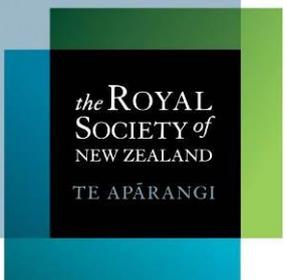


Royal Society of New Zealand

Investment Impact Report 2014–2015: Marsden Fund

December 2015

A place for knowledge and excellence
Science • Technology • Humanities



the ROYAL
SOCIETY of
NEW ZEALAND
TE APĀRANGI

Summary

For the last 20 years, the Marsden Fund has invested in investigator-initiated research aimed at generating new knowledge, with long-term benefit to New Zealand. The Fund supports excellent research projects that advance and expand the knowledge base, and contributes to the development of people with advanced skills in New Zealand.

The Marsden Fund encourages New Zealand's leading researchers to explore new ideas by fostering creativity and innovation.

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; and
- 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.

The National Statement of Science Investment (NSSI) released in 2015 confirms that the Marsden Fund is a major source of Government support for hypothesis driven and discovery-research, which provides the seeds and testing of ideas that develop into the knowledge and innovation that ultimately benefit New Zealand and maintain its position on the global academic stage.

The Marsden Fund Council has continued to provide strategic direction for the Fund and ensures the Fund operates at the highest capacity to achieve its objectives as they are defined in the Terms of Reference for the Marsden Fund. In the last two years the strategic focus has been on demonstrating the long term benefit of the Fund to New Zealand and ensuring that emerging researchers were well served by the terms of reference which were refreshed in this window.

Outcomes

Over the past two years, there have been a number of excellent research projects and outcomes. The Marsden Fund has received, evaluated and signed-off on 204 contracts during this period of time. It continues to lead to high numbers of peer-reviewed papers, including over 50 papers/year published in international journals in the top 2% of the 2014 Scimago Journal Ranking. It thus supports the advancement of knowledge in New Zealand, while contributing to maintaining our global position in research and scholarship.

In a first for New Zealand, and amongst only a handful of cases worldwide, the Fund initiated an independent project with Motu Economic and Public Policy Research to investigate the impact of the receipt of Marsden funding compared with those unsuccessful in the competition. The results show that a Marsden contract leads to a significant increase in both the publication output of funded researchers, and the citations that these works receive. It also concluded that if resources permitted, the Fund could select deeper into the proposal pool than the contemporary success rate of 8% without diminishing the quality or impact of the research funded. In addition, 2014 marked the 20th anniversary of the Fund. Celebrations were launched at Parliament by the Minister, and continued throughout that year, allowed the Fund to highlight the ground-breaking research that Marsden funded researchers have carried out for the benefit of all New Zealanders. Together with the Marsden Fund Council, the Society initiated three promotion activities: 'We're looking into that', a bill-board series supported with web-based media; "Ten by Ten", a tour of 10 Marsden researchers to 10 different centres; and, "Infrequently Asked Questions", an ongoing blog allowing the community to ask questions and engage with Marsden researchers.

Building Human Capacity

In the 20 years of the Marsden Fund's operation, it has contracted more than 3000 investigators.

The Marsden Fund continues to invest heavily in New Zealand's emerging researchers through Fast-Start contracts for researchers within seven years of their PhD; contracting 77 Principal Investigators over 2013–14, and 434 since the scheme's inception in 2001.

The Marsden Fund's contracts are associated with a large proportion of the early career researchers who are supported by government funding. For the 448 Standard contracts awarded between 2008 and 2014, funding was budgeted for post-doctoral researchers in 222 contracts, while post-graduate research positions were budgeted in 335.

Although the Fund gives strong support to those at the very early stages of their research careers, recent years have seen shifts in the type of individual being contracted in supporting roles for research. Since the Fund's inception, the level of Post-doctoral and Research Assistant involvement has declined, both as a relative proportion of the FTE supported by the Fund, and to a lesser degree in absolute terms. Post-doctoral support continues to decline with, by share of contracted FTE, 2013 and 2014 being the 3rd lowest and 5th lowest years on record, and the 4th and 5th lowest levels of Research Assistant involvement. This decline is mirrored by increases in the proportion of contracted FTEs going to post-graduate students; with 2014 being the highest level seen to date. Possible causes relate to the costs of supporting post-doctoral fellows compared with post-graduate students and influences of external factors, such as Performance Based Research Fund evaluations. The Fund remains a significant contributor to building capability in the New Zealand research system.

International Collaborations

The proportion of Marsden contracts that begin as collaborations has grown from 23% of the grants in 1995 to 57% in 2014. The Fund encourages and facilitates international connections, with over a third of the Investigators contracted based in institutes located around the world. International collaboration growth is further enhanced as a Marsden project progresses through its lifespan; for the 204 final reports received in 2013-2014, 52% included overseas researchers at their inception, but by the end of the contract the proportion which reported international collaborations had increased to over 84%. Although no financial support for international investigators is provided through the Marsden Fund, the strong participation of international researchers to New Zealand-led research projects is of enormous benefit in maintaining New Zealand's position in international science, and in facilitating the import of new science and technology into New Zealand.

This report relates to all contracts between MBIE and the Royal Society of New Zealand, which specify a requirement for Investment Impact Reporting (IIR) and on a schedule agreed between the Ministry and the Society. This IIR is limited to the Marsden Fund impacts, and other contracts are not commented on at this time.

Signed on 26 February 2016



Dr Andrew Cleland, Chief Executive
Under Authority delegated by the Royal Society of
New Zealand

Signed on 26 February 2016



Professor Juliet Gerrard
Chair of the Marsden Fund Council

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Investment Impact Report 2014–2015: Marsden Fund

This biennial report series covers the activity of nominated Society-administered programmes over the preceding two years. For the current report, the period spans 2014–2015 of the Marsden Fund.

Background

The Marsden Fund was established by the Government in 1994 to fund excellent investigator-initiated research. It is a contestable fund administered by the Royal Society of New Zealand. The Marsden Fund Council exists to oversee the Marsden Fund on behalf of the Minister of Science and Innovation.

Marsden Fund research benefits society as a whole by contributing to the development of researchers with new knowledge, skills and ideas. The research is not subject to government's short term socio-economic priorities. The Fund supports research excellence in science, engineering and maths, social sciences and the humanities. Competition for funding is intense.

The Marsden Fund Council welcomed the NSSI in recognising the importance of the Fund in the New Zealand research system (<http://www.royalsociety.org.nz/2015/11/03/marsden-fund-council-response-to-nssi/>). The NSSI clearly shows how the Marsden Fund fits into the spectrum of R&D investment, in uniquely providing a platform for new ideas, development and creativity. In its emphasis on excellence, and willingness to fund high risk research, it addresses the core themes of the investment system: excellence and impact. The research outcomes from the Fund, and capability maintenance and development, flow into the more mission-led and commercially-orientated research funded in other parts of the R&D investment system. The Fund has long-term benefit to New Zealand.

Governance

The Fund is operated under the Terms of Reference issued by the Minister of Science and Innovation, updated in 2012. A Marsden Fund Council of up to 11 eminent researchers, currently chaired by Professor Juliet Gerrard, is appointed by the Minister of Science and Innovation to make recommendations for funding. Ten panels have been established across the range of disciplines to help the Marsden Fund Council assess proposals. In accordance with the Terms of Reference, selection criteria focus on: the research merit of the proposal; the potential of the researchers to contribute to the advancement of knowledge; and the enhancement of research skills in New Zealand, especially those of emerging researchers.

The Marsden Fund Council regularly reflects on the Fund's strategic direction. In the last two years, it has had a focus on demonstrating the long-term benefit of the Fund and ensuring that emerging researchers were supported while the Terms of Reference were refreshed. In August 2015 the Council updated their strategy for the period 2015-2017. The Council has prioritised the following actions:

1. To communicate the value of the Marsden Fund to stakeholders and the public and provide a clear idea of how the Council would allocate any new resources (when they become available).
2. Refresh the commitment of the Marsden Fund to Vision Mātauranga through a review, including consultation with external stakeholders, of how Vision Mātauranga is implemented in the selection round.
3. Clarify the Marsden Fund's position in New Zealand's funding landscape; confirm the Fund's role within the NSSI; and strengthen relationships with other agencies (including the Society).

Scope and Scale of the Fund

This Impact Investment Report reports on activities related to the Marsden Fund from 1 July 2013 to 30 June 2015, covering the past two fiscal years (FY).

The Marsden Fund operates as a separate Output Class under the Ministry of Business, Innovation and Employment, non-departmental output classes. In FY 13/14 and 14/15, the Marsden Fund output class had investment budgets of respectively, \$49,255,000 and \$52,383,000 per annum (GST exclusive). During this time, 579 research contracts were operational. There were 109 new contracts funded in FY13/14 at a cost of \$58,965,214 and 101 new contracts funded in FY14/15 at a cost of \$55,687,000. Data on the historical growth of the Fund and the support given to discipline areas in past years are given in 'Appendix 1 – Scope and Scale'.

The Fund uses a two-stage selection process to reduce effort for all involved. In the first round, preliminary one-page proposals are assessed by panellists from New Zealand and Australia. In the second round, five-page proposals are scored by three independent reviewers; in the 2013 and 2014 rounds 99% of the reviews were from overseas. Proposals are then selected by panels on the basis of the independent review judgements, the applicants' rebuttals, and panel discussions.

The success rates for Standard and Fast-Start proposals has fluctuated around the 8% and 10% levels respectively, with long-term trends shown in Figure 1 below. The two years of this report are consistent with the long-term trend. This low success rate does not reduce the numbers of applications received which trend upwards each year. The long run trend for the Marsden Fund has been an increase of 30 preliminary proposals per year ($R^2 = 0.77$), with no expectation that this increased demand will reduce. In 2014 we received 1222 proposals.

