Promoting excellence in science and technology

the ROYAL SOCIETY of NEW ZEALAND

TE APĀRANGI

THE ROYAL SOCIETY OF NEW ZEALAND

INVESTMENT IMPACT REPORT

DECEMBER 2009

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EXECUTIVE SUMMARY

The Royal Society of New Zealand's (RSNZ) vision is to offer a unique contribution to research and scholarship by cultivating relationships with the public, the media, our young people and their teachers, emerging and established scientists and researchers, government and international academies. To fulfil part of its vision, the RSNZ is a research purchasing agent for the Marsden Fund.

In this report we highlight our delivery of support for the Marsden Fund and present research under the Marsden Fund over the past three years. Highlights during 2006 to 2009 include:

- The continuous increase in the government's investment in the Marsden Fund ($33.877M, $35.877M and $37.877M (GST excl) in FY06/07, FY07/08 and FY08/09).
- A steady rise in the Standard proposal success rate, coupled with a doubling in the total amount of support per Fast-Start contract.
- Examples of excellent research funded over the past three years by the Marsden Fund, showing the diversity, depth and quality of the research conducted by Marsden Fund recipients.
- The increase in high impact journal publications per year by researchers funded by the Marsden Fund. (7 in 2002/03 to 32 in 2008/09).
- The findings of the Foundations of Research Excellence (FoRE) project. The study has shown that the direct opportunities arising from the sub-set of research projects, many of which are Marsden Fund projects, exceed $120 million per annum.
- The number of Principal Investigators (PIs) and Associate Investigators (AIs) have increased by 128% and 167% since 2006. However, the number of Post-doctoral candidates has decreased over this same timeframe because of the rise in costs for Post-docs. This decrease in Post-docs has been alleviated by an increase in Post-graduates on contracts.
- Since 2007 the total number of collaborations has decreased, mainly because of a large drop-off in national collaborations. Whereas, international collaborations have remained strong.
- Emerging issues include an analysis on the total number of proposals expected and efficient and effective use of the information gained through the Marsden Fund proposal and assessment processes for future investments.

ROYAL SOCIETY OF NEW ZEALAND – OUR ACTIVITIES

This report covers a subset of the Society's activities since the cessation of the formal Performance and Achievement reporting in 2005/06 at MoRST's request. In this, the first of the biennial Investment Impact Reports, the outcomes and impacts of the Royal Society's administration of the Marsden Fund are described as a requirement of the Fund's agreement with Government.

As contracts for the other programmes administered by the Society on behalf of the Ministry are updated, their reporting will being incorporated into future reports against a schedule to be agreed between the Society and MoRST.

A selection of the additional activities of the Society supported by Government over the period 2006–2009 but not included in this report include:

Awareness and Communications
- Science Media Centre
- RSNZ Manhire Prize for Creative Science Writing
- Radio New Zealand collaboration

Education – inspiring our younger generations
- Teacher Fellowships
- CREST Awards promoting creativity in science and technology projects[1,2]
- National Waterways Programme – EMAP[1]
- Talented School Student Travel Award
- BAYERboost short environmental scholarships for students
- Genesis Realise the Dream[2]
- International exchanges for students[2]
- Publications for young people – publishing Alphas and Gammas

Expert Advice
- Committees
- Policy Unit
- Emerging Issues publications
- Science Meets Parliament – The Speaker's Science Forum

Supporting Excellence
- James Cook Research Fellowships
- Rutherford Foundation

Supporting the Profession
- Publishing the eight New Zealand scientific journals
- Support for our 70 constituent science organisations, affiliates and branches
- Newsletters and daily news for scientists and technologists
- Medals, national awards event and professional science week
- Promoting a Code of Professional Standards and Ethics for researchers

International Activities
- ISAT Fund - Bilateral Research Activities Programme
- International Conference Fund
- Membership of international scientific unions
- Co-Lab website to support NZ Science Counsellors in Brussels and Washington

[1] Supported by the Ministry of Education
[2] Partial funding

MARSDEN FUND

PURPOSE AND OBJECTIVES

The Marsden Fund invests in investigator-initiated research aimed at generating new knowledge. It supports excellent research projects that advance and expand the knowledge base and contribute to the development of people with advanced skills in New Zealand. The Marsden Fund encourages New Zealand's leading researchers to explore new ideas that may not be funded through other funding streams and fosters creativity within the research, science and technology system.

The primary objectives of the Marsden Fund are to: enhance the quality of research in New Zealand by creating increased opportunity to undertake excellent investigator-initiated research; support the advancement of knowledge in New Zealand; and contribute to the global knowledge base. A secondary objective of the Marsden Fund is to contribute to the development of advanced skills in New Zealand including support for continuing training of Post-doctoral level researchers and support for the establishment of early careers of new and emerging researchers.

GOVERNANCE

The Fund is operated under a Terms of Reference issued by the Minister of Research, Science and Technology, recently updated in 2008. An independent council, appointed by the Minister, has responsibility for allocating funds to projects and overseeing the progress of the research and supported researchers. The Fund is administered by the Royal Society of New Zealand who organise the selection process, manage the disbursement of funds, monitor progress, evaluate the outcomes from the research, and provide secretariat services to the Marsden Fund Council. A Memorandum of Understanding agreed between the Royal Society and the Marsden Fund Council describes the separation of the roles and performance expectations.

SCOPE AND SCALE

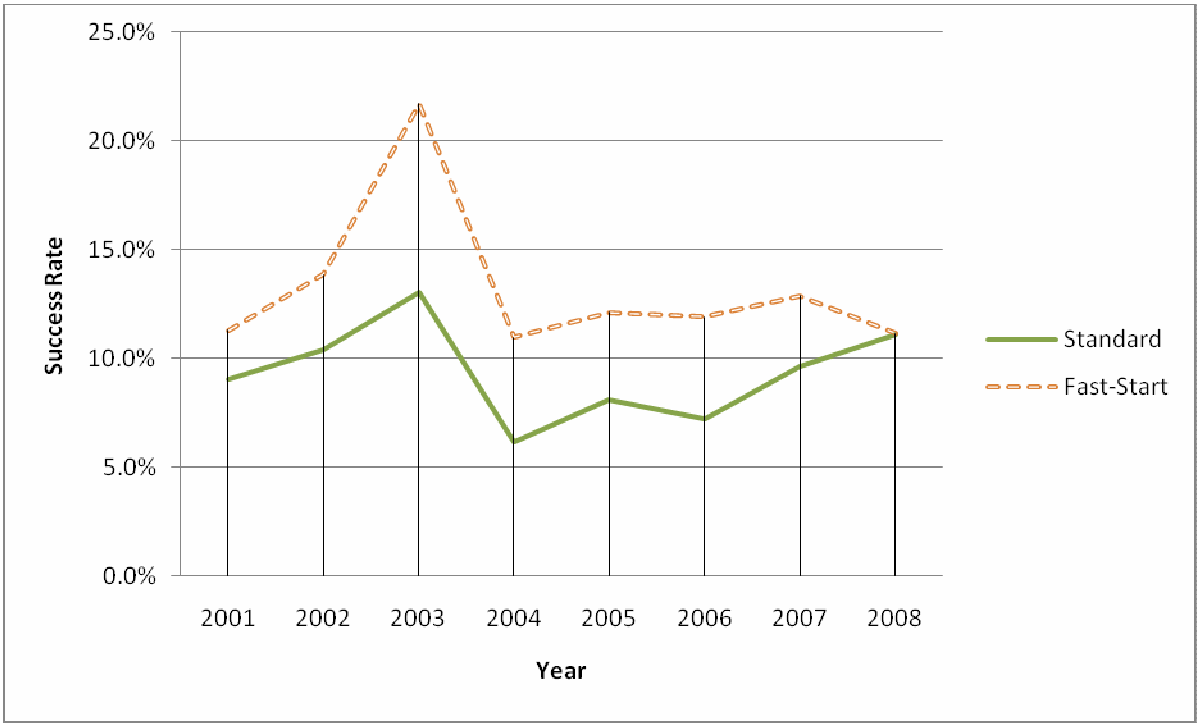
The Impact Investment Report will report on activities related to the Marsden Fund from 1 July 2006 to 30 June 2009, covering the past three Fiscal Years. The Marsden Fund operates as a separate Output Class under the Ministry of Research, Science and Technology Non-departmental output classes. In FY 06/07, FY 07/08 and FY 08/09, the Marsden Fund output class had investment budgets of $33,877,000, $35,877,000 and $37,877,000 (GST exclusive) respectively. During the same timeframe, over 400 research contracts were operational, covering the sciences, mathematics, engineering, social sciences and humanities.

Over the past three years the size of the Marsden Fund has continued to grow and so have the number of contracts created. The number of new contracts created has been 77, 95 and 91 for FY 06/07, FY 07/08 and FY08/09. Along with the growth in the Marsden Fund by the government, there have been increases in the overall success rates as shown in Table 1 and Figure 1 below.

Table 1. Success rates for Standard and Fast-Start proposals

Year	Standard			Fast-Start		
	Proposals	Contracts	Percentage	Proposals	Contracts	Percentage
2001/02	707	64	9.1%	177	20	11.3%
2002/03	671	70	10.4%	130	18	13.8%
2003/04	612	80	13.1%	129	28	21.7%
2004/05	744	46	6.2%	228	25	11.0%
2005/06	701	57	8.1%	198	24	12.1%
2006/07	722	52	7.2%	210	25	11.9%
2007/08	693	67	9.7%	217	28	12.9%
2008/09	593	66	11.1%	224	25	11.2%

Figure 1. Success rates for Standard and Fast-Start proposals 2001 – 2008.



More detail on the historical growth of the Fund and the support given to discipline areas in the past three years is given in Appendix 1.

HIGHLIGHTS

There have been a number of excellent research projects and outcomes over the past three years. During this time approximately 200 contracts have had their final reports evaluated and signed off by the Marsden Fund. Below is a small sample of the research projects that have been funded, which are creating very exciting and innovative outcomes for New Zealand.

Engineering, mathematics, physiology and disease

The cardiovascular (heart and circulatory system), respiratory (lungs) and gastrointestinal (digestive) systems are central to human health and, are adversely modified during disease. Increasingly, advanced mathematics and engineering are being applied to understand just what is happening when things go wrong. Researchers based at the University of Auckland are at the international leading edge of this work, supported in part by the Marsden Fund.

Heart disease is the leading cause of mortality in New Zealand and many of these deaths are due to electrical dysfunctions of the heart known as ventricular fibrillation. Instead of a single, coordinated electrical wave that stimulates the heart to beat regularly, the waves degenerate into multiple waves and disrupt the pumping action. Associate Professor Martyn Nash has created a three-dimensional model of the working heart, and incorporated the activity of these electrical stimuli. In so doing, he has been able to simulate ventricular fibrillation, and identify possible causes of failure; electrical currents that occur when cardiac muscle is stretched have been identified as playing a role. Dr Nic Smith has taken a similar approach to a related heart disease, ischaemia—the reduced blood flow to a region of the heart. By building anatomical models of the coronary vasculature, Dr Smith's work will increase understanding of the effects of ischemia on the mechanical performance of the heart during the critical, initial stages of coronary disease. Fast-Start researcher, Dr Vijay Rajagopal, is also applying these techniques to relating the structure and function of cardiac cells, in order to understand why diabetes is usually accompanied by reduced cardiac performance. Cells in the heart behave in a unified fashion because they communicate with one another, with currents of calcium ions playing a major role. The detailed mechanics of fluctuations in calcium ions are being studied by Professor James Sneyd and Dr Vivien Kirk. Not only do waves of calcium ions lead to contraction of heart muscle, they play a coordinating role in other functions including the secretion of saliva and digestive enzymes. This fundamental work has led to contracts with the US National Institutes of Health, in collaboration with overseas experimental groups.

The lung has also been modelled by Dr Merryn Tawhai and Professor Peter Hunter, who have created mathematical models of the complex branching airways, their associated arteries and veins, and the soft tissue of the lung. Furthermore, a Massey University Fast-Start researcher, Dr Alona Ben-Tal, has studied the irregular breathing disease known as Cheyne-Stokes respiration and come up with a mathematical description that provides insights into a causal mechanism for this disorder.

The gastrointestinal tract also acts as a pump, although on a quite different time scale to the heart, and should also amenable to similar modelling. Initial measurements of electrical activity and modelling by Professor Andrew Pullan have confirmed the promise of these techniques.

This research, supported by the Marsden Fund over the past few years, combines the disciplines of mathematics, engineering, physiology and the pathology of disease. It is new and innovative, with the expectation that its realisation will contribute to improved diagnoses and therapies.

