien species are identified, prioritized and controlled or eradicated and measures are in place to control pathways for the introduction and establishment of invasive alien species.
Invasive alien species are a major threat to biodiversity and ecosystem services, and increasing trade and travel means that this threat is likely to increase unless additional action is taken. Pathways for the introduction of invasive alien species can be managed through improved border controls and quarantine, including through better coordination with national and regional bodies responsible for plant and animal health. While well-developed and, globally-applicable indicators are lacking, some basic methodologies do exist which can serve as a starting point for further monitoring or provide baseline information. Process indicators for this target could include the number of countries with national invasive species policies, strategies and action plans and the number of countries which have ratified international agreements and standards related to the prevention and control of invasive alien species. One outcome-oriented indicator is trends in invasive alien species while other possible indicators could include the status of alien species invasion, and the Red List Index for impacts of invasive alien species.

Target 10: By [2020][2015], to have minimized the multiple pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification, so as to maintain their integrity and functioning.
Given the ecological inertias related to climate change and ocean acidification, it is important to urgently reduce other pressures on vulnerable ecosystems such as coral reefs so as to give vulnerable ecosystems time to cope with the pressures caused by climate change. This can be accomplished by addressing those pressures which are most amenable to rapid positive changes and would include activities such as reducing pollution and overexploitation and harvesting practices which have negative consequences on ecosystems. Indicators for this target include the extent of biomes ecosystems and habitats (% live coral, and coral bleaching), Marine Trophic Index, the incidence of human-induced ecosystem failure, and the health and well-being of communities who depend directly on local ecosystem goods and services, proportion of products derived from sustainable sources. UNEP/CBD/COP/10/9 Page 6 /...

Strategic goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity
Whilst longer term actions to reduce the underlying causes of biodiversity loss are taking effect, immediate actions, such as protected areas, species recovery programmes, land-use planning approaches, the restoration of degraded ecosystems and other targeted conservation interventions can help conserve biodiversity and critical ecosystems. These might focus on culturally-valued species and key ecosystem services, particularly those of importance to the poor, as well as on threatened species. For example, carefully sited protected areas could prevent the extinction of threatened species by protecting their habitats, allowing for future recovery.

Target 11: By 2020, at least [15%][20%] of terrestrial, inland-water and [X%] of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through comprehensive, ecologically representative and well-connected systems of effectively managed protected areas and other means, and integrated into the wider land- and seascape.
Currently, some 13 per cent of terrestrial areas and 5 per cent of coastal areas are protected, while very little of the open oceans are protected. Therefore reaching the proposed target implies a modest increase in terrestrial protected areas globally, with an increased focus on representativity and management effectiveness, together

with major efforts to expand marine protected areas. Protected areas should be integrated into the wider land- and seascape, bearing in mind the importance of complementarity and spatial configuration. In doing so, the ecosystem approach should be applied taking into account ecological connectivity and the concept of ecological networks, including connectivity for migratory species. Protected areas should also be established and managed in close collaboration with, and through participatory and equitable processes that recognize and respect the rights of indigenous and local communities, and vulnerable populations. Other means of protection may also include restrictions on activities that impact on biodiversity, which would allow for the safeguarding of sites in areas beyond national jurisdiction in a manner consistent with the jurisdictional scope of the Convention as contained in Article 4. Relevant indicators to measure progress towards this target are the coverage of sites of biodiversity significance covered by protected areas and the connectivity/fragmentation of ecosystems. Other possible indicators include the overlay of protected areas with ecoregions, and the governance and management effectiveness of protected areas. Good baseline information already exists from sources such as the World Database of Protected Areas the Alliance for Zero Extinction, and the IUCN Red List of Threatened Species and the IUCN World Commission on Protected Areas.

12. Appendices

12.1. *Terms of Reference for the Aquatic Environment Working Group in 2012*

Overall purpose

For all New Zealand fisheries in the New Zealand TS and EEZ as well as other important fisheries in which New Zealand engages:

to assess, based on scientific information, the effects of (and risks posed by) fishing, aquaculture, and enhancement on the aquatic environment, including:

- bycatch and unobserved mortality of protected species (e.g. seabirds and marine mammals), fish, and other marine life, and consequent impacts on populations
- effects of bottom fisheries on benthic biodiversity, species, and habitat
- effects on biodiversity, including genetic diversity
- changes to ecosystem structure and function from fishing, including trophic effects
- effects of aquaculture and fishery enhancement on the environment and on fishing

Where appropriate and feasible, such assessments should explore the implications of the effect, including with respect to government standards, other agreed reference points, or other relevant indicators of population or environmental status. Where possible, projections of future status under alternative management scenarios should be made.

AEWG assesses the effects of fishing or environmental status, and may evaluate the consequences of alternative future management scenarios. AEWG does not make management recommendations or decisions (this responsibility lies with MPI fisheries managers and the Minister responsible for Fisheries).

MPI also convenes a Biodiversity Research Advisory Group (BRAG) which has a similar review function to the AEWG. Projects reviewed by BRAG and AEWG have some commonalities in that they relate to aspects of the marine environment. However, the key focus of projects considered by BRAG is on marine issues related to the functionality of the marine ecosystem and its productivity, whereas projects considered by AEWG are more commonly focused on the direct effects of fishing.

Preparatory tasks

1. Prior to the beginning of AEWG meetings each year, MPI fisheries scientists will produce a list of issues for which new assessments or evaluations are likely to become available prior to the next scheduled sustainability round or decision process. AEWG Chairs will determine the final timetables and agendas.

2. The Ministry's research planning processes should identify most information needs well in advance but, if urgent issues arise, MPI-Fisheries or standards managers will alert MPI-Fisheries science managers and the Principal Advisor Fisheries Science, at least 3 months prior to the required AEWG meetings to other cases for which assessments or evaluations are urgently needed.

Technical objectives

3. To review any new research information on fisheries impacts, including risks of impacts, and the relative or absolute sensitivity or susceptibility of potentially affected species, populations, habitats, and systems.

4. To estimate appropriate reference points for determining population, system, or environmental status, noting any draft or published Standards.

5. To conduct environmental assessments or evaluations for selected species, populations, habitats, or systems in order to determine their status relative to appropriate reference points and Standards, where such exist.

6. In addition to determining the status of the species, populations, habitats, and systems relative to reference points, and particularly where the status is unknown, AEWG should explore the potential for using existing data and analyses to draw conclusions about likely future trends in fishing effects or status if current fishing methods, effort, catches, and catch limits are maintained, or if fishers or fisheries managers are considering modifying them in other ways.

7. Where appropriate and practical, to conduct or request projections of likely future status using alternative management actions, based on input from AEWG, fisheries plan advisers and fisheries and standards managers, noting any draft or published Standards.

8. For species or populations deemed to be depleted or endangered, to develop ideas for alternative rebuilding scenarios to levels that are likely to ensure long-term viability based on input from AEWG, fisheries managers, noting any draft or published Standards.

9. For species, populations, habitats, or systems for which new assessments are not conducted in the current year, to review and update any existing Fisheries Assessment Plenary report text in order to determine whether the latest reported status summary is still relevant; else to revise the evaluations based on new data or analyses, or other relevant information.

Working Group input to annual Aquatic Environment and Biodiversity Review

10. To include in contributions to the environment analogue of the Fisheries Assessment Plenary Report (the Aquatic Environment and Biodiversity Review, AEBAR) summaries of information on selected issues that may relate to species, populations, habitats, or systems that may be affected by fishing. These contributions are analogous to Working Group Reports from the Fisheries Assessment Working Groups.

11. To provide information and scientific advice on management considerations (e.g. area boundaries, by-catch issues, effects of fishing on habitat, other sources of mortality, and input controls such as mesh sizes and minimum legal sizes) that may be relevant for setting sustainability measures.

12. To summarise the assessment methods and results, along with estimates of relevant standards, references points, or other metrics that may be used as benchmarks or to identify risks to the aquatic environment.

13. It is desirable that full agreement among technical experts is achieved on the text of contributions to the AEBAR. If full agreement among technical experts cannot be reached, the Chair will determine how this will be depicted in the AEBAR, will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.

14. To advise the Principal Advisor Fisheries Science, about issues of particular importance that may require review by a plenary meeting or summarising in the AEBAR, and issues that are not believed to warrant such review. The general criterion for determining which issues should be discussed by a wider group or summarised in the AEBAR is that new data or analyses have become available that alter the previous assessment of an issue, particularly assessments of population status or projection results. Such information could include:

- New or revised estimates of environmental reference points, recent or current population status, trend, or projections
- The development of a major trend in bycatch rates or amount
- Any new studies or data that extend understanding of population, system, or environmental susceptibility to an effect or its recoverability, fishing patterns, or mitigation measures that have a substantial implications for a population, system, or environment or identify risks associated with fishing activity
- Consistent performance outside accepted reference points or Standards

Membership and Protocols for all Science Working Groups (paragraph numbers consistent with those in Terms of Reference for Fisheries Assessment Working Groups)

Working Group chairs

17. The Ministry will select and appoint the Chairs for Working Groups. The Chair will be a MPI fisheries scientist who is an active participant in the Working Group, providing technical input, rather than simply being a facilitator. Working Group Chairs will be responsible for:

* ensuring that Working Group participants are aware of the Terms of Reference for the working group, and that the Terms of Reference are adhered to by all participants.
* setting the rules of engagement, facilitating constructive questioning, and focussing on relevant issues.
* ensuring that all peer review processes are conducted in accordance with the Research and Science Information Standard for New Zealand Fisheries[109] (the Research Standard), and that research and science information is reviewed by the Working Group against the *P R I O R* principles for science information quality (page 6) and the criteria for peer review (pages 12-16) in the Standard.
* requesting and documenting the affiliations of participants at each Working Group meeting that have the potential to be, or to be perceived to be, a conflict of interest of relevance to the research under review (refer to page 15 of the Research Standard). Chairs are responsible for managing conflicts of interest, and ensuring that fisheries management implications do not jeopardise the objectivity of the review or result in biased interpretation of results.
* ensuring that the quality of information that is intended or likely to inform fisheries management decisions is ranked in accordance with the information ranking guidelines in the Research Standard (page 21-23), and that resulting information quality ranks are appropriately documented in Working Group reports and, where appropriate, in Status of Stock summary tables.
* striving for consensus while ensuring the transparency and integrity of research analyses, results, conclusions and final reports.
* reporting on Working Group recommendations, conclusions and action items; and ensuring follow-up and communication with the MPI Principal Advisor Fisheries Science, relevant MPI fisheries management staff, and other key stakeholders.

[109] Link to the Research Standard: http://www.fish.govt.nz/en-nz/Publications/Research+and+Science+Information+Standard.htm

Working Group members

18. Working Groups will consist of the following participants:
    * MPI fisheries science chair – required
    * Research providers – required (may be the primary researcher, or a designated substitute capable of presenting and discussing the agenda item)
    * Other scientists not conducting analytical assessments to act in a peer review capacity
    * Representatives of relevant MPI fisheries management teams
    * Any interested party who agrees to the standards of participation below.

19. Working Group participants must commit to:

    * participating in the discussion
    * resolving issues
    * following up on agreements and tasks
    * maintaining confidentiality of Working Group discussions and deliberations (unless otherwise agreed in advance, and subject to the constraints of the Official Information Act)
    * adopting a constructive approach
    * avoiding repetition of earlier deliberations, particularly where agreement has already been reached
    * facilitating an atmosphere of honesty, openness and trust
    * respecting the role of the Chair
    * listening to the views of others, and treating them with respect

20. Participants in Working Group meetings will be expected to declare their sector affiliations and contractual relationships to the research under review, and to declare any substantial conflicts of interest related to any particular issue or scientific conclusion.

21. Working Group participants are expected to adhere to the requirements of independence, impartiality and objectivity listed under the Peer Review Criteria in the Research Standard (pages 12-16). It is understood that Working Group participants will often be representing particular sectors and interest groups, and will be expressing the views of those groups. However, when reviewing the quality of science information, representatives are expected to step aside from their sector affiliations, and to ensure that individual and sector views do not result in bias in the science information and conclusions.

    Information Quality Ranking:

22. Science Working Groups are required to rank the quality of research and science information that is intended or likely to inform fisheries management decisions, in accordance with the science information quality ranking guidelines in the Research Standard (pages 21-23). This information quality ranking must be documented in Working Group reports and, where appropriate, in Status of Stock summary tables.

    * Working Groups are not required to rank all research projects and analyses, but key pieces of information that are expected or likely to inform fisheries management decisions should receive a quality ranking.
    * Explanations substantiating the quality rankings must be included in Working Group reports. In particular, the quality shortcomings and concerns for moderate/mixed and low quality information must be documented.
    * The Chair, working with participants, will determine which pieces of information require a quality ranking. Not all information resulting from a particular research project would be expected to achieve the same quality rank, and different quality ranks may be assigned to

different components, conclusions or pieces of information resulting from a particular piece of research.

Working Group papers:

23. Working group papers will be posted on the MPI-Fisheries website prior to meetings if they are available. As a general guide, Powerpoint presentations and draft or discussion papers should be available at least 2 working days before a meeting, and near-final papers should be available at least 5 working days before a meeting if the Working Group is expected to agree to the paper. However, it is also likely that many papers will be tabled during the meeting due to time constraints. If a paper is not available for sufficient time before the meeting, the Chair may provide for additional time for written comments from Working Group members.

24. Working Group papers are "works in progress" whose role is to facilitate the discussion of the Working Groups. They often contain preliminary results that are receiving peer review for the first time and, as such, may contain errors or preliminary analyses that will be superseded by more rigorous work. **For these reasons, no-one may release the papers or any information contained in these papers to external parties. In general, Working Group papers should never be cited.** Exceptions may be made in rare instances by obtaining permission in writing from the Principal Advisor Fisheries Science, and the authors of the paper.

25. Participants who use Working Group papers inappropriately, or who do not adhere to the standards of participation, may be requested by the Chair to leave a particular meeting or, in more serious instances, to refrain from attending one or more future meetings.

26. Meetings will take place as required, generally January-April and July-November for FAWGs and throughout the year for other working groups (AEWG, BRAG, Marine Amateur Fisheries and Antarctic Working Groups).

27. A quorum will be reached when the Chair, the designated presenter, and three or more other technical experts are present. In the absence of a quorum, the Chair may decide to proceed as a sub-group, with outcomes being taken forward to the next meeting at which a quorum is formed.

28. The Chair is responsible for deciding, with input from the entire Working Group, but focussing primarily on the technical discussion and the views of technical expert members:

* The quality and acceptability of the information and analyses under review
* The way forward to address any deficiencies
* The need for any additional analyses
* Contents of Working Group reports
* Choice of base case models and sensitivity analyses to be presented
* The status of the stocks, or the status/performance in relation to any relevant environmental standards or targets

29. The Chair is responsible for facilitating a consultative and collaborative discussion.

30. Working Group meetings will be run formally, with agendas pre-circulated, and formal records kept of recommendations, conclusions and action items.

31. A record of recommendations, conclusions and action items will be posted on the MPI-Fisheries website after each meeting has taken place.

32. Data upon which analyses presented to the Working Groups are based must be provided to MPI in the appropriate format and level of detail in a timely manner (i.e. the data must be available and accessible to MPI; however, data confidentiality concerns mean that such data are not necessarily available to Working Group members)

33. The outcome of each Working Group round will be evaluated, with a view to identifying opportunities to improve the Working Group process. The Terms of Reference may be updated as part of this review.

34. MPI fisheries scientists and science officers will provide administrative support to the Working Groups.

Record-keeping

35. The overall responsibility for record-keeping rests with the Chair of the Working Group, and includes:

* keeping notes on recommendations, conclusions and follow-up actions for all Working Group meetings, and to ensure that these are available to all members of the Working Group and the Principal Advisor Fisheries Science in a timely manner. If full agreement on the recommendations or conclusions cannot readily be reached amongst technical experts, then the Chair will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.
* compiling a list of generic assessment issues and specific research needs for each Fishstock or species or environmental issue under the purview of the Working Group, for use in subsequent research planning processes.

12.2. *AEWG Membership 2012*

Convenors: Martin Cryer (protected species) and Rich Ford (other issues)

Members: Blake Abernethy, Ed Abraham, Owen Anderson, William Arlidge, Chris Baigent, Karen Baird, Suze Baird, Barry Baker, Michael Batson, Michelle Beritzhoff, Jenny Black, Tiffany Bock, Laura Boren, Yoland Bosiger, Paul Breen, Stephen Brouwer, Martin Cawthorn, Simon Childerhouse, Louise Chilvers, Tom Clarke, Malcolm Clark, Deanna Clement, George Clement, Owen Cox, Rohan Currey, Igor Debski, Ian Doonan, Alastair Dunn, Charles Edwards, Ursula Ellenburg, Jack Fenaughty, Chris Francis, Malcolm Francis, Kevin Hackwell, Judi Hewitt, Rosie Hurst, Aaron Irving, Catherine Jones, Dan Kluza, Craig Lawson, Mary Livingston, Dave Lundquist, Greg Lydon, Warrick Lyon, Pamela Mace, Darryl Mackenzie, Rob Mattlin, Tania McPherson, Sarah Meadows, David Middleton, Laura Mitchell, Sophie Mormede, Mark Morrison, Richard O'Driscoll, Tracey Osborne, Milena Palka, Johanna Pierre, Irene Pohl, Kris Ramm, Vicky Reeve, Pat Reid, Yvan Richard, Jim Roberts, Ashley Rowden, Carol Scott, Ben Sharp, Liz Slooten, Paul Starr, Kevin Stokes, Katrina Subedar, John Taunton-Clarke, Alex Thompson, David Thompson, Finlay Thompson, Geoff Tingley, Ian Tuck, Dee Wallace, Barry Weeber, Richard Wells, Francene Wineti, Ray Wood, Bob Zuur.

12.3. *Terms of Reference for the Biodiversity Research Advisory Group (BRAG) 2012*

Overall purpose

Since 2000, the objectives of the Biodiversity Research Programme have been drawn directly from MFish commitments to Theme 3 of the New Zealand Biodiversity Strategy. Within this framework, the Biodiversity Medium Term Research Plan has been adapted over time as new issues emerge, to build on synergies with other research programmes and work where biodiversity is under greatest threat from fishing or other anthropogenic activity.

Within the constraints of the overall purpose of the Programme,

> "To improve our understanding of New Zealand marine ecosystems in terms of species diversity, marine habitat diversity, and the processes that lead to healthy ecosystem functioning, and the role that biodiversity has for such key processes110;"

and the NZBS definition of biodiversity (the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystem) the science currently commissioned broadly aims to:

- Describe and characterise the distribution and abundance of fauna and flora, as expressed through measures of biodiversity, and improving understanding about the drivers of the spatial and temporal patterns observed;
- determine the functional role of different organisms or groups of organisms in marine ecosystems, and assess the role of marine biodiversity in mitigating the impacts of anthropogenic disturbance on healthy ecosystem functioning;
- identify which components of biodiversity must be protected to ensure the sustainability of a healthy marine ecosystem as well as to meet societal values on biodiversity.

MPI also convenes an Aquatic Environment Working Group (AEWG) which has a similar review function to the BRAG. Projects reviewed by BRAG and AEWG have some commonalities in that they relate to aspects of the marine environment. However, the key focus of projects considered by BRAG is on marine issues related to the functionality of the marine ecosystem and its productivity, whereas projects considered by AEWG are more commonly focused on the direct effects of fishing.

BRAG may identify natural resource management issues that extend beyond fisheries management and make recommendations on priority areas of research that will inform MPI or other government departments of emerging science results that require the attention of managers, policymakers and decision-makers in the marine sector. BRAG does not make management recommendations or decisions (this responsibility lies with the MPI Fisheries Management Group and the Minister of Primary Industry).

Preparatory tasks

1. Prior to the beginning of BRAG meetings each year, MPI fisheries scientists will produce a list of issues for which new research projects are likely to required in the forthcoming financial year. The BRAG Chair will determine the final timetables and agendas.

[110] See MFish Biodiversity Research Programme 2010: Part 1. Context and Purpose

2. The Ministry's research planning processes should identify most information needs well in advance but, if urgent issues arise, MPI fisheries managers will alert the Aquatic Environment and Biodiversity Science Manager and the Principal Advisor Fisheries Science at least three months prior to the required meetings where possible.

BRAG Technical objectives

3. To review, discuss and convey views on the results of marine biodiversity research projects contracted by Ministry for Primary Industries MPI (formerly Ministry of Fisheries).

It is the responsibility of the BRAG to review, discuss, and convey views on the results of marine biodiversity research projects contracted by MPI and the former Ministry of Fisheries. The review process is an evaluation of how existing research results can be built upon to address emerging research issues and needs. It is essentially an evaluation of "what we already know" and how this can be used to obtain "what we need to know". This information should be used by the BRAG to identify gaps in our knowledge and for developing research plans to address these gaps.

4. Discuss, evaluate, make recommendations and convey views on a 3 to 5 year Medium Term Research Plan.

It is the responsibility of BRAG participants to discuss, evaluate, make recommendations and convey views on a 3 to 5 year Medium Term Research Plan for its particular research area as required. Individual related projects on a species or fishery or research topic need to be integrated into Medium Term Research Plans. The Medium Term Research Plans should encompass research needs and directions for at least the next 3 to 5 years.