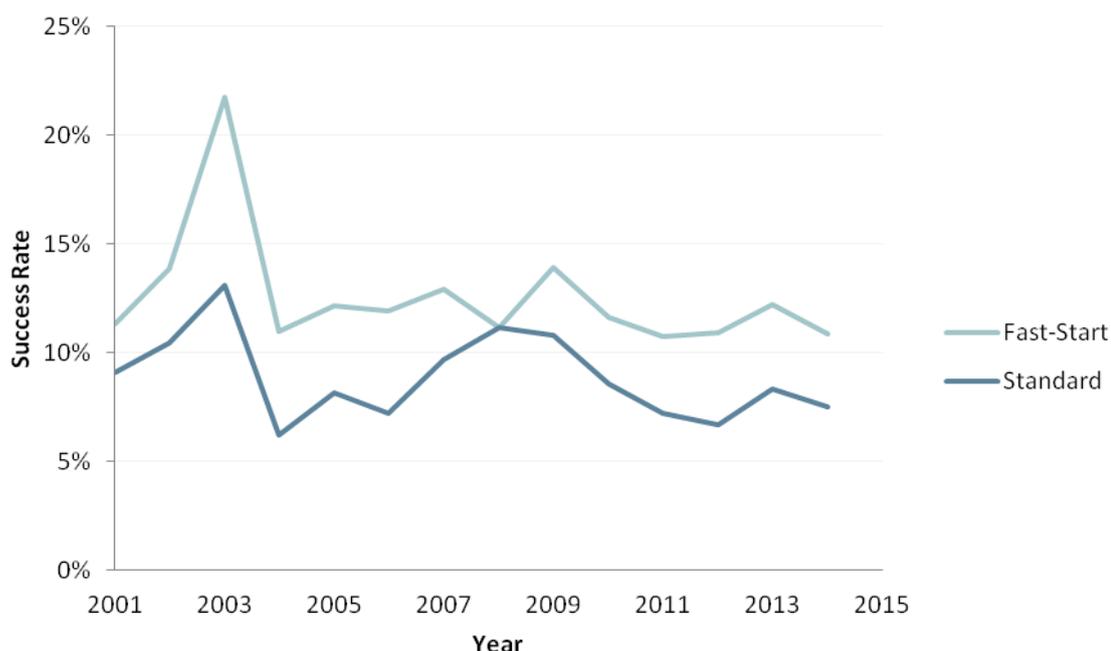


Figure 1. Success rate for Standard and Fast-Start proposals to the Fund, 2001–2014. Surplus funds were released in 2003 resulting in an atypically high success rate for that year.

Although only 8% of proposals were funded over the years considered in this review, approximately 15% were graded as excellent by international peer-review. There is potential to significantly increase investment to fund more applications (and likely increase the impact proportionally), without diminishing the quality of funded research.

Research Productivity and Quality

The contracts under the Marsden Fund continue to publish in the world's premier journals. Figure 2 below shows the number of articles published in journals in the top 2% of the Scimago Journal Ranking for 2014, while Figure 3 describes the productivity of the Fund in totality, and in terms of peer-reviewed publications per million dollars of Government investment.

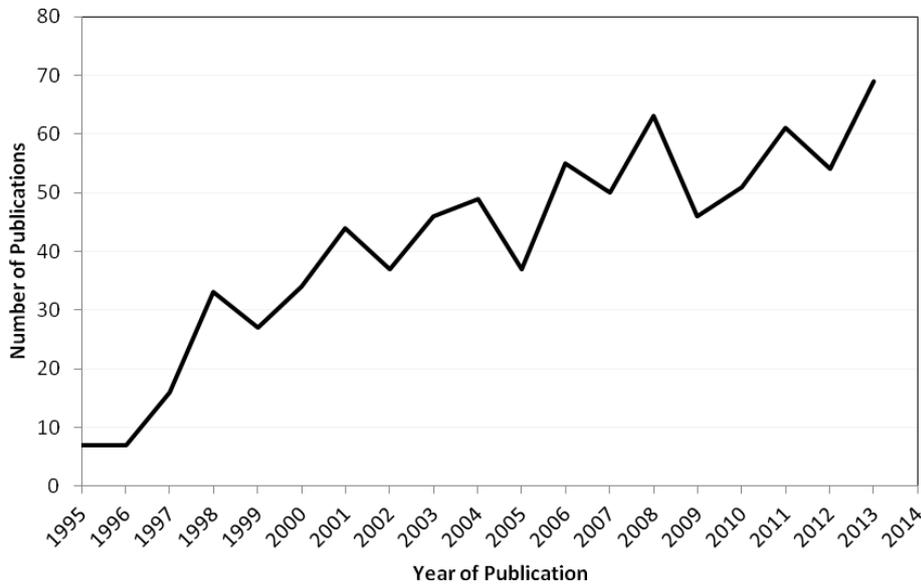


Figure 2. Number of Marsden Fund-attributed articles published in journals in the top 2% of the 2014 Scimago Journal Ranking. Data for 2014 and 2015 not yet complete due to reporting cycle.

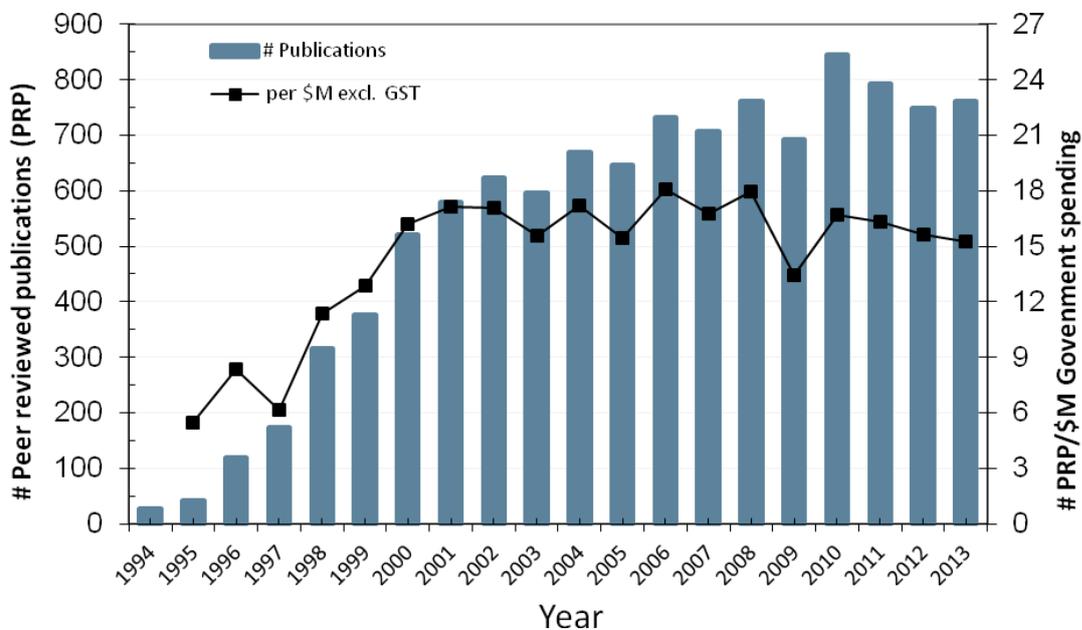


Figure 3. Count of the published output of the Fund (papers, refereed conference proceedings, books and book chapters), and output expressed as the ratio of published output to nominal Govt investment. Data for 2014 and 2015 not yet complete due to reporting cycle.

The source data for the Figures is set out in Appendix 2.1 Research Productivity.

A government initiative, 'Reducing Transaction Costs', was introduced in 2010 with the intention of lowering the transaction costs associated with applying, reviewing and reporting on grants for research within the Science and Innovation sector. Within the different cost saving initiatives was one to lessen the burden on researchers by reducing the number of reports required for each Marsden funded project from three to two, omitting the second-year report. A consequence is that the output measurement for some publications is delayed a year, and thus total output is systematically undercounted in the two most-recent years. Thus, data for 2014 are not yet available.

The effect of the Marsden Fund on scholarly output and research impact

The impact of participating in the Marsden Fund on a researcher's publication productivity and citations were estimated through an independent evaluative project undertaken in collaboration with Motu Economic and Public Policy Research.¹ This study was enabled by the quality of the long-term records kept for the Marsden Fund by the Society.

The performance of funded researchers was compared with those who were invited to submit proposals to the second round but were not funded. Two separate approaches were used: firstly, having the proposal as the unit of analysis and considering the publications from all members who were named at any point in that proposal or subsequent contract; and secondly, investigating the effect of interactions with the Fund over time on individuals.

For teams, funding was found to be associated with a 6-15% increase in publications and a 22-26% increase in citation-weighted papers. In the second approach, for individuals, funding is associated with a 3-5% increase in annual publications and a 5-8% increase in citation-weighted papers for 5 years after grant, with subsequent funding expected to have additive effects, see Figure 4 below.

With the high number of "excellent" or better rated proposals considered by the Marsden Fund, coupled with the low success rates (see Scope and Scale of the Fund, and Appendix 2.2 Research Quality), it is perhaps no surprise that ranking in Marsden's second round was not found to be significantly predictive of future career success. Rather, the very existence of the Marsden Fund and its processes appears to be successful in increasing both scholarly performance and proxies for scholarly relevance. This is consistent with a positive impact on researcher development.