A new state of matter – new physics and new opportunities

In 1995 the world was intrigued to hear that a fifth state of matter had just been created in the lab, the Bose-Einstein condensate. This was duly followed by the award of Nobel Prizes in 2001 to the three experimental physicists who achieved it. Bose-Einstein condensates represent a form of matter in which millions of constituent atoms are merged into a collective state, with the atoms losing their individual identities. This requires extremely low temperatures, infinitesimally close to absolute zero. This new entity, the condensate, takes the form of a single quantum "wave", behaving quite differently from the "particle-like" objects that are evident all around us. And being huge by the standards of quantum physics, some fractions of a millimetre across, they offer a ready means of studying quantum phenomena.

Associate Professor Andrew Wilson was involved in making the first condensate at Otago University in 1998. Since then, sometimes working with the Nobel laureates, he and his team have made many notable contributions to the field. A major achievement has been to arrange for two condensates to collide, building an understanding of how they interact that is fundamental to the development of any future devices based on Bose-Einstein condensation. Current work seeks to achieve ultracold molecules, so as to investigate quantum chemistry at this state.

The study of Bose-Einstein condensates promises a revolutionary new ways of doing things, as has happened with other landmark discoveries in quantum physics—the laser, the transistor, and nuclear magnetic resonance. While there is speculation about atom lasers and quantum computing, the full benefits remain to be realised. Nonetheless, there has been an immediate spin-off – the research is extremely challenging and the detailed technical knowledge that is required for it has led to the founding of a company, Photonic Innovations Ltd, headquartered in Dunedin. Using advanced laser technologies developed during the experimental programme, this company produces gas detectors for industrial purposes that are the most technologically advanced, cost-effective and reliable products available in the world.

Surface waves on silver – a path to nanofabrication and to single molecule detection

It is a fundamental physical property of light that it can cause oscillations of charge, known as plasmons, on the surface of metals. This effect is being used for groundbreaking work by two research teams in the MacDiarmid Institute, both currently supported by the Marsden Fund.

Light is the standard means of creating microscopic patterns, e.g., for the fabrication of microelectronic circuits and for data storage devices. However, the patterns are limited to dimensions comparable to the wavelength of light, which restricts the resulting patterns to dimensions slightly smaller than a millionth of a metre. In his first Marsden Fund project, Professor Richard Blaikie at the University of Canterbury used plasmons to reduce this size further. In a second, he improved the resolution even more by making a silver "superlens". In the process, he achieved world fame by implementing a proposed, revolutionary idea ("negative refraction") that causes light to bend the wrong way when it passes from one medium to another. In his current Marsden project, Professor Blaikie has teamed up with leading researchers in the US to turn the results from his laboratory into a widely applicable technique that may well have significant implications for the digital industry.

Identifying the molecules that a substance contains is useful in many areas, from medicine, to the food industry, to art and archaeology. Raman spectroscopy is a widely used tool for this purpose, which involves using laser light to interact with substances to determine their component molecules. It is non-destructive, can be automated, and provides definitive answers. One major drawback, however, is that traditional Raman spectroscopy is not very sensitive, meaning that it is unsuitable for detecting trace quantities of molecules. However, Marsden-supported research has found that the proximity of tiny nanoscale-sized particles of gold and silver can boost Raman signals from molecules by many orders of magnitude, as a result of plasmons being created on the surface of the particles by the laser. Using this technique, Professor Pablo Etchegoin at Victoria University of Wellington has shown experimentally that it is possible to observe just one molecule at a time, and to quantify the observation. This opens up "surface enhanced Raman spectroscopy" as an immensely powerful diagnostic tool. Professor Etchegoin likens the current state of the field to that of magnetic resonance imaging in the 1970s. Should the potential to reliably observe single molecules be fulfilled, it would have immeasurable benefits for society.

Finding our way around computers – thirty years of research in a single hit

As most of us know only too well, finding files or commands on computer systems and mobile devices usually involves navigating through hierarchical structures of menus and folders. The shape and structure of these hierarchies governs how long we take, and yet this critical design issue is normally resolved using intuition or guesswork. For thirty years researchers have been trying to answer the question of whether hierarchical structures should be "broad and shallow" (many choices through few levels) or "narrow and deep" (few choices through many levels), with experimental results varying widely – it seems there is no clear answer.

In his recent research, supported by the Marsden Fund and published in the top journal, *Human-Computer Interaction*, Professor Andy Cockburn from the University of Canterbury describes a theory that accurately predicts user performance with hierarchical structures, neatly explaining thirty years of empirical results in this area. In essence, this theory crisply demonstrates that performance depends on the degree to which users can predict the location of items at each level of the hierarchy, how much visual search is involved; and how users migrate from search to prediction as they gain experience with the dataset.

This model has abundant practical applications in translating user interface design (for desktop computers, mobile devices, and home/vehicle appliances) from an intuition based art to a firm science.

New model for the effect of temperature on enzymes

The way enzymes respond to temperature is fundamental to many areas of biology. The textbook model for the effect of temperature on enzyme activity is that higher temperatures increase activity while at the same time causing activity to be lost through the enzyme's denaturation. However, denaturation takes time and at extreme temperatures activity is predicted to be high, at least for the short time until denaturation occurs. However, empirical results have shown that activity stops much more quickly than expected.

Professor Roy Daniel and his team from the University of Waikato, along with collaborators from the United Kingdom, have devised a radical, alternative model that explains the data for all enzymes tested. They are proposing an intermediate stage, in which the enzyme is catalytically inactive but not yet denatured. This model has major implications for biotechnology. In particular it has provided an explanation of why attempts to engineer enzymes for enhanced activity at high temperatures have, so far, been so unsuccessful. A new Marsden project, in association with Associate Professor Vic Arcus, is now under way to attempt to exploit this information to better engineer enzyme activity at extreme temperatures.

Clever ways of tracking human settlement

Professor Russell Gray, Dr Alexei Drummond and Dr Simon Greenhill, from the University of Auckland, have applied techniques for tracing evolution through genetics to the development of languages. In a paper published in the prestigious journal, *Science*, they have used this method to show that the settlement of the Pacific, which originated from Taiwan 5,200 years ago, proceeded in a series of expansionary pulses, followed by settlement pauses. They have dated the various phases, and related the expansions to specific technological advances.

As for the arrival of Māori in New Zealand, Dr Janet Wilmshurst from Landcare Research has investigated seeds gnawed by ancient kiore (the Pacific rat), as a way to establish the time at which human settlement took place. Kiore spread throughout the islands of the Pacific with voyaging humans, tagging along as a stowaway in Polynesian canoes. Because of the kiore's close association with human migration, knowing the time of its earliest presence helps to pin down the date that people first arrived. The research shows that the kiore was widespread by AD 1280, confirming other evidence that humans arrived in New Zealand around AD 1280-1300.

Mau Moko: the world of Māori tattoo* and *The Dragon and the Taniwha

In the traditional Māori world, the moko, or tattoo, was part of everyday life; everyone had some patterning on their skin. After almost dying out in the twentieth century, Māori skin art is now experiencing a powerful revival, with many young urban Māori displaying the moko as a gesture of ethnic pride and identity.

Arising from a Marsden Fund grant and authored by Professor Ngāhuia Te Awekōtuku, Dr Linda Waimārie Nikora, Mohi Rua and Rolinda Karapu, from the University of Waikato, Mau Moko investigates the origins, significance, technology and practice of moko, from the pre-contact period to contemporary times. Winner of the Lifestyle and Contemporary Culture section of the 2008 Montana New Zealand Book Awards, it includes many portraits by renowned photographer, Becky Nunes. "For us, this book reflects the pepeha, *E hara taḵu toa i te toa taḵitahi, engari taḵu toa, taḵitini e,*" says Professor Te Awekōtuku. "It is a triumph for all of us, a collective success."

Supported by a grant from the Marsden Fund, Associate Professor Manying Ip from the University of Auckland has produced a new book, *The Dragon & The Taniwha: Māori & Chinese in New Zealand*. The book examines how Māori and Chinese have interacted in New Zealand over the last 150 years and explores the relationship between the tangata whenua and the country's earliest and largest non-European immigrant group. The book's twelve contributors analyse from a variety of different angles issues such as how Māori and Chinese media portray each other, the changing demography of Māori and Chinese populations, and Māori and Chinese experience of inter-marriage.

Why the MIS in Mister?

The journey to become either male or female begins very early in development, where differences in the production of hormones such as testosterone and oestrogen begin to kick in. In males, another hormone, Müllerian Inhibiting Substance (MIS), plays a role, masculinising the embryo by inhibiting the development of the Fallopian tubes and uterus. However, since the discovery of MIS, it has been an enduring puzzle why its levels should remain high in boys until the onset of puberty.

A team at the University of Otago, led by Associate Professor Ian McLennan and Dr Kyoko Koishi, has discovered that MIS contributes to differences between male and female behaviour. In mice, males are known to explore a new environment more extensively than female mice, but the researchers found that males with higher levels of MIS were more likely to explore beyond their immediate confines. On the other hand, male mice with low MIS explored their surroundings in a manner similar to females. The team is now looking to see whether differences in MIS levels are associated with similar effects in humans.

This is an important advance in developmental biology and may help to explain why some medical conditions are more common in one gender, or affect men and women in different ways. For example, major depression, phobia and anorexia are prevalent in women; whereas men are more prone to childhood ADHD, motor neuron disease and anti-social personality disorder. A better understanding of the mechanisms behind these differences may lead to more effective treatments for these conditions.

Taking advantage of tuberculosis

At any time there are billions of T-cells in human blood seeking out and destroying foreign proteins, organisms, and pre-cancerous cells. Mostly, these processes work extremely efficiently but sometimes T-cells attack healthy tissues, causing autoimmune diseases, or conversely, fail to deal with cancerous tumours. Identifying chemicals that can modulate the immune response is important for the development of future therapies (for diseases of excess immunity) or vaccines (for infectious disease or cancer).

The fatty cell wall components from micro-organisms are a rich source of chemicals that can modulate immune responses. In a research programme funded by a Marsden grant, a team led by Dr Gavin Painter and Dr Wayne Severn from IRL have shown that a specific chemical from the cell wall of the tuberculosis bacterium can alternatively activate and suppress immune responses. While this is surprising, it does explain the way that tuberculosis acts as a disease.

Work is ongoing and has attracted Capability Fund and FRST funding. The team has expanded to include researchers from AgResearch, the Malaghan Institute and the University of Otago. Already, this chemical is being used in the development of a tuberculosis vaccine for cattle, and is also being applied to asthma research.

A bee-line into memory mechanisms

Honeybees learn rapidly to associate an odour with either punishment or reward, as indicated by the extension of their sting (if an unpleasant experience is in the offing) or the extension of their proboscis (if food is on offer). In work funded by the Marsden Fund, Professor Alison Mercer and her team from the University of Otago have made two surprising discoveries: while 2-day old bees can learn to associate an odour with a food reward, they are not yet able to learn to associate an odour with punishment; and, when the association with punishment first develops at around 3-4 days of age, it can be blocked by a pheromone from the queen bee, while leaving the association of odour with reward unaffected. Oddly enough, the two types of learning have been traced to the same structures in the brain and there is compelling evidence that they are formed in the very same cells.

These findings are being investigated further in a new Marsden Fund grant that will advance significantly the understanding of the cellular and molecular mechanisms that underlie the acquisition and storage of memories that predict punishment, and their potential interactions with mechanisms that support the formation of memories predicting reward. The results will be of broad scientific interest and have potential relevance to medicine and psychology.

Hedging your bets – an evolutionary trait

Professor Paul Rainey's team at Massey University has achieved the cover story in a 2009 issue of *Nature*, observing for the first time an evolutionary ploy termed "bet-hedging". In all facets of life, the majority of us hedge our bets, adopting a variety of courses of action in order to limit our losses in an unpredictable environment, e.g., financial diversification. Nature adopts the same strategy, and this is well known to evolutionary scientists, but the actual evolution of bet hedging had never been observed before.

By forcing bacteria to evolve in ever-changing conditions, Professor Rainey and his team have induced a behaviour in which colonies formed by microbes with identical genes take radically different forms. Under some conditions, the microbes formed smooth clumps; under other conditions, colonies grew in a fast-spreading, wrinkled form. However, in two cases, microbes from exactly the same brew formed both smooth and wrinkled colonies, despite having identical genetics. These hybrid forms of microbial colony allow the bacteria to survive in a wider range of environments.

Biologists have long recognised that bet hedging makes sense in the long run but as a sophisticated strategy it was believed that may have taken hundreds of millions of years to emerge. These findings capture the adaptive evolution of bet hedging in the simplest of organisms, and suggest that risk-spreading strategies may have been among the earliest evolutionary solutions to life in fluctuating environments.

