
December 2017

Investment Impact Report July 2015– June 2017:

Marsden Fund

Royal Society Te Apārangi

Summary

For the last 22 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 Marsden Fund received welcome news with an unprecedented increase of \$66 million (excl. GST) over four years in the Budget 2016 communications. The Council looks forward to building on the Fund's legacy with this new investment, which presents an exciting opportunity to expand the Fund's reach, allowing it to make a bigger impact at home and maintain our international standing.

Assessment of the Strategy and Management of the Marsden Fund

Within this period, the Ministry of Business, Innovation and Employment completed an Assessment of Strategy and Management of the Marsden Fund in April 2017. The Minister of Science and Innovation has published the report¹ and endorsed its recommendations². The Marsden Fund Council has welcomed the Assessment³ and worked to implement the recommendations through the:

- Development of an Investment Plan that sets out the strategic direction of the Fund, addresses the issues identified in the Assessment Report, and shows how the Fund will be managed to achieve its objectives; and,
- Development of a draft Performance Framework that will include periodic review by international experts to provide assurance of the value of the Government's investment.

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 refreshing the Fund's commitment to the Vision Mātauranga policy across a wide range of panels; building relationships with other agencies (including the Royal Society Te Apārangi); and, communicating value to stakeholders and the public demonstrating the long-term benefit of the Fund.

Building Human Capacity

In the 22 years of the Marsden Fund's operation, it has contracted more than 3600 investigators. The Marsden Fund continues to invest heavily in New Zealand's emerging researchers through contracts for researchers within seven years of their PhD; contracting 78 new Principal Investigators over 2015–16, and a total 484 since the Fast-Start 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 443 Standard contracts awarded between 2010 and 2016, funding was budgeted for post-doctoral researchers in 236 contracts, while post-graduate research positions were budgeted in 318.

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

¹ Marsden Fund Assessment: <http://www.mbie.govt.nz/info-services/science-innovation/research-organisations/key-partners/royal-society-of-new-zealand>

² Minister's Press release on Marsden Fund Assessment: <https://www.beehive.govt.nz/release/marsden-fund-assessment-report-released>

³ Marsden Fund Council's response to the Assessment: <https://royalsociety.org.nz/news/marsden-fund-councils-response-to-the-recent-assessment-of-the-fund/>

in absolute terms. These changes are mirrored by increases in the proportion of contracted FTEs going to post-graduate students, with 2015 being the third 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.

With these people, New Zealand can take advantage of all the research that takes place globally and play our part in this international community. The recent boost in Government investment in the Fund will allow expansion in our national community of excellent researchers, and increase the breadth and depth of the projects undertaken.

International Collaborations

The proportion of Marsden contracts that begin as collaborations has grown from 23% of the grants in 1995 to 59% in 2016. 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 170 final reports received in 2015-2016, 56% included overseas researchers at their inception, but by the end of the contract the proportion that reported international collaborations had increased to over 85%. 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.

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 183 contracts during this period. It continues to lead to high numbers of peer-reviewed papers, including over 60 papers/year published in international journals in the top 2% of the 2016 Scimago Journal Ranking. It thus supports the advancement of knowledge in New Zealand, while contributing to maintaining our global position in research and scholarship.

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 21 December 2017

Signed on 20 December 2017



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

Professor Juliet Gerrard
Chair of the Marsden Fund Council

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Investment Impact Report 2016–2017: 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 2016–2017 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 mathematics, social sciences and the humanities. Competition for funding is intense.

Governance

The Fund is operated under the Terms of Reference issued by the Minister of Science and Innovation, which were updated in 2017. A Marsden Fund Council of up to 11 eminent researchers, 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 (2012) and which were in operation, the Fund's selection criteria focused 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 and put forward new strategic priorities for the 2015-2017 period. In the last two years, the Fund has had a focus on: refreshing the Fund's commitment to the Vision Mātauranga policy across a wide range of panels; building relationships with other agencies (including the Royal Society Te Apārangi); and, communicating value to stakeholders and the public to demonstrate the long-term benefit of the Fund. The Marsden Fund Council progressed the strategic direction well, completing a Vision Mātauranga review and implementing changes in the proposal process from the 2016 selection round onward. Furthermore, the interagency connections were realized through: the Chair of the Fund attending a number of the Royal Society Te Apārangi Council meetings; the President of the New Zealand Association of Scientists, Dr Craig Stevens, attending a Marsden Fund Council meeting; and, the Council's regular interactions with Universities NZ, Science NZ, and IRANZ. Interagency connections at an operational level were promoted through a new initiative in the form of the "Three Agencies" forum between the Society, MBIE and HRC. A higher profile of the successful research projects was communicated through both web-based articles and an increased focus on the use of social media to inform the public about the Marsden Fund research outcomes.

Marsden Fund Assessment

MBIE completed an Assessment of the Strategy and Management of the Marsden Fund in 2017. The Minister of Science and Innovation has published the report and endorsed its recommendations. The Report found that the Marsden Fund is effective at selecting high-quality research, but recommended some changes to ensure it continues to deliver benefits for New Zealand. Consequently, there was a significant increase in the governance role of this Marsden Fund Council over the period of reporting through its strategic direction and production of the Investment Plan in response to the Assessment of the Strategy and Management of the Marsden Fund.

Key recommendations from the Assessment include:

- developing an Investment Plan that sets out the strategic direction of the Fund, addresses the issues identified in the Assessment Report, and shows how the Fund will be managed to achieve its objectives;
- developing a Performance Framework that will include periodic review by international experts to provide assurance of the value of the Government's investment; and
- including more international Councillors on the Council.

The Marsden Fund Council developed a strategic direction to show how the Fund would be managed to achieve its objectives and contribute to the NSSI vision and Goals. The Investment Plan outlined key changes to the Fund, with many of these to be implemented for the 2018 funding round. These include:

- introducing a new award to support large interdisciplinary projects, worth up to \$3 million;
- allowing researchers to apply for follow-on awards to sustain momentum for outstanding research;
- modifying assessment criteria to align more closely with the National Statement of Science Investment (NSSI), including the potential for significant scholarly impact;
- trialling a broader assessment panel structure;
- undertaking additional moderation between panels to ensure the quality and consistency of research selected from all disciplines; and
- providing more feedback to unsuccessful applicants and institutions following on from preliminary proposals.

Scope and Scale of the Fund

This Impact Investment Report reports on activities related to the Marsden Fund from 1 July 2015 to 30 June 2017, covering the past two fiscal years (FY). The Marsden Fund Council welcomed news of the budgeted increase of \$66 million (excl. GST) over four years as announced in the Government’s Budget 2016 communications (see Figure 1).

The Marsden Fund operates as a separate Output Class under the Ministry of Business, Innovation and Employment, non-departmental output classes. In FY 15/16 and 16/17, the Marsden Fund output class had investment budgets of respectively, \$53,627,000 and \$57,755,000 per annum (GST exclusive). During this time, 558 research contracts were operational. There were 92 new contracts funded in FY15/16 at a cost of \$53,535,000 and 117 new contracts funded in FY16/17 at a cost of \$65,245,000.

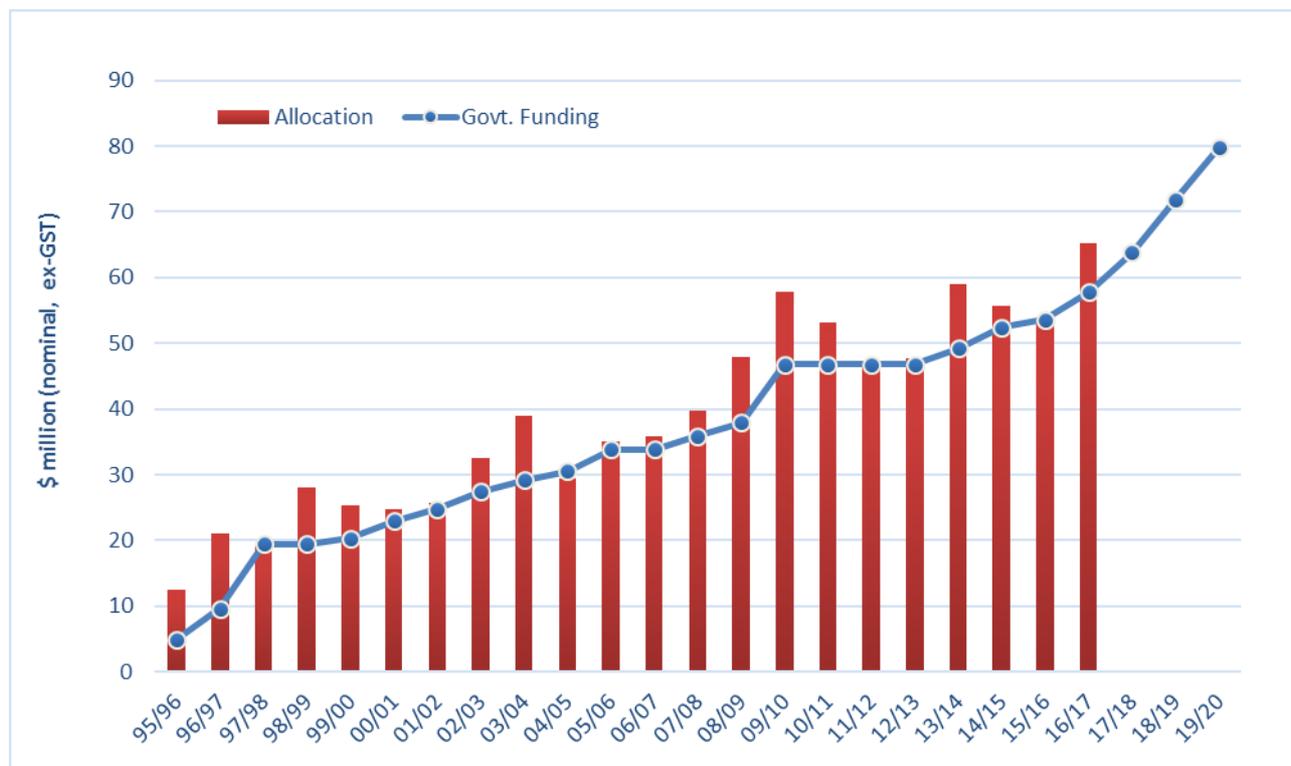


Figure 1. Annual Allocation by, and Government investment in, the Marsden Fund including the projected staged increase communicated in the 2016-17 Budget (in Millions of nominal dollars, GST-exclusive).

With contracts running over three-years, approximately a third of the round’s allocation is distributed in each year following the round. The Marsden Fund Council determines the annual amount allocated in each funding round by balancing its dual requirements never to anticipate a Fund deficit and to have the Fund operate with the lowest practical reserve. Consequently, years where the Fund’s reserves have built up and/or Government has signaled an increase have led to greater allocation than the direct funding would suggest, with flow-on effects for those year’s success rates (see Figure 2).

Data on the inflation-adjusted investment in 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 panelists from New Zealand and Australia. In the second round, five-page “full” proposals are scored by a target of three independent referees. In the 2015 and 2016 rounds, 99% of these referees were from outside New Zealand and 87% of full proposals were reviewed by three referees with none seen by fewer than the promised two. Proposals are then selected for funding by each panel based on the independent referees’ judgements, the applicants’ rebuttals, and panel discussions.

The success rates for Standard and Fast-Start proposals has fluctuated around the 9% and 13% levels respectively, with long-term trends shown in Figure 2 below. The two years of this report are consistent with the long-term trend. This low success rate may now be having the effect of reducing the numbers of applications received. While the long run trend for the Marsden Fund has been an increase of 25 preliminary proposals per year ($R^2 = 0.72$), the number of proposals appears to have peaked in 2014 when 1222 proposals were received. This recent plateau in preliminary proposal pressure has occurred even though this coincides with a significant increase in the size of the Fund available. It may be that at this demand, the Fund is currently serving the natural level of interest for the New Zealand research community.

Although only 9% of proposals were funded over the years considered in this review, approximately 13% were graded as excellent by international peer-review. With the increase in investment allowing funding of more applications in future (and likely increasing the Fund’s impact proportionally), evidence from the ongoing collaboration with Motu argue that increases will not diminish the quality of funded research⁴.

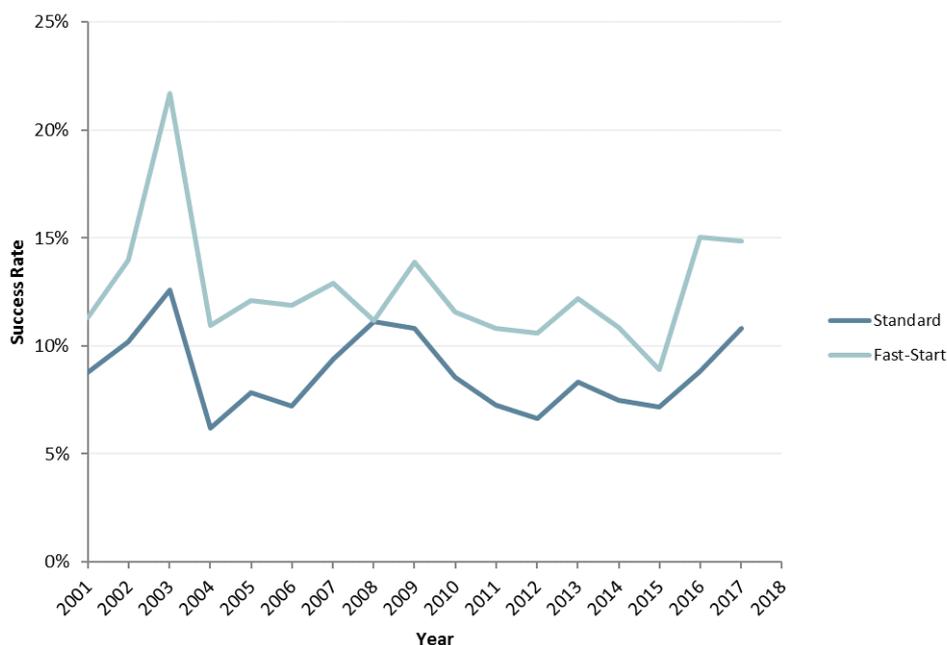


Figure 2. Success rate for Standard and Fast-Start proposals to the Fund, 2001–2016.
NB: Surplus funds were released in 2003 resulting in an atypically high success rate for that year.

⁴ Gush, J *et al.* The effect of public funding on research output: the New Zealand Marsden Fund (2017) <https://doi.org/10.1080/00779954.2017.1325921>

Research Productivity and Quality

The contracts under the Marsden Fund continue to publish in the world's premier journals. Figure 3 below shows the number of articles published in journals in the top 2% of the Scimago Journal Ranking for 2016⁵, while Figure 4 describes the productivity of the Fund in totality, and in terms of peer-reviewed publications per million dollars of Government investment.