The Biodiversity Medium Term Research Plan is aligned to relevant strategic and policy directions such as the "MPI Statement of Intent" and any Strategic Research Plan (Fisheries 2030, Deepwater 10 year research plan) and fisheries plans developed for the appropriate species/fishery or research area, including biodiversity.

The recommendations on project proposals for the next financial year will be submitted via the Chair of BRAG to the Principal Science Advisor Fisheries (MPI).

5. The Biodiversity Research Programme includes research in New Zealand's TS, EEZ, Extended Continental Shelf, the South Pacific Region and the Ross Sea region and has seven scientific work streams as follows:

    - To develop ecosystem-scale understanding of biodiversity in the New Zealand marine environment
    - To classify and characterise the biodiversity, including the description and documentation of biota, associated with nearshore and offshore marine habitats in New Zealand
    - To investigate the role of biodiversity in the functional ecology of nearshore and offshore marine communities.
    - To assess developments in all aspects of biodiversity, including genetic marine biodiversity and identify key topics for research
    - To determine the effects of climate change and increased ocean acidification on marine biodiversity, as well as effects of incursions of non-indigenous species, and other threats and impacts.

- To develop appropriate diversity metrics and other indicators of biodiversity that can be used to monitor change
- To identify threats and impacts to biodiversity and ecosystem functioning beyond natural environmental variation

BRAG input to MPI "Aquatic Environment and Biodiversity Annual Review"

6. To contribute to and summarise progress on biodiversity research in the Aquatic Environment and Biodiversity Annual Review. This contribution is analogous to Working Group Reports from the Fishery Assessment Working Groups.

7. To summarise the assessment methods and results, along with estimates of relevant standards, references points, or other metrics that may be relevant to biodiversity objectives by MPI, the Biodiversity Strategy and international obligations.

8. It is desirable that full agreement among technical experts is achieved on the text of these contributions. If full agreement among technical experts cannot be reached, the Chair will determine how this will be depicted in the Aquatic Environment and Biodiversity Annual Review, will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.

9. To advise the Principal Science Advisor Fisheries (MPI), about issues of particular importance that may require review by a plenary meeting or summarising in the Aquatic Environment and Biodiversity Annual Review. The general criterion for determining which issues should be discussed by a wider group include:

    - Emerging issues, recent or current biodiversity status assessments, trends, or projections
    - The development of a major trend in the marine environment that will impact on marine productivity or ecosystem resilience to stressors
    - Any new studies or data that impact on international obligations

Membership and Protocols for all Science Working Groups (NOTE: paragraph numbers consistent with those in Terms of Reference for Fisheries Assessment Working Groups)

Working Group chairs

17. The Ministry will select and appoint the Chairs for Working Groups. The Chair will be a MPI fisheries scientist who is an active participant in the Working Group, providing technical input, rather than simply being a facilitator. Working Group Chairs will be responsible for:

* ensuring that Working Group participants are aware of the Terms of Reference for the working group, and that the Terms of Reference are adhered to by all participants.
* setting the rules of engagement, facilitating constructive questioning, and focussing on relevant issues.
* ensuring that all peer review processes are conducted in accordance with the Research and Science Information Standard for New Zealand Fisheries[111] (the Research Standard), and that

[111] Link to the Research Standard: http://www.fish.govt.nz/en-nz/Publications/Research+and+Science+Information+Standard.htm

research and science information is reviewed by the Working Group against the *P R I O R* principles for science information quality (page 6) and the criteria for peer review (pages 12-16) in the Standard.

* requesting and documenting the affiliations of participants at each Working Group meeting that have the potential to be, or to be perceived to be, a conflict of interest of relevance to the research under review (refer to page 15 of the Research Standard). Chairs are responsible for managing conflicts of interest, and ensuring that fisheries management implications do not jeopardise the objectivity of the review or result in biased interpretation of results.
* ensuring that the quality of information that is intended or likely to inform fisheries management decisions is ranked in accordance with the information ranking guidelines in the Research Standard (page 21-23), and that resulting information quality ranks are appropriately documented in Working Group reports and, where appropriate, in Status of Stock summary tables.
* striving for consensus while ensuring the transparency and integrity of research analyses, results, conclusions and final reports.
* reporting on Working Group recommendations, conclusions and action items; and ensuring follow-up and communication with the MPI Principal Advisor Fisheries Science, relevant MPI fisheries management staff, and other key stakeholders.

Working Group members

18. Working Groups will consist of the following participants:
    * MPI fisheries science chair – required
    * Research providers – required (may be the primary researcher, or a designated substitute capable of presenting and discussing the agenda item)
    * Other scientists not conducting analytical assessments to act in a peer review capacity
    * Representatives of relevant MPI fisheries management teams
    * Any interested party who agrees to the standards of participation below.

19. Working Group participants must commit to:

    * participating in the discussion
    * resolving issues
    * following up on agreements and tasks
    * maintaining confidentiality of Working Group discussions and deliberations (unless otherwise agreed in advance, and subject to the constraints of the Official Information Act)
    * adopting a constructive approach
    * avoiding repetition of earlier deliberations, particularly where agreement has already been reached
    * facilitating an atmosphere of honesty, openness and trust
    * respecting the role of the Chair
    * listening to the views of others, and treating them with respect

20. Participants in Working Group meetings will be expected to declare their sector affiliations and contractual relationships to the research under review, and to declare any substantial conflicts of interest related to any particular issue or scientific conclusion.

21. Working Group participants are expected to adhere to the requirements of independence, impartiality and objectivity listed under the Peer Review Criteria in the Research Standard (pages 12-16). It is understood that Working Group participants will often be representing particular sectors and interest groups, and will be expressing the views of those groups. However, when reviewing the quality of science information, representatives are expected to

step aside from their sector affiliations, and to ensure that individual and sector views do not result in bias in the science information and conclusions.

Information Quality Ranking:

22. Science Working Groups are required to rank the quality of research and science information that is intended or likely to inform fisheries management decisions, in accordance with the science information quality ranking guidelines in the Research Standard (pages 21-23). This information quality ranking must be documented in Working Group reports and, where appropriate, in Status of Stock summary tables.

* Working Groups are not required to rank all research projects and analyses, but key pieces of information that are expected or likely to inform fisheries management decisions should receive a quality ranking.
* Explanations substantiating the quality rankings must be included in Working Group reports. In particular, the quality shortcomings and concerns for moderate/mixed and low quality information must be documented.
* The Chair, working with participants, will determine which pieces of information require a quality ranking. Not all information resulting from a particular research project would be expected to achieve the same quality rank, and different quality ranks may be assigned to different components, conclusions or pieces of information resulting from a particular piece of research.

Working Group papers:

23. Working group papers will be posted on the MPI-Fisheries website prior to meetings if they are available. As a general guide, Powerpoint presentations and draft or discussion papers should be available at least 2 working days before a meeting, and near-final papers should be available at least 5 working days before a meeting if the Working Group is expected to agree to the paper. However, it is also likely that many papers will be tabled during the meeting due to time constraints. If a paper is not available for sufficient time before the meeting, the Chair may provide for additional time for written comments from Working Group members.

24. Working Group papers are "works in progress" whose role is to facilitate the discussion of the Working Groups. They often contain preliminary results that are receiving peer review for the first time and, as such, may contain errors or preliminary analyses that will be superseded by more rigorous work. **For these reasons, no-one may release the papers or any information contained in these papers to external parties. In general, Working Group papers should never be cited.** Exceptions may be made in rare instances by obtaining permission in writing from the Principal Advisor Fisheries Science, and the authors of the paper.

25. Participants who use Working Group papers inappropriately, or who do not adhere to the standards of participation, may be requested by the Chair to leave a particular meeting or, in more serious instances, to refrain from attending one or more future meetings.

26. Meetings will take place as required, generally January-April and July-November for FAWGs and throughout the year for other working groups (AEWG, BRAG, Marine Amateur Fisheries and Antarctic Working Groups).

27. A quorum will be reached when the Chair, the designated presenter, and three or more other technical experts are present. In the absence of a quorum, the Chair may decide to proceed as

a sub-group, with outcomes being taken forward to the next meeting at which a quorum is formed.

28. The Chair is responsible for deciding, with input from the entire Working Group, but focussing primarily on the technical discussion and the views of technical expert members:

* The quality and acceptability of the information and analyses under review
* The way forward to address any deficiencies
* The need for any additional analyses
* Contents of Working Group reports
* Choice of base case models and sensitivity analyses to be presented
* The status of the stocks, or the status/performance in relation to any relevant environmental standards or targets

29. The Chair is responsible for facilitating a consultative and collaborative discussion.

30. Working Group meetings will be run formally, with agendas pre-circulated, and formal records kept of recommendations, conclusions and action items.

31. A record of recommendations, conclusions and action items will be posted on the MPI-Fisheries website after each meeting has taken place.

32. Data upon which analyses presented to the Working Groups are based must be provided to MPI in the appropriate format and level of detail in a timely manner (i.e. the data must be available and accessible to MPI; however, data confidentiality concerns mean that such data are not necessarily available to Working Group members)

33. The outcome of each Working Group round will be evaluated, with a view to identifying opportunities to improve the Working Group process. The Terms of Reference may be updated as part of this review.

34. MPI fisheries scientists and science officers will provide administrative support to the Working Groups.

Record-keeping

35. The overall responsibility for record-keeping rests with the Chair of the Working Group, and includes:

* keeping notes on recommendations, conclusions and follow-up actions for all Working Group meetings, and to ensure that these are available to all members of the Working Group and the Principal Advisor Fisheries Science in a timely manner. If full agreement on the recommendations or conclusions cannot readily be reached amongst technical experts, then the Chair will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.
* compiling a list of generic assessment issues and specific research needs for each Fishstock or species or environmental issue under the purview of the Working Group, for use in subsequent research planning processes.

12.4. *BRAG attendance 2011-2012*

Convenor: Mary Livingston (MPI chair),

Members: Malcolm Clark, Mark Morrison, Wendy Nelson, Cliff Law, Di Tracey, Dennis Gordon, Anne-Nina Lorz, Stuart Hanchet, Richard O'Driscoll, Jonathon Gardner, Simon Thrush, David Bowden, Matt Pinkerton, Els Maas, Ashley Rowden, Carolyn Lundquist, Judi Hewitt, Drew Lohrer, Alison MacDiarmid, Julie Hall, Vonda Cummings, Kate Neill, Tracy Farr, Di Tracey, Barb Hayden (all NIWA), Richard Wells, Greg Lydon (SeaFIC), Rich Ford (MPI), Shane Lavery, Mark Costello (Auckland University)

12.5. *Generic Terms of Reference for Research Advisory Groups (Sept 2010)*

Overall purpose

1. The purpose of the Research Advisory Groups (RAGs) is to develop research proposals to meet management information needs and support standards development.

Context

2. To assist RAG members with their work this section outlines the wider process that RAGs will operate within.

Fisheries Plans will guide the management of fisheries

3. From 1 July 2011 the Ministry of Fisheries (MFish) will be using Fisheries Plans in the following five areas to guide the management of fisheries:
   - Deepwater
   - Highly Migratory Species
   - Inshore – Finfish
   - Inshore – Freshwater
   - Inshore – Shellfish

4. In each of those five areas there will be:

   - A Fisheries Plan that sets out management objectives over a 5 year period.
   - An Annual Operational Plan that sets out what will be done in a financial year to help meet those objectives, including in the areas of science research, compliance and observer coverage (i.e., the Annual Operational Plan will be where priorities are set each year). Note that external stakeholders will have an opportunity to provide comment on prioritisation through draft Annual Operational Plans.
   - An Annual Review Report that will assess progress made against the management objectives, and help identify gaps to be considered in setting the next set of priorities.

RAGs will largely be aligned to the Fisheries Plan areas

5. There will be a RAG for each of the five Fisheries Plan areas above.

6. In addition there will be a RAG for Aquatic Environment (Standards), for research needed to support standards development, and another for Antarctic research. (Note that biodiversity research is dealt with through a separate process that has more of a cross-agency focus.)

   RAGs will develop research proposals to be considered as part of a subsequent prioritisation process

7. As part of the process for developing the Annual Operational Plans, the identification and prioritisation of science research will broadly occur as follows:
   i. MFish fisheries managers will identify the fisheries management objectives and information needs that they want the relevant RAG to consider. This will be done in conjunction with MFish scientists, and will draw on the following:
      - The relevant Annual Review Report discussed above
      - Existing research plans
      - Science Assessment Working Groups' feedback arising from research that has been evaluated previously
      - Ad-hoc issues as they arise
      - Initial indications of the available budget
   ii. The RAGs will then develop proposals for scientific research to meet those management and information needs.
   iii. MFish fisheries managers will then run a process for prioritising the research proposals that have been developed and updating multi-year research plans, in conjunction with MFish scientists. This will be part of the wider process for developing Annual Operational Plans.

8. In the Aquatic Environment (Standards) and Antarctic areas a similar process will be followed to that above, involving relevant MFish managers.

9. In practice, these processes are likely to iterate between the above steps, e.g., when prioritising research proposals fisheries managers may identify additional questions that they want a RAG to consider.

10. RAGs will only be convened when necessary. If, for example, all of the research for the coming year under review has previously been approved as part of a multi-year funding package for an area, and no additional management needs have emerged, the relevant RAG will not be convened.

11. During 2010-11 RAGs will be used, as required, in all areas except Inshore, given that the three Inshore Fisheries Plans are still being developed through the year. For the Inshore areas a transitional process will be used, with RAGs commencing during 2011-12.

Research proposals

12. RAGs will provide recommendations to fisheries managers on research to meet management needs. This section provides more detail on the research proposals that the RAGs will produce.

13. The RAGs will produce an initial set of project proposals to meet the management and information needs provided to the RAG, for consideration in the subsequent prioritisation process.

14. The proposals may be in the form of multi-year projects where appropriate.

15. While the prioritisation of research is outside the scope of the work of the RAGs, the proposals will include information on potential cost and feasibility to guide decisions on prioritisation. Cost estimates should be specified as ranges so as to not unduly influence subsequent research provider costings.

16. Where the RAG identifies more than one desirable option for scientific research to meet management and information needs, the RAG's proposals will cover those options, their relative pros and cons, their respective potential costs, and the RAG's recommendation as to the preferred option.

17. Once prioritisation decisions have been made on the initial set of research proposals, the RAG may be asked to produce more fully developed project proposals for inclusion in the relevant Annual Operational Plan, and for the purposes of cost recovery consultation and tendering.

Membership

18. Membership of RAGs is expertise-based.

19. Membership will be by invitation from MFish only.

20. A RAG will consist of a core group of one MFish scientist and one manager from the relevant Fisheries Plan or Standards team, with the option to "call in" relevant technical expertise (internal and/or external) as needed.

21. External participants will be paid for their time. This will include preparing for and attending RAG meetings, and any time spent writing proposals.

Protocols

22. All RAG members will commit to:
    - participating in the discussion in an objective and unbiased manner;
    - resolving issues;
    - following up on agreements and tasks;
    - adopting a constructive approach;
    - facilitating an atmosphere of honesty, openness and trust;
    - having respect for the role of the Chair; and
    - listening to the views of others, and treating them with respect.

23. RAG meetings will be run formally with agendas pre-circulated and formal records kept of recommendations, conclusions and action items.

24. Participants who do not adhere to the standards of participation may be requested by the Chair to leave a particular meeting or, in more serious instances, will be excluded from the RAG.

Chairpersons

25. The Chair of each RAG will be a MFish scientist with appropriate expertise.

26. The Chair commits to undertaking the following roles:
    - The Chair is an active participant in RAGs, who also provides technical input, rather than simply being a facilitator.
    - The Chair is responsible for: setting the rules of engagement; promoting full participation by all members; facilitating constructive questioning; focussing on relevant issues;

reporting on RAG recommendations, conclusions and action items, and ensuring follow-up; and communicating with relevant MFish managers.

27. The Chair is responsible for facilitating consultative and collaborative discussions.

Decision-making

28. The Chair is responsible for working towards an agreed view of the RAG members on their recommendations to the fisheries manager, but where that proves not to be possible then the Chair is responsible for determining the final recommendation. Minority views should be clearly represented in proposals in those cases.

29. A record of recommendations, conclusions and action items will be circulated by e-mail after each meeting by the Chair.

30. Each RAG round will be evaluated by MFish, with a view to identifying opportunities to improve the process. The Terms of Reference may be updated as part of this review.

Non-disclosure agreements

31. Participants may be asked to sign a Non-Disclosure Agreement relating to documents that disclose cost details.

Conflicts of Interest

32. New Zealand is a small country and fisheries research is a relatively limited market, even internationally. People with the necessary skills and knowledge to participate in this advisory process may also have close working relationships with industry, research providers and other stakeholders. This will apply to nearly all external members of a RAG.

33. Participants will be asked to declare any "actual, perceived or likely conflicts of interest" before involvement in a RAG is approved, and any new conflicts that arise during the process should be declared immediately. These will be clearly documented by the Chair.

34. Management of conflicts of interest will be determined by the Chair in consultation with Fisheries Managers, and approved by the Deputy Chief Executive, Fisheries Management prior to meetings commencing.

Frequency of Meetings

35. Relevant MFish managers, in consultation with the Chair of the RAG, will decide on the frequency and timing of RAG meetings.

Documents and record-keeping

36. Unless signalled by the Chair, all RAG documents (papers, agendas, formal records of recommendations, conclusions and action items) will be available to all interested parties through the Ministry of fisheries website (www.fish.govt.nz), except where confidentiality is required for reasons of commercial sensitivity (e.g. cost estimates).

37. RAG documents will be distributed securely.

38. Participants who use RAG papers inappropriately may not be invited to subsequent RAG meetings.

39. The overall responsibility for record-keeping rests with the Chair and includes:
    - Records of recommendations, conclusions and follow-up actions for all RAG meetings and to ensure that these are available in a timely manner.
    - If full agreement on the recommendations or conclusions cannot readily be reached amongst technical experts, then the Chair will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.

12.6. *Fisheries 2030*

Use outcome – Fisheries resources are used in a manner that provides the greatest overall economic, social, and cultural benefit. This means having:

- An internationally competitive and profitable seafood industry that makes a significant contribution to our economy
- High-quality amateur fisheries that contribute to the social, cultural, and economic well-being of all New Zealanders
- Thriving customary fisheries, managed in accordance with kaitiakitanga, supporting the cultural well-being of iwi and hapū
- Healthy fisheries resources in their aquatic environment that reflect and provide for intrinsic and amenity value.

Governance conditions – Fundamental to achieving our goal is the recognition that our approach must be based on sound governance. This means having arrangements that lead to:

- The Treaty partnership being realised through the Crown and Māori clearly defining their respective rights and responsibilities in terms of governance and management of fisheries resources
- The public having confidence and trust in the effectiveness and integrity of the fisheries and aquaculture management regimes
- All stakeholders having rights and responsibilities related to the use and management of fisheries resources that are understood and for which people can be held individually and collectively accountable
- Having an enabling framework that allows stakeholders to create optimal economic, social, and cultural value from their rights and interests
- An accountable, responsive, dynamic, and transparent system of management.

Fisheries 2030 draws on a number of values and principles. These seek to outline the behaviour and approach that should be used to undertake the actions, make decisions, and achieve the goal for New Zealand fisheries.

Values

- Tikanga: the Mäori way of doing things; correct procedure, custom, habit, lore, method, manner, rule, way, code, meaning, reason, plan, practice, convention. It is derived from the word tika meaning ‘right’ or ‘correct’.
- Kaitiakitanga: The root word in kaitiakitanga is tiaki, which includes aspects of guardianship, care, and wise management. Kaitiakitanga is the broad notion applied in different situations.
- Kotahitanga: Collective action and unity.
- Manaakitanga: Manaakitanga implies a duty to care for others, in the knowledge that at some time others will care for you. This can also be translated in modern Treaty terms as “create no further grievances in the settlement of current claims”.
- Integrity: Be honest and straightforward in our dealings with one another. If we agree to do something we will carry it out.

- Respect: Treat each other with courtesy. We will respect each other's right to have different values and hold different opinions.
- Constructive relationship: Strive to build and maintain constructive ways of working with each other, which can endure.
- Achieving results: Focus on producing a solution rather than just discussing the problem.

Principles

- Ecosystem-based approach: We apply an ecosystem-based approach to fisheries management decision-making.
- Conserve biodiversity: Use should not compromise the existence of the full range of genetic diversity within and between species.
- Environmental bottom lines: Biological standards define the limits of extraction and impact on the aquatic environment.
- Precautionary approach: Particular care will be taken to ensure environmental sustainability where information is uncertain, unreliable, or inadequate.
- Address externalities: Those accessing resources and space should address the impacts their activities have on the environment and other users.
- Meet Settlement obligations: Act in ways that are consistent with the Treaty of Waitangi principles and deliver settlement obligations.
- Responsible international citizen: Manage in the context of international rights, obligations, and our strategic interests.
- Inter-generational equity: Current use is achieved in a manner that does not unduly compromise the opportunities for future generations.
- Best available information: Decisions need to be based on the best available and credible biological, economic, social, and cultural information from a range of sources.
- Respect rights and interests: Policies should be formulated and implemented to respect established rights and interests.
- Effective management and services: Use least-cost policy tools to achieve objectives where intervention is necessary and ensure services are delivered efficiently.
- Recover management costs for the reasonable expenses of efficiently provided management and services, from those who benefit from use, and those who cause the risk or adverse effect.
- Dynamic efficiency: Frameworks should be established to allow resources to be allocated to those who value them most.