RESEARCH PRODUCTIVITY AND QUALITY

The contracts under the Marsden Fund continue to produce high quality outputs through refereed journal articles, books, invited presentations (international and national) and public outreach. The high standard of outputs over the past three years has been maintained and the quantity has only slightly reduced, as can be seen in Appendix 2. The level of Peer Reviewed Publications (PRP) has decreased per dollar spent from approximately 19 PRP/ $million in 2006/07 to 14 PRP/$million in 2008/09. However, the overall standard and quantity still remain extremely high at the international and national level (highest of any fund within Vote: RS&T for New Zealand). Table 2 represents the number of articles published in three high impact journals (*Nature*, *Science* and *The New England Journal of Medicine*). The statistics here show that the number of articles has increased in these high impact journals with the largest number of articles in 2008/09.

Table 2. Number of high impact journal articles per year.

Year	*Nature*	*Science*	*NEJM*	Total
2002/03	2	3	2	7
2003/04	9	5	2	16
2004/05	11	6	3	20
2005/06	12	7	5	24
2006/07	10	5	8	23
2007/08	14	6	4	24
2008/09	19	7	6	32

TANGIBLE SOCIO-ECONOMIC BENEFITS

The Royal Society of New Zealand commissioned a study—the Focussing On Research Excellence (FoRE) project—on the socio-economic benefits from a set of 65 precursor research projects funded by the Marsden Fund, the HRC, and FRST, along with a small number of charities, which were funded as investigator-initiated research. A broad cross section of disciplines and research institutions was included in the project set.

The study has shown that the direct opportunities arising from this sub-set of research projects exceed $120 million per annum. The study only included financial and other benefits directly accruing to New Zealand, where the opportunities were expected to persist over an extended period, i.e., at least 15 years.

Results of the Analysis
The results from the analysis of 65 projects are summarised in Table 3 below.

Table 3. Financial opportunities per year (2008 $ millions).

Financial Opportunities	Total ($millions)	No of Projects	% of Total	Max/ Min
Directly from Commercialisation	$124	22	34%	15/0.1
Estimated Indirect Benefits	>$2,000	14	22%	600/1
Improve Skills	>$8	56	86%	.6/.02
New Methods/Instruments Y/N		46	71%	
Build Basic Knowledge No. Papers	2,417	62	95%	38.7 ave
Better Inform Policymakers Y/N		29	45%	
International Knowledge		63	97%	5.5 ave
Unexpected Outcomes (Yes)				
Knowledge		58	89%	
Application *		43	93%	

*Out of a total of 46 with commercial or indirect benefits

Table 4 gives the direct benefits for five different sectors and the time lag for applications arising from the research to appear in the marketplace, in government policy, as productivity improvements, environmental interventions and in social benefit.

Table 4. Sectors studied and their direct benefits and time lags.

Results by Sector	Direct ($M)	Total Projects	Time lag Average (yrs)
Agriculture	31	4	6
Health	50	23	9
Energy	7	4	5
Manufacturing	34.5	12	7
Social	1.6	18	6
Total	124.1	65	

Direct opportunities are significant at over $124M when compared with an Australian study where in 2003 only a total of A$88M was found in this category from all research funded by Australian Research Council to 2000. In the FoRE project there appeared to be a bigger spread of contributors to this category but this may be deceptive because of the project selection method. The largest contributor to this category was $15M. While indirect opportunities are clearly the most significant contributing category, they are extremely difficult to measure. In New Zealand because agriculture is a very large industry, productivity improvements can make significant annual contributions. In health also, because it is so universal, a small improvement in productivity can make a substantial net contribution. It is to be noted that four projects make up a large percentage of the total in this category.

The FoRE project grouped benefits into a broad set of categories as shown in Table 3. Improvement in skills, estimated at an annual return of over $8M is a significant contribution. New Methods and Instruments, was found, somewhat unexpectedly in over 70% of the projects which described the development of new methods and instrumentation. The project stated that the outcomes of building basic knowledge were very difficult to measure and it was concluded that they are likely to be more significant than is obvious from the study. The number of projects which inform legislation and or government policy in New Zealand was considerable. Finally, in all but three cases of Commercial and Indirect Benefit, the commercial avenues and other benefit outcomes were not anticipated by the Principal Investigators (PIs) at the beginning of the research programme. Even at the time of the relevant research's completion, for about one third of the projects that eventually gave rise to Commercialisation or Indirect Benefits, these applications were not obvious or had not been chosen by the PI.

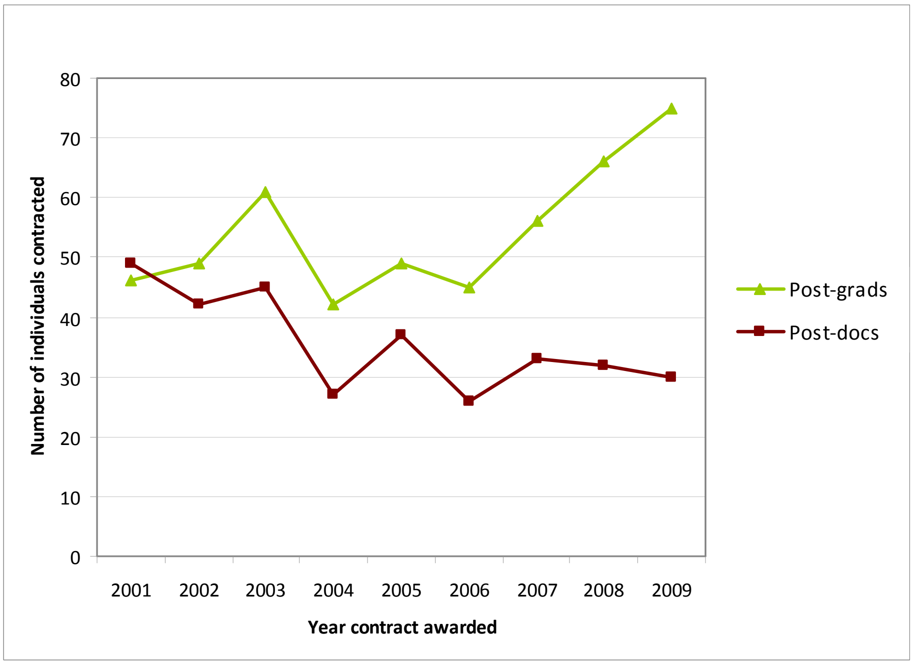
BUILDING HUMAN CAPACITY

The Marsden Fund has supported established researchers by funding Standard contracts within the Marsden Fund scheme. Over the past four years the number of PIs and the number of Associate Investigators (AIs) has grown from 111 PIs in 2006 to 143 PIs in 2009; and 108 AIs in 2006 to 183 AIs in 2009.

The Marsden Fund continues to strongly support New Zealand's emerging researchers, through the Fast-Start scheme. The Fast-Start scheme has shown great success since its inception in 2001. From its beginning, the scheme has grown from a minimally funded two-year scheme ($50k per year for two years) to a reasonably funded three-year scheme ($100k per year for three years). The three-year lifetime has made a large impact on attracting PhD students for the emerging researchers.

The Marsden Fund has always been a strong support mechanism for Post-doctoral candidates and Post-graduates; however the number of Post-doctoral candidates has decreased while the number of Post-graduate students has increased, apparently making up a decline in the Post-doctoral researchers in the scheme. The total number of Post-doctoral researchers and Post-graduate students is shown in Figure 2 for 2001 to 2008. The decrease in Post-Docs is directly related to the increase in cost of the position. In 2006, a fully funded Post-doctoral researcher was ~$130K per year, by 2009 the cost has risen to ~$160K per year.

Figure 2. Number of individuals contracted as Post-Docs and Post-grads from 2001 to 2008 contracts.



PEOPLE SUPPORTED BY MARSDEN

Many researchers supported by the Marsden Fund are awarded prizes, appointments, and awards. In the past three years a long list has been created, including the NZ Order of Merit; Rutherford Medals; Pickering Medals; amongst other distinctions (see Appendix 2).

The Marsden Fund supports, on average, a researcher earlier in their career than the average researcher calculated from a profile of New Zealand researchers. This is in part due to the Fast-Start scheme, but is also well documented from the Standard proposals. The 2006 to 2008 contracts has seen a flattening off of the past trend of increasingly younger PIs. However, the past three years show over 40% of the PIs have less than 10 years research experience as opposed to New Zealand's profile, which estimates that less than 20% of the research population has less than 10 years of research experience.

The percentage of PIs who are women was highest in the contracts of 2007/08, but has since levelled off. This level of involvement of women in research is an accurate reflection of the proportion of applications received from women. Appendix 2 has further statistical information.

LEVERAGING INTERNATIONAL RESEARCH

More than three quarters of all research projects funded by the Marsden Fund have an international component to their research. The leverage of international research into New Zealand's knowledge base is directly affected by the international collaboration accomplished under the Marsden Fund.

The ANtarctic DRILLing project (ANDRILL) was partially funding by the Marsden Fund. The ANDRILL project is an excellent example of international leverage, using international logistics, knowledge and laboratories to accomplish much more than could have ever been done without international partnerships and collaborations.

The goal of ANDRILL/New Zealand is to obtain a proximal record of Antarctic Ice Sheet behaviour from the time of formation of the East Antarctic Ice Sheet (EAIS) about 40 Ma (million years ago) to the present. In the 2006/7 and 2007/8 seasons this goal was addressed, in part, by drilling two boreholes – one on the western edge of the Ross/McMurdo Ice Shelf (termed MIS), and the other on sea ice in the Southern McMurdo Sound (termed SMS). Both of these efforts were highly successful in terms of percent of core recovered (98%), and depth (below seabed) of core drilled (>1100 m in both cases) – the two deepest holes ever drilled on the Antarctic continental margin. The technological success of the drilling program is due to a dazzling array of technological solutions to the problems of drilling on thin sea ice and thick ice shelves. These areas are difficult, if not impossible, to reach with ship-based or traditional land-based drilling rigs, making the ANDRILL capabilities unique. The high quality of the cores enabled a suite of interpretations that easily reach the highest international benchmarks of scientific merit.

Most prominent of the scientific findings is the discovery of repeated intervals of warm and cold oscillations from about 1.7-5.0 million years ago in the western Ross Sea. These can be interpreted in terms of waxing and waning of the West Antarctic Ice Sheet (WAIS). If this interpretation can be verified through future work, it could imply an unexpected sensitivity of the WAIS that would have very significant implications for global warming impacts (see Science Quality section). Melting of this ice sheet can contribute up to 6 m of global sea-level rise. Such information is of high value to the international community, as the magnitude of sea level due to anthropogenic greenhouse gas increases represents perhaps the largest uncertainty of the recently published Fourth Assessment Report of the Intergovernmental Panel for Climate Change (IPPC).

As the founding and leading members of the ANDRILL consortium, New Zealand scientists have established the significant linkages that have allowed the ANDRILL project to be internationally funded and supported. The larger, international ANDRILL programme has somewhat limited membership (4 countries), compared to the total of 28 Antarctic Treaty nations. The links, especially with the USA, who provide 50% project funding, are excellent. The leadership role being assumed by Italian scientists also testifies to good links there. German scientists from the Alfred Wegener Institute in Bremerhaven are enthusiastic participants, albeit involving only a few personnel.

The stability and future behaviour of the WAIS looms large in most discussions of the impacts of global climate change on sea level. Understanding of the Antarctic sea-ice-atmosphere system will permit better modelling and will allow New Zealand representatives to influence the views of the international community on impacts of Antarctic variability on climate change and its global impacts.

The ANDRILL project is but one of more than a hundred examples of international leverage from contracts funded over the past three years.

COLLABORATIONS

During the past two years, 2007/08 and 2008/09, the number of active contracts has increased. This has also led to an increase in the number of international collaborations, but there has been a decrease in the number of national collaborations over this same timeframe. The number of contracts, international collaborators and national collaborators are shown in Table 5.

This information shows a decrease in national collaboration, most likely related to competition and the amount awarded to each project. International collaborators have not been affected because they are not supported directly by the Marsden Fund. Only their travel costs can be funded by the Marsden Fund. This makes international collaborations more attractive to Marsden Fund contractors whereas, New Zealand collaborators would require direct salary support within the Marsden Fund contract.

Table 5. Contracts and collaborations reported for 2007/08 and 2008/09.

Year	Number of Contracts	Total number of Collaborations	International Collaborations	National Collaborations
2007/08	392	704	495	209
2008/09	409	602	519	83

The countries involved in international collaborations have remained the same for a number of years. Table 6 shows the countries collaborating with Marsden Fund contractors in 2008/09.