¹ "The effect of public funding on research output: the New Zealand Marsden Fund". Available here <http://motu.nz/our-work/productivity-and-innovation/science-and-innovation-policy/the-effect-of-public-funding-on-research-output-the-new-zealand-marsden-fund/>

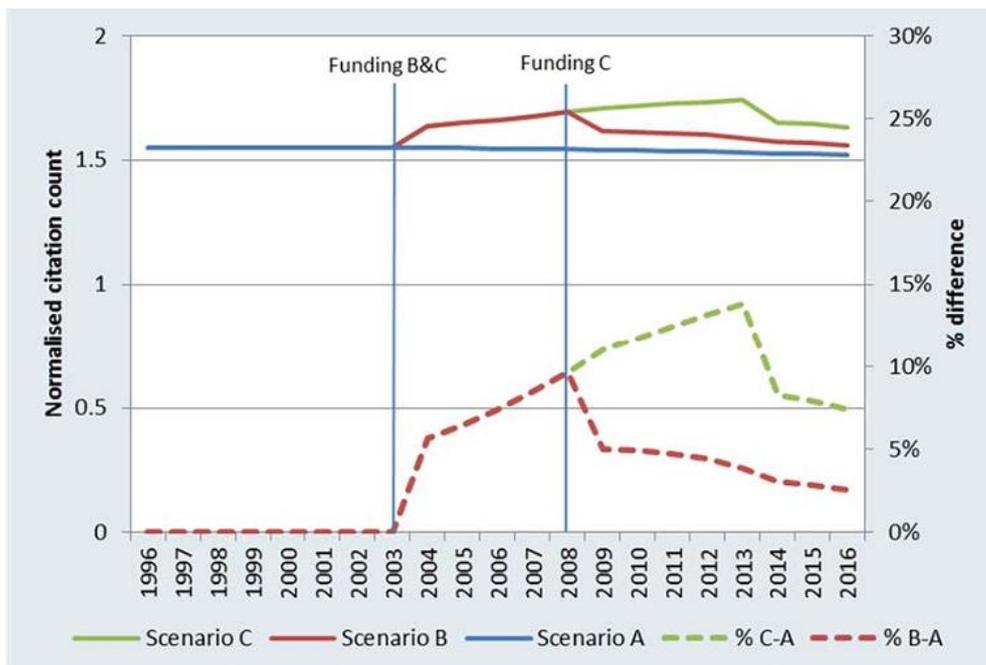


Figure 4. Modelled effect of Marsden Funding on the typical researcher’s citations. The researcher in Scenario B is funded in 2003, while Scenario C is funded twice in 2003 and again in 2008; Scenario A describes the control situation of a researcher who is participating in Marsden but is unsuccessful. Taken from “The effect of public funding on research output: the New Zealand Marsden Fund”.

Post-Contract Impact Evaluation

The Marsden Fund is unusual in the New Zealand Science and Innovation system in that it systematically reviews the intermediate term outcomes of its contracts through site-visits of completed contracts by research-literate staff. These site-visits occur between the first and second anniversary of the contract’s close and provide an opportunity for Marsden researchers to discuss the outcomes of the projects, the consequence for themselves and their staff and students, and ongoing work together with less-structured and informal comments, such as their views on the New Zealand funding system.

The Society has recently undertaken a pilot study to determine whether the scripts from these semi-structured interviews are amenable for analysis. The scripts from 63 site-visits conducted over 2012–2014 were subjected to a Qualitative Data Analysis research strategy. This pilot study found that:

Almost all (97%) of contractors felt their contracts were successful in improving human knowledge within their specialist domain(s), aligning with the objectives of the Marsden Fund under its Terms of Reference. Similarly high proportions believed that their Marsden grant had enabled collaboration to occur with international experts (84%),

“The contract helped cement international collaborations with Germany and major new collaborations with North American and Australian scientists (NSF-funded).”

“The funded research has led to international collaborations with leading scholars... and other early career researchers who are making significant impacts on the field”

and had resulted in learning, or creating, new skills (79%).

“The Fast-Start occurred when I was starting as an independent researcher so it helped facilitate the set-up of new skills that continue on in my research group”

When asked of the effect of the grant on their research progress, solid majorities have consistently reported that the Marsden Fund had enabled research that would not have been possible otherwise (see Figure 5).

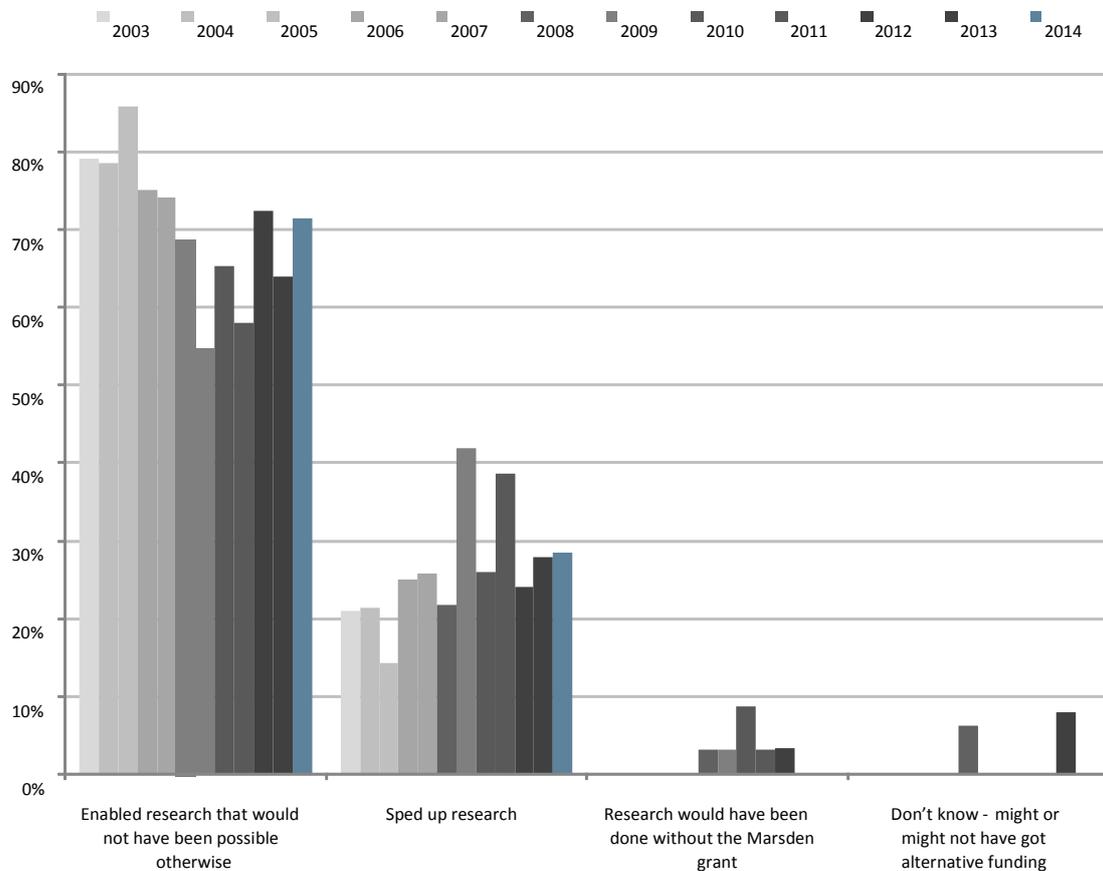


Figure 5. Proportion of responses to the question: “What effect has the grant had on research progress?”

“This important research project is unlikely to have gone ahead without Marsden funding. The funding allowed us to carry out an ambitious, theoretically innovative and empirically grounded research project that holds important insights into policy decision making in the area of new technologies.”

In terms of impact, 68% felt they had made an impact on the body of knowledge in their research discipline, with 48% concluding novel research, and 40% believing they’d achieved a first for their field.

“Ours is the only existing methodology for doing this.”

Beyond the researchers' research domain, equal numbers stated that their research finding had impact in the areas of human health or that it was of broad multi-domain relevance (both 17%).

“Many of the studies generated from this project go well beyond the initial aims and also beyond the field.”

When asked of the translation of their research outside the scholarly sphere the following beneficiaries were noted: industry/business (6%); society (5%); central government (3%); and, education (3%). It should be noted that these forms of impact often take many years so measurement just one–two years post-completion will underestimate the eventual total impact.

“These results will include answers to questions such as who should pay for networks: consumers or generators?”

Slightly less than half (44%) indicated that they were directly extending the research programme begun with their Marsden contract.

Most Marsden contractors (78%) believed that the Marsden Fund had been a positive influence on the morale of themselves, and their teams. A majority (60%) also volunteered their belief that the Fund was necessary for New Zealand.

“The Marsden Fund has had a profound influence on the research environment in New Zealand, and for many research fields, provides the only means of conducting externally funded basic research that is internationally competitive. It also provides crucial funding for recruiting and retaining skilled personnel in the form of post-doctoral fellowships. The Marsden Fund has been essential for my own personal research programme, and without this funding source, I would be unable to conduct research in New Zealand.”

These responses reinforce our conclusion that the existence of a Fund, which attracts so many applications, helps to develop researcher skills even amongst those who are not funded.

We are exploring methods to investigate impacts at longer time frames. If sufficient resources were available within the Society's research contract management funding, this type of post-contract evaluation could be incorporated into the regular administration of the Marsden Fund.

Marsden 20th Anniversary: Case studies and promotion activities

With the Society's administration of the Marsden Fund having begun in 1995, 2014 marked the 20th anniversary of the Fund. Celebrations throughout the year, launched at Parliament by the Minister, allowed the Fund to highlight the ground-breaking research that Marsden-funded researchers have carried out for the benefit of all New Zealanders. Together with the Marsden Fund Council, the Society initiated three promotion activities: 'We're looking into that', a bill-board series supported with web-based media; "Ten by Ten", a tour of 10 Marsden researchers to 10 different centres; and, "Infrequently Asked Questions", an ongoing blog allowing the community to ask questions and engage with Marsden researchers.

Case studies of twelve researchers and their research programmes that have received serial Marsden Support are presented in Appendix 3 – Case studies from 20-years of the Marsden Fund. For more detail on these and the Marsden 20 celebrations, see the 50th edition of the Marsden Update:

<http://www.royalsociety.org.nz/media/2015/06/Marsden-Update-50.pdf>.

Building Human Capacity

The Marsden Fund continues to strongly support New Zealand's emerging researchers, through both the Fast-Start scheme and Post-doctoral researchers funded within Standard grants. The Fast-Start scheme was started in 2001 as a minimally funded two-year scheme (\$44.4k per year for two years, ex-GST). This scheme now awards \$100k per year for three years. The three-year timeframe for Fast-Start contracts has made a large impact on attracting PhD students to these emerging researchers' projects. This along with the incentives from the Tertiary Education Commission for PhD student support have dramatically increased the number of postgraduate students supported by Marsden funded grants. Figure 6 shows the proportion of total full-time equivalent (FTE) contracted in each round from 1995 onwards, for both Standard and Fast-Start grants. The increase in postgraduate students is offset somewhat by the decrease in post-doctoral researchers during the same timeframe.

The Fund's maximum grant size is set to balance the requirements for fully costing research while maximising success rate. The rate of international research cost inflation (which is believed to be significantly higher than New Zealand domestic inflation) has not yet been reflected in an increase in the Fund, which would enable a lifting in the maximum grant size. This creates a challenge for the affordability of post-doctoral fellows in some panels with consequences for the impact of the Fund, as post-doctoral researchers are expected to be more productive than post-graduate students. Shifts in the ratio of post-doctoral researchers: post-graduates are also contributing to research workforce imbalance. The Marsden Fund Council keeps a watching brief on these tensions across panels, and has signalled that it will lift the cap in the more expensive disciplines when the Fund increases.