Fisheries 2030 includes a "plan of action" for the five years from 2009, including: improving the management framework; supporting aquaculture and international objectives; ensuring sustainability of fish stocks; improving fisheries information; building sector leadership and capacity; meeting obligations to Māori; and enabling collective management responsibility. The key components guiding this document are ensuring sustainability of fish stocks and improving fisheries information:

Ensuring sustainability of fish stocks

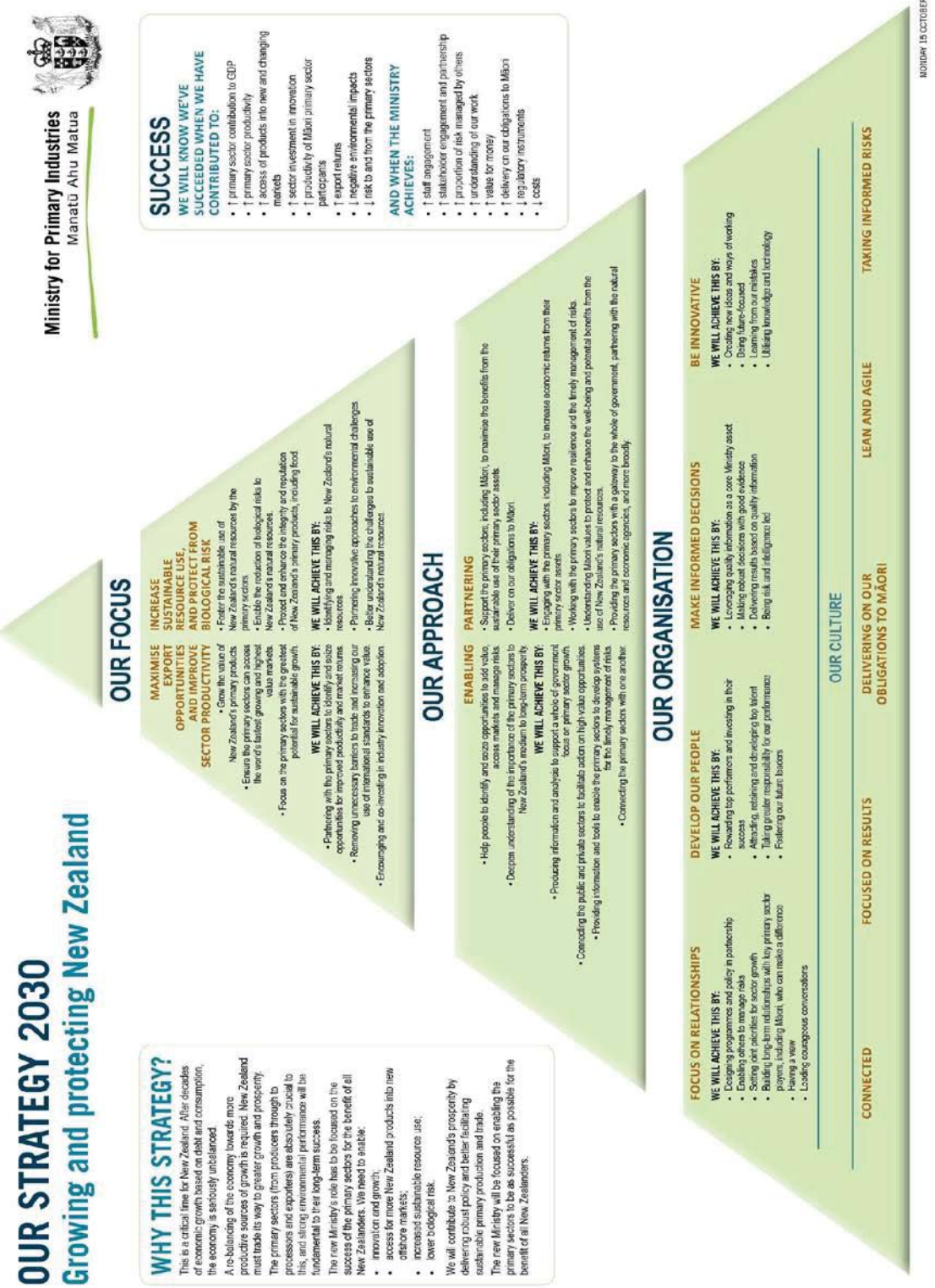
- Setting and implementing fisheries harvest strategy standards
- Setting and monitoring environmental standards, including for threatened and protected species and seabed impacts
- Enhancing the framework for fisheries management planning, including the use of decision rules to adjust harvest levels over time

Improving fisheries information

- Determining best options for information collection on catch from amateur fisheries, including the implementation of charter boat reporting
- Improving our knowledge of fish stocks and the environmental impacts of fishing through long-term research plans
- Gaining access to increased research and development funding

12.7. *OUR STRATEGY 2030: Growing and protecting New Zealand*

Also available at: http://www.mpi.govt.nz/Portals/0/Documents/about-maf/strategy.pdf



12.8. *Other strategic policy documents*

12.8.1. Biodiversity Strategy

New Zealand's Biodiversity Strategy was launched in 2000 in response to the decline of New Zealand's indigenous biodiversity — described in the State of New Zealand's Environment report as our "most pervasive environmental issue". It can be found on the government's biodiversity website at:

(http://www.biodiversity.govt.nz/picture/doing/nzbs/contents.html)

The Strategy also reflects New Zealand's commitment, through ratification of the international Convention on Biological Diversity, to help stem the loss of biodiversity worldwide. Strategic Priority 7 of the strategy was "*To manage the marine environment to sustain biodiversity*". Fishing practices, the effects of activities on land, and biosecurity threats are identified as constituting the areas of greatest risk to marine biodiversity. Pertinent objectives and summarised actions from the strategy are as follows:

Objective 3.1: Improving our knowledge of coastal and marine ecosystems (Substantially increase our knowledge of coastal and marine ecosystems and the effects of human activities on them, especially assessing the importance of, and threats facing, marine biodiversity, and establishing environmental monitoring capabilities to assess the effectiveness of measures to avoid, remedy or mitigate impacts on marine biodiversity).

Objective 3.4: Sustainable marine resource use practices (Protect biodiversity in coastal and marine waters from the adverse effects of fishing and other coastal and marine resource uses, especially maintaining harvested species at sustainable levels, integrating marine biodiversity protection into an ecosystem approach, applying a precautionary approach, identifying marine species and habitats most sensitive to disturbance, and integrating environmental impact assessments into fisheries management decision making.)

Objective 3.6: Protecting marine habitats and ecosystems (Protect a full range of natural marine habitats and ecosystems to effectively conserve marine biodiversity, using a range of appropriate mechanisms, including legal protection, especially establishing a network of areas that protect marine biodiversity.)

Objective 3.7: Threatened marine and coastal species management (Protect and enhance populations of marine and coastal species threatened with extinction, and prevent additional species and ecological communities from becoming threatened.)

In addition to its annual reviews (http://www.biodiversity.govt.nz/news/publications/index.html), the Biodiversity Strategy was reviewed by Green and Clarkson at the end of its 5-year term. This review was published in 2006 (http://www.biodiversity.govt.nz/pdfs/nzbs-5-year-review-synthesis-report.pdf). Most relevant to this synopsis were their findings on Objective 3.4 (Sustainable marine resource use) where they cited "Moderate progress". "*The policy move towards adopting a more ecosystem approach to fisheries management should be encouraged and strengthened. We acknowledge, however, the difficulties associated with obtaining the necessary information to make this approach effective. There are links to Objective 3.1 and the need for a more coordinated approach to identifying priority areas for marine research.*"

12.8.2. Biosecurity Strategy

In its 2003 Biosecurity Strategy, The Ministry of Agriculture and Forestry's Biosecurity NZ defined biosecurity as "*the exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health*". New Zealand is highly dependent on effective biosecurity measures because our indigenous flora, fauna, biodiversity, and, consequently, our primary production industries, including fisheries are uniquely at risk from invasive species. Information can be found on the Biosecurity New Zealand website at: (http://www.biosecurity.govt.nz/biosec/sys/strategy/biostrategy/biostrategynz
A complementary Biosecurity Science Strategy for New Zealand was developed in 2007 to address the science expectations of the Biosecurity Strategy. The science strategy identified the need to:

- prioritise science needs;
- minimise biosecurity risks at the earliest stage possible by increasing focus on research that is strategic and proactive;
- improve planning, integration and communication in the delivery of science;
- ensure research outputs can be used effectively to improve biosecurity operations and decision making.

12.8.3. Marine Protected Areas Policy

The Marine Protected Areas (MPA) Policy and Implementation Plan was released for consultation in December 2005 jointly by the Ministry of Fisheries and Department of Conservation. It confirmed Government's commitment to ensuring that New Zealand's marine biodiversity was protected, and established MPA Policy as a key component of that commitment. The MPA Policy objective is to protect marine biodiversity by establishing a network of Marine Protected Areas that is comprehensive and representative of New Zealand's marine habitats and ecosystems. The Policy involved a four-stage approach to implementation:

Stage 1: Development of the approach to classification, formulation of a standard of protection, and mapping of existing protected areas and/or mechanisms. Scientific workshops will be used to assist with the process, and the results will be put on the website for comment
Stage 2: Development of the MPA inventory, identification of gaps in the MPA network, and prioritisation of new MPAs
Stage 3: Establishment of new MPAs to meet gaps in the network. This will be undertaken at a regional level and a national process will be followed for offshore MPAs
Stage 4: Evaluation and monitoring.

Stage 1 and the inventory specified for Stage 2 are complete and regional forums were established for the Subantarctic and West Coast bioregions. In June 2009, these planning forums released consultation documents on implementation of the MPA Policy in their bioregions:

Consultation Document - Implementation of the Marine Protected Areas Policy in the Territorial Seas of the Subantarctic Biogeographic Region of New Zealand:
http://www.biodiversity.govt.nz/pdfs/seas/subantarctics-mpa-policy-consultation-document.pdf

Proposed Marine Protected Areas for the South Island's West Coast Te Tai o Poutini: A public consultation document:
http://www.westmarine.org.nz/documents/ProposedMPAsWestCoastSubmissiondocumentwebresv2.pdf

The MPA Classification, Protection Standard, Implementation Guidelines, together with a summary of subsequent consultation processes around implementing the policy can be found on the Government Biodiversity website at:

http://www.biodiversity.govt.nz/seas/biodiversity/protected/mpa_consultation.html

12.8.4. Revised Coastal Policy Statement

The revised New Zealand Coastal Policy Statement (NZCPS) came into force in December 2010, replacing the original 1994 NZCPS. The statement is to be applied, as required by the Resource Management Act 1991 (RMA), by persons exercising functions and powers under that Act. The documentation can be read on the Department of Conservation's website at:

http://www.doc.govt.nz/publications/conservation/marine-and-coastal/new-zealand-coastal-policy-statement/new-zealand-coastal-policy-statement-2010/

The NZCPS does not directly apply to fisheries management decision-making, although the Minister of Fisheries is required to have regard to the Statement when making decisions on sustainability measures under section 11 of the Fisheries Act. In addition, this synopsis include chapters on land use issues and habitats of particular significance for fisheries management for which the main threats are managed under the RMA (e.g., land use practices could increase sedimentation and affect the estuarine nursery grounds of important fishstocks). In other areas, management of effects under the RMA can complement management of the effects of fishing (e.g., complementary management of the habitat and bycatch of a protected species). The following objectives and policies are considered relevant (numbering as per NZCPS, text in parentheses summarises subheadings in the Statement of most relevance to fisheries values):

Objective 1: To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land (especially by maintaining or enhancing natural biological and physical processes in the coastal environment).

Objective 6: To enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development (especially by recognising that the protection of habitats of living marine resources contributes to social, economic and cultural wellbeing and that the potential to utilise coastal marine natural resources should not be compromised by activities on land).

Policy 5: Land or waters managed or held under other Acts (especially to consider effects on coastal areas held or managed under other Acts with conservation or protection purposes and to avoid, remedy or mitigate adverse effects of activities in relation to those purposes).

Policy 8: Aquaculture: Recognise the significant existing and potential contribution of aquaculture to the social, economic and cultural well-being of people and communities (especially by taking account of the social and economic benefits of aquaculture, recognising the need for high water quality, and including provision for aquaculture in the coastal environment).

Policy 11: Indigenous biodiversity: To protect indigenous biological diversity in the coastal environment (especially by avoiding, remedying or mitigating adverse effects on: habitats that are important during the vulnerable life stages of indigenous species; ecosystems and habitats that are particularly vulnerable to modification; and habitats of indigenous species that are important for recreational, commercial, traditional or cultural purposes).

Policy: 21 Enhancement of water quality: Where the quality of water in the coastal environment has deteriorated so that it is having a significant adverse effect on ecosystems, natural habitats, or water based recreational activities, or is restricting existing uses, such as aquaculture, shellfish gathering, and cultural activities, give priority to improving that quality.

Policy 22: Sedimentation (especially with respect to impacts on the coastal environment).

Policy 23: Discharge of contaminants (especially with respect to impacts on ecosystems and habitats).

12.8.5. Management of Activities in the EEZ

In August 2007 the Ministry for the Environment (MfE) released a discussion paper "*Improving regulation of environmental effects in New Zealand's Exclusive Economic Zone*" seeking comment on a preferred legislative option for managing the impacts of activities in the EEZ. The discussion paper stated that environmental effects in the EEZ were, at that time, managed by sector-specific legislation, which creates the following problems:

- gaps and inconsistencies in the operational control of environmental effects
- unclear environmental outcomes against which activities and their effects should be assessed
- uncertainty for investors about the regulatory environment
- uncertainty about how the effects of activities on each other should be managed.

The MfE website (http://www.mfe.govt.nz/issues/oceans/current-work/index.html) states that EEZ legislation is a priority for the current government. In response to the Gulf of Mexico oil spill, the Ministry of Economic Development is commissioning an independent study on New Zealand's health, safety and environmental provisions around minerals activities such as deep sea drilling. This report, along with the proposed legislation developed by the last government, will be considered by Ministers before making final policy and timeline decisions for EEZ legislation.

Proposals for EEZ legislation to manage effects other than those caused by fishing do not directly apply to fisheries management decision-making under the Fisheries Act. However, there are issues around the management of cumulative effects (e.g., of more than one activity on benthic communities) and around effects of any proposed new activities in the EEZ on fishing activity already occurring. Some projects already completed or currently underway are likely to be useful for these processes (e.g., detailed maps of fishing effort produced under ENV2001/07 and BEN2006/01 and enhancements of the Marine Environment Classification produced under ZBD2005-02 for demersal fishes and BEN2006/01A for benthic invertebrates).

12.8.6. Ministry for Research Science and Technology Roadmaps

The Ministry for Science Research and Technology (MRST, now a component of the Ministry of Business, Innovation and Employment, MBIE) stated in its 2006 overview "*Science for New Zealand*" that our science system aims to set long-term direction for RS&T, but allows flexibility to alter direction as needs and opportunities change. Recent direction setting has replaced periodic national processes with a range of continuous processes, often focused on particular areas or topics including:

- Government-led strategy processes around particular areas of national need or opportunity. The Biodiversity Strategy and Biosecurity Strategy are recent examples that have led to changes in institutional arrangements, policies, and funding in RS&T.
- More focused processes by research organisations and or user communities around how a particular area of science could better support national needs, or may be needed to retain or build new capability. These may be endorsed by Ministers or implemented directly by research organisations.
- 'Roadmaps for Science', led by MRST, aimed at developing and coordinating RS&T directions and bringing a stronger RS&T perspective to other Government strategies. Roadmaps describe New Zealand's current research activity, interpret Government's objectives and strategies in the area, and provide guidance to public research investment agencies as well as other participants in the science system.

Roadmaps for Science were published by MRST for Energy Research (December 2006), Nanoscience & Nanotechnologies (February 2007), Biotechnology Research (March 2007), and Environment Research (June 2007). Probably the most relevant of these is that for Environment Research which can be found at MRST's website at:

http://www.msi.govt.nz/update-me/archive/publications-archive/

(*if you would like to request a copy of this publication, please email info@msi.govt.nz).*

It is important to note that these roadmaps relate primarily to research funded by the erstwhile Foundation for Research Science and Technology (FRST, now also part of MBIE) and much less to applied, operational research purchased by the Ministry of Fisheries and some other government departments. However, the Environmental Roadmap for Science noted that environmental management decisions increasingly require an understanding of whole system processes and a multi-dimensional approach. More integrated and systems-based approaches can offer environmental managers and decision-makers answers to many of the questions they are facing. A crucial task then becomes one of creating a New Zealand science environment within which systems-based approaches can develop and flourish, acknowledging that small-scale studies remain important to underpin these approaches. MRST identified three overarching themes that require additional focus: systems understanding and integration (e.g., ecosystem aspects of fisheries management); transfer and uptake (including adaptive management to advance scientific understanding); and information systems (including management of databases and collections.

From a suite of six key research areas (global environmental change, land, water and coasts, including the coastal marine area, urban design and hazards, biosecurity, biodiversity, and oceanic systems), MRST identified five key research directions, two of which are of most relevance to fisheries interests:

Direction 4: Over the next few years, the government will give priority to developing more integrated multidisciplinary approaches, and to improving transfer, uptake and information systems in the following areas:

- global environmental change – with a focus on providing the knowledge for integrated ecological, physical and socio-economic modelling of climate change impacts on water and soil resources, land use, biosecurity, biodiversity and potential global impacts;
- land, water and coasts – with a focus on sustainable land and coastal aquatic use, including the impacts of land use on freshwater and the impacts of freshwater, land management and aquatic production on coastal marine environments;
- biosecurity – reflecting the directions set in the Biosecurity Science Research and Technology Strategy.

Direction 5: Over the longer-term, the government will focus on more integrated multidisciplinary approaches, and improved transfer and uptake, and information systems in the biodiversity and oceanic systems areas.

MRST believes that the Environmental Science Roadmap will make a difference by:

- Equipping environmental managers with integrated research results and tools which will help them avoid, remedy or mitigate future environmental problems.
- Enhancing New Zealand's potential as a test bed and world leader for new innovations and business developments in environmental technologies.
- Improved predictions of and responses to natural hazards events.
- Improved responses to climate change.

12.8.7. National Plan of Action to Reduce the Incidental Catch of Seabirds in New Zealand Fisheries

The National Plan of Action (NPOA) to Reduce the Incidental Catch of Seabirds in New Zealand Fisheries came into action in April 2004. The NPOA-Seabirds provides a framework to inform the management of seabird/fisheries interactions. It also sets a number of time-bound objectives to be reached by partnering with the fishing industry to reduce the incidental catch of seabirds.
The document is available online at:

http://www.doc.govt.nz/documents/conservation/native-animals/birds/npoa.pdf

A revised version of this document is currently under consultation, with a draft version available online through the consultations page of the Fisheries website of the Ministry for Primary Industries at:

http://www.fish.govt.nz/en-nz/Consultations/default.htm?wbc_purpose=bas

Note that these links are likely to change due to the current revision. The revised document will be available early in 2013.

12.8.8. New Zealand National Plan of Action for the Conservation and Management of Sharks

The New Zealand National Plan of Action (NPOA) for the Conservation and Management of Sharks was approved by the Minister of Fisheries on 13 October 2008. The purpose of the NPOA-Sharks is to ensure the conservation and management of sharks and their long-term sustainable use. It also contains a set of actions in order to meet this purpose. The document is available online at:

http://www.fish.govt.nz/NR/rdonlyres/F0530841-CD61-4C3E-9E50153A281A4180/0/NPOAsharks.pdf

Note that the NPOA-Sharks is currently under review with a revised edition due in 2013.

12.9. *Appendix of Aquatic Environment and Biodiversity funded and related projects*

The following listing of projects are those relevant to aquatic environment research that have been through research planning and subsequently been funded by the Ministry of Fisheries (MFish), the Ministry for Primary Industries (MPI) or the fishing industry. These projects have been ordered by the research themes:

1. Protected species
2. Non-protected bycatch
3. Benthic impacts
4. Ecosystem effects
5. Biodiversity

Within these themes projects are ordered chronologically (from the most recent to the oldest). A list of references cited within the table is included at the end of this appendix.

Each project or row of the table is described by a project number (used by MFish/MPI), a project title, specific objectives (where there are many objectives and some are clearly not relevant to aquatic environment research they may not be listed), project status and any relevant citations from the project.

Citations listed below can be accessed differently depending upon the type of output. Finalised FARs (Fisheries Assessment Reports) and AEBRs (Aquatic Environment and Biodiversity Reports), historical FARDs (Fisheries Assessment Research Documents) and MMBRs (Marine Biodiversity and Biosecurity Reports), and some FRRs (final Research Reports) can be found at: http://fs.fish.govt.nz/Page.aspx?pk=61&tk=209. Increasingly, reports will be available from the MPI website at: http://www.mpi.govt.nz/news-resources/publications. For unpublished documents or those not available on either of these websites please contact Science.Officer@mpi.govt.nz. Every attempt has been made to make this table comprehensive and correct, but if any errors are found please send suggested corrections or additions through to Science.Officer@mpi.govt.nz.