Table 6. International linkages in 2008/09.

Country	Number of Linkages
United States of America	137
Australia	83
United Kingdom	73
Germany	27
France	25

Japan	18
Canada	16
Singapore	11
Italy	8
Spain	8
The Netherlands	7
Israel	5
Kenya	5
Finland	4
Denmark	4
Sweden	4
People's Republic of China	3
Switzerland	3
Korea	3
Austria	3
Norway	3
Thailand	3
New Caledonia	3
Hungary	3
Czech Republic	3

In addition, collaborations were also reported with Argentina, Belgium, Brazil, Chile, Fiji, Greece, Hong Kong, India, Ireland, Oman, Papua New Guinea, Poland, Portugal, Romania, Russia, Samoa, Serbia, the Slovak Republic, Slovenia, South Africa, and Taiwan.

EMERGING ISSUES / RECOMMENDATIONS

Success rates and number of proposals

The success rate for the Marsden Fund has been low since its beginning. Figure 1 shows the success rates for Fast-Start and Standard proposals over the years has been at, or around, the 10% level. The low success rate could be a combination of under-funding and over-bidding. The Marsden Fund has continued to get increases in funding to help solve the under-funding issue. However, the potential over-bidding issue has not been looked at in detail until recently.

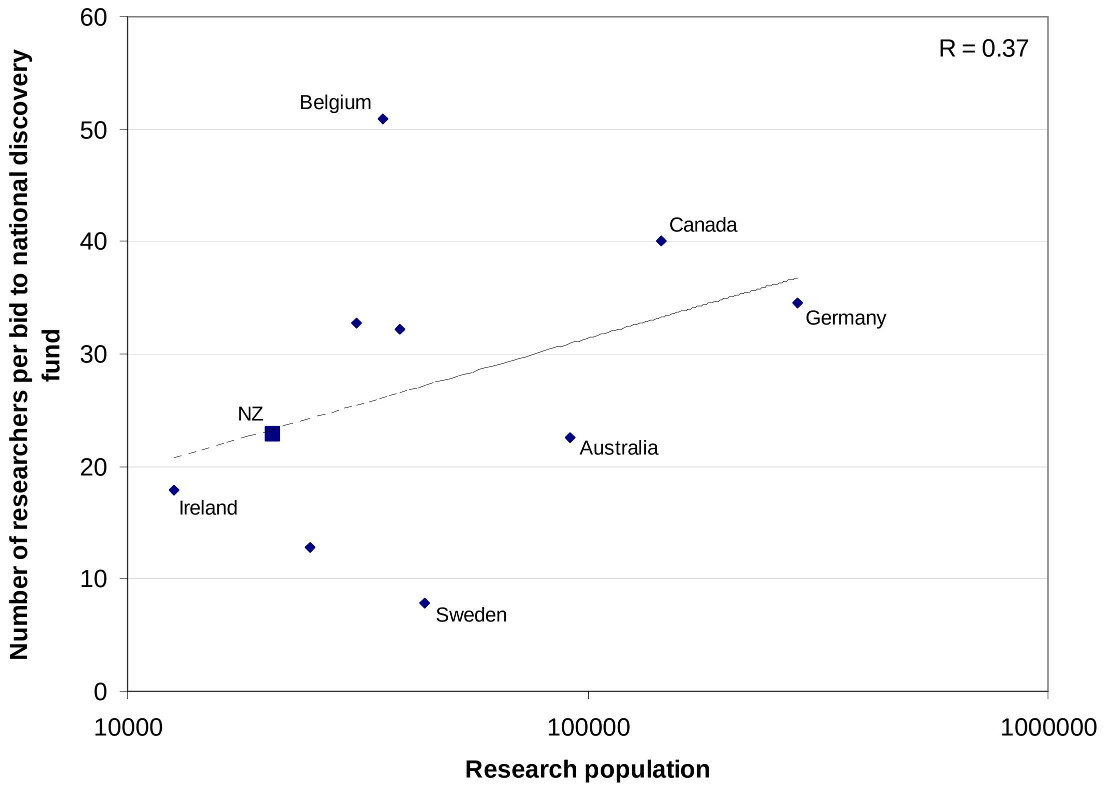
The number of potential researchers involved with fundamental research that could apply to a fund, similar to the Marsden Fund can be estimated for each country. Table 7 and Figure 3 show the results for a few countries including New Zealand in 2007. From this information it can be stated that a common or 'healthy' number of eligible researchers per application for fundamental research funding is 20 to 25 for a country with a science population of 20,000. New Zealand, Ireland and Australia fall into this range even though Australia has five times more researchers and Ireland has less. The number of applications has fluctuated slightly for the Marsden Fund, but has not varied greatly over the years. It is therefore, the Marsden Fund executive's opinion that the number of proposals will not change markedly with further increases in the total amount of the fund. Therefore, in the future the Marsden Fund success rate should increase with any increases in total funding.

Table 7. A comparison of the number of applications to national "discovery" funds for the size of the national researcher population in 2007.

Nation	Fund name	Administered by:	Applications*	No. researchers†	#researchers/ application
Switzerland	Investigator-Driven Research	FNSNF	1951	*24972*	12.8
Ireland	Research Frontiers	SFI	704	*12611*	17.9
Australia	Discovery	ARC	4033	*91274*	22.6
New Zealand	Marsden	RSNZ	910	*20762*	22.8
Finland	General research grants	Akatemia	1211	39000	32.2
Austria	Austrian Science Fund-Stand alone projects	FWF	*957*	31352	32.8
Germany	Research Grants-Individual Grants Programme	DFG	*8269*	286000	34.6
Canada	Discovery	NSERC	3617	*144985*	40.1
Belgium	Research Projects, also much smaller Research Grants	FWO	705	35937	51.0
Sweden	Research Grants	SRC	5600	44276	7.9

*Sourced from administrator reports
†Source OECD (MSTI 2008-2)

Figure 3. A comparison of the number of applications to national "discovery" funds for the size of the national researcher population in 2007.



Better utilisation of research funding information

A reasonable estimate for the amount of money spent each year on applying for Marsden Fund support, evaluating proposals and finalising the contracts is approximately 1/3 of the total allocation of the fund for that year. This would mean that of the $65 million allocated this year, approximately $20 million was spent before starting the research. There is a large investment by the research providers, in the preliminary and full proposal stages, who must pay for the creation and refinement of the proposals. It is estimated to cost approximately $10,000 per preliminary proposal and $20,000 per full proposal in FTEs to create the proposal and set-up the needed collaborations. This is only an estimate; however, summed over 1,000 preliminary proposals and 220 full proposals, a total of $14.4 million is spent in researcher's time to write the proposals each year.

Beyond a doubt, the time spent creating the new ideas and building the collaborations needed for research is valuable and a necessity to research in New Zealand. The proposal stage is where many of the ideas are generated and refined to a point of planning a project for success in the future. The proposal stage is a vital part of the research process. However, the information gained from the process is not utilised to its full extent, because the project may not get funded or the project never reaches its full benefit to New Zealand over its three-year lifetime. To better utilise this information the Marsden Fund executive suggest that some follow-on research funding mechanism either be established formally or informally with the Foundation for Research, Science and Technology (FRST) and the Health Research Council (HRC) to take on high performing Marsden Fund research projects.

The projects that are coming to an end and have shown great advancement in knowledge and potential for further benefit in economic, social or environmental areas, through the research assessments and reports, could be taken directly to the next phase of funding without another contestable funding round. Most of the information needed for this process to take place is already gathered through the Marsden Fund assessment process. Currently, there is no mechanism for this information to be passed on to FRST or the HRC. The Marsden Fund executive have a large wealth of information about all the contracts that pass through the fund and would be more than willing to share this information with FRST and HRC to better utilise the funding costs from the on-set of the Marsden Fund proposal process.

The second portion of research that could be better supported is the research that makes it into the second round of the Marsden Fund process, but is not selected for support. Many of these projects have excellent research ideas and well thought out plans. These projects are often picked-up for internal funding within the universities, but the government could also directly fund these projects, at a reduced amount, to better utilise the proposal process costs, while still supporting excellent research projects, although at a reduced level. The Marsden Fund executive suggests that the possibility of this form of funding be explored.

APPENDICES

APPENDIX 1 – MARSDEN FUND – SCOPE AND SCALE

The Fund has increased in size, almost, steadily since its inception 15 years ago and currently stands at $46.878 million ($52.7M including GST) following its increase by $9 million in the 2009/10 budget (the biggest single increase in both absolute and relative terms since the first years of the Fund).

Each year, approximately one third of the total budget becomes available for new projects from expired projects and new money allocated to the Fund. In 2008/09 and 2009/10, funding totalling $47.86 and $58.8 million respectively were awarded to contracts to run over the following three–five years. Figure A1.1 shows the trends in both Government funding and the Fund's disbursement.

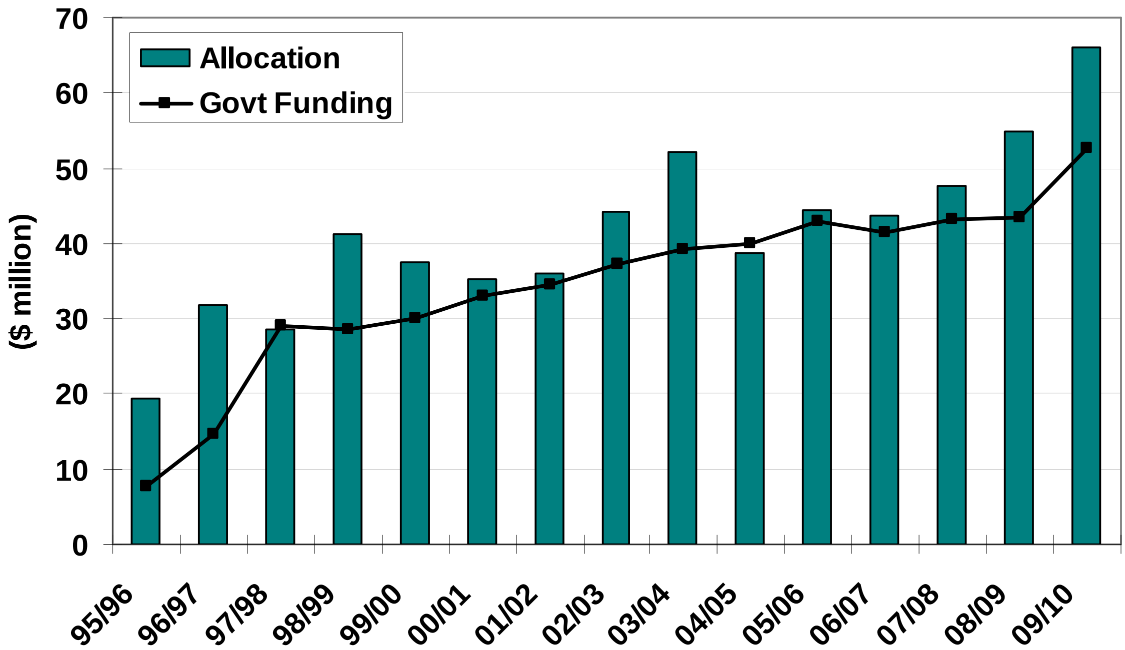


Figure A1.1. Funds allocated to new Marsden Fund projects (Real Sept 2009 dollars, GST-inclusive)

The distribution of the Fund by research area over 2002/03 to 2009/10, is shown in Table A1.1 and Figure A1.2. Note that the proportion of the Fund allocated to each area of research is not predetermined, but is a consequence of the numbers of proposals received within each discipline.

Table A1.1. Distribution of Marsden grants by research discipline over time (in millions of nominal dollars).