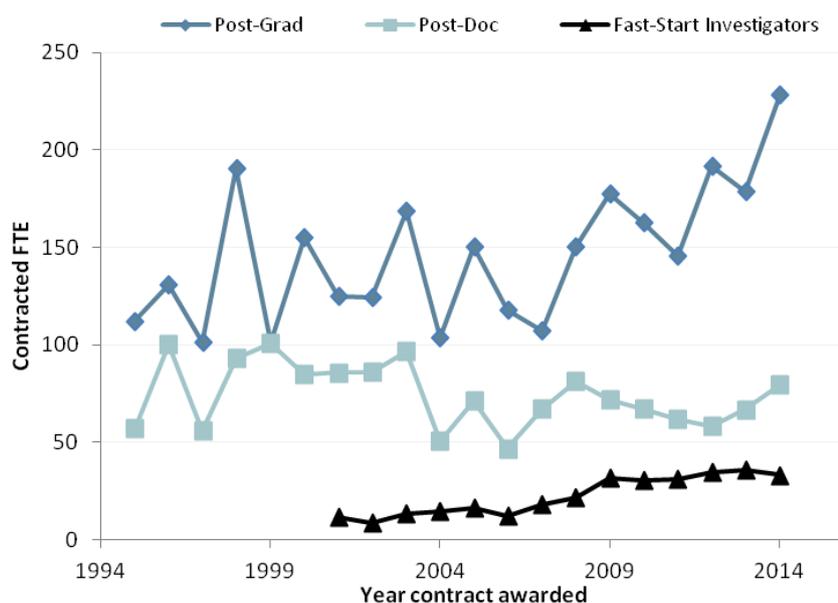


Figure 6. FTE contracted by Marsden grants going to different emerging and early career roles

For more information please refer to Appendix 2.3.2 New and Emerging Researchers.

Many researchers supported by the Marsden Fund are recipients of prizes, appointments, and awards. Reporting from Marsden contractors reveal winners of the Prime Minister's Scientist award; the Rutherford, Callaghan, Hector, Shorland, Marsden, and Verco Medals; and admission to the New Zealand Order of Merit; as well as other evidence of national and international recognition including election to international scholarly academies.

Figure 5 shows that the Marsden Fund supports a larger number of emerging researchers than would be expected from New Zealand's distribution of researchers. This is in part due to the Fast-Start scheme, but is also shown to be true within the Standard scheme. The contracts over the past five years have shown this consistent trend of younger Principal Investigators (PIs). In fact, for the past five years 41% of PIs and 28% of Associate Investigators (AIs) have been within the first 10 years of their PhDs (see Figure 7 below).

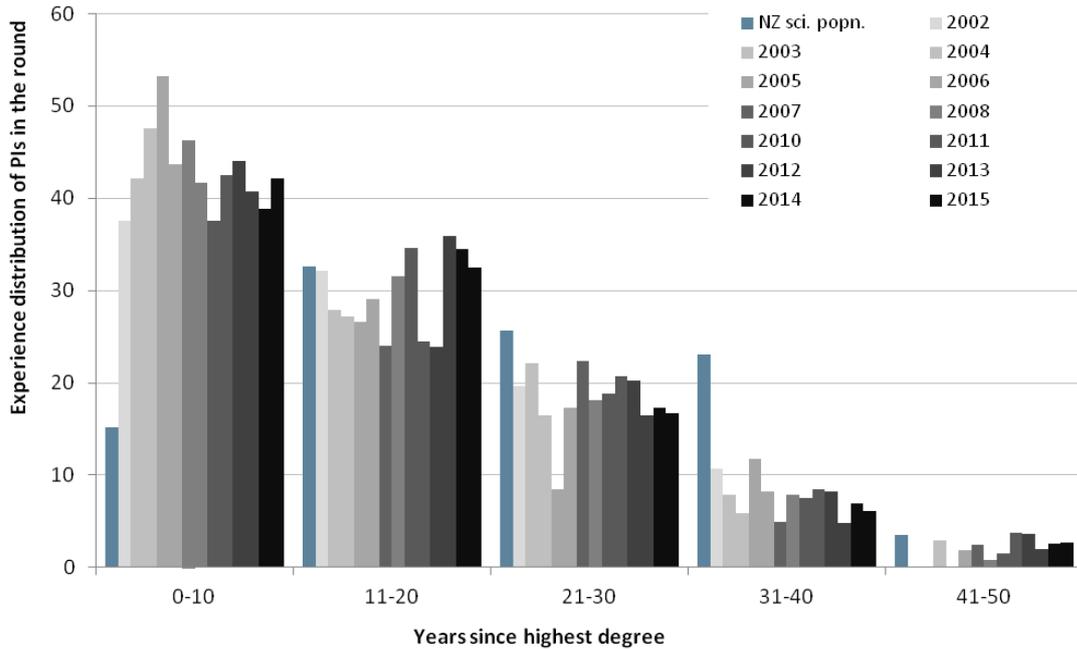


Figure 7. Experience of principal investigators (PIs) on contracts awarded from 2000–2013, as estimated from the number of years since the principal investigator obtained their highest degree

The percentage of PIs who are women was a record for the Fund in the 2014 round at 38%, which was in turn beaten by the 2015 round’s figure of 44% (see Figure 8). The Marsden Fund Council will continue to monitor this trend. Of note, the number of women PIs and AIs is consistent with the number of women applicants, and shows no obvious bias in funding (in either direction).

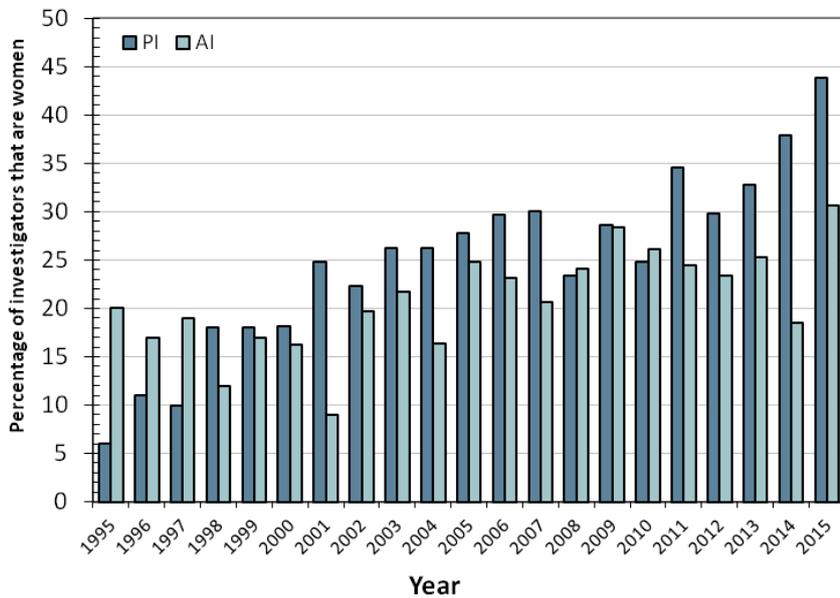


Figure 8. Proportion of principal (PI), and associate (AI), investigators who are women

Also of note in the early years of the Fund’s operation, women applicants were more likely to be Associate than Principal Investigators; a trend which has reversed in the later years. Appendix 2.3.3 Women Researchers has further statistical information.

For contracts initiated throughout 2011–2015, Māori researchers were involved with 7.4% of the projects as an investigator. Over the same period, the percentage of all investigators who self-identify as Māori was 3.8%, and of New Zealand-based investigators was 4.8%. Appendix 2.3.4 Māori Researchers has further statistical information.

Collaborations and International Research

The proportion of Marsden contracts that involve institutional collaborations has steadily increased over the years. In 1995, 77% of projects involved investigators who were from a single institution, but by 2003 the degree of collaboration supported by Marsden reached its current high state, such that only 40% of contracts (of which many are Fast-Starts) are not contracted as multi-centre collaborations at their inception (see Appendix 2.4 Collaborations and International Research). At least three quarters of the contracts reporting collaborations involve international investigators while in recent years only a third to a half possessed national partners.

Conclusions

Operation of the Marsden Fund

The Marsden Fund's process continues to have significant impact. Close attention is paid to maintaining quality in the peer-review process used to assess proposals, and to the overall management of the contracts through reporting and assessment of the research.

The Society has supported the Marsden Fund to realise its full potential impact through sound administration of the Fund and the conduct of evaluations such as the post-contract impact evaluation pilot, and the collaboration with Motu Economic and Public Policy Research resulting in "The effect of public funding on research output: the New Zealand Marsden Fund".

Impacts and effectiveness of the Marsden Fund

This report shows that the Marsden Fund has been effective in meeting its primary objectives as specified in its Terms of Reference. The Fund has had an impact through:

- Consistently funding excellent researchers and research projects to the limits of the funding available;
- Increasing international collaboration, leading to global connectedness with international partners;
- Developing advanced skills, and supporting early- and emerging-career researchers through the Fast-Start awards and the support of post-doctoral researchers;
- Advancing the body of global knowledge; and,
- Longer-term realisation of some of the new knowledge in the form of economic, social, health and environmental impacts

The Marsden Fund Council has continued to provide significant additional value through their participation in the NSSI consultation and their continued leadership and guidance in directing the Fund.

Appendices

Appendix 1 – Scope and Scale

The Marsden Fund has increased in size since its inception 21 years ago, and currently stands at \$53.627 million (\$61.7M including GST) following its increase by \$5 million in the 2013/14 budget and the re-phasing of \$1.872 million from 2013/14 to align with funding of contracted payments. The Fund baseline is expected to return to \$51.755 from 2016/17.

Each year, approximately one third of the Fund's budget becomes available for new projects. In 2014/15 and 2015/16, funding totalling \$55.69 and \$53.54 million respectively were awarded to contracts to run over the following three years. Figure A1 shows the trends in both Government funding and the Fund's disbursement.