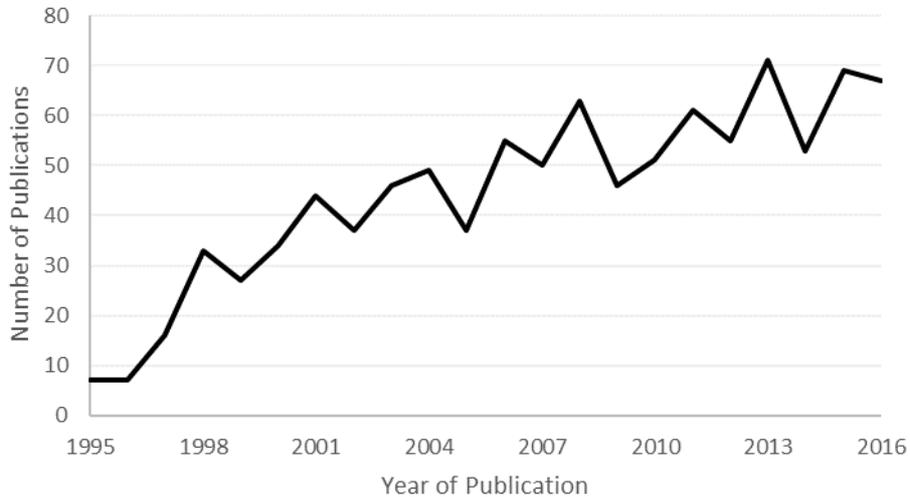


Figure 3. Number of Marsden Fund-attributed articles published in journals in the top 2% of the contemporary Scimago Journal Ranking. Data for 2017 not yet complete due to reporting cycle.

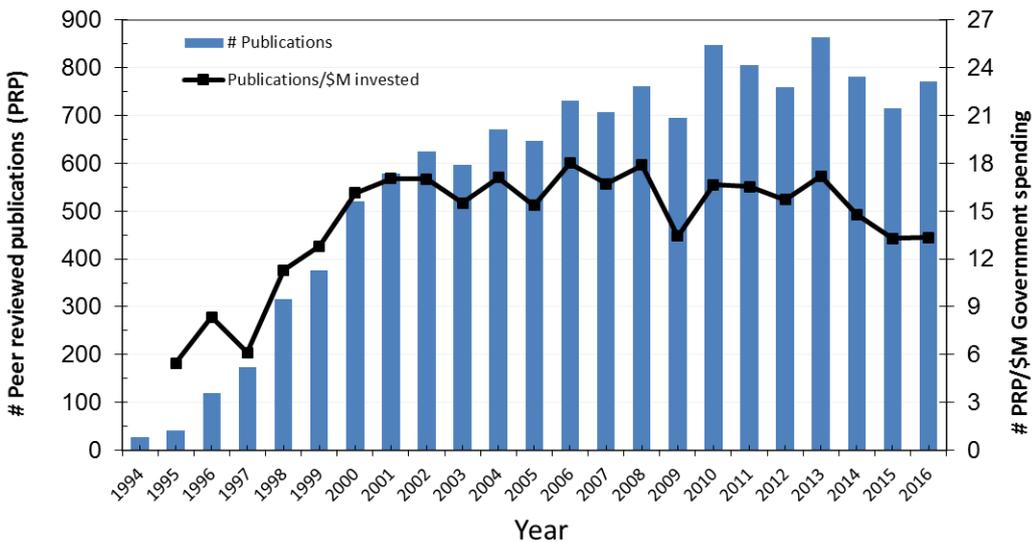


Figure 4. Count of the published output of the Fund (papers, refereed conference proceedings, books and book chapters), and output expressed as the ratio of published output to nominal Government investment. Data for 2017 not yet complete due to reporting cycle.

The source data for these figures is set out in Appendix 2.1 Research Productivity. Apparent declines in productivity per \$M should not be over-interpreted. The Fund's experience is that publications attributable to Marsden will continue to be reported over the next five years. Contracts let as a consequence of recent increases in Government support will expected to report publications towards or after the end of these contract's conclusion.

⁵ Get cite and time of SJR publish date.

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.

Through analysis of these short-term follow up interviews, it is revealed that a solid majority of Marsden-contractors believe that their funding enabled research that would not have been possible without it (see Figure 5). Of note, perceptions of the Fund's importance in enabling research have been very stable over time.

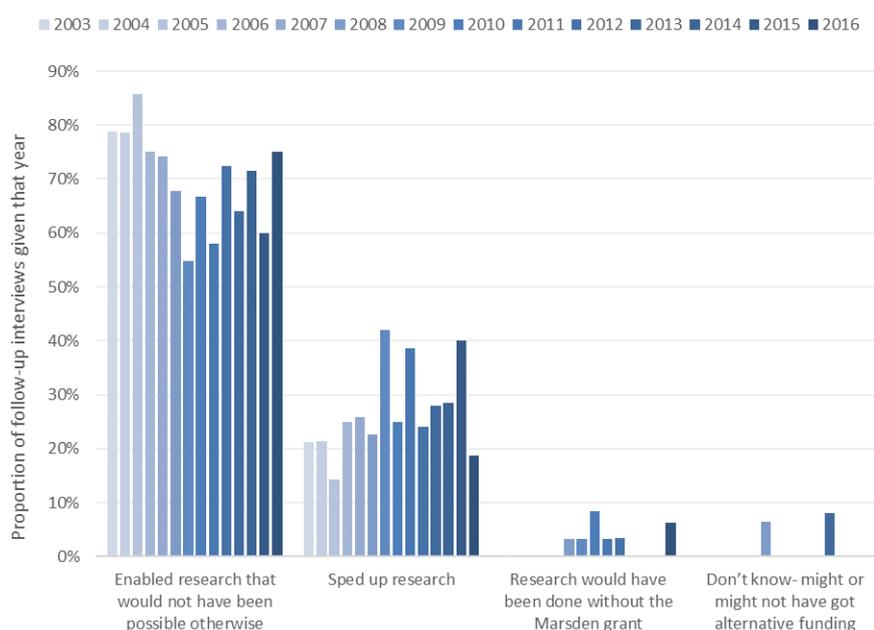


Figure 5. Proportion of responses to the question: "What effect has the grant had on research progress?"

"Pretty much this is the only way this project could be funded"

"It is unlikely the project would have proceeded without Marsden funding, except on a much smaller scale."

"This research could not have occurred without Marsden funding. The scope of our study... could not have gone ahead without paid dedicated research staff and the funded Masters student."

"Would this research have gone ahead without Marsden Funding? Definitely Not. This field was quite new research area to [the investigator] as well and it was a risky project at the beginning; later on it converted to being a very fruitful and very reputed project team."

"The main research undertaken would likely have occurred anyway, but at a much slower pace, and because of time pressure it would not have been at the same level of quality that we have been able to achieve."

The vast majority of completed contractors are of the opinion that their contracts benefited their research teams (95%) and their field (82%). Marsden scholars assert that their contracts have led to both international (89%) and national (86%) research collaborations.

A broad majority (96%) report that following their contact's completion their team morale was improved as a consequence of Marsden Funding.

“Our group would not exist without past support from Marsdens. Marsden created this research. It would not have happened without it.”

“It kept [a co-Investigator] and myself from applying at Universities in Australia”

“Given the low rate of success in getting a full proposal funded by Marsden - getting a project funded always has a good effect on morale, particularly younger researchers who get a significant boost to the early stages of their career from a 3 year funded project.”

“This fast start came at a critical career stage, allowing me to begin a research programme, attract good students, receive some relief from teaching workload, and develop a track record in managing my own research grant. This had a very positive effect on my career and morale”

Almost all contractors (92%) report that their research efforts continue to build on their Marsden-supported project and most (73%) indicate that they’ve been able to attract ongoing financial support for these efforts.

“[T]he grant has been fantastic for getting a research programme up and running, and having a very positive effect on collaborations and subsequent grant applications... Many indirect benefits.”

Although comments are mixed with respect to concerns, e.g., the perceived small size of the Fund, the majority (95%) express one or more statements on the values of the Fund to New Zealand.

“A fund that targets 'blue sky research' enables ideas that at first seem abstract and theoretical to develop quickly. On paper my research topic... seems an obscure and purely theoretical topic. The applications are not obvious to people outside the field and so the applied aspects can be overlooked. The Marsden Fund enabled me to test the idea and to get it working within a relatively short period of time. I was able to bring in top international researchers to help me and was able to visit overseas laboratories to get feedback on the approach. Now that we have a proof of principle and can demonstrate what it does, suddenly many applications become obvious.”

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); however, since 2011 this scheme has awarded \$100k (ex-GST) per year for three year projects. 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, has dramatically increased the number of postgraduate students supported by Marsden funded grants. Figure 6 shows the proportion of total full-time equivalents (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. As post-doctoral researchers are expected to be more productive than post-graduate students, and a maximum grant size creates a challenges for the affordability of post-doctoral fellows in some panels, this is likely to have consequences for the impact of the Fund. Shifts in the ratio of post-doctoral researchers: post-graduates may also contribute to a research workforce imbalance. The Marsden Fund Council keeps a watching brief on these tensions across panels, and has signalled that it will lift the maximum grant size in the more expensive disciplines with the Fund's increase. With the development of the strategic direction indicated in the Council's Investment Plan, the Council's goals:

- Grants should provide resource for a significant portion of a Principal Investigator's time and a post-doctoral researcher in those disciplines that need them; and
- Funding as many excellent research proposals as possible and stimulating creativity across the full range of research fields.

In response, the Council has lifted the maximum grant size by approximately 10% for the 2017 funding round.

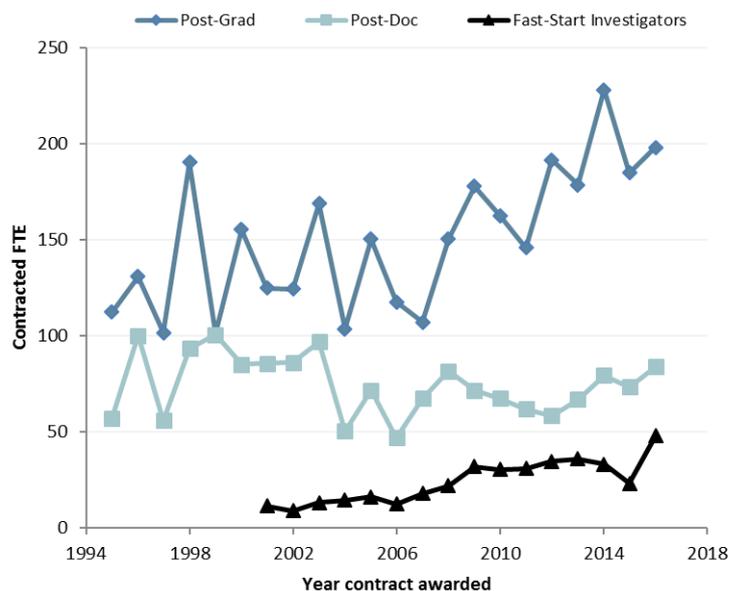


Figure 6. FTE contracted by Marsden grants going to different emerging and early career roles.

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 Science awards; the Liley, Hector, Mason Durie, McDiarmid, Grahame Clark and Marsden 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 7 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 existence of Fast-Start contracts, but is also shown to be true within the Standard scheme. Since ~93% 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".⁶ The participation of emerging researchers is significantly greater than would be expected from demographic considerations alone. Contracts over the past thirteen years have shown this consistent trend of younger Principal Investigators (PIs). For the past five years, 42% of PIs and 31% of Associate Investigators (AIs) have been within the first 10 years of their highest-degree, which is typically a PhD.

⁶ Sommer J (2010) "2008 Survey of New Zealand scientists and technologists" *New Zealand Science Review* 67(1):1–40.

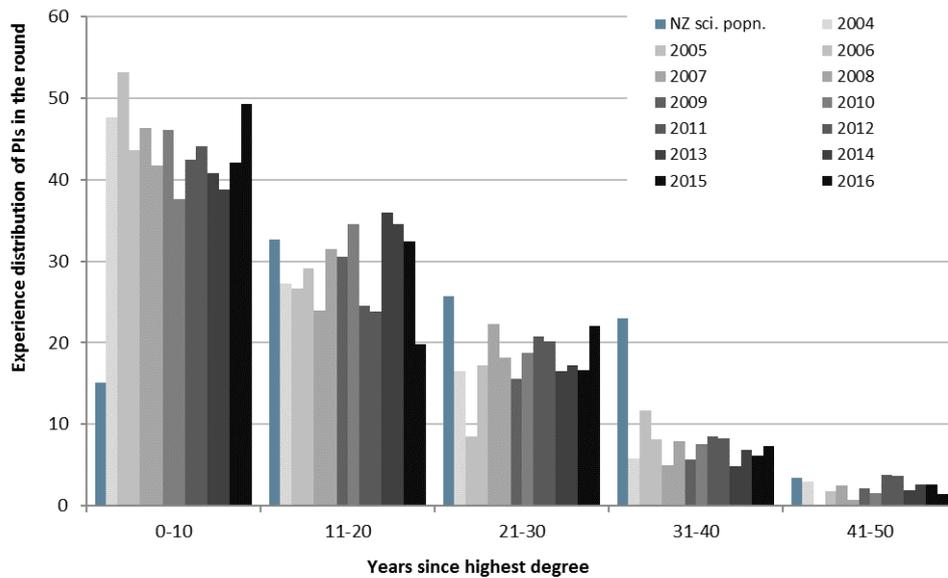


Figure 7. Experience of principal investigators (PIs) on contracts awarded from 2004–2016, as estimated from the number of years since the principal investigator obtained their highest degree⁷

The percentage of PIs who are women continues to be high for the Fund, with 36% in 2016, although behind the record 44% seen in the 2015 round (see Figure 8 below). 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).

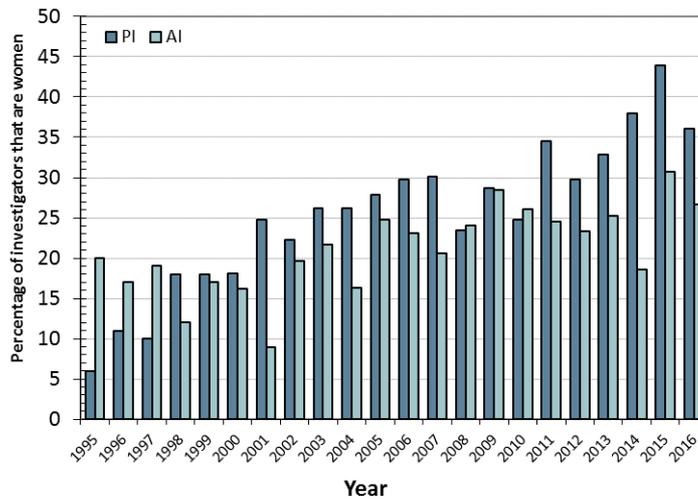


Figure 8. Proportion of principal (PI), and associate (AI), investigators who are women

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 2012–2016, Māori researchers were involved with 8% of projects as an investigator. Over the same period, the percentage of all investigators who self-identify as Māori was 4.1%, and of New Zealand-based investigators was 5.6%. For success rates see Figure 9. See Appendix 2.3.4, Māori Researchers, for further statistical information.

⁷ 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.