	Round							
Panel†	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
CMP	$ 5.779	$ 6.547	$ 4.672	$ 5.319	$ 4.858	$ 5.158	$ 6.698	$ 8.262
BMS	$ 5.606	$ 6.488	$ 4.628	$ 5.132	$ 4.432	$ 5.139	$ 6.816	$ 8.844
EEB	$ 5.443	$ 6.129	$ 4.741	$ 5.628	$ 5.754	$ 6.880	$ 7.598	$ 8.479
MIS	$ 2.261	$ 2.387	$ 2.272	$ 2.516	$ 2.612	$ 2.924	$ 3.633	$ 5.127
PSE	$ 5.382	$ 6.934	$ 4.158	$ 4.750	$ 5.000	$ 5.662	$ 6.212	$ 8.516
ESA	$ 3.537	$ 3.760	$ 3.406	$ 4.160	$ 3.822	$ 4.320	$ 5.236	$ 6.331
HUM	$ 1.600	$ 1.810	$ 1.438	$ 1.763	$ 2.214	$ 2.300	$ 2.838	$ 3.251
SOC	$ 2.903	$ 4.876	$ 4.033	$ 5.762	$ 3.603	$ 3.803	$ 5.056	$ 6.305
EHB	$ -	$ -	$ -	$ -	$ 2.472	$ 3.476	$ 3.769	$ 3.689

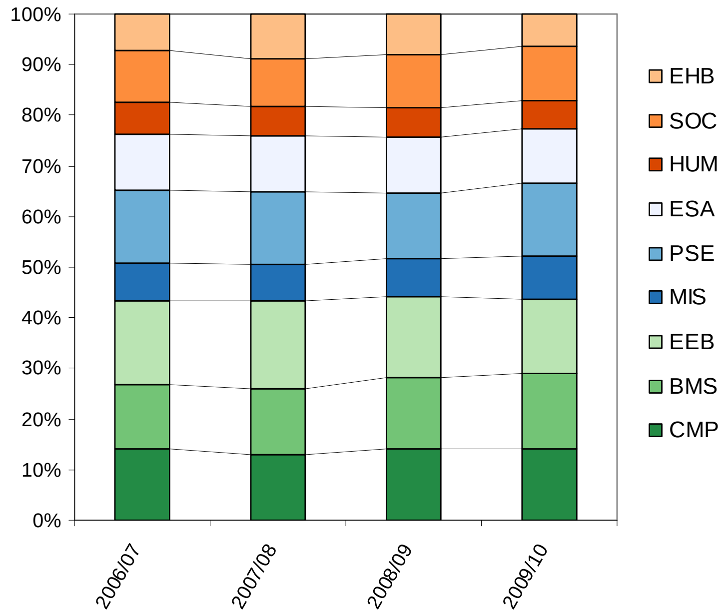


Figure A1.2. Share of funding by research area† for new contracts and year of award

†The research areas are: CMP - Cellular, Molecular & Physiological Biology; BMS - Biomedical Sciences; EEB - Ecology, Evolution and Behaviour; PSE - Physical Sciences and Engineering; ESA - Earth Sciences and Astronomy; SOC - Social Sciences; EHB – Economics, Human and Behavioural Sciences; MIS - Mathematical and Information Sciences; and, HUM - Humanities.

For the last two rounds of contracts: 44 % of the funding is to the medical and life sciences; 32–34 % to the physical/earth sciences and mathematics; 17–18 % to the social sciences; and, 6 % to the humanities. The disciplinary spread has been relatively constant since the creation of the EHB panel in 2006.

APPENDIX 2 – MARSDEN FUND – QUANTITATIVE INDICATORS AND QUALITATIVE ACHIEVEMENTS

BUILDING HUMAN CAPACITY

PRINCIPAL AND ASSOCIATE INVESTIGATORS

The Marsden Fund has supported established researchers by:

Funding contracts that started over 2006/07–2009/2010 year that involve 461 principal investigators (all except thirty-one of whom were based in New Zealand) and 536 associate investigators (of whom 47 % are based in New Zealand).

Table A2.1. Number of investigators associated with Marsden contracts.

	Round				
Investigators	2006/07	2007/08	2008/09	2009/10	Individuals
Principal	111	121	127	143	461
Associate	108	129	132	183	536
All	219	241	252	320	937

NEW AND EMERGING RESEARCHERS

The Marsden Fund continues to invest heavily in New Zealand's emerging researchers.

Over 2006/07 to 2009/10, 114 Fast-Start contracts were awarded to researchers who have had no more than 7 years of research experience since completing their Ph.D (25 in 2006 and 2008, 28 in 2007, and 36 in 2009).

The Marsden Fund's contracts are associated with a large number of the postdoctoral researchers funded through Vote RST. For the 261 contracts awarded between 2006 and 2008, funding has been available for postdocs in 83, i.e., roughly a third of them. Of note, while this represents the equivalent of 65 full-time 3-year appointments this level represents an overall decline in the level of post-doctoral support directly attributable to the Fund (cf 43 % for all contracts let between 1996 and 2005, or some 266 full-time 3-year appointments).

For the 261 contracts awarded between 2006 and 2008, 164 requested funding for post graduate students, i.e., 63% of contracts cf. 57 % of contracts let between 1996 and 2005. In the three most recent years for which contracting has been completed, contracts provided support for a total of 375.1 FTE in postgraduate positions.

Although the Fund has traditionally given strong support to those at the very early stages of their research careers, recent years have seen a shift in the type of individual being contracted in support roles for Marsden's research. Of interest, the level of Post-doctoral involvement appears to be mirrored in the proportion of contract FTE going to post-graduate students (Figure A2.1), suggesting a relatively constant need for Post-doctoral and Post-graduate support in Marsden contracts, but that researchers effectively substitute one for the other as external drivers dictate.

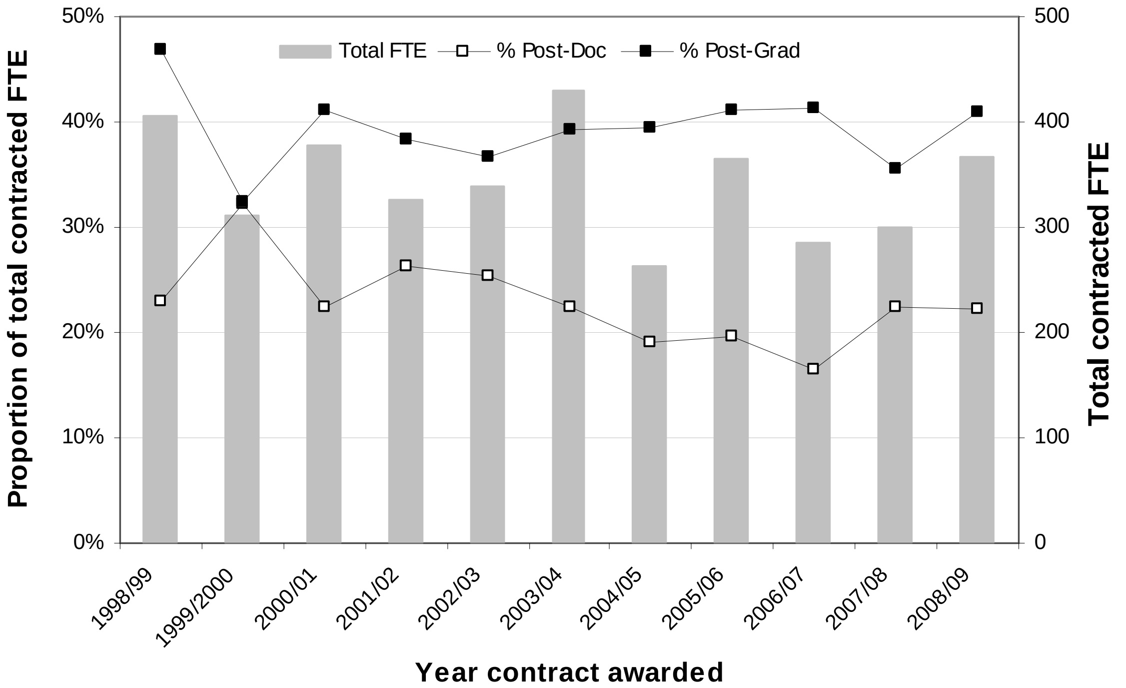


Figure A2.1. Relative proportions of the FTE contracted by Marsden grants going to post-doctoral fellows, post-graduate students, and all others

Over 2006/07 to 2008/09, between 42 % and 46% of all principal investigators (and from 32–36 % of all associate investigators) were within just 10 years of completing their Ph.D. (that is, in most cases, are under 35 years of age).

Since 79 % of contracts are in the science area, this distribution for principal investigators has been compared with the distribution of ages of New Zealand scientists, from "Profiles – A Survey of New Zealand Scientists and Technologists"[34]. The participation of emerging researchers is significantly greater than would be expected from demographic considerations alone (Figure A2.2).

[3] Sommer, J. and D., 1997, "Profiles – A Survey of NZ Scientists and Technologists", The Royal Society of New Zealand

[4] Note: the horizontal variables (years since highest degree and age, respectively) have been matched by assuming that the highest degree is obtained at 24 years of age.

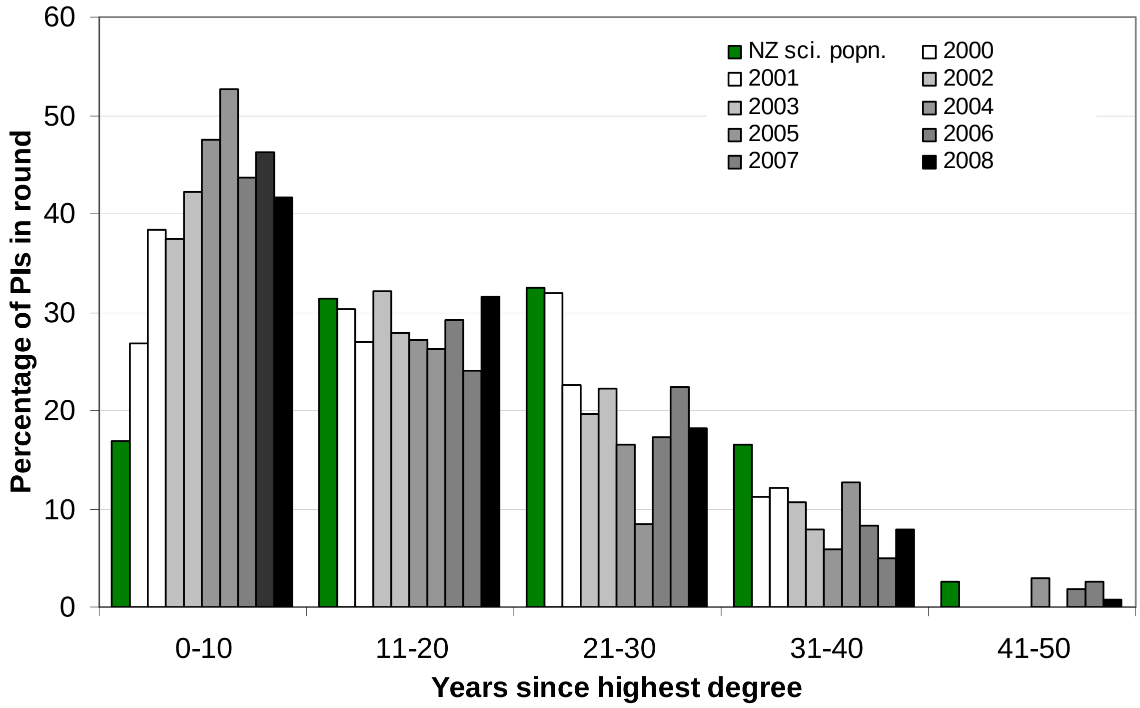


Figure A2.2. Experience of principal investigators (PIs) on contracts awarded from 2000–2008, as estimated from the number of years since the principal investigator obtained their highest degree.

WOMEN RESEARCHERS

The contracting in 2007/08 represents the highest year to date for women leading Marsden-contracted research with the overall trend being strongly in favour of increasing participation by women with the Fund[5].

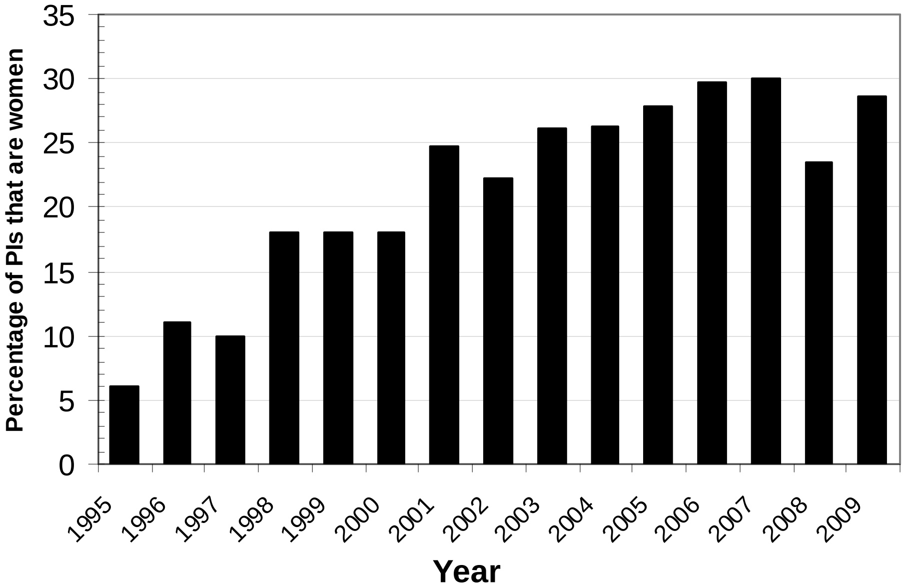


Figure A2.3. Percentage of principal investigators (PIs) who are women.