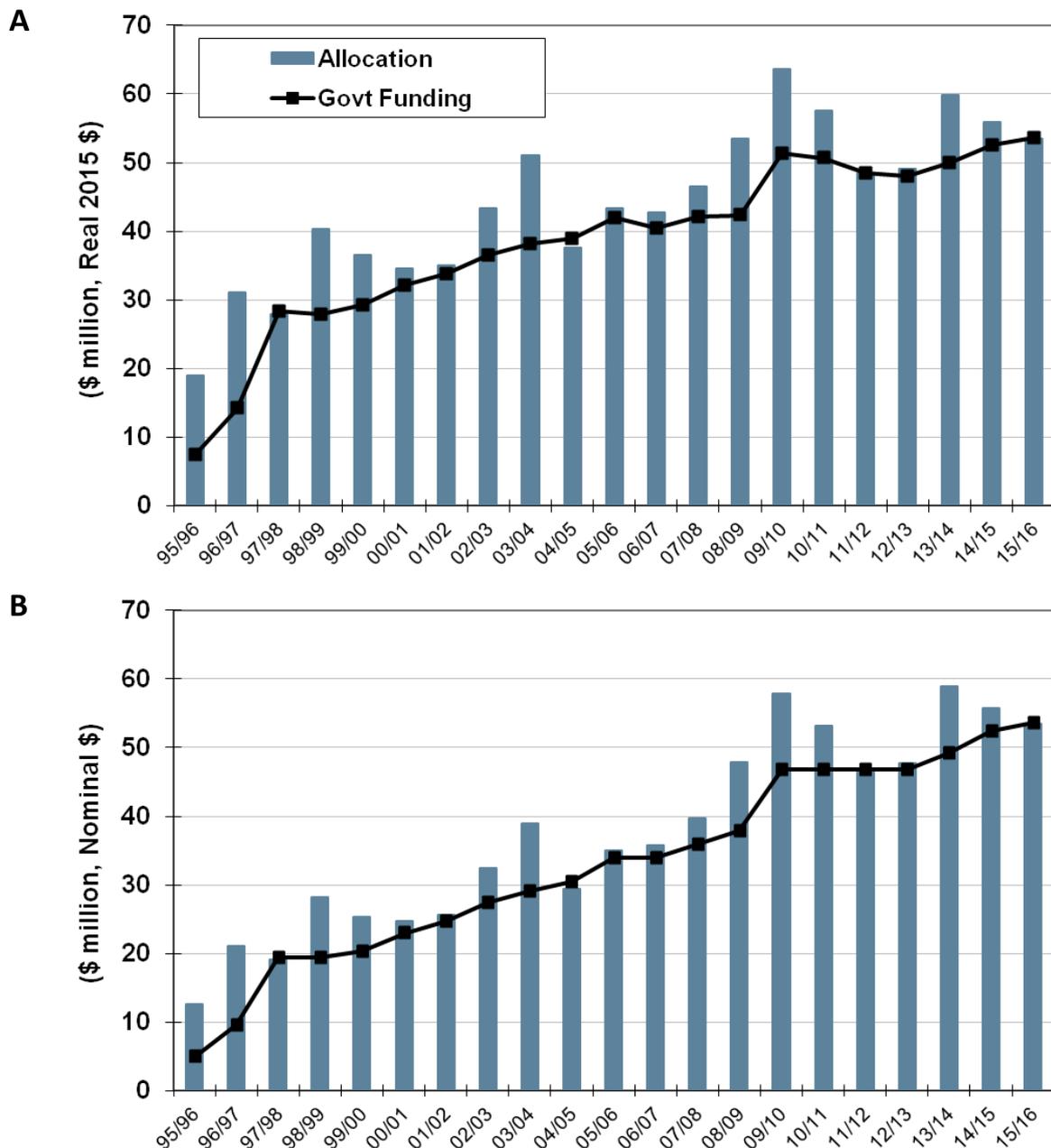


Figure A1. Panel A: Funds allocated to new Marsden Fund projects (in Millions of 2015 dollars using the Sept release of the CPI SE9A series, GST-exclusive). Panel B: Funds allocated to new Marsden Fund projects (in Millions of nominal dollars, GST-exclusive).

Year	Standard			Fast-Start		
	Proposals	Contracts	Percentage	Proposals	Contracts	Percentage
2003	612	77	12.6%	129	28	21.7%
2004	744	46	6.2%	228	25	11.0%
2005	701	55	7.8%	198	24	12.1%
2006	722	52	7.2%	210	25	11.9%
2007	693	65	9.4%	217	28	12.9%
2008	593	66	11.1%	224	25	11.2%
2009	675	73	10.8%	259	36	13.9%
2010	795	68	8.6%	294	34	11.6%
2011	783	57	7.3%	296	32	10.8%
2012	811	54	6.7%	302	32	10.6%
2013	827	69	8.3%	328	40	12.2%
2014	881	66	7.5%	341	37	10.9%

Table A1. Success rates for Standard and Fast-Start proposals

The distribution of the Fund by research area over 2002 to 2013, is shown in Table A2 and Figure A2 below. 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 in the current round and the immediate past.

Panel†	Round									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CMP	\$4.9	\$5.2	\$6.7	\$8.3	\$6.4	\$5.3	\$4.4	\$6.0	\$5.2	\$4.9
BMS	\$4.4	\$5.1	\$6.8	\$8.8	\$6.9	\$5.6	\$4.8	\$5.8	\$6.4	\$6.0
EEB	\$5.8	\$6.9	\$7.6	\$8.5	\$8.9	\$7.3	\$6.3	\$8.1	\$7.6	\$7.2
ESA	\$3.8	\$4.3	\$5.2	\$6.3	\$7.4	\$5.9	\$4.9	\$6.9	\$6.0	\$5.5
PSE/PCB	\$5.0	\$5.7	\$6.2	\$8.5	\$6.5	\$5.3	\$4.5	\$6.1	\$5.7	\$5.2
EIS					\$6.2	\$5.4	\$4.1	\$6.0	\$4.9	\$4.9
MIS	\$2.6	\$2.9	\$3.6	\$5.1	\$3.3	\$4.1	\$4.4	\$4.2	\$4.4	\$4.5
EHB	\$2.5	\$3.5	\$3.8	\$3.7	\$4.1	\$4.0	\$4.3	\$5.1	\$4.4	\$4.7
SOC	\$3.6	\$3.8	\$5.1	\$6.3	\$6.6	\$6.6	\$6.1	\$6.3	\$7.2	\$7.1
HUM	\$2.2	\$2.3	\$2.8	\$3.3	\$3.4	\$4.3	\$3.5	\$4.4	\$3.8	\$3.5

Table A2. Distribution of Marsden support by research discipline over time

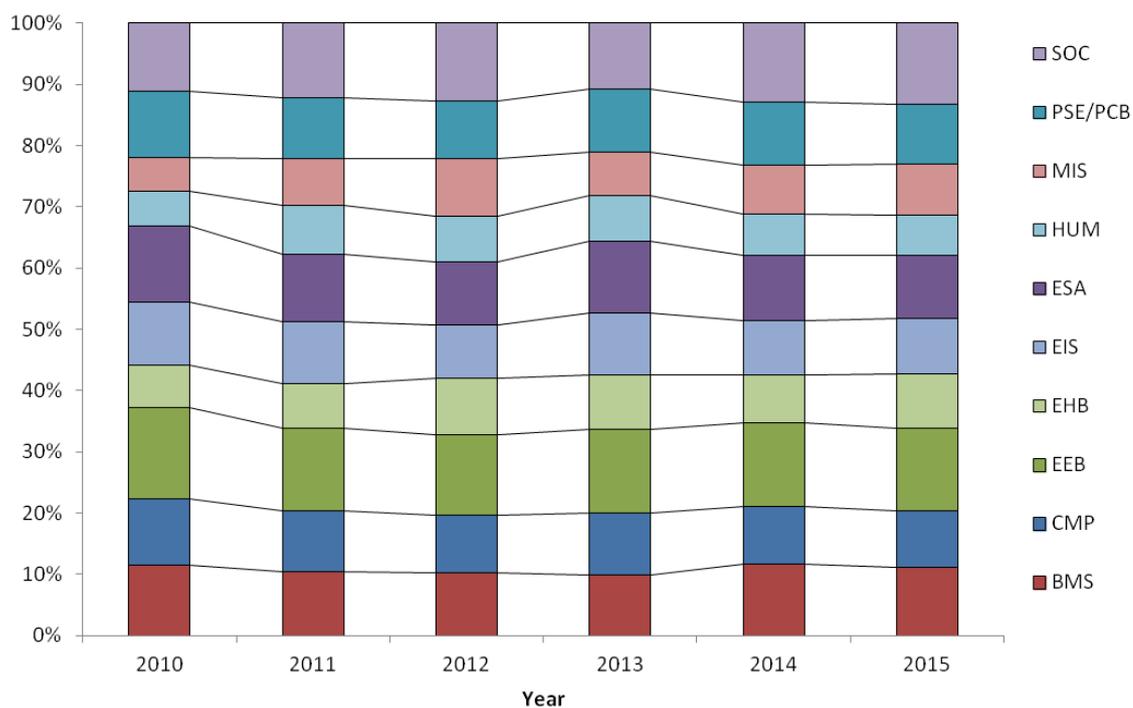


Figure A2. Share of funding by research area† for new contracts and year of award
 †The research areas are: BMS - Biomedical Sciences, CMP - Cellular, Molecular & Physiological Biology; EEB - Ecology, Evolution and Behaviour; EHB – Economics and Human and Behavioural Sciences; EIS – Engineering and Interdisciplinary Sciences; ESA - Earth Sciences and Astronomy; HUM – Humanities; MIS - Mathematical and Information Sciences; PSE/PCB – from 2010 Physics, Chemistry and Biochemistry, prior to this Physical Sciences and Engineering; and, SOC - Social Sciences.

For the last two rounds of contracts: 35% of the funding allocated was to the medical and life sciences; 37% to the physical sciences, engineering and mathematics; and 28% to the social sciences and, humanities. The disciplinary spread has been relatively constant since the creation of the EIS panel in 2010.