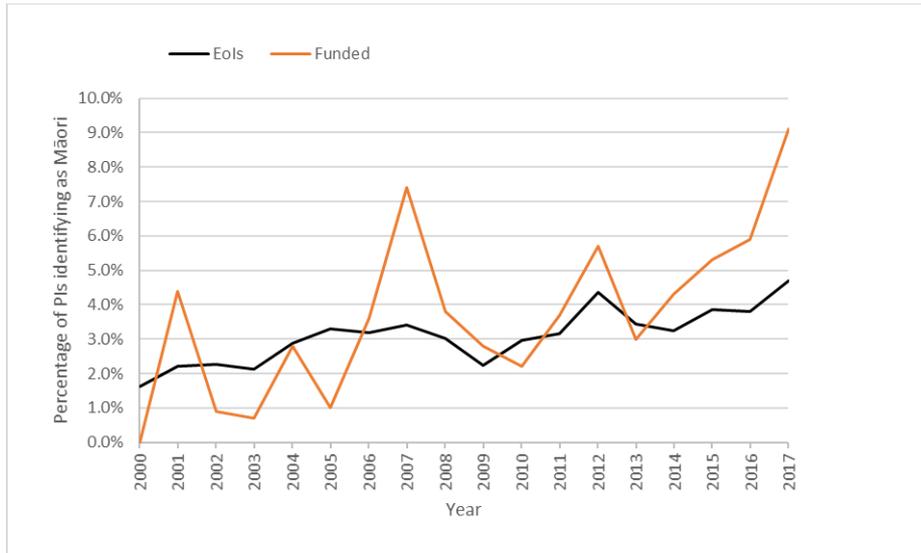


Figure 9. The percentage of Principal Investigators identifying as Māori in the Marsden Fund at the preliminary proposal (Eol) and contracting (Funded) stages.

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 roughly half indicated national collaboration partners.

Conclusions

Operation of the Marsden Fund

The Marsden Fund continues to have significant scholarly 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.

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 economic⁸, social⁹, health¹⁰ and environmental¹¹ impacts.

Mechanisms for the full identification of the long-term impacts of the Fund are anticipated to be incorporated in the Performance Framework, which is currently being developed. The international impact panel assessment will also provide evidence and review of the impact and effectiveness of the Marsden Fund.

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. Now that both the Assessment and the Council's Investment Plan have been completed, the Council has provided the research community with the strategic settings for the Fund over the next three years.

⁸ e.g., "Why don't Governments implement growth-maximising fiscal policies?" (Appendix xxvii); "Maurice Wilkins Centre collaboration solves elusive protein structure" (Appendix xxvi); and, "Swim speed: Salmon study unlocks sexual secrets" (Appendix ix).

⁹ e.g., "Kia ora: how Māori borrowings shape New Zealand English" (Appendix x); "The dark side of religion: how ritual human sacrifice helped create unequal societies" (Appendix xxix); and, "Religious New Zealanders most tolerant of Muslims" (Appendix xxxi).

¹⁰ e.g., "Otago researchers find valuable new clues in fight against multi-drug resistance" (Appendix xvi); and, "Mimicking evolution to treat cancer" (Appendix xix).

¹¹ e.g., "Scientists attribute rising methane levels to agriculture" (Appendix xxxii); "Marsden-funded Antarctic research published in Nature" (Appendix xx); "Prehistoric demise of Chatham's sea lion a stark warning for conservation of NZ sea lion" (Appendix xxiv); "Marsden Fund Research Reveals Factors Regulating Toxin Production" (Appendix xxxiii); "Bees 'dumb down' after ingesting tiny doses of pesticide" (Appendix xxxiii); and "What will the wasp plague be like this year?" (Appendix xx).

Appendices

Appendix 1 – Scope and Scale

The Marsden Fund has increased in size since its inception 21 years ago, and currently stands at \$63.755 million (\$73.3M including GST) following its \$6 million increase over baseline announced in the 2016/17 budget. The Fund baseline is expected to reach \$79.755 million by 2019/20.

Each year, approximately one third of the Fund's budget becomes available for new projects. In 2015/16 and 2016/17, funding totalling \$53.54 and \$65.25 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.

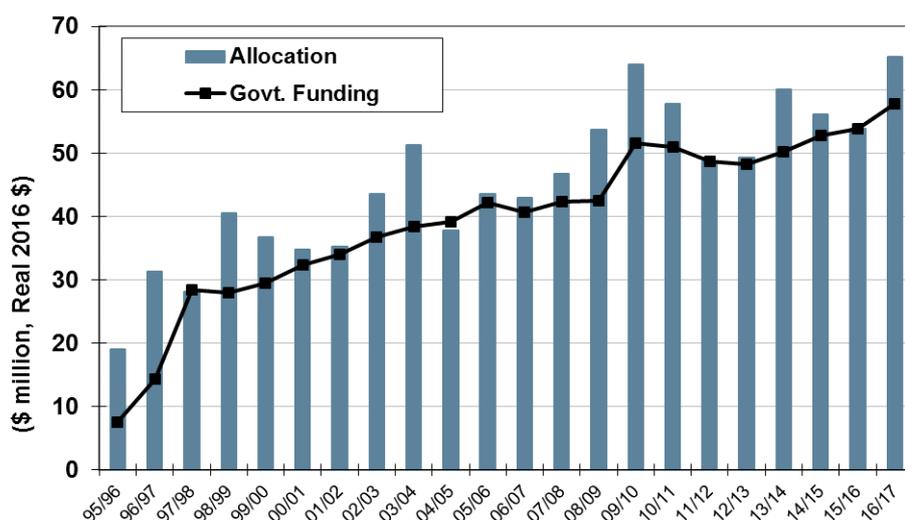


Figure A1. Panel A: Funds allocated to new Marsden Fund projects (in Millions of 2016 dollars using the Sept release of the CPI SE9A series, GST-exclusive).

Year	Standard			Fast-Start		
	Proposals	Contracts	Percentage	Proposals	Contracts	Percentage
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%
2015	876	63	7.2%	325	29	8.9%
2016	771	68	8.8%	326	49	15.0%

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

The distribution of the Fund by research area over 2007–2016 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									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CMP	\$5.2	\$6.7	\$8.3	\$6.4	\$5.3	\$4.4	\$6.0	\$5.2	\$4.9	\$6.0
BMS	\$5.1	\$6.8	\$8.8	\$6.9	\$5.6	\$4.8	\$5.8	\$6.4	\$6.0	\$7.5
EEB	\$6.9	\$7.6	\$8.5	\$8.9	\$7.3	\$6.3	\$8.1	\$7.6	\$7.2	\$9.1
ESA	\$4.3	\$5.2	\$6.3	\$7.4	\$5.9	\$4.9	\$6.9	\$6.0	\$5.5	\$6.7
PSE/PCB	\$5.7	\$6.2	\$8.5	\$6.5	\$5.3	\$4.5	\$6.1	\$5.7	\$5.2	\$6.7
EIS				\$6.2	\$5.4	\$4.1	\$6.0	\$4.9	\$4.9	\$6.0
MIS	\$2.9	\$3.6	\$5.1	\$3.3	\$4.1	\$4.4	\$4.2	\$4.4	\$4.5	\$5.4
EHB	\$3.5	\$3.8	\$3.7	\$4.1	\$4.0	\$4.3	\$5.1	\$4.4	\$4.7	\$5.4
SOC	\$3.8	\$5.1	\$6.3	\$6.6	\$6.6	\$6.1	\$6.3	\$7.2	\$7.1	\$8.4
HUM	\$2.3	\$2.8	\$3.3	\$3.4	\$4.3	\$3.5	\$4.4	\$3.8	\$3.5	\$4.1

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

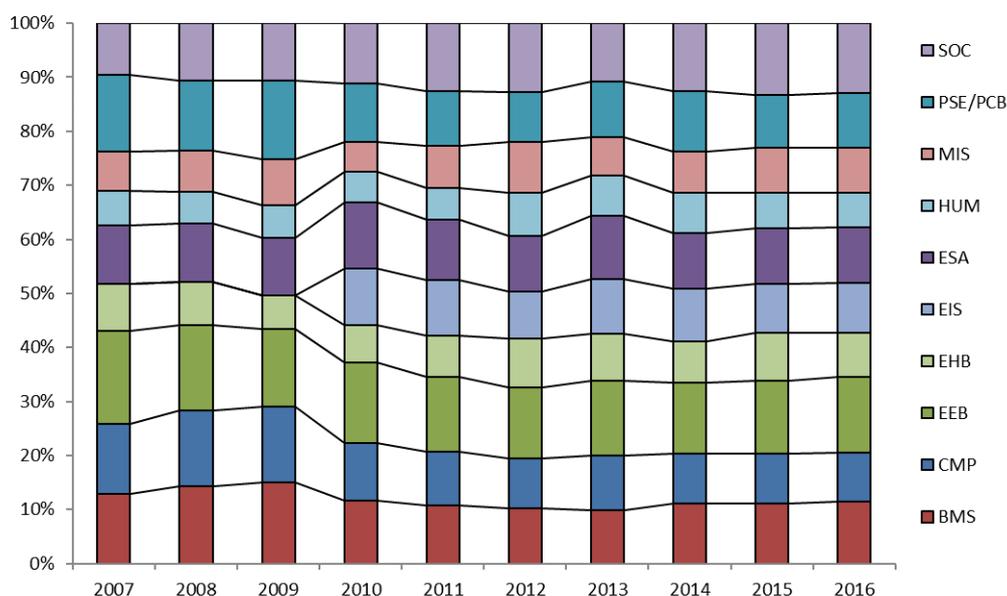


Figure A2. Share of funding by research area† for new contracts and year of award

†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: 34% of the funding allocated was to the medical and life sciences; 38% to the physical sciences, engineering and mathematics; and 28% to the social sciences and humanities. The disciplinary spread has remained relatively constant ever 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	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	All Years
Papers	560	541	567	507	641	617	555	638	574	552	561	9867
Refereed Conference Proceedings	96	88	98	102	98	76	114	122	121	96	100	1726
Book Chapters	65	67	80	71	88	95	77	87	80	59	98	1319
Books	11	11	16	14	20	17	13	16	6	8	12	213
Edited Volumes	13	8	9	14	9	5	10	12	11	3	8	156
Reports	7	8	7	19	20	14	23	15	25	23	25	314
Patents	3	3	3	1	2		3	3	2	3	2	58
Software	4	3	2	4	5	1	3	9	5	7	9	62
Total	759	729	782	732	883	825	798	902	824	751	815	13715

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.

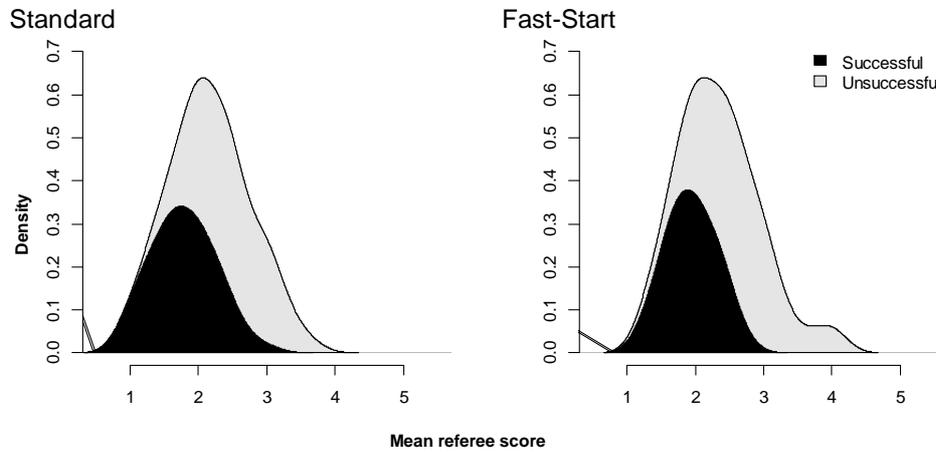
Year of Activity	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	All Years
Invited conference talk	208	235	225	220	333	268	235	259	212	244	232	3782
Contributed conference talk	308	446	321	371	434	383	392	422	358	362	330	6554
Conference poster	177	141	155	133	194	175	143	153	135	115	116	2857
Other†	90	119	91	122	132	127	80	88	126	104	126	1605
Total	783	941	792	846	1093	953	850	922	831	825	804	14798

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.

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.

A. 2015



B. 2016

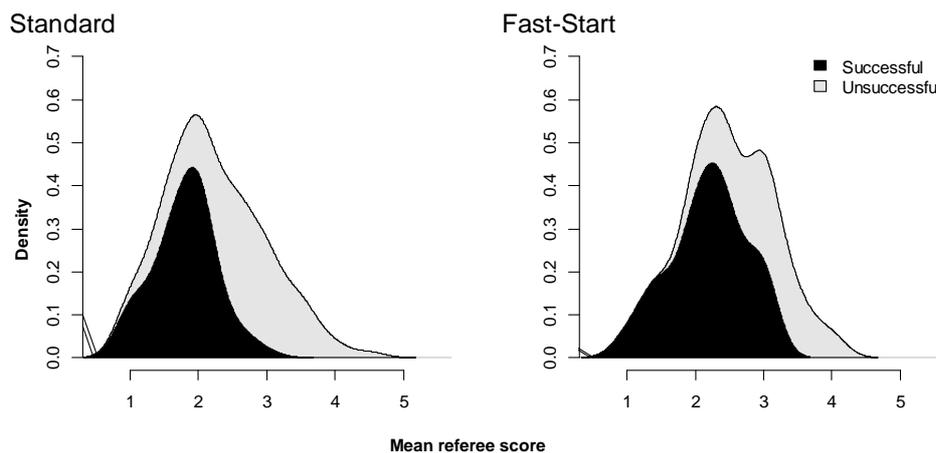


Figure A3. Distribution of the average referee score received for funded and both funded and unfunded proposals to the 2015 (panel A) and 2016 (panel B) funding rounds.¹²

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.

¹² 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 2016 involving 3612 distinct investigators (spread over 2525 principal investigator and 2829 associate investigator roles). The Fund maintains its high international presence with 541 of the 1564 (i.e., 35%) individuals contracted as investigators over 2012-2016 based outside New Zealand.

Investigators	2011	2012	2013	2014	2015	2016	Individuals [†]
Principal	107	104	134	117	114	136	1738
Associate	147	120	196	167	163	180	2472
All	250	222	324	276	276	312	3612

Table A5. Number of investigators associated with Marsden projects contracted in the year
[†]The total number of individuals contracted through 1995–2016

2.3.2 New and Emerging Researchers

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

Over 2012 to 2016, 187 Fast-Start contracts were awarded to researchers who have had no more than 7 years of research experience since completing their PhD (32 in 2012, 40 in 2013, 37 in 2014, 29 in 2015, and 49 in 2016).

The Marsden Fund's contracts are associated with a large number of the post-doctoral researchers supported by government funding. Of the 243 Standard contracts awarded between 2012 and 2016, funding has been available for post-doctoral fellows in 166, i.e., roughly half of them. Over these five-years this represents a total contracted 362 FTE of Post-Doc support that was directly attributable to the Fund.