Table A2.2. Proportion of proposals at each stage having a female principal investigator.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	All
Preliminary	25.9%	29.9%	31.0%	30.1%	31.3%	32.7%	33.8%	34.2%	35.5%	31.7%
Contracts	27.8%	29.3%	30.2%	33.3%	38.0%	36.7%	37.7%	35.5%	30.8%	31.1%

As can be seen from Table 1.2, proposals to the Marsden fund are awarded to female PIs at approximately the rate at which they apply (i.e., yearly success rate independent of PI-gender, χ^2 p~0.83).

[5] Data from the 2006 Census shows that of "Design, Engineering, Science and Transport Professionals', 24.8% of were women. The corresponding figures for scientists, excluding computer professionals, in 2001 and 1996 were 27.5% and 24.0% respectively, although note that not all scientists are researchers.

MAORI RESEARCHERS

For contracts initiated throughout 2006/07–2008/9, Māori researchers were involved with 12 % of the projects as either a PI or an AI. Over the same period, the percentage of investigators who self-identify as Māori was 5.2 %. In the 1997 Royal Society survey (referred to above), 0.7 % of scientists identified themselves as Māori.

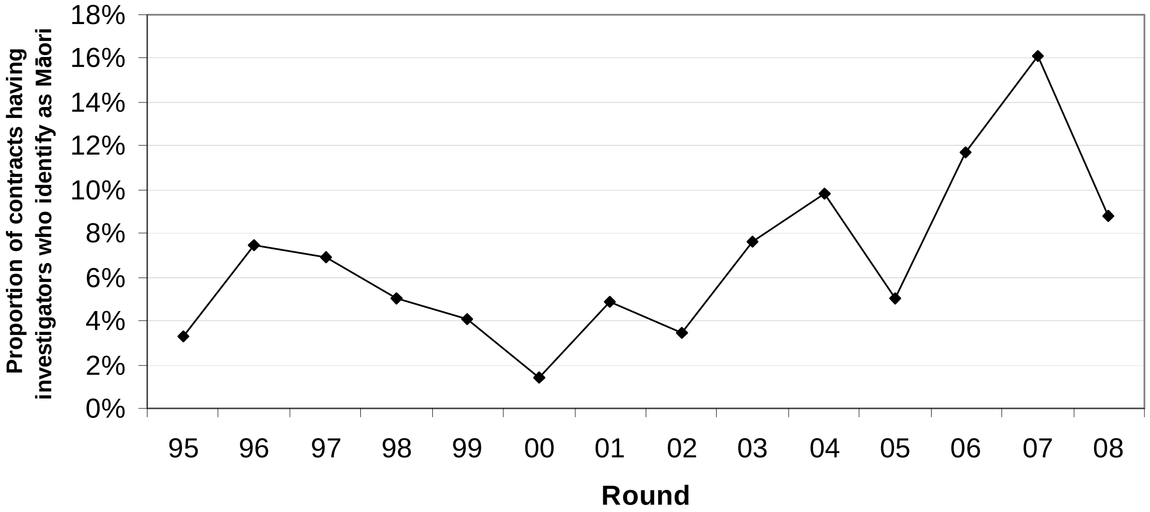


Figure A2.4. Proportion of contracts with principal, (PI) and associate (AI), investigators that identify as Māori.

SUMMARY-PEOPLE SUPPORTED IN MARSDEN CONTRACTS

Table A2.3. Participation in Marsden grants.

Building human capacity	**'99–'00**	**'00–'01**	**'01–'02**	**'02–'03**	**'03–'04**	**'04–'05**	**'05–'06**	**'06–'07**	**'07–'08**	**'08–'09**
Investigators – Number of separate individuals acting as principal[6] and/or associate[7] investigators on current contracts	660	729	769	791	923	896	924	942	943	964
Emerging researchers – Percentage of PIs on contracts awarded in the funding round who have received their highest degree within the last 10 years	26%	27%	38%	38%	43%	48%	53%	44%	46%	42%
Postdoctoral fellows[8] – Percentage of standard contracts in the year's funding round which involve postdoctoral fellows	53%	47%	40%	42%	36%	31%	39%	29%	31%	35%
Students[9] – Percentage of contracts in the year's funding round which support postgraduate students	46%	61%	55%	57%	56%	56%	58%	57%	58%	73%
Women – Percentage of PIs on contracts awarded in the funding round that are women	18%	18%	25%	22%	26%	26%	28%	30%	31%	24%
Māori – Percentage of PIs and AIs on contracts awarded in the funding round identifying as Māori	1.6%	0.9%	4.0%	1.3%	5.6%	4.1%	1.8%	4.6%	6.6%	4.4%

[6] PIs – Principal Investigators –researchers who lead the research, contribute the main ideas and are responsible, with their institution, for the achievements of the objectives and the management of the contract

[7] AIs – Associate Investigators – researchers who play a lesser role than principal investigators and sometimes are involved with onlylimited aspects of the work.

[8] Postdoctoral fellows – emerging researchers who have completed a Ph.D., usually within the last few years, and are employed on contract (often 2-3 years). They do much of the day-to-day work on the research programme, and are looking to gain experience to establish themselves as permanently employed researchers.

[9] Postgraduate students – researchers who are working on a Masters of Ph.D. thesis.

ENHANCING GLOBAL CONNECTEDNESS

The 08/09 funding round saw historic highs for the Fund, both in terms of the number of contracts involving international collaboration, and those involving collaboration of any kind. The proportion of the contracts involving principal and associate investigators from just a single institution has decreased from 77 % in 1995 to 34 % in 2008 (see Figure A2.5). It must be noted however, that the bulk of collaboration at the contracting level is of an international nature, and that national linkages remain comparatively modest.

The percentage of contracts let over 2006/07 to 2008/09 that specifically include overseas principal or associate investigators at their onset was 43–58 %. Further collaboration occurs during the course of the research. For 241 projects with final reports due over within this period, 46 % included overseas researchers at their inception; but the time they had finished, 95 % had reported the formation of additional international collaborators.

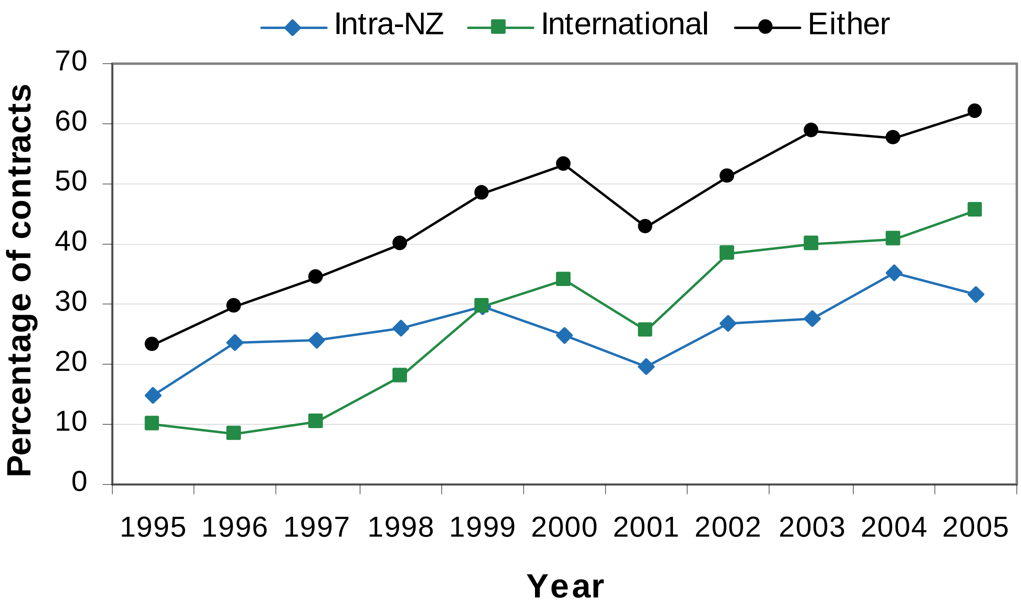


Figure A2.5. The percentage of contracts for which a principal or associate investigator is from outside the host institution, categorised according to whether the collaborator is from New Zealand or another country. The percentage of contracts demonstrating either type of collaboration is also shown. The year refers to the starting date of the contract.

Table A2.4. International collaboration and communication on Marsden grants.

International collaboration and communication	'99–'00	'00–'01	'01–'02	'02–'03	'03–'04	'04–'05	'05–'06	'06–'07	'07–'08	'08–'09
International collaboration – successful proposals in the year's funding round with PIs and/or AIs from overseas	30%	34%	26%	38%	40%	41%	48%	44%	43%	58%
International collaboration – current contracts[10] with international collaboration (excepting proposals funded in the year's round)	73%	67%	67%	65%	66%	†				
International collaboration – contracts completed in the year with PIs and/or AIs from overseas						29%	41%	52%	41%	46%
International collaboration – contracts completed in the year with international collaboration						84%	80%	96%	94%	96%
International Presentations – current contracts (excluding those awarded in the year's funding round) which were presented at international conferences	67%	63%	65%	72%	78%	69%	86%	81%	71%	53%

† Series discontinued

[10] Current contracts – those operating in the Government financial year indicated

BUILDING NEW ZEALAND'S KNOWLEDGE BASE

RESEARCH PRODUCTIVITY AND DISSEMINATION

Table A2.5. Publications, patents and software reported as directly attributable to Marsden grants.*

Year of Publication	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	All Years
Papers	135	255	304	397	428	430	429	479	476	551	515	516	5074
Refereed Conference Proceedings	27	34	43	77	86	106	77	107	84	103	80	85	926
Book Chapters	11	25	27	42	53	65	66	70	72	64	67	73	646
Books	1	2	2	3	10	10	14	11	13	11	12	13	103
Edited Volumes		2	3	2	9	11	5	12	8	13	5	8	78
Reports	15	13	22	12	15	9	17	9	14	7	8	5	152
Patents		1	3	1	3	1	2	4	5	3	4	2	29
Software		1				3	2	1	3	4	3	2	19
Total	189	333	404	534	604	635	612	693	675	756	694	704	6722

*either published or in press, and either wholly or partially attributed to the Marsden Fund. Represents a minimum estimate, as publications from previous years continue to be reported.

Figure A2.6. Count of the published output of the Fund (papers, refereed conference proceedings, books and book chapters), and output expressed as the ratio of published output to Govt investment (Sept 2009 dollars).

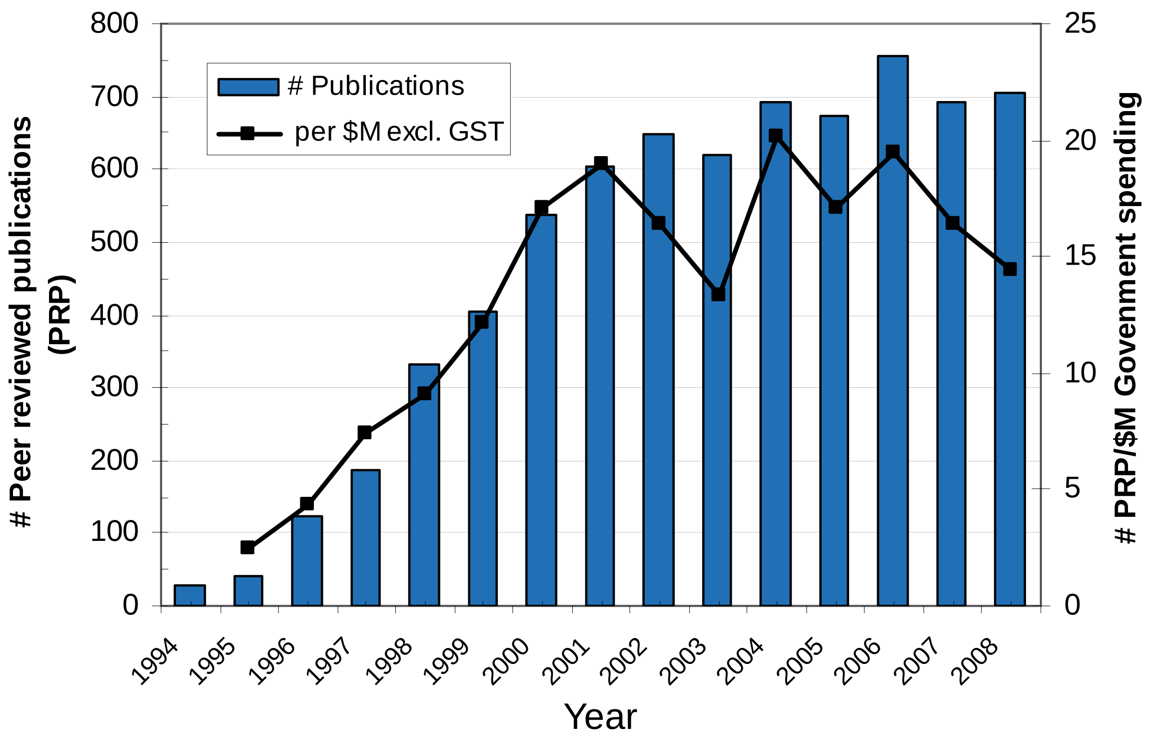


Table A2.6. Dissemination of Marsden results through conferences and other channels.