Appendix 2 – Quantitative Indicators

2.1 Research Productivity

Building New Zealand’s Knowledge Base

Year of Publication	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	All Years
Papers	437	482	478	558	541	567	502	631	506	364	559	429	8519
Refereed Conference Proceedings	76	102	81	96	88	98	103	93	63	54	112	88	1483
Book Chapters	67	75	73	65	67	80	71	83	62	46	75	53	1113
Books	16	11	13	11	11	16	14	19	15	11	16	5	192
Edited Volumes	6	13	8	13	8	9	14	8	5	8	11	8	141
Reports	16	9	14	7	8	7	19	18	10	7	13	18	257
Patents	4	4	5	3	3	3	1	2		1	3	2	47
Software	2	1	3	4	3	2	4	4	1		9	5	46
Total	624	697	675	757	729	782	728	858	662	491	798	608	11798

Table A3. Publications, patents and software reported as directly attributable to Marsden contracts

NB: 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 for at least a decade post-publication.

Year of Activity	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	All Years
Invited conference talk	175	214	229	208	235	225	219	322	205	128	226	137	3190
Contributed conference talk	319	291	332	308	446	321	369	408	291	184	369	212	5648
Conference poster	119	142	176	177	141	155	133	187	139	83	138	79	2546
Other†	58	89	102	88	117	91	118	135	94	41	73	88	1299
Total	671	736	839	781	939	792	839	1052	729	436	806	516	12683

Table A4. Dissemination of Marsden results through conferences and other channels

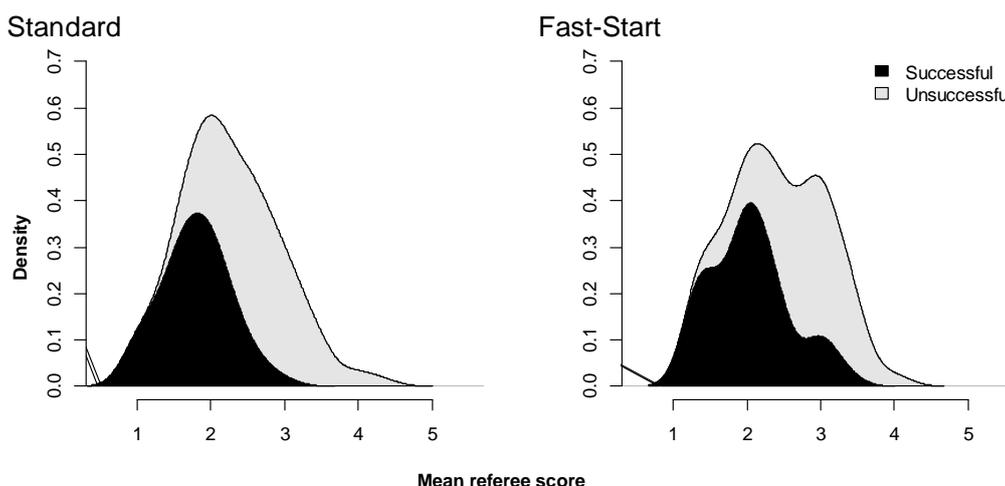
†Types of other output include: articles in non-specialist journals, gene sequences deposited in public databases, reagents developed, documentaries, radio interviews, websites, online databases, CDs distributed, and editorials and letters in specialist journals.

As proposed in IIR 2013, the apparent reduction of publications attributed to the Marsden Fund in recent years is revealed as an artefact of the staggered reporting introduced as part of the Society’s approach to 'Reducing Transaction Costs', i.e., rather than 2012 having the lowest publication output in 15-years productivity for 2012 is revealed as typically high with subsequent reporting, see Figure 3.

2.2 Research Quality

The quality of Marsden-funded research is ensured by rigorous selection procedures, including peer review of all proposals that proceed to the second stage of the evaluation process. The following figures show that projects receiving funding are typically judged as being excellent–outstanding by their, predominantly, international reviewers.

2013 Round:



2014: round:

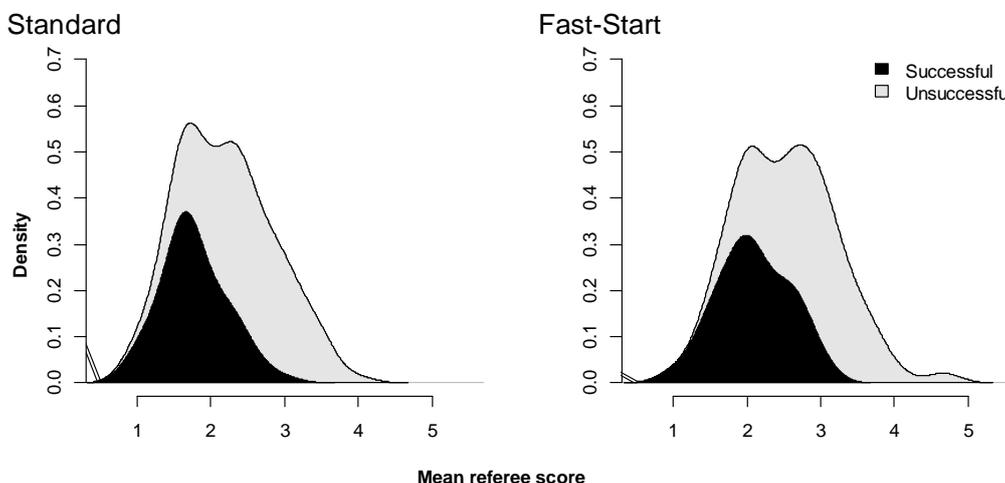


Figure A3. Distribution of the average referee score received for both funded and unfunded proposals to the 2013 and 2014 funding rounds.²

The vast majority of successful Standard and Fast-Start proposals come from this highest ranked, “Excellent” to “Outstanding”, group. As can be seen from these charts, there are many proposals judged as excellent–outstanding but which are unsuccessful due to funding limitation.

² 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”.

2.3 Building Human Capacity

2.3.1 Principal and Associate Investigators

The Marsden Fund has supported established researchers by funding contracts that started over 1995 to 2015 involving 3185 distinct investigators (spread over 2520 principal investigator and 2774 associate investigator roles). The Fund maintains its high international presence with 490 of the 1437 (i.e., 34%) individuals contracted as investigators over 2008-2013 based outside New Zealand.

Investigators	2010	2011	2012	2013	2014	2015	Individuals†
Principal	133	107	104	134	117	114	2520
Associate	138	147	120	196	167	163	2774
All	270	250	222	324	276	276	3185

Table A5. Number of investigators associated with Marsden projects contracted in the year
†The total number of individuals contracted through 1995–2015.

2.3.2 New and Emerging Researchers

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

Over 2010 to 2015, 204 Fast-Start contracts were awarded to researchers who have had no more than 7 years of research experience since completing their Ph.D (34 in 2010, 32 in both 2011 and 2012, 40 in 2013, 37 in 2014, and 29 in 2015).

The Marsden Fund's contracts are associated with a large number of the post-doctoral researchers supported by government funding. Of the 489 contracts awarded between 2010 and 2014, funding has been available for post-doctoral fellows in 162, i.e., roughly a third of them. Of note, while this represents a total contracted FTE of 341, this is an overall decline in the level of post-doctoral support directly attributable to the Fund.

For the contracts awarded between 2010 and 2014, 322 requested funding for post graduate students, i.e., 66% of contracts compared with 52% of contracts let between 1996 and 2000. In the three most recent years for which contracts have been awarded, the Fund provided support for a total of 596 FTE in postgraduate positions.

Although the Marsden Fund gives strong support to those at the very early stages of their research careers, recent years have seen shifts in the type of individual being contracted in supporting roles for contracted research. Since the Fund's inception, the level of post-doctoral and research assistant involvement has declined, both as a relative proportion of the FTE supported by the Fund, and to a lesser degree in absolute terms. Post-doctoral support continues to decline with 2014 supporting to the fifth lowest level of post-doctoral involvement, and the highest level of post-graduate involvement (as a share of contracted FTE) over the Fund's history (Figure A4).

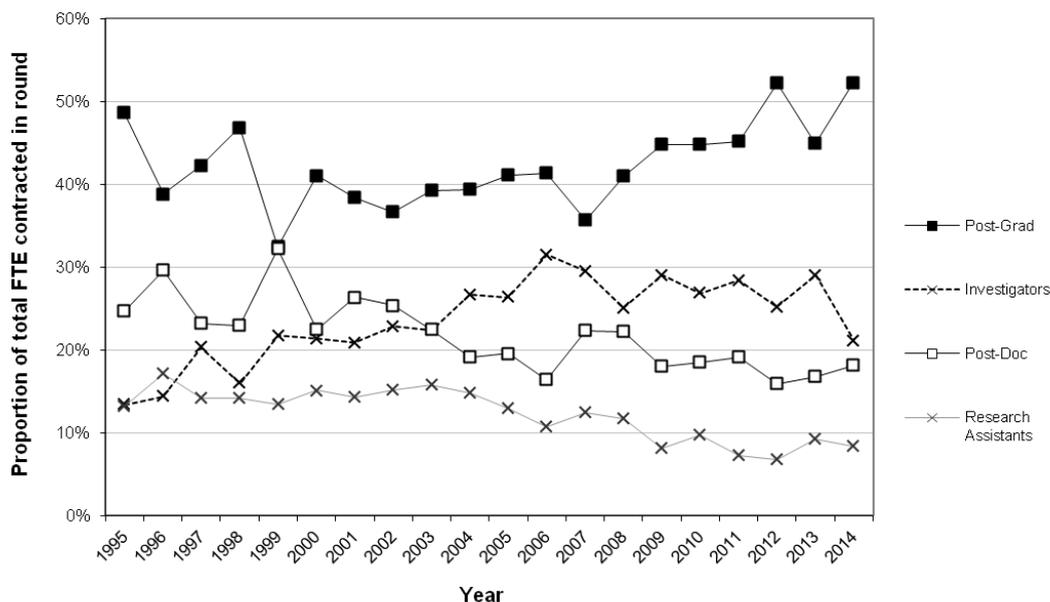


Figure A4. Relative proportions of the FTE contracted by Marsden grants going to different roles

Over 2010 to 2015, 41% of principal investigators, and 29% of associate investigators, were within 10 years of completing their Ph.D (that is, in most cases, are assumed to be under 37 years of age).