For the 479 contracts awarded between 2012 and 2016, 316 requested funding for post graduate students, i.e., 66% of contracts compared with 52% of contracts let between 1996 and 2000. In the five most recent years for which contracts have been awarded, the Fund provided support for a total of 981 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. Over the last decade, team composition appears to have stabilized: 20%–30% Investigator FTE; ~20% Post-Doc FTE; 40%–50% Post-Grad FTE; and, ~10% Research Assistants (see Figure A4)

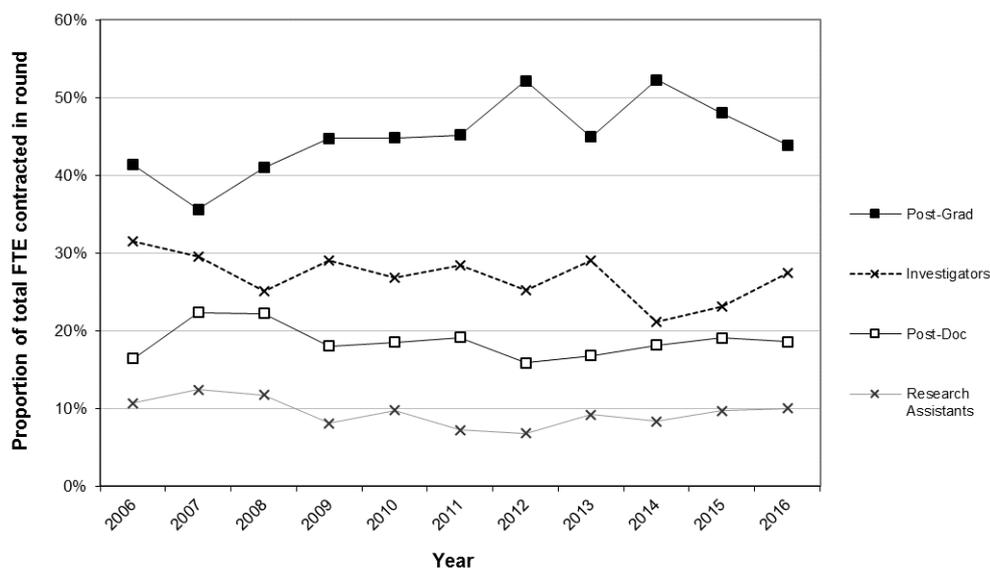


Figure A4. Relative proportions of the FTE contracted by Marsden grants going to different roles

Over 2012 to 2016, 43% of principal investigators, and 29% of associate investigators, were within 10 years of completing their PhD (that is, in most cases, are assumed to be under 37 years of age).

2.3.3 Women Researchers

In the 2016 round, 36% of the PIs on successful applications are women, making this the third highest year to date. Over the same period, the proportion of contracts having one or more female PIs was 42% (see Figure A6).

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	All (2000–16)
Preliminary	33.8	34.2	35.5	35.7	34.1	38.5	35.8	37.3	38.2	37.1	37.4	34.5
Contracts	37.7	35.5	30.8	32.1	31.4	40.4	32.6	39.4	40.8	46.7	41.9	35.7

Table A6. Proportions 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, χ^2 $p \sim 0.83$).

2.3.4 Māori Researchers

For contracts initiated throughout 2012–2016, Māori researchers were involved with 8.1% of the projects as an investigator. Over the same period, the percentage of all investigators who self-identify as Māori was 4.1%, and of New Zealand-based investigators was 5.6%.

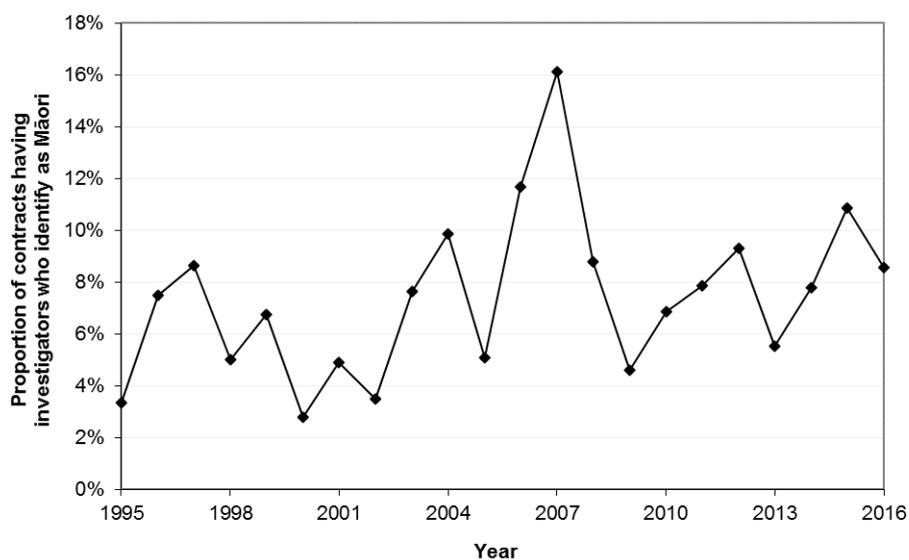


Figure A5. Percentage of contracts with investigators identifying as Māori

2.3.5 Statistical Compendia of Participation

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Investigators – Number of separate individuals acting as principal ¹³ and/or associate ¹⁴ investigators on current contracts	943	964	1056	1123	1133	1159	1191	1190	1203	1243
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	46%	42%	46%	38%	43%	44%	41%	39%	43%	49%
Post-doctoral fellows ¹⁵ – Percentage of Standard contracts in the year's funding round having FTE for post-doctoral fellows	41%	40%	36%	41%	49%	50%	50%	52%	57%	53%
Students ¹⁶ – Percentage of contracts in the year's funding round which support postgraduate students	53%	62%	62%	62%	64%	63%	63%	72%	67%	61%
Women – Percentage of PIs on contracts awarded in the funding round that are women	31%	24%	29%	25%	35%	30%	33%	38%	44%	36%
Māori – Percentage of PIs and AIs on contracts awarded in the funding round identifying as Māori	6.6%	4.4%	2.8%	3.0%	4.3%	5.0%	1.9%	4.0%	4.3%	5.8%

Table A7. Participation in Marsden contracts, 2007-2016

¹³ 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

¹⁴ AIs – Associate Investigators – researchers who play a lesser role than principal investigators and sometimes are involved with only limited aspects of the work.

¹⁵ 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.

¹⁶ 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 41% in 2016 (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.

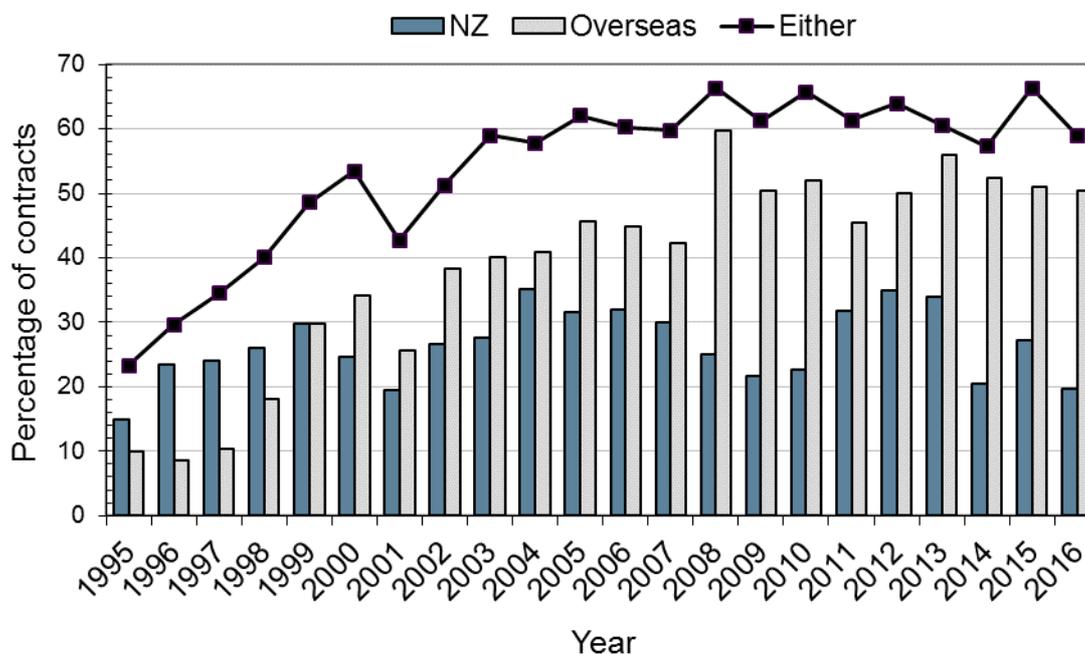


Figure A6. The percentage of projects for which a principal or associate investigator is from outside the contract's host institution, categorised according to whether the collaborations were national, international, or either.

While a little more than half of the contracts that were let over 2015 and 2016 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 170 projects with final reports received in 2015–2016, 56% included overseas researchers at their inception; but by the time they had finished, 85% had reported one or more additional international collaborators.

International collaboration and communication	2010	2011	2012	2013	2014	2015	2016
Contracts awarded having investigators overseas	52%	46%	52%	56%	53%	51%	50%
Contracts completing in the year with international investigators	50%	52%	50%	53%	52%	60%	51%
Contracts completing in the year reporting additional international collaborations	94%	86%	95%	85%	84%	83%	88%

Table A8. International collaboration and communication on Marsden Fund contracts

Appendix 3 – Marsden Fund promoted projects 2016–2017

Swim speed: Salmon study unlocks sexual secrets

(UOO1209; 2012; \$300,000; Contact PI Dr Patrice Rosengrave)

Kiwi scientists have revealed how females in one species can influence which competing sperm make it to their eggs first - with possible implications for understanding our own reproduction system.

A New Zealand study has shown how male chinook salmon, also known as king salmon, can adjust their sperm's swimming speed if competing with a rival to reproduce. The insights, by Canterbury and Otago researchers, could help us better understand male fertility in other species - including humans.

It's known that the males of many species fight to establish social dominance and control over access to females and the opportunity to reproduce. In humans, this was quirkily signalled by one Australian study that found mixed-gender pornography stimulated male sperm faster than all-women porn.

In this case, University of Canterbury PhD student Michael Bartlett and his colleagues looked to chinook salmon to investigate the link between male social status, which influenced the competition for sperm, and the quality of their sperm, or how fast it could swim. Using a series of innovative social manipulation experiments at Canterbury's Salmon Smolt NZ hatchery, the researchers were able to show, for the first time, exactly how this manipulation of ejaculate worked in response to social cues. They revealed how males were able to change their sperm swimming speed, in less than 48 hours, if challenged by another male. When males changed their sperm velocity, via semen or seminal fluid, this altered the number of eggs that they fertilised relative to a rival male, Bartlett said.

"In other words, the adjustment of sperm velocity altered male reproductive success and therefore fitness."

Specifically, the study showed "sub-dominant" males had faster-swimming sperm compared to dominant ones.

Seminal fluid from subdominant males increased the sperm swimming speed of sperm from dominant males, and conversely, the seminal fluid from dominant males slowed sperm swimming speed of the sperm from subdominant males.

The study involved a fascinating experiment where the researchers set up competitive in vitro fertilisation experiments at the hatchery to effectively "race" sperm between each set of paired males, using natural and remixed ejaculates. They then genotyped the eggs to see which male sired the greater proportion of eggs, finding subdominant males fathered more of them. The effect seminal fluid had on sperm function also affected a male's fertilisation success, as sperm incubated in the seminal fluid of subdominant males sired more eggs than sperm incubated in the seminal fluid of dominant males.

The discovery contributed to a better understanding of the reproductive biology of chinook salmon, a commercially important aquaculture species also highly sought after by sport fishers.

Improved knowledge of the effects that seminal fluid had on sperm function may also have important consequences for our wider understanding of male fertility, Bartlett said.

"This rapid change in sperm speed is caused by differences in seminal fluid, not the sperm themselves. At present, we still don't know what component of seminal fluid is involved. Taken together, our results provide novel insight into the evolution of male reproductive biology."

Study co-author Professor Neil Gemmill, of Otago University, said that how males were able to beef up their sperm production when challenged had been largely unknown.

"What we have discovered is that males tailor the seminal fluids of their ejaculates to rapidly optimise their reproductive approach based on their perception of competition for mating opportunities. Such competition is widespread in nature and thus our work has a wide bearing for many systems, including humans."

More knowledge about the effects of seminal fluid on sperm function and its effects on male reproductive performance and fitness could have important implications for our understanding of male fertility in humans, livestock, and aquaculture.

The research, to feature in international eLife, was undertaken as a component of a Marsden Fund grant held by his principal supervisor Dr Patrice Rosengrave, a research fellow in the Department of Anatomy, University of Otago and fellow of the University of Canterbury.

Dr Tammy Steeves, of the University of Canterbury's School of Biological Sciences, was also involved in the study.

The new paper followed an earlier study, also co-authored by Gemmell, that revealed how the ovarian fluid that female salmon released with their eggs could help or hinder sperm swiftness - depending on the male it came from.

Kia ora: how Māori borrowings shape New Zealand English (UOW1603; 2016; \$300,000; Contact PI Dr Andreea Calude).



New Zealand English is one of the youngest dialects of English. It exhibits a number of unique features and the use of words from the indigenous Māori language is probably the most salient and easily recognisable one.

In our latest research, we found that the process by which Māori words are most frequently borrowed resembles the Darwinian concept of evolutionary fitness.

Of words and genes

Borrowings from Māori are so common that visitors to New Zealand only have to exit the plane to be greeted by haere mai.

New Zealand English is spoken nearly 20,000 kilometres away from the language which gave rise to it. Distinct from its closely related cousin, Australian English, but often mistaken for it, our variety of English is unique to New Zealand/Aotearoa.

New Zealand English is, of course, not alone in borrowing words from other languages. British English is no stranger to this, exhibiting words from as far as China and Japan to the east (ginseng, chow mein, kimono), and Native American languages to the west (tepee, toboggan). It is not exceptional in its array of foreign words, being both a donor and a receiver. This is the norm for many languages.

The flow of words around the world can be compared to the flow of genes across species. Luigi Cavalli-Sforza and his colleagues showed in a ground-breaking paper in 1988 that Darwin's idea that linguistic and genetic evolution paths go hand-in-hand was spot on.

Like genes, words rely on the existence of a host (a population of speakers in this case) and they evolve and adapt to the needs of their host. The host is crucial. When the last speaker of a language dies, the language itself dies.

Like genes, words can be understood to compete for the attention of their speakers, and this process can be modelled with mathematical and computational tools developed by geneticists. That is not to say that languages and genes are transferred by the same mechanism, but there are certainly parallels in their transfer. One crucial similarity is that humans take both their genes and their languages with them wherever they go.

What is more, like genes, language tells a story of who we are. It cannot be reduced to a mere process of information transfer - implanting an idea from one brain into another, without surgery. In reality, as any newspaper section of "letters to the editor" reveals, people invest much personal anguish in assessing current linguistic usage and they are critical of incoming changes.

The worry is that such changes may bring about the demise of the entire language. The use of foreign words can be seen as one such catalyst.

Māori borrowings in New Zealand English

Borrowings have been met with general disapproval by some, partly because the process implies that foreign words are merely borrowed from another language to fill a gap in the original language. This gap might be a speaker's own lack of proficiency of the language, which prompts the adoption of a foreign word that spreads to the rest of the population of speakers, or it could be a gap in the lexical resources available (language Y does not have a word for X).

Borrowed words act as gap fillers and as such, they point out what might be (wrongly) perceived as deficiencies.

Could this be why Māori borrowings show up in New Zealand English? In a [recent paper](#), we investigate the relative success of various Māori borrowings, taking into account how often a loanword is used as a ratio of its potential use, for example, the frequency of “aroha” (love) as a ratio of the total frequency of “aroha” and its English counterpart “love”.