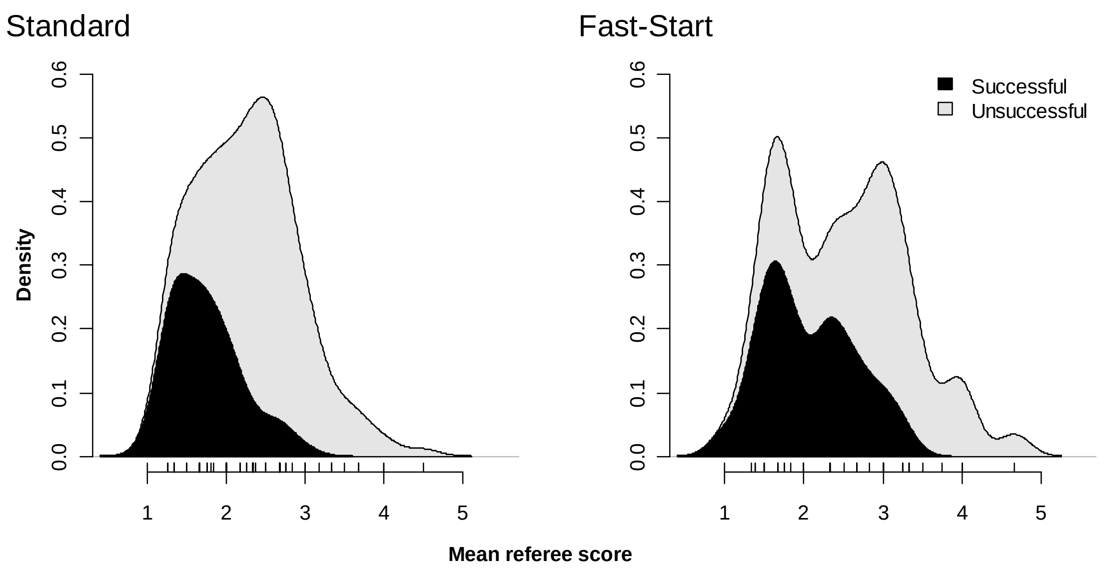
Year of Activity	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	All Years
Invited conference talk	36	44	63	96	109	128	175	212	229	206	226	193	1733
Contributed conference talk	71	128	249	312	410	286	318	288	328	290	422	274	3402
Conference poster	116	170	155	99	88	91	119	142	175	176	138	135	1668
Other†	6	10	11	26	36	41	59	90	104	83	104	65	635
Total	229	352	478	533	643	546	671	732	836	755	890	667	7438

†Types of other output include: articles in non-specialist journals, gene sequences deposited in public databases, reagents developed, documentaries, radio interviews, websites, online databases, CDs distributed, and editorials and letters in specialist journals.

RESEARCH QUALITY

The quality of Marsden-funded research is ensured by rigorous selection procedures, including national and international peer review of all proposals that proceed to the second stage of the evaluation process.

2007 Round:



2008: round:

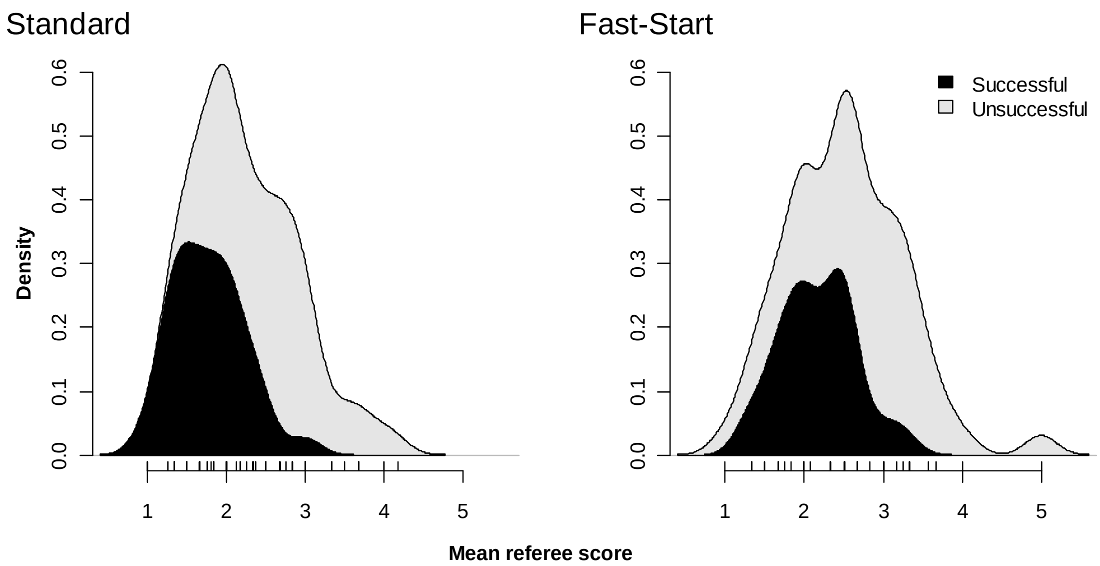


Figure A2.7. The estimated distributions of the average referee score received for both funded and unfunded proposals to the 2007 and 2008 funding rounds[11].

Mean referee scores for both standard and Fast-Start applications range between one and five, and both categories appear to have the same three populations of proposal type although in different proportions with means centred on: "Excellent" to "Outstanding"; "Well above average"–"Excellent"; and, "Above average" to "Well above average". The vast majority of successful Standard and Fast-Start proposals come from the highest ranked, "Excellent" to "Outstanding", population. However, it must be noted that there are as many excellent-outstanding proposals that are unsuccessful due to funding limitation.

Measures of research excellence for contracts active in the 2006-09 years follow below:

Papers reported as attributable to Marsden contracts over 2006-2008 have been published in prestigious journals (e.g., see examples listed in Table A2.7), such as the Nature stable of publications, Science, the Proceedings of National Academy of Sciences, etc.

Of the 15 holders of the prestigious James Cook Research Fellowship throughout 2005/06 and 2008/09, 11 were investigators on Marsden contracts active over the same period.

Numerous prizes and awards to Marsden researchers, as listed in Table A2.8.

[11] Scores equate to: 1 = "Outstanding – among the top 5% of proposals worldwide"; 2 = "Excellent – among the top 10% of proposals worldwide"; 3 = "well above average, top 20%"; 4 = "above average"; and 5 = "average or below average".

Table A2.7: A selection of papers of note, published throughout 2006-2008:

- J. Sneyd et al., "A method for determining the dependence of calcium oscillations on inositol trisphosphate oscillations," *Proceedings of the National Academy of Sciences* 103, no. 6 (2006): 1675.
- Barak Dayan et al., "A Photon Turnstile Dynamically Regulated by One Atom," *Science* 319, no. 5866 (February 22, 2008): 1062-1065, doi:10.1126/science.1152261.
- Howard Carmichael, "Cavity QED: Signs of anharmonicity," *Nat Phys* 4, no. 5 (May 2008): 346-347, doi:10.1038/nphys953.
- B. M. Kennedy, A. Mark Jellinek, and J. Stix, "Coupled caldera subsidence and stirring inferred from analogue models," *Nature Geoscience* 1, no. 6 (2008): 385.
- B. S. Gaudi et al., "Discovery of a Jupiter/Saturn Analog with Gravitational Microlensing," *Science* 319, no. 5865 (February 15, 2008): 927-930, doi:10.1126/science.1151947.
- Poole and D. Penny, "Eukaryote evolution: engulfed by speculation.," *Nature* 447, no. 7147 (2007): 913.
- W. C. Warren et al., "Genome analysis of the platypus reveals unique signatures of evolution," *Nature* 453, no. 7192 (2008): 175-183.
- G. Kurland, L. J. Collins, and D. Penny, "Genomics and the Irreducible Nature of Eukaryote Cells," *Science* 312, no. 5776 (May 19, 2006): 1011-1014, doi:10.1126/science.1121674.
- M. Dragunow, "High-content analysis in neuroscience," *Nature Reviews Neuroscience* 9, no. 10 (2008): 779-788.
- T. Fukami et al., "Immigration history controls diversification in experimental adaptive radiation," *Nature* 446, no. 7134 (2007): 436-439.
- G. M. Weinstock et al., "Insights into social insects from the genome of the honeybee Apis mellifera," *Nature* 443, no. 7114 (2006): 931-949.
- Jeremy R Corfield et al., "MRI of postmortem specimens of endangered species for comparative brain anatomy," *Nat. Protocols* 3, no. 4 (April 2008): 597-605, doi:10.1038/nprot.2008.17.
- Y. Kinjo et al., "Natural killer T cells recognize diacylglycerol antigens from pathogenic bacteria," *Nature immunology* 7, no. 9 (2006): 978-986.
- T. Aoki et al., "Observation of strong coupling between one atom and a monolithic microresonator," *Nature* 443, no. 7112 (2006): 671-674.
- Vanina Vergoz, Haley A. Schreurs, and Alison R. Mercer, "Queen Pheromone Blocks Aversive Learning in Young Worker Bees," *Science* 317, no. 5836 (July 20, 2007): 384-386, doi:10.1126/science.1142448.
- Christine C Winterbourn, "Reconciling the chemistry and biology of reactive oxygen species," *Nat Chem Biol* 4, no. 5 (May 2008): 278-286, doi:10.1038/nchembio.85.
- V. K. Ward et al., "Recovery of infectious murine norovirus using pol II-driven expression of full-length cDNA," *Proceedings of the National Academy of Sciences* 104, no. 26 (2007): 11050.
- Michael Foote et al., "Rise and Fall of Species Occupancy in Cenozoic Fossil Mollusks," *Science* 318, no. 5853 (November 16, 2007): 1131-1134, doi:10.1126/science.1146303.
- P. E. Czabotar et al., "Structural insights into the degradation of Mcl-1 induced by BH3 domains," *Proceedings of the National Academy of Sciences* 104, no. 15 (2007): 6217.
- M. Dragunow, "The adult human brain in preclinical drug development," *Nature Reviews Drug Discovery* 7, no. 8 (2008): 659–666.
- P. B. Rainey, "Unity from conflict," *Nature* 446 (2007): 616.