Since 83% of contracts are in the sciences, 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”.^{3,4} The participation of emerging researchers is significantly greater than would be expected from demographic considerations alone (see 0).

³ Sommer J (2010) "2008 Survey of New Zealand scientists and technologists" New Zealand Science Review 67(1):1–40.

⁴ Note: the horizontal variables (years since highest degree and age, respectively) have been matched by assuming that the highest degree is obtained at 26 years of age.

2.3.3 Women Researchers

In the 2015 round, 44% of the PIs on successful applications are women, making this the highest year to date.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	All (2000–15)
Preliminary	32.7	33.8	34.2	35.5	35.7	34.1	38.5	35.8	37.3	38.2	37.1	34.2
Contracts	36.7	37.7	35.5	30.8	32.1	31.4	40.4	32.6	39.4	40.8	46.7	35.2

Table A6. Proportion of proposals at each stage having a female principal investigator

As can be seen from Table A6, proposals to the Marsden Fund are awarded to female PIs at approximately the rate at which they apply (i.e., yearly success rates are independent of PI-gender, $\chi^2 p \sim 0.84$).

2.3.4 Māori Researchers

For contracts initiated throughout 2011–2015, Māori researchers were involved with 7.4% of the projects as an investigator. Over the same period, the percentage of all investigators who self-identify as Māori was 3.8%, and of New Zealand-based investigators was 4.8%.

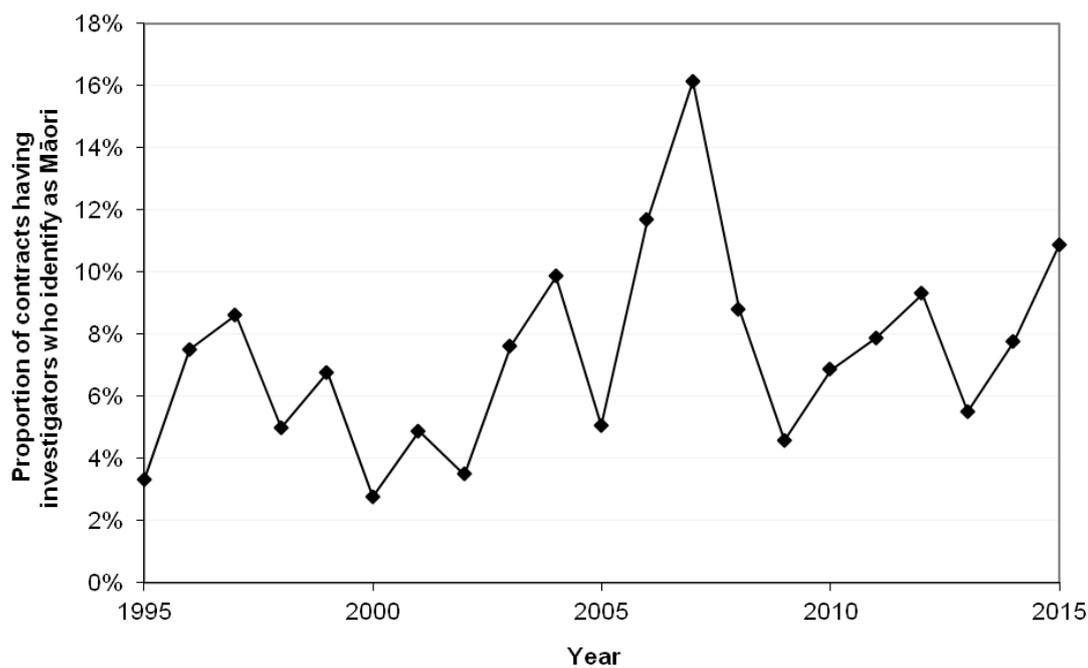


Figure A5. Percentage of contracts with investigators identifying as Māori

2.3.5 Statistical Compendia of Participation

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Investigators – Number of separate individuals acting as principal ⁵ and/or associate ⁶ investigators on current contracts	924	942	943	964	1056	1123	1133	1159	1191	1190
Emerging and early career researchers – Percentage of PIs on contracts awarded in the funding round who have received their highest degree within the last 10 years	53%	44%	46%	42%	46%	38%	43%	44%	41%	39%
Post-doctoral fellows ⁷ – Percentage of Standard contracts in the year's funding round having FTE for post-doctoral fellows	51%	40%	41%	40%	36%	41%	49%	50%	50%	52%
Students ⁸ – Percentage of contracts in the year's funding round which support postgraduate students	58%	54%	53%	62%	62%	62%	64%	63%	63%	72%
Women – Percentage of PIs on contracts awarded in the funding round that are women	28%	30%	31%	24%	29%	25%	35%	30%	33%	38%
Māori – Percentage of PIs and AIs on contracts awarded in the funding round identifying as Māori	1.8%	4.6%	6.6%	4.4%	2.8%	3.0%	4.3%	5.0%	1.9%	4.0%

Table A7. Participation in Marsden contracts, 2005–2014

⁵ 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

⁶ AIs – Associate Investigators – researchers who play a lesser role than principal investigators and sometimes are involved with only limited aspects of the work.

⁷ Post-doctoral 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.

⁸ Postgraduate students – researchers who are working on a Masters or Ph.D. thesis.

2.4 Collaborations and International Research

The proportion of Marsden Fund contracts that involve institutional collaborations is now stable at a high level. Projects involving investigators from a single institution comprised 77% of contracts at the Fund's start at the Society in 1995, but now stands at 43% in 2014 (see Figure A6). The bulk of contracted collaborations is of an international nature, while national linkages remain comparatively modest; i.e., for projects with contracted collaborations, typically, at least three quarters involve international investigators while in recent years only a third to a half possessed national collaborations.

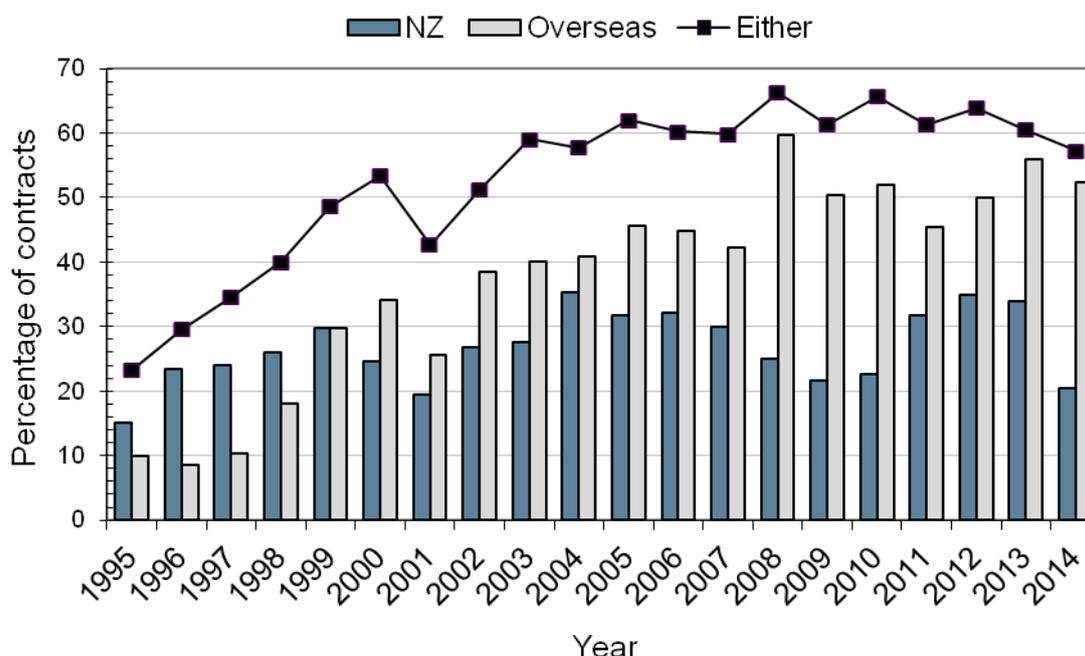


Figure A6. The percentage of projects for which a principal or associate investigator is from outside the contract's host institution, categorised according to whether the collaborations were national, international, and either.

While a little more than half of the contracts that were let over 2013 and 2014 involved overseas investigators at their onset, as is typical for Marsden-funded projects, additional collaborations were reported to have been developed throughout the course of the research. For the 106 projects with final reports received in 2013–2014, 51% included overseas researchers at their inception; but the time they had finished, 83% had reported, one or more, additional international collaborators.

International collaboration and communication	2008	2009	2010	2011	2012	2013	2014
Contracts awarded having investigators overseas	58%	51%	52%	46%	52%	56%	53%
Contracts completing in the year with international investigators	50%	52%	50%	52%	50%	53%	52%
Contracts completing in the year reporting additional international collaborations	92%	91%	94%	86%	95%	85%	84%

Table A8. International collaboration and communication on Marsden Fund contracts.

Appendix 3 – Case studies from 20-years of the Marsden Fund

Subject area: SUPERCONDUCTORS

Powering the future

Jeff Tallon

Principal Scientist, Robinson Research Institute

Victoria University of Wellington

Thanks to many years of research, and because New Zealand backed a team of talented scientists in a highly competitive field, we are now poised at the forefront of new industries based on high-temperature superconductors.

The problem with superconductivity - the ability to conduct electricity with no resistance – has been that most materials only display this behaviour at hundreds of degrees below freezing. So far the best known applications of superconductors have been MRI scans and test high-speed magnetic-levitation trains. New Zealand scientists have been pivotal in the slow task of making superconductors more practical: finding materials that superconduct at significantly higher temperatures, making superconducting wires less brittle, and helping us understand the complex and still-mysterious physics involved.



Professor Jeff Tallon

Subject area: ECOSYSTEM BOUNDARIES

Re-weaving the web of life

Jason Tylianakis

Professor of Terrestrial Ecology

University of Canterbury

Caterpillars can cause major damage to pine plantations. By cleverly measuring how species move between different areas of vegetation, researchers have found that nearby native forest actually helps control pest incursions into pine forests, by providing a source of caterpillar-controlling wasps. Outbreaks in exotic forests, on the other hand, upset the balance in nearby, more diverse native ecosystems.