[Our results show](#) that when comparing the relative success of Māori borrowings, the Darwinian concept of evolutionary fitness comes into play. A desire for economy of expression can help to explain why a word like “reo” (language) is relatively more frequent than “hōhonu” (deep): “reo” is shorter than “language”, whereas “hōhonu” is longer than “deep”. The same goes for borrowings whose closest counterparts in English can only be expressed by phrases, and not single words.

The social factors of borrowing

There is more to the story though. While speakers agree in their desire for economy of expression, we find variation in borrowing behaviours across speakers. Unsurprisingly, Māori speakers of English are the chief users of borrowings, with Māori women leading the way. Female-led [language change](#) is typical when the change is seen as the new “standard” of that language variety.

What prompts New Zealanders of European origins to incorporate Māori word in English seems to have to do with whom they are addressing. If addressing Māori or a group containing one, they are much more likely to use borrowings, presumably in order to show affinity with their audience. Interestingly, none of the New Zealand European speakers in our data reported being able to speak Māori. Furthermore, they seem to avoid borrowings with multiple meanings (possibly due to being unsure about the exact meaning of such words).

Consequences for language change

If speakers who do not speak Māori will nevertheless use Māori words in their day-to-day English, could this have larger consequences for the Māori language itself?

Following a long period of decline in Māori proficiency rates to near extinction, the Māori Language Act was passed in 1987, awarding Māori official status.

This year marks 30 years since that historic day and since the establishment of the Māori Language Commission, whose aim is to support the language. Today, Māori is spoken by just under 4% of all New Zealanders, and by 21% of Māori New Zealanders (according to the latest 2013 census).

The Māori Language Commission actively encourages the use of Māori words by everyone in New Zealand, whether they speak the language or not, and offers freely downloadable posters to this end. Thus the official stance is certainly that borrowings could well pave the way to higher proficiency rates by raising awareness and increasing language prestige. It will be interesting to see whether the future agrees with these assumptions.

Otago study links hormone to maternal nurturing trait (UOO1610; 2016; \$810,000; Contact PI Professor Dave Grattan).



Dr Rosie Brown

The same hormone that stimulates milk production also helps establish the nurturing link between mother and baby, new University of Otago research has found.

The study has established for the first time that the hormone prolactin, best known for its role enabling milk production, establishes and maintains the normal parental care that ensures the survival of offspring.

The research team at the university's Centre for Neuroendocrinology deleted targeted prolactin receptors in the preoptic area of the brains of adult female mice.

Study co-author Dr Rosie Brown said the team observed that mice without prolactin receptors were able to get pregnant and give birth normally, but abandoned their litters about 24 hours after birth.

The researchers found that signalling by the hormone prolactin to its receptors in a specific brain region was essential for mothers to show vitally important maternal nurturing behaviour towards their young.

"Our findings establish a critical role for prolactin for more than simply milk production. This work is the first to show this hormone is a literal life saver in that it establishes and maintains the normal parental care that ensures offspring survival," Dr Brown said.

"Prior studies suggested prolactin might alter the timing of when a virgin animal shows maternal nursing behaviour. Our study is the first one that has managed to finely manipulate the expression of the prolactin receptor gene in just a region of the brain and then look at the mother's behaviour during pregnancy and lactation.

"Unlike previous studies, our data shows that prolactin plays an essential role, not just in the timing of behaviour but in its continued display, and therefore the survival of offspring."

Disruptions in the ability of prolactin to communicate in the brain could lead to problems for mothers establishing a bond with their baby. This may in part explain issues with some animal species abandoning their young, she said.

This work was supported by a Health Research Council of New Zealand grant and a Marsden Grant from the Royal Society of New Zealand and has been published in the international journal PNAS.

Can action sports help make a better world?

(UOW1504; 2015; \$300,000; Contact PI Dr Holly Thorpe)

Waikato University Associate Professor Holly Thorpe has been researching skateboarders in Afghanistan, parkour (free running) athletes in Gaza and how action sports have helped rebuild resilience and community in Christchurch and New Orleans.

Through the sport of parkour, young men in Gaza have found an outlet, a space for expression and even a form of peaceful political protest, Prof Thorpe says.

They have learnt parkour through YouTube videos, she says. "They're running off buildings, off sand dunes, learning to flip and tumble and roll. "They're using these spaces to contest that these are their spaces, for play, for performance."

The men can't travel, but are able to connect with the worldwide parkour community via online videos.

"They are opening up these spaces of conversation where they feel support from a global community. We assume that young people in these spaces are victims, are needing our versions of support. What I'm seeing are some really creative, resourceful approaches they're using themselves to try to create change and improve their lives and [others' lives]."

The inclusive global culture of skateboarding makes it a powerful tool for diplomacy, PhD student and skating ambassador Neftalie Williams says. The diverse community of skateboarding is what first drew Williams to the sport.

"I saw that it didn't matter how much money you had or where you came from, everyone was skateboarding together."

The global ethos of skateboarding is that skaters support each other, explore spaces together and have fun together. Generally, the skating community is open to diverse groups coming in and adding to the fabric of their culture, so in this way it can be a powerful tool for diplomacy, he says.

"It doesn't matter where we're at in the world you'll see that bond between all skateboarders."

Skateboarding can give young people a "new set of eyes" to see possibility in their environment, he says. "We want to get [young people] thinking about how they could re-imagine that energy in academia ... There's levels of art and entrepreneurship deeply embedded in skateboarding culture.

"[We're trying to show] those kids how that can be a pathway to higher education or starting your own business... It's a multi-prong message that skateboarding as a whole can be something to help kids re-imagine all the spaces around them, not just the physical."

More than 200 organisations around the world are now using action sports for social development and peace-building, Thorpe says. She's set up [a website](#) she hopes will bring the community together to share knowledge and resources.

New findings on the dawn of agriculture

(UOO1413; 2014; \$720,000; Contact PI Dr Sian Halcrow)



Atacama child

Learning to cultivate crops and other agricultural food – rather than relying on hunter-gathering – is often thought of as a key milestone in the history of humanity.

However, new evidence from the University of Otago and the Universidad de Tarapacá in Chile indicates that the adoption of agriculture was associated with poor maternal and infant health in the ancient Atacama Desert.

This work provides the first direct evidence for maternal-foetal transfer of a nutritional deficiency in an archaeological sample.

Study lead author and PhD candidate Anne Marie Snoddy, of the Department of Anatomy, says agriculture does provide some evolutionary advantages, including increased resources for population growth.

“However, crop foods are quite poor in many nutrients needed by growing babies and their mothers. Women and children are particularly vulnerable to the negative effects of agricultural intensification and resource scarcity.”

The research team’s findings appear in *International Journal of Paleopathology*.

“Our new paper sheds light on to the impact of the agricultural transition on these past people, showing rare evidence for newborns and foetuses, including a possible mother-baby pair, with signs of pathology related to food deficiencies.

“This kind of direct evidence of maternal-foetal transfer of a nutritional deficiency is not something we have ever seen in the archaeological record.”

This research aimed to assess if there was any impact on the reduction of dietary diversity with the adoption of agricultural food practices, by investigating disease evidence on the skeletons of individuals from a transitional Early Formative Period site (3,600-3,200 years before present).

All the infants at this site showed potential evidence for nutritional insufficiency in the form of scurvy (vitamin C deficiency).

“Scurvy leaves its signature on bones. Prolonged vitamin C deficiency causes poor bone formation and leaky blood vessels. Small amounts of blood collect at muscle attachment sites and this can cause abnormal bone to form,” Ms Snoddy says.

“By analysing the patterning of this abnormal bone formation throughout the skeleton, we can identify people who suffered from a period of vitamin C deficiency during their life, and this can give us information about the general quality of their diet. Scurvy is associated with low dietary diversity and generally poor nutrition.”

Senior author Dr Sian Halcrow, of the Department of Anatomy, says there has been a focus archaeologically on the exploration of the pre-agricultural Chinchorro people and associated elaborate mummy burials.

However, recent research highlights periods of increasing infant mortality during the transitional period from hunter-gatherer to agricultural practices, and biological anthropologists are beginning to investigate the reasons for this.

“This work is important for the wider interpretation of the environmental context of the Atacama Desert, in northern Chile, in which these populations lived. This desert is one of the harshest environments in the world, with the least amount of rainfall (<2 mm per year) of any hot desert.

“The stresses on these people may have gotten worse with the adoption of agricultural food crops, which are poor sources of many important nutrients,” she says.

Ms Snoddy says the researchers interpreted that the vitamin C deficiency was possibly due to periodic food shortages from El Niño events in the area.

“In this paper, we argue that the extreme arid environment of the Atacama means that it is particularly ecologically unstable, with climate change causing major impact on both marine and land resources.”

Dr Halcrow says “importantly, the group’s latest findings also contribute to an understanding of the sensitive relationship between the ill health of the mother and infant in the past”.

“Ongoing work on bone and tooth chemistry and microfossil analyses of dental plaque may provide further insights into the transition to agriculture at this time.”

This project was supported by a Marsden Grant (UOO1413 "Transitions in prehistory: subsistence and health change in northern Chile") from the Royal Society of New Zealand, a CONICYT Anillo award, and a University of Otago Doctoral Scholarship.



Atacama, Chile

Otago researchers find valuable new clues in fight against multi-drug resistance

(UOO1305; 2013; \$773,913; Contact PI Professor Richard Cannon)



Dr Erwin Lamping

Research into yeast, the single-celled organism behind a range of human infections, has led to University of Otago Faculty of Dentistry researchers identifying a previously unknown piece of genetic sleight-of-hand which may enable multi-drug resistance, a major emerging global health problem.

The research, led by Dr Erwin Lamping from the Sir John Walsh Research Institute at Otago, was investigating how yeast becomes drug resistant. Through coming to an unexpected understanding of the resistance process, researchers may now be able to design ways to overcome drug resistance in humans.

To explain what they found Dr Lamping starts with the basic process of gene mutation that organisms use to adapt.

"When a gene mutates and has another function, the original gene function is lost. However, another way organisms adapt is by gene duplication, where they make a second copy of the gene. This has the advantage that if one copy mutates and changes its function, the organism still has the original gene with its original function. This allows organisms to adapt by using almost identical genes to develop a range of different functions or abilities."

While studying how the yeast behind human infections such as oral and vaginal thrush becomes drug resistant, Dr Lamping and his team found the organism makes a protein which pumps the drug out of the yeast cell.

"We also found, by chance, that there was a very similar gene next door - an example of gene duplication. What we discovered, which has not been found before, was that while large parts of the adjacent genes were identical, six short regions were different and had remained different for over 130 million years. The reason why they had remained different is because they were the regions that allowed the two pumps to pump different drugs."

"We carefully studied genes from seven yeast strains originating from different parts of the world and found 30 copies of the pump gene, all with the same pattern: they had large regions that were exactly the same and small regions that differed. This shows that this mechanism of evolution is widespread – in the entire yeast population studied," he says.

"This repetition of almost identical genes, but with different functions, may have gone unnoticed in other organisms including humans."

This may help understand why cancer cells become resistant to multiple drugs, why people react differently to drugs and why some drugs do not work for some people.

This research has been published in the journal *Genetics* and [highlighted by the Genetics Society of America](#).

This research was supported, in part, by funding from the Royal Society Te Apārangi Marsden Fund, contract UOO1305 'Fungal drug resistance: not as simple as A-B-C'

Jumping spiders can count 1, 2, and many

(UOC1301; 2013; \$826,087; Contact PI Professor Robert Jackson)



Portia africana

Portia, a jumping spider, targets other spiders as its preferred prey and it has a variety of predatory strategies up its sleeve to avoid getting eaten in the process

Like other jumping spiders, Portia has legendary eyesight but it leads the pack when it comes to having intricate vision-guided behaviour. Besides having the capacity to make plans, act on the basis of object permanence, represent specific goals and solve novel problems, Portia often has to confront more than one other spider at the same time.

Portia's capacity to represent exact numbers of prey has now featured in a [new article](#) in the Royal Society's journal *Interface Focus* by Fiona Cross and Robert Jackson from the University of Canterbury and the International Centre of Insect Physiology and Ecology. Experiments were based on showing Portia a specific number of prey (ranging between 1–6) that could only be accessed by walking along a detour path that first went directly away from the prey.

These experiments were also based on using expectancy-violation methods, which is unconventional in studies on spiders and other arthropods, but conventional in many studies on the numerical aptitudes of primates, including human infants. During experiments, Portia's view of the prey was obstructed during part of the detour and, during this time, the number of prey in the scene was changed, or it was kept the same in control trials. This meant that when Portia could again view the prey, the number might or might not be the same as what had been seen before. Evidence of expectancy violation was observed when Portia hesitated before continuing to move towards the prey.

A change of number between 3 vs. 4 prey or 3 vs. 6 prey did not result in expectancy violation, but expectancy violation was observed for every other change in number. This was observed independently of whether the larger number was seen first or second, and independently of prey size and orientation. The results of this study can be characterized as Portia counting 1, 2, and many, which is similar to what has been observed with human infants.

This work has arisen from Marsden grant UOC1301 "The strategies by which miniature predators use highly structured working memory"

Scientists discover extreme geothermal activity in South Island (GNS1001; 2010; \$686,957; Contact PI Professor Rupert Sutherland)



Alpine Fault Drilling site, Westland

A collaboration by scientists who drilled nearly 900 metres into the South Island's Alpine Fault has revealed surprisingly high temperatures and the potential for large geothermal resources in the area.

The Deep Fault Drilling Project, jointly led by Victoria University of Wellington, GNS Science and the University of Otago, was carried out in 2014 in Westland, north of Franz Josef Glacier.

The site was drilled by a team of more than 100 scientists from 12 countries, who were working to understand how earthquakes occur on geological faults.

The team identified the Whataroa site as the best place in the world to understand what a fault looks, feels, and sounds like just before an earthquake occurs. The Alpine Fault is known to rupture in magnitude 8 earthquakes approximately every 300 years, plus or minus 90 years.

The results of the project, published today in prestigious international journal *Nature*, discuss the site's geothermal gradient—a measure of how fast the temperature increases going deeper beneath the Earth's surface.

The project team discovered water at 630 metres depth that was hot enough to boil. Similar geothermal temperatures are normally found at depths greater than three kilometres.

Lead scientist Victoria University's Professor Rupert Sutherland says the geothermal conditions discovered are extreme by global standards and comparable to those in major volcanic centres like Taupo—but there are no volcanoes in Westland.

"The geothermal environment is created by a combination of tectonic movement and groundwater flow. Slippage during earthquakes has uplifted hot rocks from about 30 kilometres deep, and the rocks are coming up so fast that they don't get a chance to cool properly.

"Earthquakes fracture the rocks so extensively that water is able to infiltrate deep beneath the mountains and heat becomes concentrated in upwelling geothermal fluids beneath valleys. River gravels that are flushed by abundant West Coast rain and snow dilute this geothermal activity before it reaches the surface.

"Nobody on our team, or any of the scientists who reviewed our plans, predicted that it would be so hot down there. This geothermal activity may sound alarming but it is a wonderful scientific finding that could be commercially very significant for New Zealand."

The discovery could transform the economy and resilience of Westland, and provide a significant and sustainable clean energy resource that could be developed using local people and equipment, says Warren Gilbertson, Chief Operating Officer of Development West Coast.

"The location of geothermal activity and its possible benefit and association to the dairy and tourism sectors provide real opportunities from an economic perspective."

It is still too early to say just how big and how hot the geothermal resource might be, says Professor Sutherland, and additional exploration and drilling will be needed to assess the economic potential.