PROTECTED SPECIES

Project Code	Project Title	Specific Objectives	Status	Citation/s
PRO2012-02	Assessment of the risk to marine mammal populations from New Zealand commercial fisheries	1. To scope the risk assessment, including producing an agreed list of marine mammal populations (in concert with MAF and DOC). 2. To review the literature, compile the required information and evaluate the appropriate level of risk assessment for the marine mammal populations identified in objective 1. 3. To conduct a risk assessment for the marine mammal populations identified in objective 1 using, where possible, a risk index reflecting the ratio of fisheries-related mortality to the level of potential biological removal. 4. To refine the results of the risk assessment for priority marine mammal populations by incorporating spatially and temporally-explicit abundance, distribution and capture information.	Approved but not contracted	
PRO2012-07	Cryptic mortality of seabirds in trawl and longline fisheries	1. To review available information from international literature and unpublished sources to characterize and inform estimation of cryptic mortality and live releases for at-risk seabirds in New Zealand trawl and longline fisheries 2. To review the extent to which fisheries observer data informing current estimates of seabird captures may be used to also estimate cryptic mortalities in different fishery groups in the seabird risk assessment, and identify key assumptions and associated uncertainty in the estimation of cryptic mortalities. 3. To identify those species and/or fishery groups for which current uncertainty regarding cryptic mortality contributes most strongly to high risk scores for at-risk seabird species, and recommend options to improve estimation of cryptic mortality for those species / fishery group combinations.	Approved but not contracted	

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
PRO2012-08	Improved estimation of spatio-temporal overlap with fisheries for at-risk seabird species	1. To generate seabird distribution map layers for seabird species which the existing level 1 risk assessment identifies as being at-risk, but for which no level 2 assessment has been completed. 2. To modify seabird distribution layers used in the current level 2 risk assessment, for those species that the L2 assessment identifies as at-risk and for which: i) spatial distributions used in the current L2 assessment are known to be wrong, or ii) improved spatial distribution layers are readily available (e.g. from new satellite telemetry data). 3. To seasonally disaggregate seabird spatial distribution data layers for those at-risk seabird species with a strongly seasonal abundance and/or distribution in the New Zealand EEZ4. To utilize updated spatial/seasonal seabird distribution layers to generate improved estimates of spatio-temporal overlap with fisheries, for integration into the existing level 2 seabird risk assessment framework.	Approved but not contracted	
PRO2012-09	Improvements to key information gaps for highest risk seabird populations TBC	1. To improve estimates of the population size of specified seabirds where this will substantially reduce uncertainty in the risk ratio estimated in the Level 2 seabird risk assessment. 2. To improve estimates of the age at first breeding for specified seabird populations where this will substantially reduce uncertainty in the risk ratio estimated in the Level 2 seabird risk assessment. 3. To improve estimates of the average adult survival rate for specified seabird populations where this will substantially reduce uncertainty in the risk ratio estimated in the Level 2 seabird risk assessment.	Approved but not contracted	
PRO2012-10	Level 3 risk assessment for Antipodean albatross TBC	1. Develop an Antipodean albatross population model 2. Assess the effect of fisheries mortality on population viability 3. As information permits, assess the effect of alternative management strategies	Approved but not contracted	
ENV2011-01	NPOA-sharks science reivew	1. To collate and summarise information in support of a review of the National Plan of Action for the Conservation and Management of Sharks (NPOA-sharks). 2. To identify research gaps from objective 1 and suggest cost-effective ways these could be addressed.	Completed	Francis & Lyon 2012

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
No project number	A risk assessment of threats to Maui's dolphins	To evaluate of the risks posed to Maui's dolphin to support the review of the TMP.	Completed	Currey *et al.* 2012
SRP2011-03	Probabilistic modelling of sea lion interactions	1. Estimate the probability that a sea lion suffers mild head trauma following a collision with a SLED grid	Completed	Abraham 2011
SRP2011-04	HSL Modelling	1. Revise Breen-Fu-Gilbert sea lion model	Completed	Breen *et al.* 2010
DEE2010-03	Development of a methodology to estimate crypticmortalities to ETP species from DW fishing activity	1. To conduct a review of existing national and international techniques to estimate cryptic mortality of endangered, threatened and protected species caused by deepwater fishing activities 2. To develop one or more approaches to estimating cryptic mortality of endangered, threatened and protected species caused by deepwater fishing activities 3. To field test one or more approaches to estimating cryptic mortality of endangered, threatened and protected species caused by deepwater fishing activities	Ongoing analysis	
No project number	A risk assessment framework for incidental seabird mortality associated with New Zealand fishing in the New Zealand EEZ	To describe the conceptual and methodological framework of this risk assessment approach to guide the completion of similar risk assessments elsewhere.	Completed	Sharp *et al.* 2011
PRO2010-01	Estimating the nature and extent of incidental captures of seabirds, marine mammals and turtles in New Zealand commercial fisheries	1. To estimate the nature and extent of captures of seabirds, marine mammals and turtles, and the warp strikes of seabirds in New Zealand fisheries for the fishing years 2009/10, 2010/11 and 2011/12.	Ongoing analysis	Thompson *et al.* 2011
PRO2010-02	Research into key areas of uncertainty or development of mitigation techniques for the revised npoa-seabirds	1.To provide the information necessary to underpin the revised NPOA-seabirds or develop mitigation techniques to reduce risk identified via the revised NPOA-seabirds.	Ongoing analysis	

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
SRP2010-03	Fur Seal interactions with a SED excluder device	1. Fur seal interactions with SED excluder device (Dr J Lyle)	Completed	Lyle 2011
SRP2010-05	Fur seal interaction with an SLED excluder device	• Using a series of 10-15 impact tests at a maximum collision speed of 5 or 6 ms-1, develop a "HIC map" for the SLED grid to enable the consequences of collisions with different parts of the grid by sea lions of different head masses to be predicted (scaling values (for eq 3) will include -1/3, -2/3, and -3/4) • Using a small number of collision tests, verify that the HIC for a glancing blow can be predicted with sufficient accuracy by resolving vectors • Calculate the maximum possible sensitivity to different boundary conditions using the relative masses of the SLED grid and sea lion heads • Clarify in the final research report that undertaking tests in air (as opposed to underwater) should not affect the results	Completed	Ponte *et al.* 2011
IPA2009-09	Sea Lion bioenergetics modelling	1. To review and collate data on growth, metabolism, diet and reproductive parameters of NZ sea lions or, if data are inexistent, of other sea lions species 2. To analyse the energy density of various NZ sea lion prey items 3. To incorporate the data acquired in objectives 1. and 2. into a bioenergetics model to estimate the energy and food requirements of NZ sea lions	Completed	Meynier 2010
IPA2009-16	Preliminary impact assessment of NZ sea lion interaction with SLEDS	1. Preliminary impact assessment of New Zealand sea lion interactions with SLEDs	Completed	Ponte *et al.* 2010
IPA2009-19/20	Level 2 seabird risk assessment rerun	1. To examine the risk of incidental mortality from commercial fishing for 64 seabird species in New Zealand trawl and longline fisheries	Completed	Richard *et al.* 2011
No project number	External review of NZ sea lion bycatch necropsy data and methods	The primary purposes of this review were to determine whether, in the opinion of a group of independent experts: - the interpretation of necropsy findings and trauma classification system used by Dr Wendi Roe are valid - sea lions recovered from trawl nets have sustained clinically significant trauma - some or all of the sea lions exiting through SLEDs are likely to survive	Completed	Roe 2010a
PRO2009-01A	Abundance & distribution of Hector's & maui'sdolphins (5 year project)	1. To estimate the distribution of the South Coast South Island Hector's dolphin sub-population in both winter and summer. 2. The work for this sub-project was subsequently extended to include data collection necessary to estimate abundance.	Completed	Clement & Mattlin 2010

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
PRO2009-01B	Abundance, distribution, and productivity of Hector's (and Maui's) dolphins	1. To estimate the likely precision of abundance estimates from summer aerial surveys for Hector's dolphins along the East Coast South Island (ECSI; from Farewell Spit to Nugget Point) under different levels of sampling intensity and stratification. 2. To estimate the likely precision of abundance estimates and the likely quality of distribution information from winter aerial surveys for Hector's dolphins along the ECSI under different levels of sampling intensity and stratification. 3. To identify and quantify trade-offs between the precision of abundance estimates and the quality of distribution information as well as between overall precision and likely cost (e.g., based on the number of flying hours required). 4. To identify key areas and times for which it would be particularly useful to have information on Hector's dolphin distribution (e.g., where risk may come from overlap with particular fisheries) and quantify trade-offs between the precision of ECSI-wide surveys and collecting such fine-scale information. 5. Assess the extent to which two-phase or adaptive approaches would be useful to improve the surveys' utility for assessing dolphin distribution, particularly the seaward limit.	Ongoing analysis	
PRO2009-04	Development and efficacy of seabird mitigation measures	1. To test the efficacy of a variety of configurations of mitigation techniques at reducing seabird mortality (or appropriate proxies for mortality) in longline fisheries	Completed	No reports specified as required output
ENV2008-03	Bycatch of basking sharks in New Zealand fisheries	1. To review the productivity of basking sharks 2. To describe the nature and extent of fishery-induced mortality of basking sharks in New Zealand waters and recommend methods of reducing the overall catch.	Completed	Francis & Smith 2010
PRO2008-01	Risk assessment of protected species bycatch in NZ fisheries	1. To provide an assessment of the risk posed by different fisheries to the viability of New Zealand protected species, and to assign a risk category to all New Zealand fishing operations.	Completed	Waugh *et al.* 2009

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
SAP2008-14	Sea lion population modelling, additional	1. To assess the likely performance of different bycatch control rules for the SQU6T fishery. 2. To correct and update the Breen-Fu-Gilbert (2008) sea lion model- including assessment of the performance of 200-series and 300-series management control rules. 3. To document the development of the model- including all four objectives of project IPA2006/09 and objective 1 of this project- in a single report suitable for an international review.	Completed	Breen *et al.* 2010
Deepwater Group	Necropsy of marine mammals captured in New Zealand fisheries in the 2007-08 fishing year	Necropsy of marine mammals captured in New Zealand fisheries in the 2007-08 fishing year	Completed	Roe 2009a
IPA2007-09	Protected species risk assessment	To provide an asessment of the risk posed by different fisheroes to the viability of NZ protected species- and to assign a risk category to all NZ fishing operations	Completed	Waugh *et al.* 2008
PRO2007-01	Estimating the nature and extent of incidental captures of seabirds in New Zealand commercial fisheries	1. Estimate capture rates per unit effort and total captures of seabirds for the New Zealand EEZ and in selected fisheries by method, area, target fishery, in relation to mitigation methods in use, and, where possible, by seabird species for the fishing year 2006/07, 2007/08 and 2008/09. 2. Examine the incidence of seabird warp strike in trawl fisheries where these data are available from fisheries observers, and estimate the rate of incidents (birds affected per hour) and total number of seabirds affected by fishery, area and method. Examine the factors (fishery, environmental, seasonal, mitigation, area) that influence the probability of warp-strike occurring.	Completed	Abraham 2010; Abraham & Thompson 2009a; 2010; 2011a; b; Thompson & Abraham 2009a; Abraham *et al.* 2010b
PRO2007-02	Estimating the nature and extent of incidental captures of seabirds in New Zealand commercial fisheries	1. Estimate capture rates per unit effort and total captures of seabirds for the New Zealand EEZ and in selected fisheries by method, area, target fishery, in relation to mitigation methods in use, and, where possible, by seabird species for the fishing year 2006/07, 2007/08 and 2008/09. 2. Examine the incidence of seabird warp strike in trawl fisheries where these data are available from fisheries observers, and estimate the rate of incidents (birds affected per hour) and total number of seabirds affected by fishery, area and method. Examine the factors (fishery, environmental, seasonal, mitigation, area) that influence the probability of warp-strike occurring.	Completed	Abraham *et al.* 2010a; Thompson & Abraham 2009a; 2009b; 2009c; 2010; 2011; Thompson *et al.* 2010a; 2010b

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2006-05	The use of electronic monitoring technology in New Zealand longline fisheries	1. Trial the deployment of electronic monitoring systems in selected longline fisheries, monitoring incidental take of protected species. 2. Evaluate the efficacy of electronic monitoring in allowing enumeration and identification of protected species captures. 3. Recommend options for data management and information transfer arising from the deployment of electronic monitoring in selected fisheries.	Completed	McElderry *et al.* 2008
IPA2006-02	The efficacy of warp strike mitigation devices: trials in the 2006 squid fishery	1. Groom the mitigation trial data and produce a summary of the data (100%) 2. Examine strike rates and capture rates on warps and mitigation devices (100%) 3. Determine the relative efficacy of mitigation devices tested in the trial (100%) 4. Make recommendations regarding future trials (100%) 5. Compare seabird warp strike data for 2005 and 2006 (100%) 6. Work with SeaFIC and the mitigation trials TAG to produce analyses and outputs (100%)	Completed	Middleton & Abraham 2007
IPA2006-09	Modelling interactions between trawl fisheries and New Zealand Sea lion interactions	1. Model the New Zealand sea lion population and explore alternative management procedures for controlling New Zealand sea lion bycatch in the SQU 6T fishery 2. Collate and review all available sea lion biological data- fisheries data- and sea lion bycatch data relevant to a population model and management strategy evaluation for the Auckland Islands sea lion population 3. Update and improve the existing Breen and Kim sea lion population model (2003) to incorporate all relevant data and address model uncertainties including but not necessarily limited to those identified by the AEWG 4. Fit the revised model to all available data and test sensitivity including but not necessarily limited to runs identified by the AEWG 5. Test a range of management procedures (rules) with the model to determine if they meet agreed management criteria	Completed	Breen 2008

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
IPA2006-13	Identification of Marine Mammals Captured in New Zealand Fisheries	1. To determine, through examination of returned marine mammal carcasses, the species, sex, reproductive status, and age-class of marine mammals returned from New Zealand fisheries. 2. To detail any injuries and, where possible, the cause of mortality of marine mammals returned from New Zealand fisheries, and examine relationships between injuries and body condition, breeding status, and other associated demographic characteristics.	Completed	Roe 2009b
PRO2006-01	Data collection of demographic, distributional and trophic information on selected seabird species to allow estimation of effects of fishing on population viability	1 To gather demographic, distributional and dietary information on selected seabird species to allow assessment of effects of fishing on population viability.	Completed	Sagar & Thompson 2008; Sagar *et al.* 2009a; b; 2010a; b; c; Baker *et al.* 2008; 2009; 2010
PRO2006-02	Modelling of the effects of fishing on the population viability of selected seabirds	1. Model the effects of fisheries mortalities on population viability compared with other sources of mortality or trophic effects of fishing 2. Examine the overlap of fishing activity with species distribution at sea for different stages of the breeding and life-cycle and for different sexes, and assess the likely risk to species or populations from fisheries (by target species fisheries, fishing methods, area and season) in the New Zealand EEZ	Completed	Francis & Bell 2010; Francis 2012
PRO2006-04	Estimation of the nature and extent of incidental captures of seabirds in New Zealand commercial fisheries	1. To estimate the nature and extent of captures and warp-strikes of seabirds in New Zealand fisheries for the fishing year 2005/06.	Completed	Baird & Smith 2008
PRO2006-05	Estimating the nature and extent of marine mammal captures in New Zealand commercial fisheries	1. To estimate and report the total numbers, releases and deaths of marine mammals where possible by species, fishery and fishing method, caught in commercial fisheries for the years 1990 to the end of the fishing year 2005/06. 2. To analyse factors affecting the probability of fur seal captures for the years 1990 to the end of the fishing year 2005/06. 3. To classify fishing areas, seasons and fishing methods into different risk categories in relation to the probability of marine mammal incidental captures for the years from 1990 through to the end of the fishing year 2005/06.	Completed	Mormede *et al.* 2008; Baird 2008a; 2008b; Smith & Baird 2009; Smith & Baird 2011; Baird 2011.

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
PRO2006-07	Characterise non-commercial fisheries interactions	1. To characterise non-commercial fisheries interactions with seabirds and marine mammals 2. Characterise non-commercial fisheries risk to seabirds and marine mammals by area and method Recommend mitigation measures appropriate for uptake in non-commercial fisheries in which seabird or marine mammal captures occur	Completed	Abraham *et al.* 2010a; Thompson & Abraham 2009a; 2009b; 2009c; 2010; 2011; Thompson *et al.* 2010a; b; c
ENV2005-06	Estimation of protected species captures in longline fisheries using electronic monitoring	1. To provide estimates of seabird and marine mammal mortalities from longline fisheries in New Zealand using electronic monitoring systems and to recommend deployment and data management options for ongoing use of these systems for estimation of protected species incidental take.	Completed	McElderry *et al.* 2007
ENV2005-01	Estimation of the nature and extent of incidental captures of seabirds in New Zealand fisheries	1. To estimate the nature and extent of captures of seabirds in selected New Zealand fisheries for the fishing year 2004/05.	Completed	Baird & Smith 2007a; Baird & Gibbert 2010
ENV2005-02	Estimation of the nature and extent of marine mamal captures in New Zealand fisheries	To examine the nature and extent of the captures of marine mammals in New Zealand fisheries, for the whole New Zealand EEZ, by Fishery Management Area and fishing season, and by smaller metric as appropriate for the fishing year 2004/05. 2. Examine alternative methods for estimating sea lion captures and recommend one or more alternative standardised methods for describing and estimating sea lion captures in the SQU 6T fishery.	Completed	Abraham 2008; Baird 2007; Smith & Baird 2007b; Baird & Smith 2007b
ENV2005-04	Identification of marine mammals captured in New Zealand	1. To determine the species- sex- and where possible- age and reproductive status of marine mammals captured in New Zealand fisheries. 2. To necropsy marine mammals captured incidentally to New Zealand fishing operations to determine life-history characteristics and the likely cause of mortality. 3. To determine- through examination of returned marine mammal carcasses- the taxon to species-level- sex- and reproductive status- and age-class of marine mammals captured in New Zealand fisheries. 4. To detail the injuries and where possible the cause of mortality of marine mammals returned from New Zealand fisheries- along with their body condition and breeding status- and other associated demographic characteristics. 5. To detail the protocol used for the necropsy of marine mammals- to provide a standardised procedure for autopsy to determine species- age- sex and associated demographic characteristics for fishery-killed specimens.	Completed	Roe 2007

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2005-09	Data collection to estimate key performance indicators in the Chatham albatross, Diomedea eremita.	1. To gather data on key population parameters for Chatham albatross Diomedea eremita- to enable population viability to be assessed- and the responses of key parameters to fisheries mortality and fisheries management activities to mitigate fisheries related risk 2. To undertake field research to collect data on population growth rates- adult survival- inter-breeding season survival- mortality due to predation at the colony- fecundity and associated parameters for Chatham Albatross- following the study design project 3. To undertake field research to determine the range and extent foraging movements of Chatham albatrosses within New Zealand fishing waters- and examine the nature and extent of any association between Chatham albatrosses and fishing activities.	Completed	No reports specified as required output
ENV2005-13	Assessment of risk to yellow-eyed penguin Megady-ptes antipodes from fisheries incidental mortality	1. To review existing data on yellow-eyed penguin M. antipodes population performance and fisheries information and provide an analysis of the potential effect of fishing mortality and other factors on population viability. 2. To recommend data collection requirements and protocols for the assessment of the effects of fishing on yellow-eyed penguins.	Completed	Maunder 2007
ENV2004-04	Characterisation of seabird captures in New Zealand fisheries	1. Characterisation of seabird captures in New Zealand fisheries.	Completed	Mackenzie & Fletcher 2006
ENV2004-05	Modelling of impacts of fishing-related mortality on New Zealand seabird populations	1. To examine and identify modelling approaches to analyse seabird demographic impacts that may be occurring as a result of fisheries mortality. 2. To compile databases of available demographic and distributional data on selected seabirds affected by fisheries mortality and New Zealand fisheries and estimate key population parameters and seasonal distribution for each species. 3. To estimate rates of removals related to fishing activities in New Zealand for selected seabird species, where possible by age class and sex. 4. To describe the spatial overlap of seabird distributions at sea, with fisheries where the risk of incidental mortality has been demonstrated to be moderate to high. 5. To examine the potential for factors other than fisheries removals within the New Zealand zone to influence the population dynamics of the selected study species. 6. To characterise selected seabird populations' abilities to sustain removals related to fishing operations within the New Zealand EEZ, and to recommend, where possible environmental standards for assessing the sustainability of selected fishing operations in relation to impacts on seabird populations.	Completed	Fletcher *et al.* 2008