More recently, a world-leading experiment by the team examined the combined impact of future climate change and increased fertiliser use on pest species. Heating coils were placed under the earth and nitrogen-rich fertiliser added to the soil. Herbivores increased disproportionately with important implications for both crop protection and carbon sequestration. Now the research has led onto additional work on how climate change and nitrification alter soil microbe activity, a huge factor affecting the carbon balance worldwide.



Professor Jason Tylianakis

Subject area: PSYCHOLOGY

Social media and our drinking culture

Antonia Lyons

Associate Professor of Psychology

Massey University

In the digital age, New Zealand's heavy drinking culture has gone online. Young adults organise drinking activities on social networking sites, know and emulate celebrity drinking culture, then 'celebrity' their own behaviour by posting images online. Differences exist, with women more wary of how they look, and young Māori, Pasifika or unemployed adults more careful about what they put online.

New marketing techniques – such as using geolocation-enabled smartphone notifications of nearby drinks specials – are often welcomed by internet savvy young people. But this marketing penetrates far into friend networks, and blurs the line between commercial and non-commercial content. To tackle the expensive and difficult social issue of problematic youth drinking, we need to understand how social media affects and reinforces our culture of drinking to intoxication.



Associate Professor Antonia Lyons

Subject area: PROTEIN BIOCHEMISTRY

The life and death of a cell

Catherine Day

Professor of Biochemistry

University of Otago

The number of cells in the human body is maintained by the miraculously delicate balance between cell division and cell death. If too few cells die, illnesses such as cancer or autoimmune disease can result.

It's a long-term goal determining the three-dimensional structure and workings of the proteins – the biological workhorses at the molecular level – that regulate these processes.

Unique and internationally valued research over the last 20 years has taken important steps forward – understanding how particular proteins attach together and discovering ways to regulate these interactions.

The work has now contributed to an understanding of how cell death is regulated and how initial drugs can be improved to efficiently trigger cell death for cancer treatment.



Professor Catherine Day

Subject area: GEOMETRY

The elegant shape of space

Dillon Mayhew

Senior Lecturer in Mathematics

Victoria University of Wellington

New Zealand has developed a huge reputation in certain areas of theoretical mathematics. The study of matroids is one; a theory that follows the traditions of ancient Greek and Babylonian mathematicians in better understanding the arrangements of objects in space.

Matroids have long had practical applications, particularly in optimisation problems, such as finding the cheapest way to build a network of roads or organising airport flight schedules. Because matroids are good at representing the kind of discrete '0s and 1s' space that computers use, future applications will likely be in computer science. Mathematics is a slow burn science, where a hundred years can elapse before a theory becomes useful in everyday life. Right now, however, this world-leading research contributes to the elegance, interest and beauty of life.



Senior Lecturer Dillon Mayhew

Subject area: LANGUAGE

A unique variety of English

Jennifer Hay

Professor of Linguistics

University of Canterbury

New Zealand makes a great natural laboratory, not least in the way our speech has developed over time. Between 1946 and 1948, a mobile unit toured the country recording the stories of pioneer New Zealanders, some born as early as the 1850s. Together with later recordings, these make 'New Zealandese' the only variety of English for which recordings are available that cover its entire history.

Shortly after our first settlers arrived with a variety of dialects, their children were heard speaking with what was disparagingly called a 'colonial twang'. The researchers examined how the development of this varied around the country, and combined archival work with innovative experiments to provide important insights into how we speak, how we listen, and how languages evolve over time.



Professor Jennifer Hay

Subject area: MĀORI CULTURE

Sustaining the art of moko

Ngahuia Te Awekotuku

Professor of Māori Research and Development

University of Waikato

After almost dying out in the 20th century, moko is now worn by many young Māori as a symbol of identity and ethnic pride. The research team looked at the history and technology of moko – searching through old manuscripts and artefacts held by institutions across the world.

Community participation was an essential part of documenting the modern moko revival. The Marsden-funded research team interviewed moko wearers and artists and examined the cultural and spiritual issues surrounding moko wearing, including the controversy sometimes apparent in modern life. They also examined the exploitation of moko in popular culture around the world by figures such as rock singers and football players. Finally the research was beautifully documented in *Mau Moko: the world of Māori tattoo*, the winner of the inaugural Ngā Kupu Ora Māori book of the decade.



Professors Ngahuia Te Awekotuku and Linda Waimarie Nikora autographing copies of their book at the Ngā Kupu. Ora Māori Book Awards. Photo courtesy of Massey University

Subject area: FERTILITY

What makes a good egg?

Ken McNatty

Professor of Biological Sciences

Victoria University of Wellington

After a phone call from an Akaroa farmer, whose sheep just kept on having triplets, scientists developed a very fertile herd. Then the mutation and growth factor found in the sheep's eggs themselves produced the realisation that eggs control their own environment: changing how cells surrounding the egg behave, determining the number of offspring and even keeping a check on ovarian cancer.

This research has led to a new technique which helps humans. By measuring a few key genes in the discarded cells next to IVF fertilised eggs, the best eggs can be chosen for implantation, dramatically increasing fertility clinic success rates. In future, these new insights may also help limit reproduction in mammalian pests such as wild deer, wild dogs or even possums.



Professor Ken McNatty

Subject area: NEW MEDICINES

Healing wounds

Colin Green

Professor of Ophthalmology

University of Auckland

Shortly after the start of the Marsden Fund, student curiosity led to a surprise discovery. Rather than making a brain injury worse, a synthetic DNA sequence that reduced cell-to-cell communication actually limited the how far the lesion grew. This serendipitous finding began a research programme of nearly 20 years.

Another chance event, the successful healing of a seemingly untreatable chemical eye burn, took the research team in the direction of non-healing wounds. Now *Nexagon* – a clear gel that is dripped onto wounds such as venous or diabetic leg ulcers – is ready for Phase III clinical trials. A new culture of entrepreneurship prevails in the research group, which is working towards treating diseases that require systemic delivery, such as strokes or heart attacks, and novel approaches to cancer therapy.



Professor Colin Green

Subject area: BIOENGINEERING

From molecules to mankind

Peter Hunter

Professor of Engineering Science

Director, Auckland Bioengineering Inst.

University of Auckland

Diseases involve a complex array of factors, from genetic and environmental causes to the interplay between different organs. The Physiome Project integrates all-of-body systems to develop a personalised 3D model of an entire human being.

Work that began modelling the human heart has developed into a 200-person cross-faculty research institute, leading the world in the integration of computational physiology with medical device technologies. Aspects of heart disease and arrhythmia can already be simulated for a particular person. Work is now bringing all 12 of the body's organ systems together. Within a few years computer models may be used to personalise medicine, trial new drugs or perform virtual surgery, producing individualised, more effective and lower cost healthcare.



Professor Peter Hunter (right) and team

Subject area: Memory

Puzzles of the human mind

Harlene Hayne

Vice Chancellor and Professor of Psychology
University of Otago

Early childhood experiences have a major impact on human development. Given this, it is puzzling that as adults we have little or no memory for these early, important experiences. A series of ingenious experiments that first began with Dunedin infants in 1995 has thrown light on this by demonstrating when children first develop different types of memory, how those memories are accessed and how the language used by parents can affect which memories are established and maintained.

Combining innovative research techniques with extensive community links, the researchers have disseminated their findings to parents, teachers, lawyers and as advice to government. Further research that followed the Marsden-funded work has examined the connections between adolescent brain development, alcohol use, and risk taking.



Professor Harlene Hayne

Subject area: Earthquakes

Unlocking the secrets of tectonic plates

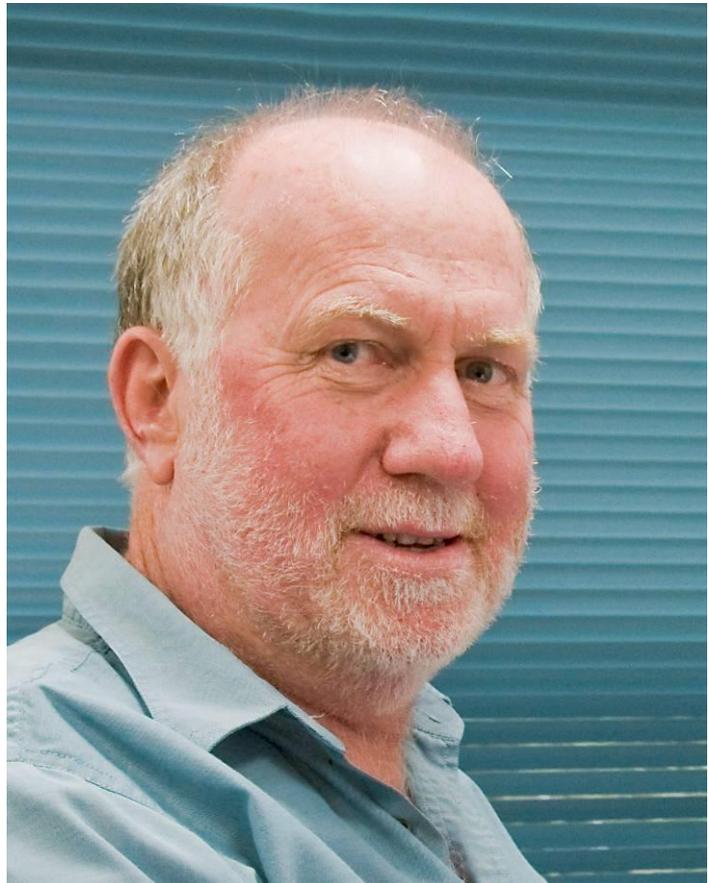
Martin Reyners

Principal Scientist

GNS Science

By using earthquake waves themselves to map our underlying plates – the earthquake equivalent of a medical scan – Marsden-funded researchers have developed a three-dimensional model of the rock structure under New Zealand. The project explains why our tectonic plates are locked in some areas but not others; rock with more fluid moving through it tends to cause faults to slide. This knowledge helps us understand where strain might be building up across the country.

After the Canterbury earthquakes, the model was able to provide an explanation for some of the puzzling features of those shakes: why there was a five and a half month delay between large quakes, why the larger earthquakes involved so much shaking, and why all the aftershocks migrated to the east, rather than both ways.



Principal Scientist Martin Reyner