Novel technologies were used to gather the data, including precise temperature and seismic measurements that were made using lasers and a fibre-optic cable installed in the borehole. Ongoing work, supported by the Marsden Fund managed by the Royal Society of New Zealand and led by Professor Neil Broderick from the University of Auckland, aims to develop these technologies and use the existing borehole to monitor subtle changes and search for new earthquake-related phenomena over coming years.

Overall, the Deep Fault Drilling Project fell short of achieving all of its technical goals as the fractured and strongly-layered rocks and extremely hot temperatures provided engineering challenges.

However, many scientific measurements were made and the borehole continues to provide interesting data, says Victoria's Professor John Townend, a co-leader of the project.

"In scientific research, unexpected is just another word for really interesting. The findings reinforce the need for the international science community to better understand conditions that prevail around earthquake-generating geological faults."

Mimicking evolution to treat cancer

(VUW0704; 2007; \$151,111; Contact PI Associate Professor David Ackerley)



Associate Professor David Ackerley

Artificial forms of evolution are being used by a Victoria University of Wellington scientist to improve the ability of microbes to attack tumours.

Research led by Associate Professor David Ackerley, director of Victoria's Biotechnology programme, has underpinned the development of a new form of chemotherapy that exclusively targets cancer cells.

A key goal of this chemotherapy is a more targeted treatment method that results in fewer side effects for cancer patients.

To achieve this goal, Associate Professor Ackerley and his team engineered enzymes that can transform a relatively safe and non-toxic compound (a "pro-drug") into a drug that is highly toxic to cancer cells.

The genes encoding these enzymes are delivered to cancer cells using viruses or bacteria that are only able to replicate in tumours.

The pro-drug the team worked with is called PR-104A, and was developed by scientists at the University of Auckland, including Associate Professor Ackerley's collaborators on this study, Associate Professor Adam Patterson and Dr Jeff Smail.

"The enzyme we started with was moderately active with PR-104A," says Associate Professor Ackerley. "However, this was purely by chance—nature has never evolved enzymes to recognise these very artificial types of molecules.

"We reasoned that by mimicking evolution in the laboratory—by introducing random mutations into the gene encoding our target enzyme, then selecting the tiny minority of variants where chance mutations had improved activity—we might eventually achieve a more specialised enzyme that could more effectively activate PR-104A."

Not only is the team's artificially evolved enzyme significantly better at activating PR-104A within living cells, it also addresses another major problem—how to keep track of the microbes in patients to make sure they are only infecting cancerous cells.

"A unique aspect of our work is that our enzymes can also trap radioactive molecules called 'positron emission tomography (PET) probes'," says Associate Professor Ackerley. "We hope that this will allow a clinician to put a patient in a full body PET scanner to safely identify the regions where the microbes are replicating."

The team's research has been published in this month's edition of high-profile research journal [Cell Chemical Biology](#), and has been supported by several New Zealand funding agencies including the Marsden Fund managed by the Royal Society of New Zealand, the Health Research Council of New Zealand and the New Zealand Cancer Society.

In ongoing work, Dr Smaill and Associate Professor Patterson have been developing more effective pro-drugs to partner with Associate Professor Ackerley's enzymes. The team has been collaborating with groups at the University of Nottingham in the United Kingdom and Maastricht University in the Netherlands, aiming to progress the therapy into clinical trials in cancer patients.

The research has been funded through Marsden contract VUW0704; "New and improved: anti-cancer enzymes from bacteria".

What will the wasp plague be like this year?

(VUW1302; 2013; \$826,087; Contact PI Prof Phil Lester)



New research from Victoria University of Wellington has revealed the population of the common wasp is amplified by spring weather, with warmer and drier springs often meaning more wasps and wasp stings in summer.

The study, [published today in the Journal of Animal Ecology](#), examined 23 years of data from New Zealand and 39 years from the United Kingdom, which included the annual Rothamsted Insect Survey.

"We saw different populations exposed to different weather conditions, which substantially influenced population numbers. The patterns typically show lower numbers of wasps after cold, wet springs, and higher numbers after warm, dry springs," says lead author Professor Phil Lester from Victoria's School of Biological Sciences.

"This year we've had a really wet spring in many areas across New Zealand. These places that have seen a lot of spring rainfall could expect lower numbers of wasps than average this summer."

Professor Lester says climate change could considerably increase wasp numbers.

"The average global temperature is rising each year. We are therefore likely to see more wasp abundance in the future as our weather gets warmer.

"We saw this at Rothamsted in the United Kingdom. The area experienced a change in climate in the 1990s, and its warmer spring weather has resulted in considerably higher numbers of wasps."

The study also found population densities for the upcoming year are heavily dependent on numbers from the previous year.

"If we saw a high abundance of wasps in one year, numbers are likely to be lower in the following year," explains co-author Dr John Haywood from Victoria's School of Mathematics and Statistics.

"This is a relatively common way that insect populations change over time. We also determined that wasp populations don't 'cycle'—we can't predict the abundance of wasps three, four or more years from now based on their current numbers. There is no predictable rise and fall of numbers over the long term."

The invasive common wasp is a native species in the United Kingdom and became established in New Zealand in the 1970s. The insect is a major pest in both countries—in New Zealand it has been estimated to cost the economy in excess of \$130 million each year.

Other authors on the study are Dr Michael Archer from York and Chris Shortall from Rothamsted Research, both in the United Kingdom.

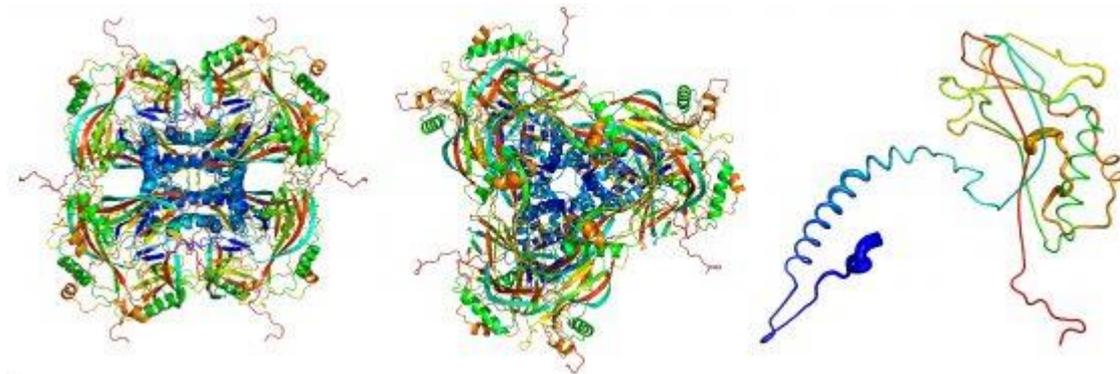
The study was supported by the Marsden Fund managed by the Royal Society of New Zealand, as well as New Zealand's Biological Heritage National Science Challenge, for which Professor Lester leads research into novel pest control technologies.

The Marsden Fund contract is VUW1302; "Using interaction networks to explain invasion success and community dominance: wasps in an old and new world".

Using a free electron laser to improve atomic level biological imaging

(UOA1221; 2012; \$843,478; Contact PI Professor Peter Metcalf)

High resolution science requires high energy beams. The downside is that high energy beams are also extremely destructive. Structural biologists working to visualize the complex atomic world underlying living things face a fundamental problem because the beams of X-rays or electrons they use destroy samples before they can be clearly seen. Research from a New Zealand / German collaboration published this week in the journal *Proceedings of the National Academy of Sciences of the United States of America* aims to solve this problem using a giant new X-ray laser to record structural information from samples a few femtoseconds before they explode. Despite using radiation doses hundreds of times greater than previously used in structural biology and over thirty million times the fatal dose for humans, the experiment was a success revealing the atomic structure of a nano-crystalline virus without damage, validating the idea and pointing the way forward to future X-ray imaging of non-crystalline biological samples.



Atomic model of the crystalline occlusion bodies, derived from the X-ray diffraction images recorded at the LCLS. The individual proteins (right) stick together to form the building blocks (left, seen from the side; centre, seen from above) of the crystalline occlusion bodies. Credit: Dominik Oberthür, CFEL/DESY

Peter Metcalf, from the School of Biological Sciences at the University of Auckland, has been working with insect virologist Johannes Jehle from the Julius Kühn Institute in Damstadt on granulovirus since 2008 and started the collaboration with Henry Chapman at the Centre for Free Electron Science in Hamburg in 2011. He commented 'It has been a huge privilege to work with Henry and the team of over 40 people at the Centre for Free Electron Laser Science in Hamburg and the Linear Coherent Light Source at Stanford using a billion dollar machine to elucidate the atomic structure of an esoteric nano-crystalline codling moth virus, but more importantly to make progress overcoming the fundamental damage problem in structural biology.'

The research was supported by Marsden contract UOA1221 awarded in 2012: "Towards atomic resolution biological imaging using free electron X-ray laser radiation - the granulovirus connection".

Marsden-funded Antarctic research published in Nature

(VUW1203; 2012; \$300,000; Contact PI Dr Nicholas Golledge)

A paper entitled "Centennial-scale Holocene climate variations amplified by Antarctic Ice Sheet discharge" and coauthored by Dr Nicholas Golledge, a senior research fellow at Victoria University of Wellington's Antarctic Research Centre, was published today by *Nature*.

The paper arose from research connected with VUW1203, a 2012 Marsden-funded project led by Dr Golledge. This project entitled "Will the East Antarctic Ice-Sheet contribute to global sea-level rise under warmer-world scenarios?" aimed to simulate the evolution of the East Antarctic Ice Sheet under a range of oceanic and atmospheric conditions.



Recently detached icebergs float in the sea surrounding the Antarctic Ice Sheet

An international team, including Dr Nick Golledge, senior research fellow at Victoria University of Wellington’s Antarctic Research Centre, used computer models to investigate what would happen if pulses of meltwater were released by the Antarctic ice sheet into the Southern Ocean.

The models showed that although the influx triggered cooling of the sea surface around Antarctica, temperatures deeper in the ocean began to rise, says Dr Golledge.

“This response is well-known, but what is less-known is that the input of fresh water also leads to changes far away in the Northern Hemisphere, because it disrupts part of the global ocean circulation.

“This means that meltwater from the Antarctic ice sheet won’t just raise global sea level, but might also amplify climate changes around the world. Some parts of the north Atlantic may end up with warmer air temperatures as a consequence of part of Antarctica melting.”

The team, led by Dr Pepijn Bakker from the Center for Marine Environmental Sciences in Bremen, Germany, used its models to simulate how Antarctica and the global climate may have changed during the last 8,000 years.

“I used a computer model to simulate how the Antarctic ice sheet changed as we came out of the last ice age and into the present, warm period,” says Dr Golledge.

“We then took the outputs and fed them into the climate model to see what the effect on global temperatures would be. We ran lots of experiments and compared the results with data from geological records to get a better idea of the timescales involved in these processes.”

The study also found that high-frequency changes in ocean temperatures tend to be absorbed by the Antarctic ice sheet, which then responds more slowly.

“Whilst this might be seen as a good thing, it also implies that once the ice sheet starts responding, by melting, it may be too late to prevent the consequences.”

Interpreting these results, Dr Bakker and his team conclude that the Antarctic ice sheet plays a major role in regional and global climate variability—a discovery that may also help explain why sea ice in the Southern Hemisphere has been increasing despite the warming of the rest of the Earth.

Other authors on the study include Professor Peter Clark and Dr Andreas Schmittner from Oregon State University in the United States, and Dr Mike Weber from the University of Bonn in Germany.

Last year Dr Golledge led another study, also published in *Nature*, which found that future ice melt from Antarctica could lead to sea-level rise up to 10 metres above present day if greenhouse gas emissions continue at present rates.

Marsden Fund Research Reveals Factors Regulating Toxin Production (UOW1202; 2012; \$800,000; Contact PI Professor David Hamilton)

An international team of scientists researching toxic algal blooms in lakes have provided new insights into why these microscopic organisms produce toxins. The research team, co-led by Prof David Hamilton from the University of Waikato and Dr Susie Wood from Cawthron Institute, have been investigating what triggers toxin production in planktonic cyanobacteria (blue-green algae) as part of three-year Marsden Fund project. Also working on the project is post-doctoral researcher Dr Jonathan Puddick (Cawthron Institute) and Prof Dan Dietrich (University of Konstanz, Germany).

“Thanks to this research, we’ve gained new knowledge on the ecological role of toxin production. It appears one of the reasons they produce toxins is as a coping mechanism in response to extreme shifts in their environment created when blooms form” says Dr Wood. “Unlike many organisms which produce toxins to protect themselves against predation, we believe that toxin production in cyanobacteria protects the cells from adverse conditions.”

In collaboration with Prof Ian Hawes from the University of Canterbury the team used micro-profiling techniques to show how harsh the conditions inside a cyanobacterial bloom are. “At certain times during the day pH reaches 11 inside the bloom, that’s as basic as ammonia solution. We really weren’t expecting to see these levels and such fine-scale changes within the surface layers – they can go from anoxic conditions (low oxygen) to normal levels in less than a centimeter,” Prof Hamilton says.

Using new cryogenic sampling tools which allow samples to be instantly frozen, the team have observed freshwater microbial communities at resolutions never seen before. “Like a submarine, these cyanobacteria can control their buoyancy. During the day they rise up and form a ‘scum’ on the surface. This is where we see really high pH and oxygen levels – it’s also where toxin production is greatest,” says Dr Puddick. “We’ve not been able to show these things before because we haven’t been using sampling techniques which enable such a high-definition picture of the natural world.” The scientists’ next step is to take these new techniques and combine them with other molecular and biochemical tools to understand toxin production at an even finer-scale. “Right now (using this new technique) we can look at blooms at a millimetre-scale, the next step is to take it to a micrometre-scale and understand how the cyanobacteria are interacting as a community.”

As well as novel technologies, the scientists also trialled a different approach by studying toxin production in the field instead of working in the laboratory. The team has spent the last three cyanobacterial bloom seasons at Lake Rotorua in Kaikoura. “Cyanobacteria kept in the lab don’t respond the same as those found in the natural environment, so we created a lab in the field,” Dr Puddick says. However, working outside did present the team with some difficulties. “It can be really challenging as there are so many complex things to consider, you don’t get to decide when your experiment starts, nature is in control. One year we had to contend with a tropical cyclone, there was duck shooting season and then we had an extreme once in a 75-year drought.”

In the future, the researchers hope to be able to predict toxin production in real time. “Our ultimate goal is to protect human health by providing governments, councils and regulators with the capability to predict and model the times and regions of highest risk. In the future, this might mean that they have the tools to better inform the public on the safest places to swim at certain times of the day or the week,” Prof Hamilton says. “We’re not quite there yet, there’s still a lot more we need to understand about toxin production in cyanobacteria, but we’re another step closer now.”

Their recent research using novel cryogenic sampling techniques has just been published in the prestigious scientific journal ‘Limnology and Oceanography: Methods’ and is freely available at: <http://onlinelibrary.wiley.com/doi/10.1002/lom3.10115/pdf>. For more information on the team’s research and to keep up-to-date with their latest work, check out their Vimeo channel (<https://vimeo.com/cyanoresearch>) or on Twitter #CyanoResearch.

The research is being funded though Marsden contract UOW1202; “Toxic in crowds: the triggers of toxin production in planktonic cyanobacteria”.