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2004-02	Estimation of New Zealand sea lion incidental captures in New Zealand Fisheries	1. To estimate the level of New Zealand sea lion (Phocartos hookeri) incidental capture in New Zealand fisheries	Completed	Smith & Baird 2007a
ENV2004-06	Maui's dolphin study	1. To quantify and compare summer and winter distribution of maui's dolphin	Completed	Slooten *et al.* 2005
IPA2004-14	Seabird warp strike in the southern squid trawl fishery	1. To document seabird warp strike in the southern squid trawl fishery, 2004-05	Completed	Abraham & Kennedy 2008
ENV2003-05	Review of the Current Threat Status of Associatedor Dependent Species	1. To assess the current threat status of selected associated or dependent species.	Completed	Baird *et al.* 2010
No project number	QMA SQU6T New Zealand sea lion incidental catch and necropsy data for the fishing years 2000-01, 2001-02 and 2002-03	Objectives unknown	Completed	Mattlin 2004
MOF2002-03L	Exploring alternative management procedures for controlling bycatch of Hooker's sea lions in the SQU 6T squid fishery	Objectives unknown	Completed	Breen & Kim 2006
ENV2001-01	Estimation of seabird incidental captures in New Zealand fisheries	1. To estimate the level of seabird incidental capture in New Zealand fisheries. 2. To recommend appropriate levels of observer coverage for estimation of seabird incidental capture in New Zealand fisheries.	Completed	Baird 2004a; b; c; Smith & Baird 2008b
ENV2001-02	Incidental capture of Phocarctos hookeri (New Zealand sea lions) in New Zealand commercial fisheries, 2001-02.	1. To estimate and report the total numbers of captures, releases, and deaths of *Phocarctos hookeri* caught in fishing operations, including separate estimates for SQU 6T and other areas, as appropriate, during the 2001102 fishing year, including confidence limits and an investigation of any statistical bias in the estimate.	Completed	Baird 2005a; b; c; Baird & Doonan 2005
ENV2001-03	Estimation of *Arctocephalus forsteri* (New Zealand fur seal) incidental captures in New Zealand fisheries	1. To estimate the level of Arctocephalus forsteri incidental capture in New Zealand fisheries. 2. To recommend appropriate levels of observer coverage for estimation of Arctocephalus forsteri incidental capture in New Zealand fisheries.	Completed	Smith & Baird 2008a; Baird 2005d; e; f

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2000-01	Protected species bycatch	1. To estimate the total numbers of captures, releases, and deaths of seabirds and marine mammals - by species -caught in fishing operations during the 1999-2000 fishing year.	Completed	Baird 2003
ENV2000-02	Estimation of incidental mortality of New Zealand sea lions in New Zealand fisheries	1. To examine the factors that may influence the level of incidental mortality of New Zealand sea lion in New Zealand fisheries 2. To recommend appropriate levels of observer coverage for estimation of incidental mortality of New Zealand sea lion in New Zealand sea lion fisheries	Completed	Doonan 2001; Bradford 2002; Smith & Baird 2005a; b
ENV99-01	Incidental capture of seabirds, marine mammals and sealions in commercial fisheries in New Zealand waters	Objectives unknown	Completed	Baird 2001; Doonan 2000
ENV98-01	Estimation of nonfish bycatch in commercial fisheries in New Zealand waters, 1997–98	Objectives unknown	Completed	Baird 1999b; Baird & Bradford 1999
No project number	Annual review of bycatch in southern bluefin and related tuna longline fisheries in the New Zealand 200 n. mile Exclusive Economic Zone	Objectives unknown	Completed	Baird *et al.* 1998
SANF01	Report on the incidental capture of nonfish species during fishing operations in New Zealand waters	Objectives unknown	Completed	Baird 1997
No project number	Nonfish Species and Fisheries Interactions	Objectives unknown	Completed	Baird 1996
No project number	Nonfish Species and Fisheries Interactions	Objectives unknown	Completed	Baird 1995
No project number	Incidental catch of Hooker's sea lion in the southern trawl fishery for squid, summer 1994	Objectives unknown	Completed	Doonan 1995

PROTECTED SPECIES *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
No project number	Analyses of factors which influence seabird bycatch in the Japanese southern bluefin tuna longline fishery in New Zealand waters, 1989-93	1. to assess the inhence that 15 monitored environmental and fishery related factors had on seabird bycatch rates, and to gauge the effectiveness of various mitigation measures	Completed	Duckworth 1995
No project number	Nonfish Species and Fisheries Interactions	Objectives unknown	Completed	Baird 1994
No project number	Incidental catch of fur seals in the west coast South Island hoki trawl fishery, 1989-92	Objectives unknown	Completed	Mattlin 1993

NON-PROTECTED BYCATCH

Project Code	Project Title	Specific Objectives	Status	Citation/s
DAE2010-02	Bycatch monitoring & quantication for scampi bottom trawl	1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded in the specified fishery, for the fishing years since the last review, using data from Ministry of Fisheries Observers and commercial fishing returns. 2. To compare estimated rates and amounts of bycatch and discards from this study with previous projects on bycatch in the specified fishery. 3. To compare any trends apparent in bycatch rates in the specifiedfishery with relevant fishery independent trawl surveys. 4. To provide annual estimates of bycatch for nine Tier 1 species fisheries and incorporate into the Aquatic Environment and Biodiversity Report specified in Objective 3 for SQU, SCI, HAK, HOK, JMA, ORH, OEO, LIN, SBW	Completed	Anderson 2012
ENV2009-02	Bycatch and discards in oreo and orange roughy trawl fisheries	1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the trawl fisheries for oreos for the fishing years 2002/03 to 2008/09 using data from Scientific Observers and commercial fishing returns. 2. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the trawl fisheries for orange roughy for the fishing years 2004/05 to 2008/09 using data from Scientific Observers and commercial fishing returns.	Completed	Anderson 2011
IDG2009-01	Finfish field identification guide	1. To complement the field identification guide under IDG2006/01 with the remaining 120 fish species caught by commercial fishers in New Zealand waters	Completed	McMillan 2011 a;b;c
ENV2008-01	Fish and invertebrate bycatch and discards in southern blue whiting fisheries	1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the trawl fisheries for southern blue whiting for the fishing years 2002/03 to 2006/07 using data from Scientific Observers and commercial fishing returns.	Completed	Anderson 2009b
ENV2008-02	Estimation of non-target fish catch and both target and non-target fish discards in hoki, hake and ling trawl fisheries	Estimates of the catch of non-target fish species, and the discards of target and non-target fish species in the hoki (Macruronus novaezelandiae), hake (Merluccius australis), and ling (Genypterus blacodes) trawl fisheries for the fishing years 2003–04 to 2006–07 using data from Scientific Observers and commercial fishing returns	Completed	Ballara *et al.* 2010
ENV2008-04	Productivity of deepwater sharks	1. To determine the growth rate, age at maturity, longevity and natural mortality rate of shovelnose dogfish (Deania calcea) and leafscale gulper shark (Centrophorus squamosus).	In the process of publication	Parker & Francis 2012

NON-PROTECTED BYCATCH *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2007-03	Productivity and Trends in Rattail Bycatch Species	1. To estimate growth, longevity, rate of natural mortality, and length at maturity of four key rattail bycatch species in New Zealand trawl fisheries. 2. To examine data from trawl surveys and other data sources for trends in catch rates or indices of relative abundance for species in Objective 1.	Completed	Stevens *et al.* 2010
DEE2006-03	Monitoring the abundance of deepwater sharks	1. To monitor the abundance of deepwater sharks taken by commercial trawl fisheries	Completed	Blackwell 2010
ENV2006-01	Bycatch and discards in ling longline fisheries	To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the longline fisheries for ling for the fishing years 1998/99 to 2005/06 using data from MFish Observers and commercial fishing returns.	Completed	Anderson 2008
IDG2006-01	Finfish field indentification guide	1. To produce a field guide for fish species in New Zealand 2. To produce a field identification guide for all QMS and other fish species commonly caught in commercial and non-commercial fisheries	Completed	McMillan 2011 a;b;c
TUN2006-02	Estimation of non-target fish catches in the tuna longline fishery	1. To estimate the catches, catch rates, and discards of non-target fish in tuna longline fisheries data from the Observer Programme and commercial fishing returns for the 2005/06 fishing year. 2. To describe bycatch trends in tuna longline fisheries using data from this project and the results of previous similar projects.	Completed	Griggs *et al.* 2008
TUN2004-01	Estimation of non-target fish catches in the tuna	To estimate the catch rates of non-target fish in the 10ngline fisheries for tuna using data from the Observer Programme and commercial fishing returns for the 2002/03, 2003/04 and 2004/05 fishing years. 2. To estimate the quantities of non-target fish caught in the longline fisheries for tuna using data from the Observer Programme and commercial fishing returns for the 2002/03, 2003/04 and 2004/05 fishing years. 3. To estimate the discards of non-target fish caught in the longline fisheries for tuna using data from the Observer Programme and commercial fishing returns for the 2002/03, 2003/04 and 2004/05 fishing years. 4. To describe trends in the non-target fish catches in the tuna longline fisheries using data from this project and the results of previous similar projects.	Completed	Griggs *et al.* 2007
ENV2005-17	Estimation of non-target fish catch and both target and non-target fish discards in jack mackerel trawl fisheries	1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the trawl fisheries for jack mackerel for the fishing years 20011/2002 to 2004/05 using data from Mfish observers and commercial fishing returns.	Completed	Anderson 2007a

NON-PROTECTED BYCATCH *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2005-18	Estimation of non-target fish catch and both target and non-target fish discards in orange roughy trawl fisheries	1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the trawl fisheries for orange roughy for the fishing years 1999/2000 to 2003/04 using data from Scientific Observers and commercial fishing returns.	Completed	Anderson 2009a
ENV2003-01	Estimation of non-target catches in the hoki fishery	1. To estimate the catch rates, quantity and discards of non-target fish catches and the discards of target fish catches in trawl fisheries for hoki, using data from the Observer Programme and commercial fishing returns for the 1999/00 to 2002/03 fishing years. 2. To compare and contrast the estimates from the four years of data in Specific Objective 1 above with the 1990/91 through 1998/99 series previously reported.	Completed	Anderson & Smith 2005
ENV2002-01	Estimation of non-target fish catch and both target and non-target fish discards for the tuna longline fishery	1.To estimate the catch rates, quantity and discards of non-target fish, particularly oceanic shark species, broadbill swordfish and marlin species, caught in the longline fisheries for tuna, using data from Scientific Observers and commercial fishing returns for the 2000/01 and 2001/02 fishing years.	Completed	Ayers *et al.* 2004
ENV2001-04	Non-target fish catch and discards in selected New Zealand fisheries	To generate estimates of the catch of non-target fish species, and the discards of target and non-target fish species in three important New Zealand trawl fisheries: arrow squid (*Nototodarus sloani & N. gouldi*), jack mackerel (*Trachurus declivis, T. novaezelandiae, & T. symmetricus murphyi*) and scampi (*Metanephrops challengeri*)	Completed	Anderson 2004
ENV2001-05	To assess the productivity and relative abundance of deepwater sharks	1. To review the relative abundance, distribution and catch composition of the most commonly caught deepwater shark species: shovelnose dogfish (*Deania catcea*), Baxter's dogfish (*Etmopterus baxten*), Owston's dogfish (*Cenhoscymnus owstoni*), longnosed velvet dogfish (*Centroscymnus crepidater*), leafscale gulper shark (*Cenhophom quamosus*), and the seal shark (*Dalatias ticha*).	Completed	Balckwell & Stevenson 2003
ENV2001-07	Reducing bycatch in scampi trawl fisheries	1. Collate and review the international literature on methods of reducing bycatch in crustacean trawl fisheries. 2. Review and analyse the data from New Zealand studies. 3. Develop recommendations on future approaches to reducing bycatch in the New Zealand scampi fishery, including some general thoughts on the experimental design of field trials.	Completed	Hartill *et al.* 2006

NON-PROTECTED BYCATCH *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
PAT2000-01	Review of rattail and skate bycatch, and analysis of rattail standardised CPUE from the Ross Sea toothfish fishery in Subarea 88.1, from 1997-1998 to 2001-02	Objectives unknown	Completed	Feanaughty *et al.* 2003; Marriot *et al.* 2003
ENV99-02	Estimation of non-target fish catch and both target and non-target fish discards in selected New Zealand fisheries	1. To estimate the quantity of non-target fish species caught in the trawl fisheries for hoki and orange roughy for the fishing years 1990-91 to 1998-99 using data from Scientific Observers, commercial fishing returns and from research trawl surveys. 2. To estimate the quantity of target and non-target fish species discarded in the trawl fisheries for hoki and orange roughy for the fishing years 1990-91 to 1998-99 using data from Scientific Observers, commercial fishing returns and from research trawl surveys. 3. To explore the effects of various factors on the total catch of non-target fish species and the discards of target and non-target fish species in the trawl fisheries for hoki and orange roughy for the fishing years 1990-91 to 1998-99. 4. To recommend appropriate levels of observer coverage for estimation of non-target fish catch and discards of target and non-target fish species in the hoki and orange roughy fisheries.	Completed	Anderson *et al.* 2001
ENV98-02	Pelagic shark bycatch in the New Zealand tuna longline fishery	To determine pelagic shark bycatch in the New Zealand tuna longline fishery	Completed	Francis *et al.* 2001
No project number	Fish bycatch in New Zealand tuna longline fisheries	Objectives unknown	Completed	Francis *et al.* 1999; 2000
ENV97-01	Estimation of nonfish bycatch in New Zealand fisheries	1. Unknown 2. To provide weekly within season estimates of total captures, releases, and deaths by sex and area for New Zealand sea lions taken in the southern squid trawl fishery beginning two (2) weeks after the start of the fishery until 15 May 1998. Estimates of the confidence intervals and coefficient of variation of the point estimates must also be provided. 3. Unknown	Completed	Doonan 1998; Baird 1999a; Baird *et al.* 1999

NON-PROTECTED BYCATCH *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
SCI97-01	Scampi stock assessment for 1998 and an analysis of the fish and invertebrate bycatch of scampi trawlers	1. To summarise catch, effort, observer, and research information for scampi fisheries in QMAs 1,2,3,4 (east and western portions), and 6A in 1998	Completed	Cryer *et al.* 1999
No project number	Incidental catch of non-fish species by setnets in New Zealand waters	Objectives unknown	Completed	Taylor 1992

BENTHIC IMPACTS

Project Code	Project Title	Specific Objectives	Status	Citation/s
BEN2012-02	Spatial overlap of mobile bottom fishing methods and coastal benthic habitats	1. To use existing information and classifications to describe the distribution of benthic habitats throughout New Zealand's coastal zone (0–200 m depth). 2. To rank the vulnerability to fishing disturbance of habitat classes from Objective 1. 3. To describe the spatial pattern of fishing using bottom trawls, Danish seine nets, and shellfish dredges and assess overlap with each of the habitat classes developed in Objective 1.	Approved but not contracted	
DAE2010-04	Monitoring the trawl footprint for deepwater fisheries	1. To estimate the 2009/10 trawl footprint and map the spatial and temporal distribution of bottom contact trawling throughout the EEZ between 1989/90 and 2009/10. 2. To produce summary statistics, for major deepwater fisheries and the aggregate of all deepwater fisheries, of the spatial extent and frequency of fishing by year, by depth zone, by fishable area, and by habitat class, and to identify any trends or changes.	Ongoing analysis	Black *et al.* In Press
DEE2010-06	Design a camera / transect study	1. To design and provide indicative costs for a programme to monitor trends in deepwater benthic habitats and communities. 2. To explore the feasibility of using existing trawl and acoustic surveys to capture data relevant to monitoring trends in deepwater benthic habitats and communities.	Ongoing analysis	
BEN2009-02	Monitoring recovery of benthic communities in Spirits Bay	1. To survey Spirits Bay and Tom Bowling Bay benthic invertebrate communities according to the monitoring programme designed in ENV2005/23. 2. To assess changes in benthic communities inside and outside the closed area since 1997.	In the process of publication	Tuck & Hewitt In Press
Internally funded 1	SPRFMO	1. To develop detection criteria for measuring trawl impacts on vulnerable marine ecosystems in high sea fisheries of the South Pacific Ocean	Completed	Parker *et al.* 2009a
Internally funded 2	SPRFMO	1. To document protection measures implemented by New Zealand for vulnerable marine ecosystems in the South Pacific Ocean	Completed	Penney *et al.* 2009
Internally funded 3	CCAMLR	1. An Impact Assessment Framework for Bottom Fishing Methods in the CCAMLR Convention Area	Completed	Sharp *et al.* 2009
Internally funded 4	SPRFMO	1. to develop a bottom Fishery Impact Assessment: Bottom Fishing Activities by New Zealand Vessels Fishing in the High Seas in the SPRFMO Area during 2008 and 2009	Completed	Ministry of Fisheries 2008

BENTHIC IMPACTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
IFA2008-04	Guide for the rapid identification of material in the process of managing Vulnerable Marine Ecosystems	To produce a guide for the rapid identification of material in the process of managing Vulnerable Marine Ecosystems	Completed	Tracey *et al.* 2008
IFA2007-02	Development of a Draft New Zealand High-Seas Bottom Trawling Benthic Assessment Standard	1. To generate data summaries and maps of New Zealand's recent historic high-seas bottom trawling catch and effort in the proposed convention area of the South Pacific Regional Fisheries Management Organization (SPRFMO). 2. To map vulnerable marine ecosystems (VMEs) in the SPRFMO area. 3. To develop a draft standard for assessment of benthic impacts of high-seas bottom trawling on VMEs in the proposed SPRFMO convention area.	Completed	Parker 2008
BEN2007-01	Assessing the effects of fishing on soft sediment habitat, fauna, and processes	1. To design and test sampling and analytical strategies for broad-scale assessments of habitat and faunal spatial structure and variation across a variety of seafloor habitats. 2. To design and carry out experiments to assess the effects of bottom trawling and dredging on benthic communities and ecological processes important to the sustainability of fishing at scales of relevance to fishery managers.	Ongoing analysis	
BEN2006-01	Mapping the spatial and temporal extent of fishing in the EEZ	1. To update maps and develop GIS layers of fishing effort from project ENV2000/05 to show the spatial and temporal distribution of mobile bottom fishing throughout the EEZ between 1989/90 and 2004/05. 2. To produce summary statistics of major fisheries and the aggregate of all bottom impacting fisheries in terms of the extent and frequency of fishing by year, by depth zone, by fishable area, and, to the extent possible, by habitat type. 3. To identify and document any major trends or changes in fishing effort or fishing behaviour. 4. To identify, discuss the implications of, and make recommendations on data quality and other problems with current reporting systems that complicate characterisation and quantification of bottom fishing effort. 5. To integrate information on the distribution, frequency, and magnitude of fishing disturbance with habitat characteristics throughout the EEZ, using information stored in national databases, expert opinion, and the MEC.	Completed	Baird *et al.* 2009; 2011; Baird & Wood 2010; Leathwick *et al.* 2010; 2012

BENTHIC IMPACTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2005-15	Information for managing the Effects of Fishing on Physical Features of the Deep-sea Environment	1. To provide an updated database that identifies all known seamounts in the "New Zealand region", encompassing the area from 24o00' – 57o30'S, 157o00'E – 167o00'W. The database will catalogue relevant data (e.g. physical, biological, location, fishing effort) for individual seamounts. 2. To identify indicators and measures suitable for the assessment of risk pertaining to the effects of fishing disturbance on the benthic biota of seamounts, and review suitable ecological risk assessment methods, that can be derived or utilise information contained within the seamount database.	Completed	Rowden *et al.* 2008; Clark *et al.* 2010b
ENV2005-16	Investigate the Effects of Fishing on Physical Features of the Deep-sea Environment	1. To monitor changes in fauna and habitats over time on selected UTFs in the Chatham Rise area that have a range of fishing histories. 2. To continue development of the risk assessment model to predict the effects of fishing, and provide options for the management of UTF ecosystems.	Completed	Clark *et al.* 2010a; b; c; 2011
ENV2005-17	Estimation of non-target fish catch and both target and non-target fish discards in jack mackerel trawl fisheries	1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the trawl fisheries for jack mackerel for the fishing years 20011/2002 to 2004/05 using data from Mfish observers and commercial fishing returns.	Completed	Anderson 2007a
ENV2005-18	Estimation of non-target fish catch and both target and non-target fish discards in orange roughy trawl fisheries	1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded, in the trawl fisheries for orange roughy for the fishing years 1999/2000 to 2003/04 using data from Scientific Observers and commercial fishing returns.	Completed	Anderson 2009a

BENTHIC IMPACTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2005-20	Benthic invertebrate sampling and species identification in trawl fisheries	1. To produce identification guides for benthic invertebrate species encountered in the catches of commercial and research trawlers.	Completed	Tracey *et al.* 2007; Williams *et al.* 2010; Clark *et al.* 2009
ENV2005-23	Monitoring recovery of the benthic community between North Cape and Cape Reinga	1. To design a monitoring programme that will provide the following quantitative estimates: i) Estimates of the nature and extent of past fishing impacts on the benthic community between North Cape and Cape Reinga; ii) Estimates of change over time in areas previously fished but subsequently closed to fishing. Estimated parameters will include indices representing biodiversity, community composition, and biogenic structure; iii) Estimates of change over time in areas environmentally comparable to those assessed in (ii), above, but subject to ongoing fishing impacts; and iv) Estimates of change over time in areas comparable to those above, but not impacted by fishing (if any such areas can be found).	Completed	Tuck *et al.* 2010
ZBD2005-04	Information on benthic impacts in support of the Foveaux Strait Oyster Fishery Plan	1. To assess the distribution- vulnerability to disturbance- and ecological importance of habitats in Foveaux Strait- and describe the spatial distribution of the Foveaux Strait oyster fishery relative to those habitats. 2. To assemble and collate existing information on the Foveaux Strait system between the Solander Islands and Ruapuke Island or other area to be agreed with MFish. 3. To map- using best available information- substrate type- bathymetry- wave energy- and tidal flow in this area. 4. To assess the extent to which these data can be used to define useful functional categories that might serve as habitat classes. 5. To rank the vulnerability to fishing disturbance of habitat classes developed in Objective 3 using approximate regeneration times. 6. To describe the functional role and ecosystem services provided by each habitat class developed in Objective 3- including an assessment of the relative importance of each to overall ecosystem function and productivity. 7. To describe the spatial pattern and intensity of dredge fishing for Foveaux Strait oysters over the past 10 fishing years and relate this to natural disturbance regimes and habitat classes developed in Objective 3. 8. To carry out a qualitative video survey of benthic habitats in Foveaux Strait- both within the established commercial oyster fishery area and areas outside the fishery area but within OYU 5.	Completed	Michael *et al.* 2006