Table A2.8. A selection of the awards and prizes recorded for the contracts reviewed in 2006/07 through 2008/09

Researcher	Contract	Distinction awarded
A Montalban	VUW0403	Sacks Prize, for the best thesis in Logic worldwide
Alison Mercer	UOO0615	Officer of the New Zealand Order of Merit
Alona Ben-Tal	MAU0502	IIMS Distinguished Teaching Award - 2008
Andy Cockburn	UOC0707	2009 Chris Wallace award for the outstanding research contribution to Computer Science, 2005-2007.
Angela Wanhalla	UOO0705	Rowheath Trust Award and Carl Smith Medal
Assoc Prof KA Campbell	UOA0604	GSNZ Hochstetter Lecturer
Assoc Prof Roger J. Reeves	UOC0604	T.K. Sidey Medal (2007)
Assoc. Professor E W Ainscough and Professor A M Brodie	MAU208	2007 NZIC Prize for Excellence in the Chemical Sciences
Barbara Holland	MAU0509	Massey University Research Medal (Early Career)
Bedford R	UOW0402	NZ Geographical Society Distinguished NZ Geographer Medal
Beever RE	LCR301	FNZIAHS (Fellow of the NZ Institute of Agricultural and Horticultural Science (2005)
Bernhard Pfahringer	UOW306	ECML/PKDD 2006 Discovery Challenge Award
Bridgman T	VUW0708	Early Career Research Award, Victoria University of Wellington, 2008
Bryant D	UOA0502	Alexander von Humboldt Fellowship
Catherine McCartin	MAU0409	RSNZ Hatherton Award 2006
Chirok Han	UOA0711	Research Excellence Award 2007, The University of Auckland Business School
Christine Winterbourn	UOO0614	Society for Free Radical Research (International) Trevor Slater Award
CR Green	UOA0417	NZBio Inaugural Deal of the Year Award
David Ackerley	VUW0704	Victoria University of Wellington Early Career Researcher Award 2009
Deborah Prendergast	UOA301	New Zeland Genetics Society Young Investigator
Dr Christine van Dalen	MAU0508	RNZCGP General Practice Research Award
Dr Jacob Edmond	UOO0506	University of Otago Early Career Award for Distinction in Research, 2006
Dr Jadranka Travas-Sejdic	UOA0408	Early Career Research Excellence Award, UoA, 2005
Dr John Townend	VUW0508	New Zealand Geophysics Prize, 2006, joint with Prof Mark Zoback, Stanford University
Dr Mark Hauber	UOA0514	Early Career Research Excellence Award, University of Auckland Research Council

Dr Mark Vickers	UOA0606	Nick Hales Award, International Society for the Developmental Origins of Health and Disease
Dr Mark Vickers	UOA0606	2006 Hamilton Memorial Prize, Royal Society of New Zealand
Dr Michael Black	UOO0610	University of Otago Early Career Award for Distinction in Research (2008)
Dr Michelle Glass	UOA0513	Young Invesitgator, International Cannabinoid Research Society, 2009
Dr Ulrich Zuelicke	MAU0702	New Zealand Association of Scientists Research Medal 2008
Dr. Warwick Bowen	UOO0612	University of Otago Early Career Researcher Award 2007
Drummond A	UOA0502	Royal Society Hamilton Memorial Award
Drummonds A	UOA0502	Hamilton Memorial Prize 2007
Emma Coddington	UOO0402	Young Investigator Award, (Plenary Lecture) Steroid Hormones and Brian Function Group, (USA)
F Ronchese	MIM202	Inaugural 2006 J Watson award for contribution to Immunology
Fiona McDonald	UOA210	New Zealand Association of Scientists Research Medal, 2005
Fischer R	VUW0506	Early Career Award, International Academy for Intercultural Research
Fischer R	VUW0506	Early Career Researcher Award, Victoria University Wellington
G. J. Martin	MAU0711	Hector Medal of RSNZ
Geoffrey Irwin	UOA313	Elected as Fellow of the Society of Antiquaries of London (FSA)
Gerald Midgley	ESR0601	Fellow of the SOLAR Centre, University of the West of England, UK.
Gerald Midgley	ESR0601	Fellow of the Institute for the Study of Coherence and Emergence, Boston, USA.
Graham Wallis	UOO0603	Temminck Fellowship, National Museum of Natural History, Leiden, Netherlands
Gregory M. Cook	UOO313	University of Otago Early Career Award for Distinction in Research
Hayward, Bruce W.	PVT201	Hochstetter Lecturer, 2006
Hayward, Bruce W.	PVT201	MNZM, 2006
Helen Leach	UOO0408	Percy Smith Medal 2007, University of Otago
Humphries P	UOC310	Aitken Prize (2007), New Zealand Mathematical Society
Ian H. Witten and Greenstone team	UOW0604	Mellon Award for Technology Collaboration (see http://matc.mellon.org/press-release)
Ivan Reilly	UOA106	Officer of the NZ Order of Merit, ONZM, New Years Honours, 2007
J Travas-Sejdic	UOA0408	Easterfield Medal (Royal Institute of Chemistry)
J.M. Burgess	UOC311	Best communicator award at the Supramolecular Chemistry and Nanoscience Conference
J.M. O'Sullivan	MAU0401	Massey University Research Award, Early Career.
Jacob Bercovitch	UOC308	University of Canterbury Rearch Medal for excellence in research
Jade Hollis-Moffatt	UOO304	2006 National Maori Academic Excellence Award

Jadranka Travas-Sejdic	UOA0408	Easterfield Award
James Shulmeister	UOC301	Hochstetter Lecturer - Geological society of New Zealand 2005
Jasna Rakonjac	MAU210	2005 Nestle/ASM Award for outstanding phage research, May 21 2006
Jeffery Tallon	IRL301	Honorary Fellow IPENZ
JM Montgomery	UOA0512	Eppendorf and Science Prize for Neurobiology
Johanna Montgomery	UOA0512	Early Career Research Excellence Award
John Gibson	UOW0503	NZIER Economics Award for 2008
Jon Waters	UOO0403	Early Career Award for Distinction in Research, University of Otago, 2006
Julia Horsfield	UOO0713	Dunedin School of Medicine Research Publication Award
Julian Eaton-Rye	UOO309	New Zealand Society of Plant Physiologists' Outstanding Physiologist Award, 2005
Julian Eaton-Rye	UOO309	NZSBMB/Applied Biosytems Award for Research 2006
Kate McGrath	VUW0608	NZAS research medal
Ken Carlaw	UOC0406	Co-winner of the Schumpeter Prize (2006)
L J Collins	MAU303	Walter Fitch Prize (Soc. Mol Biol Evol, best paper by PhD student or young postdoc)
Laura Dimock	VUW311	Co-recipient Gerhard Laves Field Research Award, Australian Linguistic Society - 2007 ($1,000AUD)
Les Oxley	UOC0406	Biennial Medal, 2006, (Socio-economic Systems) International Environmental Modelling and Software Society (iEMSs).
Les Oxley	UOC0406	Elected Fellow, International Environmental Modelling and Software Society, (FiEMSs) July 2006
Lesley J Collins	MAU303	Fitch Prize (Soc Molec Biol. Evol. , Best presentation by recent PhD graduate)
Liping Pang	ESR0501	ESR Science Excellent Award in August 2006
Lockhart	MAU206	Microsoft Research Fellowship: Newton Institute for Mathematical Sciences (2007)
Maren Moennich	UOO0713	Biochemical Journal Young Investigator Award, Queenstown Molecular Biology Meeting 2008
Margaret Barbour	LCR201	Outstanding physiologist of the year 2006, awarded by the New Zealand Society of Plant Physiologists
Margaret Brimble	UOA0705	2008 World Class New Zealand Award (Sponsored by NZ Trade and Enterprise and Kea) Research, Science, Technology and Acad
Mark Hauber	UOA0514	Early Career Research Excellence Award, University of Auckland
Mark Hauber	UOA0514	Human Frontier Science Program Young Investigator Award
Mark Waterland	MAU211	Massey University Early Career Research Medal, 2005
Marston Conder	UOA0412	Elected President of Academy of Royal Society of New Zealand 2006-2009
McLachlan RI	MAU202	Isaac Newton Senior Visiting Fellow 2007
McLachlan RI	MAU202	SIAM Dahlquist Prize 2007
Ms Shiloh Groot	UOW0602	Maori Excellence Award 2008

Noam Greenberg	VUW0711	New Zealand Mathematical Society early career research award
Oremus M	UOA309	Best presentation by a student, International Society for Marine Mammal Science, Cape Town
P Blair Blakie	UOO0507	2006 University of Otago Early Career Award for Distinction in Research
P.J. Steel	UOC311	NZIC HortResearch prize for excellence in research in the chemical sciences 2006
Paul Callaghan	VUW0608	KEA Award, Blake Medal
Paul Callaghan	VUW310	World Class NZer award, category Research, Science Academia, 2007
Paul Callaghan	VUW310	PCNZM 2006
Paul G. Plieger	MAU0506	Massey University, College of Sciences - Early Career Award
Paul Plieger	MAU0506	College of Science - Early career award for research
Peter Barrett	GNS0401	Scientific Committee of Antarctic Research Presidents Medal
Peter Barrett	GNS0401	Wellingtonian of the Year 2007
Peter Dearden	UOO0401	Rowheath Trust Award and Carl Smith Medal
Prof Dame Anne Salmond	UOA311	2007 Fellow of the New Zealand Academy of the Humanities
Prof Dame Anne Salmond	UOA311	2007 Hakluyt Lecture for the Hakluyt Society, London
Prof Dame Anne Salmond	UOA311	2007 Montana Prize for History for Vaka Moana, contributing author
Prof David Lambert	MAU302	Massey University, Individual Award, Massey University Research Medals 2006
Prof David Schiel	UOC306	New Zealand Marine Sciences Life-time Achievement Award
Prof Jamie Sleigh	UOW307	Inaugural Waikato Kudos award for Medical Science (Nov 2007)
Prof Jim Cole	UOC0508	Research Medal, University of Canterbury, 2006
Prof Schiel	UOC306	Life Member/Outstanding Achievement, NZ Marine Sciences Society, 2004
Professor A M Brodie	MAU208	2007 RSNZ Science and Technology Medal
Professor Barry Scott	MAU0403	Massey University Research Medal (Supervisor) 2007
Professor Harlene Hayne	UOO0512	Appointed Officer of the New Zealand Order of Merit
Professor Margaret Brimble	UOA0508	L'Oreal-UNESCO Women in Science Laureate in Materials Science for Asia-Pacific
Professor Margaret Brimble	UOA0508	NZIC Hort Research Prize
Professor Neil Brewer	UOO0715	Appointed: Fellow of the Academy of Social Sciences in Australia
Professor Tim Naish	GNS0401	James Lee Wilson Award for excellence in sedimentology by the Society of Sedimentray Geology
Professor Warren Tate	UOO210	2006 University of Otago Distinguished Research Medal

Professor Warren Tate	UOO210	2005 Best Original Research Paper Award, School of Medical Sciences, University of Otago
Quispel GRW	MAU202	Elected Fellow of the Institute of Physics 2004
R Downey	VUW0403	Fellowship of the Association for Computing Machinery (2nd ever), 2008
R H Sibson	UOO216	Elected Fellow of the American Association for the Advancement of Science
Robert Poulin	UOO0403	Wardle Medal from the Canadian Society of Zoologists, for contributions to parasitology
R. Neich	UOC008	Frigate Bird Award for Contribution to the study of Pacific Arts. Pacific Arts Association, 2005
R. Neich	UOC008	Elsdon Best Memorial Medal for Maori ethnography, Polynesian Society, 2004
Richard Umstaetter	UOA204	2006 University of Auckland Best Doctoral Thesis Award
Richard Walter	UOO0711	Elected Fellow of the Society of Antiquaries
Rob Goldblatt	VUW0503	Victoria University Research Excellence Award, March 2007
Robert Poulin	UOO0403	Appointed Specialist Editor, International Journal for Parasitology, from January 2007
RS Hill	VUW207	Ministry for Culture and Heritage Publication Award for State Authority, Indigenous Autonomy: Crown–Maori Relations in New Zealand
Sean Mallon	VUW0609	Appointed Council Member of The Polynesian Society
Sebastian Link	MAU0503	College of Business Research Award 2006, Early Career Award
Sebastian Link	MAU0503	Early Career Award for Distinction in Research - Massey 2006
Shaun Lott	UOA210	Invitrogen QMB Life Science Award 2006
Shaun Lott	UOO0409	2006 InvitrogenTM Life Science Award Winner
Simon Pollard	UOC305	New Zealand Association of Scientists Science Communicator of the Year
Steven Pascal	MAU0507	IFS distinguished teaching award
Sturmfels D	UOA0502	Alexander von Humboldt Senior Research Award
Takashi Shogimen	UOO0504	Early Career Award for Distinction in Research, University of Otago, 2006
Tim Naish	GNS0401	Society of Sedimentray Geology (SEPM) 2008 James Lee Wilson Award
Tim Naish	GNS0401	Geological Society of New Zealand 2206 McKay Hammer
Tim Stern	VUW301	New Zealand Geophysics Prize, Royal Society of New Zealand, 2003 (for best paper).
Tony Kettle	UOO0614	University of Otago Christchurch Gold Medal for Research
Toshi Foster	HRT0501	HortResearch Chairmans Award
Tribble, EB	UOO0618	Fellow, Institute for Advanced Studies in the Humanities, University of Edinburgh, 2007
Vern Manville	MAU0512	Geological Society of New Zealand 2008 Hochstetter Lecturer
Vyacheslav V. Filichev	MAU0704	Massey University Early Career Research Medal, 2008
Wei Gao	UOA0411	Hsun Lee Lecture Award, Institute of Metals Research, Chinese Academy of Sciences

Wei Gao	UOA0411	Nano-Technology Award by the Workshop of "Nanotechnology Program - The Road Toward Fulfilling the Vision of the Custodia
Wendy Imlach	AGR302	Awarded 2006 McDiarmid Young Investigator of the Year category winner in "Understanding Planet Earth"
Wild JM	UOA0503	Doctor of Science, University of Auckland