Otago physicists collide ultracold atoms to observe key quantum principle

(UOO1121; 2011; \$639,130; Contact PI Associate Professor Niels Kjærgaard)

University of Otago physicists have used steerable 'optical tweezers' to split minute clouds of ultracold atoms and slowly smash them together to directly observe a key theoretical principle of quantum mechanics.

The principle, known as Pauli Exclusion, places fundamental constraints on the behaviour of groups of identical particles and underpins the structure and stability of atoms as well as the mechanical, electrical, magnetic and chemical properties of almost all materials.

Otago Physics researcher Associate Professor Niels Kjærgaard led the research, which is newly published in the prestigious journal [Nature Communications](#).

Kjærgaard and his team used extremely precisely controlled laser beams to confine, accelerate and gently collide ultracold atomic clouds of fermionic potassium. The atomic clouds had a temperature of a mere millionth of degree Kelvin above absolute zero.

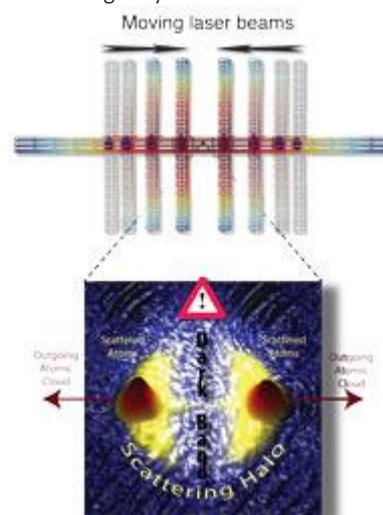
The Pauli Exclusion Principle predicts a forbidden zone along a meridian of the spherical halo of scattered particles, which the experiments indeed unveiled. "This dark band results from a 'no side-stepping' rule that the principle dictates, which is that indistinguishable fermions cannot scatter out at 90 degrees to the collision axis," Kjærgaard says.

When PhD student Ryan Thomas looked more closely at his data, he found that under some conditions the images of scattering haloes from the particles would actually display side-stepping—the dark band would be less dark.

"This is not because the rule suddenly breaks down, but because there can be situations where a particle scatters multiple times with consecutively new collision axes," Associate Professor Kjærgaard says.

This particular finding has important implications for gaining insights into the particulars of the underlying processes governing multiple particle scattering.

The work was supported by the Marsden Fund, through contract UOO1121; "Littlest Hadron Collider: a laser based accelerator for ultra-cold atoms".



Prehistoric demise of Chathams sea lion a stark warning for conservation of NZ sea lion

(UOO1112; 2011; \$763,478; Contact PI Professor Jon Waters)



An international research team led by University of Otago scientists has shown that New Zealand's Chatham Islands were once home to a unique population of sea lion that was driven to extinction soon after first human settlement.

The researchers used ancient-DNA analysis, radiocarbon dating and computational modelling to reveal the relationships of the unique prehistoric population, and also to understand the reasons for its sudden extinction a few hundred years ago.

Dr Nic Rawlence, who carried out the genetic study, says the team found a previously undiscovered lineage of sea lion on the isolated Chatham Islands, 650 km east of mainland New Zealand. The unique prehistoric Chathams sea lion was genetically clearly distinct from the modern population that persists in the Auckland and Campbell Islands, and mainland New Zealand today.

"The Chathams supported a large, genetically diverse population of this unique sea lion, which went rapidly extinct around 1650 AD, following Polynesian settlement of the islands only 200 years earlier," says Dr Rawlence.

“The regional New Zealand sea lion population now contains only a fraction of the genetic diversity it once had,” says Dr Catherine Collins, who was also involved in the study.

The Otago team used computational modelling to determine the level of human hunting likely to have caused the Chathams sea lion extinction.

“Modelling indicated that hunting rates greater than one sea lion/person/year resulted in the extinction of native populations within 200 years of first human settlement,” says Dr Justin Maxwell, an Otago archaeologist involved with the study.

“Sea lions were not able to withstand even low levels of sustained hunting pressure,” says Dr Maxwell.

The findings may also have important implications for the continued survival of New Zealand’s modern sea lions, says project leader Professor Jon Waters. “We used the same modelling approach to estimate the survival prospects for the modern population under different mortality rates.”

Sea lions are listed as endangered in the International Union for Conservation of Nature Red List. With only around 10,000 individuals remaining, the population is in serious decline (50 per cent decline in pup births since 1998), with fisheries bycatch and resource competition the likely culprits.

“The team’s computer models suggest that current reported and unreported bycatch levels may be unsustainable for the long-term survival of the species. Our study adds to the growing evidence that undetected sea lion bycatch may still be driving the decline of the species, something the government’s recently released sea lion threat management plan (TMP) dismisses,” says Associate Professor Bruce Robertson, an Otago sea lion biologist, who was involved in the study.

“Overall, this study is a great example of how ancient DNA can be used to inform conservation strategies of currently endangered species,” says Dr Rawlence.

“What our research shows is that human harvesting and sea lions do not mix. Unless measures are taken to mitigate continuing bycatch levels, the outlook for our sea lions is bleak.”

This Marsden- and Allan Wilson Centre- funded research included team members from the University of Otago, University of California, San Diego, and Southern Methodist University, as well as the Museum of New Zealand Te Papa Tongarewa and Canterbury Museum.

The research appears in the international journal [Molecular Ecology](#).

The research was partly funded through Marsden contract UOO1112; “The biogeographic importance of historical contingency: extinction and recolonisation in coastal New Zealand”.

Troubled waters ahead for marine life

(VUW1201; 2012; \$800,000; Contact PI Professor Jeff Shima)



The common triplefin.

Research from Victoria University of Wellington is investigating how coastal marine species may struggle with Earth’s increasingly intense storms.

The Intergovernmental Panel on Climate Change has forecast that rising global temperatures will mean increased intensity of storms, including tropical cyclones with higher wind speeds, a wetter Asian monsoon and possibly more intense mid-latitude storms.

Victoria PhD student Becky Focht is looking to understand how species will cope with this kind of environmental disturbance by studying the common triplefin, a small marine fish found along shallow reefs and tidal pools throughout New Zealand. The triplefin experience some of the hardest impacts of big waves.

Her study has found that the triplefin eat a higher proportion of their prey in calmer conditions.

“Fish that live in more wave-exposed areas are bigger, but when there are more waves they eat significantly less prey,” says Ms Focht.

“I’m not yet sure why—but it does suggest that predators are more adversely affected by environmental stress than prey. This could have larger implications—a decline in predation rate or boost to populations of prey.”

Ms Focht says marine species have mechanisms to survive these events but human activity is pushing the limit.

“Humans rely on the oceans for food, transport, energy and recreation, but this takes a toll on the millions of marine species that live in them.

“It’s important that we understand what their coping strategies are to determine the long-term impacts of humans.”

The study was conducted at the Victoria University Coastal Ecology Laboratory (VUCEL) in Wellington’s Island Bay using a dump bucket system to simulate waves. The triplefin were fed food in buckets that were either experiencing wave events, had no waves, or had been in waves and then were moved to calm water.

Ms Focht’s research is supervised by VUCEL’s Professor Jeff Shima and supported by the Marsden Fund.

Ms Focht presented her study this week at the joint 2016 New Zealand Marine Sciences Society and Australian Marine Sciences Association conference held at Victoria University’s Kelburn campus.

The four-day event included more than 350 international marine scientists discussing the latest advances in marine science, the competing demand for fisheries and other marine resources and the scientific work needed to help manage that demand, as well as how climate change is affecting the marine environment.

This work is being funded through Marsden contract VUW1201; “Winners and losers: effects of demographic heterogeneity on individual fitness and the dynamics of marine metapopulations”.

Maurice Wilkins Centre collaboration solves elusive protein structure (UOA1115; 2011; \$717,391; Contact PI Distinguished Professor Margaret Brimble)

A collaboration between chemists and biologists from the Maurice Wilkins Centre has enabled researchers to solve the structure of a potent antimicrobial protein with potential to tackle bacterial diseases in kiwifruit vines.

The University of Auckland based researchers, Distinguished Professor Margaret Brimble and Dr Paul Harris from the School of Chemical Sciences, and Distinguished Professor Ted Baker, Dr Christopher Squire and PhD student Horace Yeung from the School of Biological Sciences, had their novel research published as the cover article in the 17 May 2016 international edition of leading chemistry journal, *Angewandte chemie*. The article was also commended as a Very Important Paper due to its high evaluation by referees.

The snakin-1 protein is found in potatoes and was previously identified as a unique class of antibiotic. Professor Brimble, a lead investigator on the study, says unravelling the protein’s structure now enables further investigation into the production of a natural, plant-produced bactericide with potential to fight kiwifruit Psa infections – a bacterial disease that can impact productivity in kiwifruit vines.

“Solving the structure provides clues to the parts of the protein we can modify to rationally design a new class of antibiotics,” Dr Squire says.

Researchers have long held high hopes for snakin-1 and have been attempting to determine its structure for over a decade. University of Auckland chemists began work on the protein six years ago due to its promise in tackling kiwifruit disease. Dr Harris explains the protein was identified 14 years ago but was not successfully crystallised until now.

The Maurice Wilkins Centre team attributes the breakthrough to a unique collaboration between chemists and biologists within the New Zealand Centre of Research Excellence.

“The Maurice Wilkins Centre has supported the Brimble Peptide Chemistry Laboratory at the University of Auckland and, with assistance from a prestigious Marsden Fund grant, the peptide chemists had the opportunity to work with world-class X-ray crystallographers,” Dr Harris says.

Producing a protein crystal is key to determining the molecular make-up of a protein, which in turn enables its modification to develop new antibiotic compounds. The research team used an ingenious and unconventional combination of techniques from chemistry and biology to synthesize and crystallise the protein and solve its structure.

Professor Brimble says initial attempts to crystallize the synthetic snakin-1 protein were unsuccessful, so PhD student Horace Yeung turned to a newly developed approach called racemic protein crystallography. The first step was to produce a racemic protein mixture – a combination of the natural left (L) and mirror-image (D) forms of the protein to greatly increase chances of crystallisation.

Mr Yeung then worked with Professor Baker and Dr Squire to use X-ray crystallography at the Australian Synchrotron in an attempt to determine the protein's structure. Unfortunately the results showed significant signs of radiation damage and the structure remained elusive.

"In this case getting the crystals didn't allow us to get the structure straight away so we had to use radiation induced phasing," Dr Squire says. Radiation induced phasing involves deliberately damaging the crystals and looking at the diffraction of light beams before and after damage to solve the structure.

"It's a fringe technique and the first time it has ever been applied to a racemic protein mixture."

The technique worked, and the researchers were finally able to unlock the elusive structure of the snakin-1 protein. The team now hopes to produce a number of variants of the antimicrobial protein with a wide-range of potential applications.

Full details of the study can be found in the latest edition of [Angewandte chemie](#).

The research was partly funded through Marsden contract UOA1115; "The determination of protein structure by racemic protein crystallography".

Why don't Governments implement growth-maximising fiscal policies?

(MEP1201; 2012; \$773,913; Contact PI Dr Arthur Grimes)



Dr Arthur Grimes

For years, research has told us that income taxes are worse for economic growth than GST. Governments still, however, raise more money from taxes on personal income than from indirect taxes such as GST.

A new study from Motu Economic and Public Policy Research helps explain why governments may follow this lower growth path.

"For years GDP has been the measure used by most economists for measuring how well a country's economy is faring," said Arthur Grimes, Senior Fellow at Motu Economic and Public Policy Research Trust. "Now however, there is another useful option for tracking different policy options – subjective wellbeing – or how satisfied people feel with their lives."

Dr Grimes and three co-authors have just released a paper reporting on more than 30 years of fiscal data from 35 countries, cross-referenced with subjective wellbeing scores from more than 170,000 people. The research explores how people react to various fiscal decisions.

"We found that 'distortionary' taxes, like income tax are associated with better subjective wellbeing outcomes than 'non-distortionary' taxes such as GST, particularly for the poor," said Dr Grimes. "This was the case even after controlling for the effects of individual personal circumstances and country background."

"For example, if a country ranked 15th in the OECD for subjective wellbeing adjusted 10 percent of its GDP by reducing GST and increasing income tax, its ranking would rise to around 5th. In fact, changing the country's fiscal makeup like this seems to be even more effective than getting married in making people happy," said Dr Grimes.

“Richer people are affected more negatively by distortionary taxes and less by non-distortionary taxes than poorer people. They also benefit less than poorer people from expenditure on things such as education, health, housing, transport, defence and general public services,” said Dr Grimes.

In contrast, social welfare spending has most benefit for the middle class and least benefit for poorer people. This possibly reflects that many such expenditures (such as support for tertiary students) in fact benefit the middle-class the most, a phenomenon known as ‘middle-class capture’.

The research also indicates that taxation is best done centrally, while expenditure is best done by a combination of central and regional government. This is consistent with economies of scale being important for revenue raising, and with local knowledge being important for expenditure.

The study [Subjective wellbeing impacts of national and sub-national fiscal policies](#) by Arthur Grimes, Judd Ormsby, Anna Robinson, and Siu Yuat Wong was funded by Marsden Fund grant MEP1201 from the Royal Society of New Zealand: “Testing the validity and robustness of national wellbeing and sustainability measures”.

The dark side of religion: how ritual human sacrifice helped create unequal societies

(UOA1104; 2011; \$673,913; Contact PI Professor Russell Gray)

(VUW1321; 2013; \$769,565; Contact PI Dr Joseph Bulbulia)

A new study finds that ritual human sacrifice played a central role in helping those at the top of the social hierarchy maintain power over those at the bottom.

“Religion has traditionally been seen as a key driver of morality and cooperation, but our study finds religious rituals also had a more sinister role in the evolution of modern societies,” says lead author of the study Joseph Watts.

Researchers from the University of Auckland’s School of Psychology, the Max Planck Institute for the Science of Human History in Germany and Victoria University, wanted to test the link between how unequal or hierarchical a culture was – called social stratification – and human sacrifice.

The research team used computational methods derived from evolutionary biology to analyse historical data from 93 ‘Austronesian’ cultures. The practice of human sacrifice was widespread throughout Austronesia: 40 out of 93 cultures included in the study practised some form of ritualistic human killing.

Early Austronesian people are thought to have originated in Taiwan and, as they moved south, eventually settled almost half the globe. They spread west to Madagascar, east to Rapa Nui (Easter Island) and south to the Pacific Islands and New Zealand.

Methods of ritual human sacrifice in these cultures included burning, drowning, strangulation, bludgeoning, burial, being cut to pieces, crushed beneath a newly-built canoe or being rolled off the roof of a house and decapitated. Victims were typically of low social status, such as slaves, while instigators were usually of high social status, such as priests and chiefs.



Associate Professor Quentin Atkinson

The study divided the 93 different cultures into three main groups of high, moderate or low social stratification. It found cultures with the highest level of stratification were most likely to practice human sacrifice (67%, or 18 out of 27). Of cultures with moderate stratification, 37% used human sacrifice (17 out of 46) and the most egalitarian societies were least likely to practice human sacrifice (25%, or five out of 20).

“By using human sacrifice to punish taboo violations, demoralise the underclass and instil fear of social elites, power elites were able to maintain and build social control,” Mr Watts says.