BENTHIC IMPACTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2005-15	Information on benthic impacts in support of the Coromandel Scallops Fishery Plan	1. To assemble and collate existing information on the coromandel Scallop Fishery between cape Rodney and Town Point or other, wider area to be agreed with Mfish. 2. To map, using best available information, substrate type, bathymetry, wave energy, and tidal flow in this area. 3. To assess the extent to which data can be used to define useful functional categories that might serves as habitat classes. 4. To rank the vulnerability of fishing disturbance of habitat classes developed in Objective 3 using approximate regeneration times. 5. To describe the functional role and ecosystem services provided by each habitat class developed in Objective 3, including an assessment of the relative importance of each to overall ecosystem function and productivity. 6. To describe the spatial pattern and intensity of dredge and trawl fishing within the Coromandel scallop fishery over the past 15 fishing years and relate this to natural disturbance regimes and habitat classes developed in Objective 3.	Completed	Tuck *et al.* 2006a; b
ZBD2005-16	Information on benthic impacts in support of the Southern Blue Whiting Fishery Plan	1. To assemble and collate existing information on the Southern Blue Whiting fishery in SBW6A, SBW6B, SBW6I, and SBW6R or other wider area to be agreed with MFish 2. To map, using best available information, substratum type, bathymetry, wave energy, tides, and ocean currents in these areas 3. To assess the extent to which these data can be used to define useful functional categories that might serve as habitat categories. 4. To rank the vulnerability to fishing disturbance of habitat classes developed in Objective 3 using approximate regeneration times. 5. To describe the functional role and ecosystem services provided by each habitat class developed in Objective 3, including an assessment of the relative importance of each to overall ecosystem function and productivity. 6. To describe the spatial pattern and intensity of trawl fishing within the Southern Blue Whiting fishery over the past 10 fishing years and relate this to natural disturbance regimes and habitat classes developed in Objective 3.	Completed	Cole *et al.* 2007
ENV2004-02	Estimation of New Zealand sea lion incidental captures in New Zealand Fisheries	1. To estimate the level of New Zealand sea lion (Phocartos hookeri) incidental capture in New Zealand fisheries	Completed	Smith & Baird 2007a
ENV2003-03	Determining the spatial extent, nature and effect of mobile bottom fishing methods	1. To determine the spatial extent, nature and time between disturbances of mobile bottom fishing methods in the Chatham Rise trawl fisheries.	Completed	Baird *et al.* 2006

BENTHIC IMPACTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2002-04	Benthic invertebrate sampling and specific identification in trawl fisheries	1. To quantify and map the benthic invertebrate species incidental catch in commercial and research trawling throughout the New Zealand EEZ	Completed	Tracey *et al.* 2005
ENV2001-07	Reducing bycatch in scampi trawl fisheries	1. Collate and review the international literature on methods of reducing bycatch in crustacean trawl fisheries. 2. Review and analyse the data from New Zealand studies. 3. Develop recommendations on future approaches to reducing bycatch in the New Zealand scampi fishery, including some general thoughts on the experimental design of field trials.	Completed	Hartill *et al.* 2006
ENV2001-09	The effects of mobile bottom fishing gear on bentho-pelagic coupling	To describe any effects of fishing that might modify bentho-pelagic coupling (a complex, interlinked suite of processes transferring energy, oxygen, carbon, and nutrients between pelagic and benthic systems), to consider the scale of such possible effects, and to put the summary in a New Zealand context.	Completed	Cryer *et al.* 2004
ENV2001-15	The effects of bottom impacting trawling on seamounts	1. To design a programme in New Zealand waters previously trawled and now closed to trawling to monitor the rate of regeneration of benthic communities on seamounts.	Completed	Clark & O'Driscoll 2003; Clark & Rowden 2009
OYS2001-01	Foveaux Strait oyster stock assessment	1. To carry out a survey and determine the distribution and absolute abundance of pre-recruit and recruited oysters in both non-commercial and commercial areas of Foveaux Strait. The target coefficient of variation (c.v.) of the estimate of absolute recruited abundance is 20%. 2. To estimate the sustainable yield for the areas of the commercial oyster fishery in Foveaux Strait for the year 2002 oyster season. 3. To identify and count benthic macro-biota collected during the dredge survey.	Completed	Rowden *et al.* 2007
ENV2000-05	Spatial extent, nature and impact of mobile bottom fishing methods in the New Zealand EEZ	1. To determine the spatial extent, nature and impact of mobile bottom fishing methods within the New Zealand EEZ.	Completed	Cryer and Hartill 2002; Baird *et al.* 2002
ENV2000-06	Review of technologies and practices to reduce bottom trawl bycatch and seafloor disturbance in New Zealand	Objectives unknown	Completed	Booth *et al.* 2002; Beentjes & Baird 2004

BENTHIC IMPACTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV98-05	The effects of fishing on the benthic community structure between North Cape and Cape Reinga	1. To determine the effects of fishing on the benthic community structure between North Cape and Cape Reinga.	Completed	Cryer *et al.* 2000

ECOSYSTEM EFFECTS

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2012-01	A literature review of Nitrogen levels and adverse ecological effects in embayments in temperate regions.	1. To complete a literature review of Nitrogen levels and adverse ecological impacts from temperate embayments in order to assist aquaculture consenting authorities in determining at what concentration of Nitrogen adverse effects may be expected.	Approved but not contracted	
ZBD2012-06	Ocean status: trends in NZ marine environment and Tier 1 statistic	1. To provide an up to date overview of climatic trends and cycles and how they affect New Zealand oceanographic conditions, and highlight key changes since the previous assessment. 2. To identify candidate oceanographic variables for potential development as part of the proposed Tier 1 Statistic, Atmospheric and Ocean Climate Change	Approved but not contracted	
ANT2011-01	Antarctic fisheries	1. To develop, implement and refine approaches for assessing the stock status of toothfish (Dissostichus spp.) in the Ross Sea region. 2. To develop, implement and refine approaches for assessing and monitoring the status of non-target fish species, and dependent and related species. 3. To develop, implement and refine approaches for understanding and managing the ecological relationships between the toothfish (Dissostichus spp.) fishery and the Ross Sea ecosystem.	Ongoing analysis	
DAE2010-01	Taxonomic identification of benthic specimens	1. To identify benthic invertebrates in samples taken during research trawls and by Observers on fishing vessels. 2. To update relevant databases recording the catch of invertebrates in research trawls and commercial fishing.	Ongoing analysis	
DAE2010-03	Ecological risk assessment for deepwater stocks	1. To undertake a qualitative (level 1) risk assessment for tier 3 fishstocks within the deepwater fisheries plan.	Ongoing analysis	
DEE2010-04	Development of a methodology for Environmental Risk Assessments for deepwater fisheries	To review approaches to Ecological Risk Assessments (ERA) and methods available for deepwater fisheries both QMS and non-QMS. 2. To develop and recommend a generic, cost effective, method for ERA in deepwater fisheries by using or modifying methods identified in Objective 1.	Completed	Clark *et al.* In Press
DEE2010-05	Development of a suite of environmental indicators for deepwater fisheries	1. To review the literature and hold a workshop to recommend a suite of ecosystem and environmental indicators that will contribute to assessing the performance of deepwater fisheries within an environmental context. 2. To examine available data and design a data collection programme to enable future calculation of the indicators identified in Specific Objective 1.	Ongoing analysis	
ENV2010-03	Habitats of particular significance for inshore finfish fisheries management	1. To review the literature to determine the most important juvenile or reproductive (spawning, pupping or egg-laying) areas for inshore finfish target species. 2. To use a gap analysis to prioritize areas for future research concerning the important juvenile or reproductive (spawning, pupping or egg-laying) areas for target inshore finfish fisheries	Ongoing analysis	

ECOSYSTEM EFFECTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2010-05A&B and SEA 2010-15	Habitats of particular significance for fisheries management: shark nursery areas	1. Identify, from the literature, important nursery grounds for rig in estuaries around mainland New Zealand. 2. Design and carry out a survey of selected estuaries and harbours around New Zealand to quantify the relative importance of nursery ground areas. 3. Identify threats to these nursery ground areas and recommend mitigation measures.	In the process of publication	Francis *et al.* 2012; Jones *et al.* In Press
ZBD2010-42	Development of a National Marine Environment Monitoring Programme	1. To design a Marine Evnironment Monitoring Programme (MEMP) to track the physical, chemical and biological changes taking place across New Zealand's marine environment over the long term 2. To prepare an online inventory (metadatabase) of repeated (time series) biological and abiotic marine observations/datasets in New Zealand 3. To review, evaluate fitness for purpose, and identify gaps in the utility and interoperability of these datasets for inclusion in MEMP from both science and policy perspectives 4. To design a MEMP that includes relevant existing data collection and proposed new time series	Ongoing analysis	
ANT2009-01	Antarctic fisheries	1. To explore the biology of fishes captured in the toothfish fishery to underpin future stock assessment and ecosystem modelling research 2. To develop and refine stock assessment approaches for toothfish in the Ross Sea 3. To assess the status of toothfish stocks in the Ross Sea 4. To explore the Ross Sea toothfish fishery at an ecosystem level 5. To review and further develop procedures for the ageing of Antarctic toothfish (Dissostichus mawsoni) and Patagonian toothfish (D. eleginoides). 6. To review and update the species profiles for toothfish 7. To characterise the toothfish fishery in the Ross Sea up to 2009/10 8. To further develop toothfish biological and modelling parameters 9. To assess the status of the Ross Sea toothfish stock(s) with respect to CCAMLR performance measures 10. To further develop approaches to assessing the status of skates in the Ross Sea region with respect to CCAMLR performance measures 11. Further develop the SPM approach 12. To develop new approaches and refine existing approaches to understanding the impacts of fishing on potential VMEs 13. To further develop ecosystem monitoring through the analysis of the diet of toothfish in the north and slope fisheries. 14. To refine the draft data collection plan for the Ross Sea region fisheries and undertake associated preliminary reviews of fishery and observer performance against targets immediately post-season	Completed	Parker & Bowden 2010; Parker *et al.* 2009c; Tracey *et al.* 2010

ECOSYSTEM EFFECTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2009-04	Trends in relative mesopelagic biomass using time series of acoustic backscatter data from trawl surveys	1. To evaluate relative changes in abundance of mesopelagic fish and other biological components from acoustic records collected during Chatham Rise and Sub-Antarctic trawl surveys. 2. To explore links between trends in mesopelagic biomass and climate variables and variations, and condition indices of commercial species in the Chatham Rise and Sub-Antarctic areas.	Completed	O'Driscoll *et al.* 2011
ENV2009-07	Habitats of particular significance for fisheriesmanagement: kaipara harbour	1. Collate and review information on the role and spatial distribution of habitats in the Kaipara Harbour that support fisheries production. 2. Assess historical, current, and potential anthropogenic threats to these habitats that could affect fisheries values, including fishing and land-based threats. 3. Design and implement cost-effective habitat mapping and monitoring surveys of habitats of particular significance for fisheries management in the Kaipara Harbour.	Ongoing analysis	
GMU2009-01	Spatial Mixing of GMU1 using Otolith Microchemistry	1. To determine the level of spatial mixing and connectivity of grey mullet (Mugil cephalus) populations using otolith microchemistry. 2. To collect and analyse the chemical composition of grey mullet otoliths. 3. To analyse the otoliths collected under Objective 1 to determine if the samples can be spatially separated.	Ongoing analysis	
IPA2009-11	Trophic studies publication of review	1. To publish the comprehensive review of New Zealand-wide trophic studies completed in 2000 that was prepared by NIWA.	Completed	Stevens *et al.* 2011
ANT2008-03	Ecosystem effects of fishing in the Ross Sea	To evaluate the VMEIO classification accuracy of observers, identify potential causes for taxonomic confusion, and make recommendations for improvements in the classification guide, observer training, and in the data collection protocols	Completed	Parker *et al.* 2009b; 2010
AQE2008-02	Review of ecological effects of farming shellfish and other species	1. To collate and review information on the ecological effects of farming mussels (Perna canaliculus), including offshore mussel farming and spat catching, in the New Zealand marine environment. 2. To collate and review information on the ecological effects of farming oysters in the New Zealand marine environment. 3. To collate and review information on the ecological effects of farming species other than mussels (Perna canaliculus), oysters, and finfish, in the New Zealand marine environment.	Completed	Keeley *et al.* 2009

ECOSYSTEM EFFECTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
TOH2008-01	Distribution and abundance of Toheroa	1. To estimate the size structure and absolute abundance of toheroa on Oreti Beach, during February 2009. The target c.v. for the estimate of absolute abundance of legal sized toheroa (100 mm shell length) is 20%. 2. To describe changes in the size structure and absolute abundance of toheroa on Oreti Beach by comparing the results from this work with those from previous surveys. 3. To estimate the size structure and absolute abundance of toheroa on Bluecliffs Beach, during February 2009. The target c.v. for the estimate of absolute abundance of legal sized toheroa (100 mm shell length) is 20%. 4. To describe changes in the size structure and absolute abundance of toheroa on Bluecliffs Beach by comparing the results from this work with those from previous surveys.	Completed	Beentjes 2010
IFA2008-08	Inputs to the Ross Sea bioregionalisation	1. To produce one or more benthic invertebrate classifications of the Ross Sea region; 2. To use fishery catch data to examine spatial distributions of major demersal fish species; 3. To prepare other biological or environmental spatial data layers for use in the Ross Sea workshop.	Completed	Pinkerton *et al.* 2009a
ANT2007-01	Biology of fishes in the toothfish fishery	3. To develop an identification guide for observers of benthic invertebrate species (especially sponges, corals etc) caught in the Ross Sea region fisheries.	Completed	Parker *et al.* 2008
BEN2007-01	Assessing the effects of fishing on soft sediment habitat, fauna, and processes	1. To design and test sampling and analytical strategies for broad-scale assessments of habitat and faunal spatial structure and variation across a variety of seafloor habitats. 2. To design and carry out experiments to assess the effects of bottom trawling and dredging on benthic communities and ecological processes important to the sustainability of fishing at scales of relevance to fishery managers.	Ongoing analysis	
BEN2007-05	Risk assessment framework for assessing fishing &other anthropogenic effects on coastal fisheries	1. To collate existing information on the distribution, intensity, and frequency of anthropogenic disturbances in the coastal zone that could be used in a risk assessment model to estimate their likely aggregate effect on ecosystem function across habitats and over different scales of ecosystem functioning and biological organization. 2. To develop a risk assessment framework in conjunction with a variety of stakeholders and environmental scientists.	Completed	MacDiarmid *et al.* 2012
ENH2007-01	Stock enhancement of blackfoot paua	1. To assess the survival rate of enhanced paua from introduction into the wild through to harvest. 2. To assess the genetic diversity of hatchery spawned juvenile paua bred for enhancement purposes. 3. To assess interactions between introduced and wild paua populations and to recommend research and monitoring to quantify those impacts that are potentially adverse.	Ongoing analysis	

ECOSYSTEM EFFECTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2007-04	Climate and Oceanographic Trends Relevant to New Zealand Fisheries	1. To summarise, for fisheries managers, climatic and oceanographic fluctuations and cycles that affect productivity, fish distribution and fish abundance in New Zealand.	Completed	Hurst *et al.* 2012
ENV2007-06	Trophic Relationships of Commercial Middle Depth Species on the Chatham Rise	1. To quantify the inter-annual variability in the diets of hoki, hake and ling on the Chatham Rise 1992–2007 2.To quantify seasonal dietary cycles for hoki, hake and ling that have been collected from the commercial fleet throughout the year	Completed	Horn & Dunn 2010
HAB2007-01	Biogenic habitats as areas of particular significance for fisheries management	1. To collate and review available information on the location, value, functioning, threats to, and past and current status of biogenic habitats that may be important for fisheries production in the New Zealand marine environment. 2. To identify information gaps, in the New Zealand context, and recommend measures to address those important to an ecosystem approach to fisheries management	Ongoing analysis	
IPA2007-07	Land Based Effects on Costal Fisheries	1. To review and collate scientific knowledge and research on the impacts of land-based activities on coastal fisheries and biodiversity	Completed	Morrisson *et al.* 2009
TOH2007-03	Toheroa Abundance	1. To investigate variations in the abundance of toheroa. 2. To investigate sources of mortality of toheroa and factors affecting the recruitment of toheroa	Ongoing analysis	Williams *et al.* In Press
ENV2006-04	Ecosystem indicators for New Zealand fisheries	1. To carry out a literature review of potential fish-based ecosystem indicators and identify a suite of indicators to be tested in Objective 2 2. To test a suite of fish-based ecosystem indicators (identified by Objective 1) on existing trawl survey time series in New Zealand. The utility of these indicators for monitoring the effects of fishing in New Zealand should also be evaluated	Completed	Tuck *et al.* 2009
GBD2006-01	DNA database for commercial marine fish and invertebrates	1. To collect DNA sequences for vouchered specimens of commercially important marine fishes and submit the DNA data to the international Barcode of Life Database (BOLD). 2. To collect DNA sequences for vouchered specimens of commercially important marine invertebrates and submit the DNA data to the international Barcode of Life Database (BOLD). Note: The funding was limited to $60 000 for this Objective. Therefore MFish agreed to omit the invertebrate species (Objective 2) from this project and reduce the number of fish species sequenced from 100 to 80 (up to 5 specimens per species). During the course of the project MFish staff asked NIWA to identify smoked eel product, suspect shark fillets, and possible paua slime with DNA markers, consequently the project was modified to accommodate these requests	Completed	No reports specified as required output

ECOSYSTEM EFFECTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
SAP2006-06	West coast south island review	1. To publish a review document summarising oceanic and environmental research information particularly relevant to hoki- but also other fisheries- that spawn off Westland in winter 2. Update the draft chapters prepared in 2004 by oceanographers- modellers and scientists towards the overall objective 3. Incorporate a section on other west coast spawning fisheries	Completed	Bradford-Grieve & Livingston 2011
IPA2006-08	Review of the Ecological Effects of Marine Finfish aquaculture: Final Report	1. Summarise and review existing information on ecological effects of finfish farming on the marine environment in New Zealand and overseas	Completed	Forrest *et al.* 2007
ANT2005-02	Aspects of the biology of fishes in the toothfish fishery	1. Estimate length and age at maturity for Antarctic toothfish in the Ross Sea 2. Examine TOA length at age by depth and area 3. Estimate biological parameters for TOA (M, growth rates corrected for selectivity, h, r) 4. Determine stock structure of TOA based on parasite data 5. Determine length-weight relationships, diet, reproduction, age and growth of C.dewitti 6. ID and speciation of Antarctic skates 7. Develop an ID guide for scientific Observers of fish in the Ross Sea fishery 8. Identify heavy metal contents of selected fish species in the Ross Sea fishery	Completed	McMillan *et al.* 2007; Smith *et al.* 2007; Sutton *et al.* 2006
ANT2005-04	Ecosystem modelling of the Ross Sea	1. Carry out stable isotope analysis of TOA and 3 key fish prey to determine trophic links 2. Determine squid diet by analysis of squid beaks for stable isotope analysis 3. Participate in the design of an IPY survey 4. Participate in EMM as required	Completed	Pinkerton *et al.* 2007b
ENV2005-08	Experimental design of a programme of indicators	1. To assess the utility/feasibility of using demographic information to assess the effects of fishing on seabird populations. 2. To identify population indicators and to provide sampling protocols and experimental design for selected high to medium priority seabird populations. 3. To recommend experimental protocols for sampling of selected seabird populations in New Zealand influenced by fisheries mortality, employing robust-design methodology and including recommendations for inclusions of data into Ministry of Fisheries databases.	Completed	MacKenzie & Fletcher 2010
SAM2005-02	Effects of climate on commercial fish abundance	To examine the possible effects of climate on fishery yields and abundance indices for commercial fisheries around New Zealand	Completed	Dunn *et al.* 2009

ECOSYSTEM EFFECTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ANT2004-01	Characterisation of the toothfish fishery	1. update descriptive analysis of toothfish fishery in the Ross Sea to 04/05 2. analyse age, LF and sex ratio for toothfish and rattails for 04/05 3. update and refine the CPUE for TOA in Ross Sea for 04/05 4. determine diet of sub-adult TOA in the Ross Sea 5. review the TOA parasite collection protocol 6. document TOA tagging protocol 7. review approaches to monitoring and assessing rattails and skates in the Ross Sea 8. descriptive analysis of stake tagging programme in the Ross Sea 9. determine factors affecting bycatch of rattails and skates between vessels 10. carry out risk assessment for M. whitsoni and A. georgina in the Ross Sea	Completed	Smith & Notman 2005; Stevens 2006
ANT2004-05	Modelling of the ecosystem effects of fishing in the Ross Sea	1. develop an effects of fishing model based around toothfish fishery 2. investigate possible consequences of different management strategies 3. make recommendations for future research to decrease uncertainty in the model	Completed	Pinkerton *et al.* 2005; 2006
HOK2004-01	Hoki Population modelling and stock assessment	2. To investigate the prediction of year class strength from environmental variables.	Completed	Francis *et al.* 2005
AQE2003-01	Effects of aquaculture and enhancement stock sources on wild fisheries resources and the marine environment.	1. To identify, discuss the effects and qualitatively assess the risks of aquaculture and enhancement stocks improved by hatchery technology on New Zealand's wild fisheries resources and the marine environment. 2. To identify, discuss the effects and qualitatively assess the risks associated with the translocation of aquaculture and enhancement stocks on New Zealand's wild fisheries resources and the marine environment. 3. To make recommendations on priority issues, risks, or research to be undertaken, as a result of information discussed and evaluated in objectives 1-2.	Completed	Speed 2005
EEL2003-01	Non-fishing mortality of freshwater eels	1. To undertake a feasibility study on establishing an estimate of the mortality of eels caused by hydroelectric turbines and other point sources of mortality caused by human activity.	Completed	Bentjees *et al.* 2005
MOF2003-01	The implications of marine reserves for fisheries resources and management in the New Zealand context	Objectives unknown	Completed	Speed *et al.* 2006
ENV2002-03	Beach cast seaweed review	1. To collate existing information on the role of beach-cast seaweed in coastal ecosystems to assess the nature and extent of the impacts that the removal of beach cast seaweed may have on the marine environment. 2. On the basis of the review in Specific Objective 1 above, to identify key research gaps related to any marine environment impacts that the removal of beach cast seaweed may have.	Completed	Zemke-White *et al.* 2005

ECOSYSTEM EFFECTS *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ENV2002-07	Energetics and trophic relationships of important fish and invertebrate species	1. To quantify food webs supporting important fish and invertebrate species	Completed	Livingston 2004
CRA2000-01	Rock lobster stock assessment	Objective 11: To conduct a desktop study to identifi and explore data needs associated with managing the effects of rock lobsterfishing on the environment.	Completed	Breen 2005
ENV2000-04	Identification of areas of habitat of particular significance for fisheries management within the New Zealand EEZ	1. To review literature and existing data for all significant fish species, including all QMS species, encountered from the 200 1500 m contour within the New Zealand EEZ to: a) determine areas of important juvenile fish habitat; b) determine areas of importance to spawning fish populations; and c) determine areas of importance for shark populations for pupping or egg laying. 2. To review literature and existing data for all significant pelagic fish species (excluding highly migratory species) encountered within the New Zealand EEZ to: a) determine areas of important juvenile fish habitat; b) determine areas of importance to spawning fish populations; and c) determine areas of importance for shark populations for pupping or egg laying 3. To review literature and existing data for all significant marine invertebrate species encountered within the New Zealand EEZ to: a) determine areas of important juvenile habitat; and b) determine areas of importance to spawning populations	Completed	O'Driscoll *et al.* 2003
MOF2000-02A	Future research requirements for the Ross Sea Antarctic toothfish (*Dissostichus mawsoni*) fishery.	Objectives unknown	Completed	Hanchet 2000
ENV99-03	Identification of areas of habitat of particular significance for fisheries management within the NZ EEZ.	1. To determine areas of habitat of importance to fisheries management within the New Zealand EEZ for selected fish species in selected areas	Completed	Hurst *et al.* 2000
ENV99-04	A framework for evaluating spatial closures as a fisheries management tool	Unknown	Completed	Bentley *et al.* 2004
No project number	The fishery for freshwater eels (Anguilla spp.) in New Zealand	Objectives unknown	Completed	Jellyman 1994

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Project Code	Project Title	Specific Objectives	Status	Citation/s
SRP2011-02	IDG 2009-01 field guide completion	1. IDG 2009-01 field guide completion	Completed	McMillan 2011 a;b;c
ZBD2010-39	Improved benthic invertebrate species identification in trawl fisheries	1. To revise and update the document "A guide to common deepsea invertebrates in New Zealand waters (second edition)" to allow a third edition of this guide to be printed	Completed	Tracey *et al.* 2011a
ZBD2010-40	Predictive modelling of the distribution of vulnerable marine ecosystems in the South Pacific Ocean region.	1. To develop & test spatial habitat modelling approaches for predicting distribution patterns of vulnerable marine ecosystmes in the convention Area of the South Pacific Regional Fisheries Management Organisation with agreed international partners. 2. To collate datasets and evaluate modelling approaches which are likely to be useful to predict the distribtuion of vulnerable marine ecosystmes in the South pacific Ocean region.	Ongoing analysis	
ZBD2010-41	Ocean acidification in fisheries habitat	1. To assess the risks of ocean acidification to deep sea corals and deepwater fishery habitat 2. To determine the carbonate mineralogy of selected deep sea corals found in the New Zealand region 3. To assess the distribution of deep sea coral species in the New Zealand region relative to improved knowledge of current and predicted aragonite and calcite saturation horizons, assessment of potential locations vulnerable to deep water upwelling 4. Through a literature search and analysis, determine the most appropriate tools to age and measure the effects of ocean acidification on deep sea habitat-forming corals, and recommend the best approach for future assessments of the direct effects	Ongoing analysis	Tracey *et al.* 2011b
IPA2009-14	Bryozoan identificaiton guides	1. For each of ~50 species of common bryozoans, provide photos and text to allow for identification. Provide information on distribution and habitat (as far as is known) and further references for each species and on bryozoans as a whole. 2. Submit these data for publication in the Ministry of Fisheries series New Zealand Aquatic Environment and Biodiversity Research.	Completed	Smith & Gordon 2011
ZBD2009-03	To evaluate the vulnerability of New Zealand rhodolith species to environmental stressors and to characterise diversity of rhodolith beds.	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.	Completed	Nelson *et al.* 2012

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2009-10	Multi-species analysis of coastal marine connectivity	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. 2. 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. 3. In a range of invertebrate and vertebrate marine organisms determine geographic patterns of genetic variation using standardised sampling and molecular techniques. 4. 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.	Completed	Gardner *et al.* 2010
ZBD2009-13	Ocean acidification impact on key nz molluscs	1. Controlled laboratory experiments will be used to determine the effect of pCO2 levels that are predicted to occur in NZ waters over the next few decades on appropriate life history stages of at least two key NZ mollusc species. A number of response variables will be assessed. 2. Implications of these responses to the local and broader ecosystems will be assessed.	Ongoing analysis	Cummings 2011; Cummings *et al.* 2011b
ZBD2009-25	Predicting impacts of increasing rates of disturbance on functional diversity in marine benthic ecosystems	1. Further develop the 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.	Ongoing analysis	Lundquist *et al.* 2010

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2008-01	Biogenic large–habitat–former hotspots in the near-shore coastal zone (50–250 m); quantifying their location, identity, function, threats and protection	1. To collect and integrate existing knowledge on biogenic habitat-formers in the <5–150 m depth zone of New Zealand's continental shelf, from sources including structured fisher interviews, primary and grey literature, and other sources as available. 2. Using the findings of Objective 1, design and deploy a series of sampling voyages to selected locations, to map and characterise locations of significant biogenic structure (either still existing, or historical), and collect relevant biological samples (both through visual census, and physical collection). 3. Process and analyse the samples collected in Objective 2, to provide a hierarchical, quantitative description of the biogenic habitats and associated species encountered. 4. Using the findings from Objective 1–3, assess the present status, likely extent, ecological role, and threats to, biogenic habitat formers in the <5–150 m depth zone. This should include a spatial modelling and risk assessment framework. Integrate (as appropriate) with other information sources and/or approaches that may exist by the year 2010/11.	Ongoing analysis	
ZBD2008-05	Macroalgal diversity associated with soft sediment habitats	1. Conduct a targeted collection programme across diverse soft sediment environments to develop a permanent reference collection of representative macroalgae. 2. Examine algal distribution in soft sediment habitats in relation to selected environmental variables. 3. Prepare an annotated checklist of macroalgae found in soft sediment environments in the New Zealand region.	Completed	Neill *et al.* 2012
ZBD2008-07	Carbonate sediments: the positive and negative effects of land-coast interactions on functional diversity	1. To quantify shifts in community structure and functional diversity in mollusc dominated habitats along gradients associated with an estuary-coast interface in two locations. 2. To characterise the influence of estuary-derived food sources across these gradients for key species. 3. To measure changes in growth of key species in relation to changes in food supply and land-derived sediment impacts. 4. To quantify carbon and nitrogen uptake and tissue turnover rates of key species in laboratory experiments.	Completed	Thrush *et al.* In Press; Savage *et al.* 2012

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2008-11	Predicting changes in plankton biodiversity and productivity of the EEZ in response to climate change induced ocean acidification	1. To document the spatial and inter-annual variability of coccolithophore abundance and biomass- and assess in terms of the phytoplankton abundance-biomass and community composition in sub-tropical and sub-Antarctic water. 2. To document the seasonal and inter-annual variability of foraminifera and pteropod abundance and biomass at fixed locations in sub-tropical and sub-Antarctic water by analysis of sediment trap material from time-series data collection. 3. To document the spatial and seasonal distribution of the key coccolithophore species- Emiliana huxleyi- using both archived and ongoing ingestion of satellite images of Ocean Colour- and ground-truth the reflectance. 4. To determine the sensitivity of- and response of E. huxleyi and other EEZ coccolithophores to pH under a range of realistic atmospheric CO2 concentrations in perturbation experiments- using monocultures and mixed populations from in situ sampling. 5. To document the spatial variability of diazotrophs (nitrogen-fixing organisms) and associated nitrogen fixation rate- and assess in terms of phytoplankton abundance- biomass and community composition in sub-tropical waters north of the STF. 7. To determine the sensitivity of- and response of Trichodesmium spp. and other diazotrophs to pH under a range of realistic atmospheric CO2 concentrations in perturbation experiments using monocultures	Ongoing analysis	Law *et al.* 2012: Boyd & Law 2011
ZBD2008-14	What and where should we monitor to detect long-term marine biodiversity and environmental changes-remote sensing, biota, context, inshore offshore workshop	1. Identify the key questions to be addressed by long-term monitoring of marine biodiversity and environment. 2. Identify appropriate monitoring indices, how they should be spatially distributed and their sampling frequency. 3. Identify relevant existing monitoring programmes across the range of New Zealand agencies and science providers and identify gaps. 4. Provide those agencies setting environmental goals/ standards or research needs (MoRST, FRST, MFish, DoC, MfE, Commissioner for the Environment) with a thorough situational analysis, including a list of priority monitoring projects/plans.	Ongoing analysis	Livingston 2009

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2008-15	Continuous plankton recorder project: implementation and identification	1. To set up a time series of annual CPR data collection by deployment from a toothfish vessel on the annual summer transit between New Zealand and the Ross Sea. 2. To identify phytoplankton and zooplankton according to strict observation protocols determined by the SAHFOS[1] CPR Survey and SO-CPR[2]. 3. To enter species data, frequency and location along the transect into a spreadsheet that will allow spatial mapping of the plankton density and distribution. 4. To analyse the full dataset after 5 years of data collection to: (a) determine trends in the dataset and (b) compare results with Australian datasets available through SO-CPR. 5. To evaluate the continuation of the programme	Ongoing analysis	
ZBD2008-20	Ross sea benthic ecosystem function: predicting consequences of shifts in food supply	1. To increase understanding of Ross Sea coastal benthic ecosystem function 2. Conduct in situ investigations into responses to and utilisation of primary food sources by key species, at two contrasting coastal Ross Sea locations	Completed	Cummings & Lohrer 2011; Cummings *et al.* 2011a; Lohrer *et al.* 2012
ZBD2008-22	Acidification and ecosystem impacts in NZ and southern ocean waters (data collected during IPY).	1. To assess the response of cocolithophorids, and their replacement by non-calcifying organisms during incubation under a range of dissolved CO2 concentrations. 2. To describe and characterise changes in abundance and biodiversity of microbial components of the samples incubated at sea under a range of dissolved CO2 concentrations. 3.To predict the likely impacts of higher acidity on foodwebs and on carbon fixation under scenarios to be encountered in the Southern Ocean under forecasted trends associated with climate change.	Completed	Maas *et al.* 2010b
ZBD2008-23	Macroalgae diversty and benthic community structure at the Balleny Islands	1. To describe and characterise macroalgae diversity from the Balleny Islands and the Western Ross Sea. 2. To describe and quantify benthic community structure from one location at the Balleny Islands 3. To complete anatomical and morphological investigations & molecular sequencing required for the identification of macroalgae samples from the Balleny Islands & western Ross Sea coastline to describe & characterise macroalgae diversity in Balleny Isds 4. To process and analyse samples collected at the Balleny Islands- to analyse them using ICECUBE methodology- and compare results with those from other ICECUBE sampling locations along the Ross Sea coastline	Completed	Nelson *et al.* 2010

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Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2008-27	Scoping investigation into New Zealand abyss and trench biodiversity	1. Review what is already known of abyssal, canyon and trench faunas in NZ. 2. Review what is already known of abyssal, canyon and trench faunas around the world. 3. Prioritise science questions and locations for exploration. 4. Assess NZ capacity to sample at the required depths; identify sampling equipment needs. 5. Design a suitable vessel-based sampling programme	Completed	Lörz *et al.* 2012
ZBD2008-50	OS2020 Chatham Rise Biodiversity Hotspots	1. To improve understanding of the effects of trawl fishing in New Zealand on the biodiversity of seamounts- knolls and hills. 2. To describe differences in benthic biodiversity between northwestern and eastern regions of the Chatham Rise 3. To continue the time series of observations in the NW Chatham Rise to demonstrate recovery in terms of biodiversity 4. To extend the observations on fished-unfished contrasts and recovery of fauna on protected seamounts to an oceanographically distinct location	Completed	Clark *et al.* 2009
IPY2007-02	International polar year census of antarctic marine life post-voyage analysis:Ross Sea - Southern Ocean Biodiversity	1. To measure and describe key elements of species distribution- abundance (density or biomass) & biodiversity for the Ross Sea and Southern Ocean for main habitats and key functional ecosystem roles- for major groups- viruses- bacteria- archaea..... 2. To report on the diversity of Antarctic Cephalopoda (Octopus and Squid)- including a complete inventory of taxa- & reports on ontogenetic & sexual variation in species- their systematics- diversity- distribution- life histories- & trophic importance. 3. To Beak/Biomass Regression Equations 4. Life cycle determination	Completed	Garcia 2010

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
IPY2007-01	International polar year census of antarctic marine life post-voyage analysis:Ross Sea - Southern Ocean Biodiversity	1. To measure seabed depth and rugosity using the multibeam system to identify topographic features such as bottom type, iceberg scouring, seamounts etc and to determine areas for targeted benthic faunal sampling. 2. To continue the analysis of opportunistic seabird and marine mammal distribution observations from this and previous BioRoss voyages and published records, and in relation to environmental variables. 3. To identify and determine near-surface spatial distribution, diversity and abundance of phytoplankton, and zooplankton, based on Continuous Plankton Recorder samples collected during transit to and from the Ross Sea. 4. To collect & analyse data collected both underway, & at stations for salinity, temperature nutrient and chlorophyll a data, spot optical measurements with the SeaWiFS. 5. To identify and determine the spatial distribution, abundance (biomass), diversity, and size structure of epipelagic, mesopelagic (and possibly bathypelagic) species using acoustics and net sampling. 6. To identify and measure diversity, distribution & densities of mesozooplankton, macrozooplankton & meroplankton (as collected by all plankton sampling methods except transit CPR samples). 7. To determine diversity, distribution & densities of viral, bacterial, phytoplankton & microzooplankton species in the water column. 8. To determine the spatial distribution, abundance (biomass), diversity, and size structure of shelf and slope demersal fish species and associated invertebrate species using a demersal survey. 9. To determine the diversity, abundance/density, spatial distribution, and physical habitat associations of benthic assemblages across a body size spectrum from megafauna to bacteria, for shelf, slope, seamounts, and abyssal sites in Ross Sea. 10. To describe trophic/ecosystem relationships in the Ross Sea ecosystem (pelagic and benthic, fish and invertebrates). 11. Assess molecular taxonomy and population genetics of selected Antarctic fauna and flora to estimate evolutionary divergence within and among ocean basins in circumpolar species. Provide DNA barcoding.	Completed	Allcock *et al.* 2009; 2010; Submitted; Alvaro *et al.* 2011; Bowden *et al.* 2011a; In Prep; Clark *et al.* 2010a; Dettai *et al.* 2011; Eakin *et al.* 2009; Eleaume *et al.* 2011; In Prep; Ghiglione *et al.* 2012; Gordon 2000; Grotti *et al.* 2008; Hanchet *et al.* 2008a; 2008b; 2008c; 2008d; Hanchet 2009; 2010; Hanchet *et al.* In Press; Heimeier *et al.* 2010; Hemery *et al.* In prep; Koubbi *et al.* 2011; Leduc *et al.* 2012a; b; Linse *et al.* 2007; Lörz 2009; Lörz 2010a; 2010b; 2010c; Lörz & Coleman 2009; Lörz *et al.* 2007; 2009; 2012a; b; In Press; In Prep; Maas *et al.* 2010a; McMillan *et al.* 2012.; Mitchell 2008; Nielsen *et al.* 2009; Norkko *et al.* 2005; O'Driscoll 2009; O'Driscoll *et al.* 2009; 2010; O'Driscoll *et al.* In Press; O'Loughlin *et al.* 2011; Pakhomov *et al.* 2011; Pinkerton *et al.* 2007a; Pinkerton *et al.* 2009a; b; Pinkerton *et al.* In review; In press; Schiaparelli *et al.* 2006; 2008; 2010; Smith *et al.* 2011a; b; Stein 2012; Strugnell *et al.* Submitted

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2007-01	Chatham-Challenger Oceans 20/20 Post-Voyage	1. To quantify in an ecological manner- the biological composition and function of the seabed at varying scales of resolution- on the Chatham Rise and Challenger Plateau 2. To elucidate the relative importance of environmental drivers- including fishing- in determining sea bed community composition and structure. 3. To determine if remote-sensed data (e.g. acoustic) and environmentally derived classification schemes (e.g. marine environmental classification system) can be utilized to predict bottom community composition- function and diversity 4. To count- measure- and identify to species-level (where possible- otherwise to genus) all macro invertebrates (> 2 mm) and fish collected during Oceans 20/20 voyages. 5. To count- measure and identify to species-level (where possible- otherwise to genus or family) all meiofauna (> 2 mm) from multicore samples collected during the Oceans 20/20 voyages. 6. To count- measure and identify to species- level (where possible- otherwise to genus or family) all fauna collected by hyper-benthic sled during the Oceans 20/20 voyages. 7. To count- measure- and identify to species-level all macrofauna observed on DTIS images collected during the Oceans 20/20 voyages. The number of biogenic features (burrows/mounds) and habitat (spatial) complexity should also be estimated. 8. To count- measure- and identify to species-level (where possible- otherwise to genus or family) all macrofauna observed on DTIS video footage collected during the Oceans 20/20 voyages. 9. To calculate and compare the performance of a suite of diversity measures (species and taxonomic-based) at varying levels of resolution. 10. To estimate particle size composition and organic content of sediment samples. Sediment samples should be aggregated over the top 5 cm of sediment. 11. To measure the bacterial biomass (top 2 cm) of the sediment and in the sediment surface water samples- collected during the Oceans 20/20 voyages 12. To elucidate the relationships- patterns and contrasts in species composition- assemblages- habitats- biodiversity and biomass (abundance) both within and between stations- strata and areas. 13. To define habitats (biotic) encountered during the survey and assess their relative sensitivity to modification by physical disturbance- their recoverability and their importance to ecosystem function / production. 14. To quantify the productivity- energy flow (trophic networks) and the energetic coupling (bentho pelagic or otherwise) of the area surveyed areas at various levels of resolution.	Completed	Bowden 2011; Bowden *et al.* 2011 ; In press; Bowden & Hewitt 2012; Compton *et al.* 2012; Coleman and Lörz 2010; Hewitt *et al.* 2011a; 2011b; Lörz 2011a; 2011b; Nodder *et al.* 2012; Floerl *et al.* 2012

		15. To assess the extent to which patterns of species distributions and communities can be predicted using environmental data (including fishing) collected during the Ocean 20/20 voyages or held in other databases. 16. To provide an interactive- high resolution mapping facility for displaying & plotting all data collected & derived indices. Includes environmental data- the abundance of species- indices of biomass or diversity- and statistically derived groupings 17. To assess the extent to which acoustic- environmental- or other remote-sensed data can provide cost-effective- reliable means of assessing biodiversity at the scale of the Oceans 20/20 surveys. 18. To assess the extent to which the 2005 MEC and subsequent variants can provide cost-effective- reliable means of assessing biodiversity at the scale of the Oceans 20/20 surveys. 19. Collating all information and analysis from all objectives- devise a series of statistically supported recommendations for surveying marine biodiversity in the future. Including- but may not be limited to- statistical analyses and modelling.		

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Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2006-02	Ongoing NABIS development	As part of NABIS, users will be able to identify spatial information relating to the annual distribution (average distribution over the period of a year) of particular species within the waters around New Zealand and in the terrestrial environment (including off shore islands) of New Zealand. Users will also be able to interrogate metadata and attribute data related to the information layers presented. Users will employ NABIS to identify where a particular species is found, to identify what species are found within an area of interest, and be able to compare the spatial distribution of a particular species with other information layers. 2. Some species may have notable changes in their spatial distribution throughout a year. For such species, users of NABIS will be able to view spatial information relating to the seasonal distribution of particular species within the waters around New Zealand and in the terrestrial environment (including offshore islands) of New Zealand. Users will also be able to interrogate metadata and attribute data related to the information layers presented. For species with a seasonal component to their biological distribution, users will employ NABIS to identify where a particular species is found within the waters around New Zealand and in the terrestrial environment (including off shore islands) of New Zealand at a particular time of the year, to identify what species are found within an area of interest at a particular time of year, or be able to compare the distribution of a particular species at a particular time of year, with other information layers. 3. To provide analysis of the data used in determining the hotspot distribution.	Completed	Anderson 2007b

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2006-03	Antarctic coastal marine systems	1. Quantify patterns in benthic community structure and function at two coastal Ross Sea locations (Terra Nova Bay and Cape Evans). 2. Quantify benthic community structure and function at selected locations in Terra Nova Bay and Cape Evans.	Completed	Cummings *et al.* 2003; 2006b; 2008; Thrush & Cummings 2011; Thrush *et al.* 2010
ZBD2006-04	Chatham/challenger oceans 20/20	1. To collect seabed fauna, sediment samples and photographic images along transects in the Chatham Rise and the Challenger Plateau, as determined by the sampling protocol described in the Voyage Programmes for Voyages 2 and 3 of the project. Multibeam data should be collected opportunistically as time allows. 2. To describe the distribution of broad macro epifauna groups (I.D. level to be determined at sea during Surveys 2 & 3), their relative abundance, the substrate and habitat types, including representative photographic images of each sea-bed habitat and associated fauna along transects in the survey areas. 3. To provide a description of the observed evidence of fishing along transects. 4. To provide indicative measures of alpha biodiversity (richness, number of taxonomic groups) at appropriate scales within and between transects, and between the Chatham Rise and the Challenger Plateau. 5. To determine broad scale variability in sea-bed habitats and associated biodiversity within and between MEC classes at 20 class level. 6. To process and archive biological samples and data into databases and collections for future analysis in meeting the Overall Objectives above.	Completed	Nodder 2008; Nodder *et al.* 2011
ZBD2005-02	Marine Environment Classification Project	1. Co-fund the Marine Environment Classification Project (being done by NIWA) with the Department of Conservation.	Completed	Snelder *et al.* 2005; 2006; Leathwick *et al.* 2006a; b; c
ZBD2005-09	Rocky reef ecosystems - how do they function? Integrating the roles of primary and secondary production, biodiversity and connectivity across coastal habitats	1. To develop a qualitative numerical model of how New Zealand's rocky reef systems are functionally structured 2. To quantify the effects of human predation, and environmental degradation across reef gradients – top-down, or bottom-up functioning? 3. To advance our understanding of how subtidal reef systems are fuelled through primary and secondary production (from a range of sources), the role that biodiversity plays, and how this varies across different reef settings. 4. To quantify how subtidal reef systems are linked with other habitats and ecosystems at broader spatial scales, including the connectivity of MPAs with other habitats and areas.	In the process of publication	MacDiarmid *et al.* In Press c

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2005-03	Tangaroa ross sea voyage	1. To test the feasibility of obtaining estimates of demersal fish relative abundance using cameras with and without flood lights in areas of high importance for the Ross Sea toothfish fishery (principally 800-1200 m). 2. To utilise deepwater camera transects, supported by other direct sampling methods, to characterise the relative abundance, distribution, and diversity of demersal fish species (assuming Objective 1 yields satisfactory results) and of benthic macro-invertebrates, and to examine relationships between demersal fishes and benthic habitats/communities. Camera transects will be deployed opportunistically, with focus on the following high-priority areas (in order of high to low priority) wherever possible: i) Areas of the continental shelf break at depths of high importance for the toothfish fishery (principally 800-1200 m but also 600-800m & 1200-1500 m if time permits), ii) Shallow (50-200 m) water in the immediate vicinity of the Balleny Islands; iii) Deeper water in the vicinity of the Balleny Islands; iv) seamounts around and between Scott Island and the Balleny Islands; and v) at other locations (< 600 m) as opportunity arises (e.g. around Scott Island, western Ross Sea, south-eastern Ross Sea). 3. To collect specimens/tissues of selected benthic and pelagic organisms with priority in the vicinity of the Balleny Islands (and to the east/southeast, for pelagic specimens especially Antarctic krill species) and deliver specimens to other projects for stable isotope analysis in order to contribute to understanding of trophic relationships. 4. To acquire a continuous acoustic survey of the water column, opportunistically undertake species verification of acoustic marks, integrate the acoustic marks and produce a GIS map of verified and unverified distributions of functionally important mesopelagic species (e.g. krill, Antarctic silverfish). 5. To undertake routine identification and abundance estimates of marine mammal and seabird species and deliver raw and GIS summarised data to other related projects in order to generate spatially and temporally explicit population biomass and foraging distribution estimates for top air-breathing predators in the Ross Sea. 6. To undertake automated water sampling in order to monitor the identities and spatial and temporal distributions of plankton in the Ross Sea region and to allow ground-truthing of data collection from satellites (e.g. surface seawater temperature, and chlorophyll-a concentration).	In the process of publication	MacDiarmid & Stewart In Press; Mitchell & MacDiarmid 2006

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2005-01	Balleny Islands Ecology Research, Tiama Voyage (2006)	1. To characterise shallow benthic communities across a range of habitat settings around the Balleny Islands, utilising a range of data collection methodologies (including SCUBA-based rock-wall suspension feeder photo quadrats, SCUBA-based linear video transects, and drop camera photography), and to analyse community patterns with reference to possible physical/oceanographic, biological, and/or biogeographic influences on community structure. 2. To characterise aspects of the marine food web of the Balleny Islands area, using stable isotope analysis of specimens from important functional groups, and to make inferences about factors affecting ecosystem-scale trophodynamics in the Balleny Islands area and potential implications for the function of the wider ecosystem. 3. To characterise the spatial and temporal distributions of higher-level consumer species (birds, seals and whales) and of dominant pelagic prey (i.e. krill swarms) by opportunistically recording all at-sea sightings, and by systematic observation of landbased top predators (birds and seals) while sailing along the coast of the islands. 4. To collect and photograph and/or retain fish specimens from shallow benthic environments using a range of fishing methods, including food-baited fish traps, lightbaited fish traps, rotenone sampling, and/or baited lines. 5. To continuously collect bathymetric data and water-column acoustic data (i.e. mesopelagic acoustic marks) throughout the voyage, using an acoustic sounder. 6. To opportunistically collect a variety of data/materials during shore-based landings, including wherever possible: i) breast feathers from living penguins; ii) tissue samples/feathers/bones from dead seals/penguins/other sea birds; iii) seal scats; iv) visual estimates of adult and juvenile penguin numbers; v) visual assessments of penguin colony status; vi) photographs of penguin colonies; vii) sediment excavations of occupied and abandoned colonies. (Where appropriate these data will contribute to Objective 2).	Terminated	Smith 2006

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Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2005-05	Long-term effects of climate variation and human impacts on the structure and functioning of New Zealand shelf ecosystems	1. To estimate changes in marine productivity via fluctuations in ocean climate and terrestrial nutrient input over the last 1000 years. 2. To assess and collate ex isting archaeological, historical and contemporary data (including catch records and stock assessments) on relevant components of the marine ecosystem to provide a detailed description of change in the shelf marine ecosystem in two areas of contrasting human occupation over last 1000 years. 3. To collect additional oral histories from Maori and non-Maori fishers and shellfish gathers regarding the distribution, sizes and relative abundance (compared to present availability) of key fish and invertebrate stocks in both regions during the first half of the 20th century before the start of widespread modern industrial fishing. 4. To build mass-balance ecosystem models (e.g. Ecopath) of the coastal and shelf ecosystem in each area for five critical time periods: now, 60 years BP (before modern industrial fishing), 250 years BP (before European whaling and sealing), 600 y BP (early Maori phase) and 1000 years BP (before human settlement). 5. To use qualitative modelling techniques to determine the critical interactions amongst species and other ecosystem components in order to identify those that should be a priority for future research.	In the process of publication	Carroll *et al.* In Press; Jackson *et al.* In Press; Lalas *et al.* In Press a; b; Lalas & MacDiarmid In Press; Lorrey *et al.* In Press; MacDiarmid *et al.* In Press a; b; Maxwell & MacDiarmid In Press; Neil *et al.* In Press; Paul 2012; Parsons *et al.* In Press; Pinkerton In Press; Smith 2011
ZBD2004-01	Baseline information on the diversity and function of marine ecosystems	1. To quantify, and compare, the macro-invertebrate assemblage composition of a number of seamounts at the southernmost end of the Kermadec volcanic arc. 2. To compare the macro-invertebrate diversity of the southernmost end of the Kermadec volcanic arc with that of seamounts already sampled and reported on.	Completed	Rowden & Clark 2010; Smith *et al.* 2008
ZBD2004-02	Ecosystem-scale trophic relationships: diet composition and guild structure of middle-depth fish on the chatham rise	1. To quantitatively characterise the diets of abundant middle-depth fish species on the Chatham Rise, by analysis of fish stomach contents collected from the January 2005, January 2006 and January 2007 Chatham Rise middle-depths trawl surveys. 2. To quantitatively characterise Chatham Rise fish diets throughout the year, for a period of 24 months, by analysis of fish stomach contents collected opportunistically aboard industry vessels. 3. To describe and examine patterns of diet variation within each fish species as a function of spatial, temporal, and environmental variables, and of fish size. 4. To define and characterise trophic guilds for abundant fish species on the Chatham Rise, using multivariate analysis of fish diet data, and to analyse the nature and relative strength of potential trophic interactions between guilds. 5. To create and populate a diets database to store all of the dietary information collected under Objectives 1 and 2, and for use in subsequent dietary studies.	Completed	Connell *et al.* 2010; Dunn 2009; Dunn *et al.* 2010a; b; c; Dunn *et al.* In press; Forman & Dunn 2010; Horn *et al.* 2010; Stevens & Dunn 2010;

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2004-05	Assessment and definition of the biodiversity of coralline algae of northern New Zealand	1. To assess and define the biodiversity of coralline algae in northern New Zealand. 2. To develop rapid identification tools for coralline algae using molecular sequencing data. 3. To contribute representative material to the national Coralline Algal Collections. 4. To produce ID guides to common coralline algae of northern New Zealand.	Completed	Farr *et al.* 2009
ZBD2004-10	Development of bioindicators in coastal ecosystems	1. Investigate linkages between land use patterns in catchments and nitrogen loading to recipient estuaries and coastal ecosystems 2. Characterise isotopic signatures of selected bioindicator organisms in relation to different terrestrial nutrient loads; and 3. Validate the use of bioindicators using controlled laboratory and field experiments.	Completed	Savage 2009
ZBD2004-19	Ecological function and critical trophic linkages in New Zealand soft-sediment habitats	1. Define the interactive effects of two functionally important benthic species in maintaining critical trophic linkages in soft-sediment systems from a series of integrated field experiments. 2. Quantify effects of heart urchins (Echinocardium australe) on sediment properties- benthic primary production- and macrofaunal diversity through manipulative field experiments in Mahurangi Harbour. 3. Test for interactions between pinnid bivalves (Atrina zelandica) and heart urchins (Echinocardium australe) in field experiments- and measure their respective and combined contributions to sediment properties- benthic primary production- and macrofau na 4. Determine the dependence of results from objectives 1 and 2 (functional contributions of Echinocardium and Atrina) in an environmental context by conducting experiments along an estuarine-coastal gradient.	Completed	Lohrer *et al.* 2010
ZBD2003-02	Biodiversity of Coastal Benthic Communities of the North Western Ross Sea.	1. Quantify patterns in biodiversity and community structure in the coastal Ross Sea region 2. Quantify biodiversity in benthic communities at selected locations in the Ross sea north of Terra Nova Bay 3. Describe ecosystem function at selected locations in the Ross Sea north of Terra Nova Bay.	Completed	Cummings *et al.* 2003; 2006a; 2010; De Domenico *et al.* 2006; Guidetti *et al.* 2006; Norkko *et al.* 2004
ZBD2003-03	Biodiversity of deepwater invertebrates and fish communities of the north western Ross Sea	1. To describe, and quantify the diversity of, the benthic macroinvertebrates and fish assemblages of the Balleny Islands and adjacent seamounts, and to determine the importance of certain environmental variables influencing assemblage composition.	Completed	Rowden *et al.* 2012a; In Press; Mitchell & Clark 2004

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2003-04	Fiordland Biodiversity Research Cruise	1. How can ecotone boundaries be defined? 2. If you have an ecotone boundary defining the edge of a commercial exclusion zone how wide is the transition zone across the boundary? 3. If you have an area delineated as a marine protected area or a commercial exclusion zone, does it adequately represent the different habitats or biodiversity of the whole region?	Completed	Wing 2005
ZBD2003-09	Macquarie Ridge Complex Research Review	To review and summarise both biological and physical research carried out on or around the section of the Macquarie Ridge Complex that lies between New Zealand and Macquarie Island	Completed	Grayling 2004
ZBD2002-01	Ecology of Coastal Benthic Communities in Antarctica	Objectives unknown	Completed	Schwarz *et al.* 2003; 2005; Thrush *et al.* 2006; Thrush & Cummings 2011; Cummings *et al.* 2003; Sharp *et al.* 2010; Sutherland 2008
ZBD2002-02	Whose larvae is that? Molecular identification of planktonic larvae of the Ross Sea.	1. To use molecular sequencing tools in the taxonomic identification of cryptic/invasive marine 2. To provide a molecular description and characterisation of gobies that are introduced (Arenigobius bifrenatus and Acentrogobius pflaumii) cryptogenic (Parioglossus marginalis) or native (eg.Favonigobius lentiginosus and F. expuisitus). 3. To describe the molecular diversity of the above species throughout their native and introduced distributions- and characterise a range of the greatest potential invasive gobioid and blennioid species from the Australasian region. 4. To develop molecular criteria to rapidly identify invasive or cryptogenic gobioid and blennioid fish	Completed	Sewell 2005; 2006; Sewell *et al.* 2006
ZBD2002-06A	Impacts of terrestrial run-off on the biodiversity of rocky reefs	1. Conduct field and laboratory experiments to determine relationships between sediment loading, epifaunal assemblages, and mortality of filter feeding invertebrates. 2. Conduct field and laboratory experiments to identify the influence of sediment on early life stages of key grazers. 3. Determine photosynthetic characteristics and survival of large brown seaweeds and understorey algal species in relation to a sediment gradient.	Completed	Schwarz *et al.* 2006

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2002-12	Molecular identification of cryptogenic/invasive marine species – gobies.	1. To use molecular sequencing tools in the taxonomic identification of cryptic/invasive marine species 2. To provide a molecular description and characterisation of gobies that are introduced (Arenigobius bifrenatus and Acentrogobius pflaumii) cryptogenic (Parioglossus marginalis) or native (eg.Favonigobius lentiginosus and F. expuisitus). 3. To describe the molecular diversity of the above species throughout their native and introduced distributions- and characterise a range of the greatest potential invasive gobioid and blennioid species from the Australasian region. 4. To develop molecular criteria to rapidly identify invasive or cryptogenic gobioid and blennioid fish.	Completed	Lavery *et al.* 2006
ZBD2002-16	Joint New Zealand and Australian Norfolk Ridge	1. To describe the marine biodiversity of the Norfolk Ridge and Lord Howe Rise seamount communities. 2. To survey- sample and document the marine biodiversity and environmental data from seamounts on the Norfolk Ridge and Lord Howe Rise to a depth of at least 1-000m depth. (b) To preserve samples of fishes and invertebrates and hold these in ac...	Completed	Clark & Roberts 2008
ZBD2002-18	Quantitative survey of the intertidal benthos of Farewell Spit Golden Bay	1. To undertake a baseline survey of intertidal macrobenthic organisms at Farewell Spit Nature Reserve and adjacent flats. 2. To undertake an initial field survey of Zostera distribution at Farewell Spit Nature Reserve and adjacent intertidal flats. 3. To undertake a preliminary survey of sediment characteristics of the intertidal flats at Farewell Spit Nature Reserve and adjacent flats.	Completed	Battley *et al.* 2005
ZBD2001-02	Documentation of New Zealand Seaweed	1. To publish a regional algal flora of Fiordland based on voucher herbarium specimens. 2. To assemble a database of references and to review the current state of knowledge about New Zealand macroalgae.	Completed	Nelson *et al.* 2002
ZBD2001-03	Ecology and biodiversity of coastal benthic communities in Antarctica.	1. To develop sampling protocols for estimating the relative abundance of algae and benthic invertebrates 2. To quantify patterns in biodiversity and benthic community structure at two locations in McMurdo Sound 3. To analyse Ross Island Sea-Level data.	Completed	Norkko et al 2002
ZBD2001-04	“Deep Sea New Zealand”	To help publish the book "Deep Sea New Zealand"	Completed	Batson 2003
ZBD2001-05	Crustose coralline algae of New Zealand	1. To assess the biodiversity of crustose coralline algae in NZ using modern taxonomic methods and molecular sequence tools. 2. To establish the NZ National Coralline Algal Collection. 3. To produce identification guides to NZ species.	Completed	Harvey *et al.* 2005; Farr *et al.* 2009; Broom et al 2008

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Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2001-06	Biodiversity of New Zealand's soft-sediment communities	1. To review the current knowledge of the biodiversity of macroinvertebrates and macrophytes living in and on soft-sediment substrates in New Zealand"s harbours- estuaries- beaches and to 1000 m water depth. 2. To review existing published and unpublished sources of information on soft-sediment marine assemblages around New Zealand. 3. Using the results of Objective 1- identify gaps in the knowledge- hotspots of biodiversity- areas of particular vulnerability- and make recommendations on areas or assemblages that could be the subject of directed research in future years.	Completed	Rowden *et al.* 2012b
ZBD2001-10	Additional Research on Biodiversity of Seamounts	1. To determine the macro-invertebrate assemblage composition on Cavalii seamount, and adjacent seamount W1, by photographic transects and epibenthic sled sampling. 2. To determine the distniution of macro-invertebrate assemblages on the seamounts. 3. To compare the macro-invertebrate species diversity of neighbouring seamounts. 4. To evaluate and collect samples fiom suitable macro-invertebrate species for genetic analysis. 5. To map bathymetry and habitat characteristics of the seamounts. 6. To compare macro-invertebrate assemblage composition of the seamounts with nearby hard bottom low relief (under 100 m) on the slope, if suitable areas can be located.	Completed	Rowden et. al 2004
MOF2000-01	Bryozoan thickets off Otago Peninsula	Objectives unknown	Completed	Batson & Probert 2000
ZBD2000-01	A review of current knowledge describing the biodiversity of the Ross Sea region	1. To review and document existing published and unpublished information describing the biodiversity of the Ross Sea region. 2. To identify and document Ross Sea region marine communities that are under high pressure or likely to come under high pressure from human activities in the near future.	Completed	Bradford-Grieve & Fenwick 2001a; 2001b; Fenwick & Bradford-Grieve 2002a; 2002b; Bradford-Grieve & Fenwick 2002; Varian 2005
ZBD2000-02	Exploration and description of the biodiversity, in particular the benthic macrofauna, of the western Ross Sea	1. To utilise sampling opportunities provided by the presence of RV Tangaroa in the western Ross Sea in February / March 2001 to make collections of (primarily) benthic organisms as a contribution to the understanding of biodiversity in the region. 2. To identify and document the organisms collected and provide for their proper storage in national collections. 3. To describe the logistic constraints of working in the Ross Sea region, and make recommendations for future research to improve understanding of biodiversity in the Ross Sea.	Completed	Page *et al.* 2001

BIODIVERSITY *continued*

Project Code	Project Title	Specific Objectives	Status	Citation/s
ZBD2000-03	The spatial extent and nature of the bryozoan communities at Separation Point, Tasman Bay	1. To assess the present state and extent of bryozoan communities around Separation Point. 2. To characterise the bryozoan communities around Separation Point.	Completed	Grange *et al.* 2003
ZBD2000-04	Supplementary Research on Biodiversity of Seamounts	1. To determine the biodiversity of seamounts of the southern Kermadec volcanic arc (Rumble V, Rumble 111, Brothers). 2. To describe the distribution of fauna, with an emphasis on mapping the nature and extent, of biodiversity associated with hydrothermal vents. 3. To compare the biodiversity of the thee seamounts, and adjacent slope. 4. To collect samples from near the vent sources (if possible, as these are thought to be very localised) to measure chemical and thermal aspects of the environment	Completed	Rowden *et al.* 2002 and 2003; Clark & O'Driscoll 2003
ZBD2000-06	"The Living Reef: The Ecology of New Zealand's Rocky Reefs"	1. Funding to support the publication of this book.	Completed	Andrew & Francis (Eds.) 2003
ZBD2000-08	A review of current knowledge describing New Zealand's Deepwater Benthic Biodiversity	1. To review and document existing published and unpublished reports and data describing New Zealand's deepwater benthic biodiversity. 2. To make recommendations on representative communities and potentially impacted communities that could be the subject of directed research.	Completed	Key 2002
ZBD2000-09	Antarctic fish taxonomy	1. Ross Sea fishes processing and identification	Completed	Roberts & Stewart & 2001

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