Professor Russell Gray, a co-author of the study, notes that “human sacrifice provided a particularly effective means of social control because it provided a supernatural justification for punishment. Rulers, such as priests and chiefs, were often believed to be descended from gods and ritual human sacrifice was the ultimate demonstration of their power.”

A unique feature of the research was that the use of computational evolutionary methods enabled the team to reconstruct the sequence of changes in human sacrifice and social status over the course of Pacific history. This allowed the team to test whether sacrifice preceded or followed changes in social status.

Co-author, Associate Professor Quentin Atkinson says: “What we found was that sacrifice was the driving force, making societies more likely to adopt high social status and less likely to revert to egalitarian social structure.”

The study is [published in Nature](#).

Three Royal Society of New Zealand awards contributed to this research: Marsden grant UOA1104, “The cultural evolution of religion”; Marsden grant VUW1321, “The social consequences of spirituality and religion: a twenty year longitudinal study”; and a Rutherford Discovery Fellowship UOA1101 to Quentin Atkinson.

First evidence found that “cryptic female choice” is adaptive

(UOO0913; 2009; \$773,333; Contact PI Professor Neil Gemmell)

(UOO1209; 2012; \$300,000; Contact PI Dr Patrice Rosengrave)

University of Otago researchers studying chinook salmon have provided the first evidence that “cryptic female choice” (CFC) enhances fertilisation success and embryo survival.

Cryptic female choice involves females using physical or chemical mechanisms to control which male fertilises their eggs after mating, and is known to occur in a number of species.

In 2008, Department of Anatomy researchers Dr Patrice Rosengrave and Professor Neil Gemmell were the first to show that CFC occurred in salmon. When these fish spawn, eggs and sperm are shed simultaneously into the surrounding water with ovarian fluid being secreted with the eggs.

They demonstrated ovarian fluid helped or hindered sperm swiftness depending on the male it came from.

Now, after conducting a series of competitive and non-competitive fertilisation experiments, the pair and colleagues have provided the first evidence that CFC contributes to reproductive success.

Dr Rosengrave says they found that not only does a particular female’s OF give a bigger boost to some male’s sperm and not others, these speedier sperm have a significantly higher chance of winning the race to fertilise eggs and the resulting offspring have a better survival rate as embryos.

“Additionally, after assessing the genetic quality of the males we found embryo survival was linked to being sired by higher quality fathers,” she says.

The findings may have wider implications for our understanding of animal, or even human, reproduction, she adds. “There could well be equivalent mechanisms at play in environments such as mucous on vaginal or uterine walls.”

The research, which was supported by the Marsden Fund of New Zealand, appears in the UK journal *Proceedings of the Royal Society B*.

The research was carried out through Marsden contracts UOO0913; “Investigating the genetic basis for and adaptive significance of cryptic female choice in an external fertiliser – the chinook salmon (*Oncorhynchus tshawytscha*)” (Professor Neil Gemmell) and UOO1209; “How do males adjust their sperm quality in response to social cues?” (Dr Patrice Rosengrave).

Crows’ specialised bill might explain clever tool skills

(UOA1208; 2012; \$800,000; Contact PI Dr Gavin Hunt)



New Caledonia crow with pandanus stick

Famed for their intelligence, the New Caledonian crow is the only other animal on earth that makes complex tools with features such as hooks. But why and how this sophisticated tool-making ability evolved has long puzzled scientists.

Now a new piece of the puzzle has fallen into place: a team of international researchers has discovered that the New Caledonian crow’s bill is not only different to the bills of its close relatives, it may be unique in the bird world.

The team, including Senior Research Fellow Gavin Hunt from the University of Auckland’s School of Psychology, used shape analysis and CT scanning to compare the shape and structure of the New Caledonian crow’s bill with some of its crow relatives and a woodpecker species with a similar foraging niche

The team found the New Caledonian crow's bill is shorter, stouter and straighter than the bills of the other species, which included the Japanese large-billed crow and the rook. The cutting edge of the upper bill is very straight, but it is upturned at the front of the lower bill.

These features give the birds not only a vice-like grip, but enable them to efficiently guide the tool tip with sharp binocular vision as they use the tool to forage for food.

"No other crow species can hold a tool as effectively as a New Caledonian crow," Dr Hunt says. "This study shows that the novel bill contributes to the birds' ability to use and probably make tools. We argue that it became specialised for tool manipulation once the birds began using tools, and that this enhanced tool manipulation ability may have allowed the crows to make more complex tools.

"This provides some evidence that physical changes were evolutionarily selected in a nonhuman species to enhance tool skills before it increased the sophistication of its tools. It also suggests that New Caledonian crows have been evolving their tool use over possibly millions of years, as humans have."

New Caledonian crows make and use simple tools to forage for food. Stripping the leaf blade from the stem with their bills, they grip the leaf stem and poke it into tree burrows fishing for grubs and beetles.

Clever use of the tools includes poking them into the burrows of large longhorn grubs so that it irritates the grubs enough to make them clamp onto the end of the stick. The grubs are then hoisted to the surface.

New Caledonian crows on the island of Grande Terre in New Caledonia also make two types of complex hook tool. The first by cutting shapes out of the barbed leaves of the Pandanus plant. The second is a crochet-hook-like tool made from forked twigs where the crows actually form the hooks themselves. These tools are used to extract insects from their hiding places in vegetation.

The research is published in Nature's [Scientific Reports](#), and was funded through Marsden grant UOA1208; "The genetics of complex cognition".

Religious New Zealanders most tolerant of Muslims

(VUW1321; 2013; \$769,565; Contact PI Dr Joseph Bulbulia)

New Zealanders are highly accepting of religious diversity, yet some groups are the targets of more prejudice than others, researchers at Victoria University of Wellington and the University of Auckland have found.

The research also found that highly religious New Zealanders—irrespective of their religion—were the most tolerant of Muslims.

Victoria's Dr John Shaver, Dr Geoff Troughton and Associate Professor Joseph Bulbulia, and University of Auckland's Associate Professor Chris Sibley, analysed data collected from almost 14,000 New Zealanders.

They were particularly interested in the drivers of prejudice and tolerance towards Muslims, says Associate Professor Sibley.

"New Zealand is an incredibly diverse, socially progressive and tolerant country, however levels of extreme prejudice towards Muslims are twice as high as for other minority groups."

Dr Shaver says several decades of research suggests religious people are more prejudiced to those outside of their in-group. "With regard to Muslims, others have suggested that longstanding Christian-Muslim conflicts are self-perpetuating. Neither perspective is quite right."

The researchers propose that when it comes to religion and prejudice, place trumps beliefs.

"People tend to think that religious ideas drive conflict, however the same religious ideas can be interpreted in opposing ways, and it's a local history that predicts how religious ideas are put to use," says Dr Shaver. "In peaceful countries such as New Zealand, strong religious faith enhances charity and acceptance."

The researchers found that while secular people are more tolerant than those who only weakly identify with their religion, non-Muslim New Zealanders who identify as highly religious are the most tolerant of Muslims.

"Among New Zealanders, a strong religious faith is correlated with being more accepting of Muslim peoples. This correlation is about as strong as the correlation between having a postgraduate education and being more accepting of Muslim peoples," says Dr Shaver.

"Our findings are important," says Associate Professor Bulbulia, "because tolerance of Muslims lags behind other groups. Our results suggest that communities of religious non-Muslims are a key resource for bridging the Muslim acceptance gap."

The research was recently published in the international journal PLOS ONE, in a paper titled *Religion and the Unmaking of Prejudice toward Muslims: Evidence from a Large National Sample*.

It was funded through Marsden contract VUW1321, "The social consequences of spirituality and religion: a twenty year longitudinal study".

Scientists attribute rising methane levels to agriculture (NIW1002; 2010; \$260,870; Contact PI Dr Hinrich Schaefer)



Baring Head Clean Air Monitoring Station

A breakthrough in understanding about the causes of climate change has been published online in the international journal *Science*.

The research, led by NIWA atmospheric scientist Hinrich Schaefer, has concluded that increasing levels of methane in the atmosphere since 2007 are most likely due to agricultural practices, and not fossil fuel production as previously thought.

Methane is a greenhouse gas and one of the major contributors to climate change. The amount of methane in the earth's atmosphere is estimated to have increased by about 150 per cent since 1750.

NIWA scientists first noticed trends occurring in the data collected at NIWA's clean air monitoring stations at Baring Head in Wellington and Arrival Heights in Antarctica.

With only Southern Hemisphere data to go on, the scientists began to collaborate with the University of Colorado in the US, and Heidelberg University in Germany whose scientists were taking similar measurements in a number of locations across the world.

"We wanted to put all the data together, then calculate the global average for each year and look at how that has changed over time," Dr Schaefer said.

Between 1999 and 2006 scientists observed a plateau in the amount of methane in the atmosphere. The amount had been steadily increasing since pre-industrial times but then levelled out for about seven years. After 2006 it began to rise again and continues to do so.

Around the time the plateau in methane emissions occurred, economic collapse in the Soviet Union caused oil production to decline dramatically – a factor that could now be detected in atmospheric analysis but is of no great surprise to the scientists.

However, analysis since 2006 rules out fossil fuel production as the source of methane increasing again.

"That was a real surprise, because at that time the US started fracking and we also know that the economy in Asia picked up again, and coal mining increased. However, that is not reflected in the atmosphere," Dr Schaefer said. "Our data indicate that the source of the increase was methane produced by bacteria, of which the most likely sources are natural, such as wetlands or agricultural, for example from rice paddies or livestock."

Previously published studies had determined that the methane originated from an area that includes South East Asia, China and India – regions that are dominated by rice production and agriculture.

"From that analysis we think the most likely source is agriculture."

"If we want to mitigate climate change, methane is an important gas to deal with, and if we want to reduce methane levels this research shows us that the big process we have to look at is agriculture."

This work was funded through a Marsden Fast-Start contract NIW1002; "Stable carbon isotope constraints on methane sources during fast climatic transitions".

Bees “dumb down” after ingesting tiny doses of pesticide (UOO1207; 2012; \$791,304; Contact PI Professor Alison Mercer)



Honeybees suffer severe learning and memory deficits after ingesting very small doses of the pesticide chlorpyrifos, potentially threatening their success and survival, new University of Otago research suggests.

In their study, researchers from the Departments of Zoology and Chemistry collected bees from 51 hives across 17 locations in the province of Otago in Southern New Zealand and measured their chlorpyrifos levels. They detected low levels of pesticide in bees at three of the 17 sites and in six of the 51 hives they examined.

Detecting chlorpyrifos was not a surprise. In 2013, Associate Professor Kim Hageman and her team from Otago’s Department of Chemistry showed that chlorpyrifos was detectable in air, water, and plant samples even in non-sprayed areas of the country, because this pesticide has a high ability to volatilise and travel great distances.

In the laboratory they then fed other bees with similar amounts of the pesticide, which is used around the world to protect food crops against insects and mites, and put them through learning performance tests.

Study lead author Dr Elodie Urlacher says they found that chlorpyrifos-fed bees had worse odour-learning abilities and also recalled odours more poorly later, even though the dose they ingested is considered to be “safe”.

“For example, the dosed bees were less likely to respond specifically to an odour that was previously rewarded. As honeybees rely on such memory mechanisms to target flowers, chlorpyrifos exposure may be stunting their effectiveness as nectar foragers and pollinators,” Dr Urlacher says.

The study identified the threshold dose for sub-lethal effects of chlorpyrifos on odour-learning and recall as 50 picograms of chlorpyrifos ingested per bee, she says.

“This amount is thousands of times lower than the lethal dose of pure chlorpyrifos, which is around 100 billionths of a gram. Also, it is in the low range of the levels we measured in bees in the field.”

The current study is the first to establish the threshold at which a pesticide has an effect on memory specificity in bees while also measuring doses in bee populations in the field, she says.

“Our findings raise some challenging questions about regulating this pesticide’s use. It’s now clear that it is not just the lethal effects on bees that need to be taken into account, but also the serious sub-lethal ones at minute doses,” Dr Urlacher says.

The research, which appears in the *Journal of Chemical Ecology*, was supported by the Marsden Fund under contract UOO1207; “En garde! The development of a stress response in bees and its impact on learning and memory”.

When the river meets the sea, scientists will be watching

(NIW1301; 2013; \$739,130; Contact PI Dr Craig Stevens)



Lake Manapouri

Scientists are taking some high-tech equipment to Fiordland next week to find out more about what happens when a river meets the ocean.

The Manapouri tail race in Doubtful Sound will act as a natural laboratory for NIWA marine scientist Dr Craig Stevens, PhD student Rebecca McPherson from the University of Auckland, and scientists from Oregon State University and Scripps Institution of Oceanography in the US as they examine what's going on as the two waters meet and mingle.

"You fly around New Zealand and see these river plumes flowing into the ocean. They contain things like sediments and run-off from agricultural practices or roads but when you look at it from the air you have no idea how thick it is or what is really going on," Dr Stevens says.

"In fact the plumes are often only about a metre thick and dropping material at different rates depending on the speed it comes out and how mixed up it is."

"As a plume flows into the coastal ocean we are looking at how energy and material is transformed."

The measurements are difficult to obtain because the water surface is constantly changing. "In lots of ways it is much easier to measure something one kilometre down in the ocean than one metre down".

The team will use turbulence profilers which Dr Stevens describes as "mini torpedos" that shoot upwards taking measurements every couple of millimetres. They will also use a two metre-long mini research vessel, designed to operate in this environment.

The research will improve understanding about how material that flows off the land ends up in the ocean. That understanding will also result in better predictive tools to manage the ultimate fate of run-off.

"Rivers drop sediment that will smother stuff that's on the bottom or stop light penetrating the water column. Also if there's excess nutrients that can result in excess growth of algae and that also changes the light and the ecosystem. You want to know where they are going to end up and how concentrated they are."

Dr Stevens says, for a predictive tool like a computer model to work properly, it needs to be based around reliable measurements. The fiords provide a perfect "natural laboratory" where results can be used to understand how river flows into the ocean works throughout New Zealand. "At the same time we will learn more about the fjord systems which have not really been strongly explored from a physical perspective."

"These sorts of detailed measurements is what NIWA excels at. If you going to build a tool or model, you need to do your best to understand if it's even close to being right. We are making it possible for those tools to be better."

The work is funded by the Marsden Fund and the team will be in Doubtful Sound for two weeks.

The Marsden Fund contract is NIW1301; "Dilution of turbulent buoyant plumes: is it all in the how you turn the tap?"

Associate Professor Renate Meyer: Helping to create waves of change
(UOA204; 2002; \$288,000; Contact PI Associate Professor Renate Meyer)



When US-based researchers announced last Friday that they had detected gravitational waves, Renate Meyer was up at 4.30am to watch the live broadcast online from her home in Auckland. The Department of Statistics Associate Professor wouldn't have missed it – in the late 1990s, she was one of the researchers who laid the foundations for the sophisticated statistical data analysis strategies essential to the research.

Gravitational waves are distortions or 'ripples' in the fabric of space-time caused by some of the most violent and energetic processes in the distant universe arriving at Earth. When researchers from the Laser Interferometer Gravitational-wave Observatory (LIGO) in the US made their announcement, they confirmed a major prediction of Albert Einstein's 1916 general theory of relativity and opened an unprecedented new window onto the cosmos.

"It was a truly momentous occasion," says Renate, an Associate Professor in the Department of Statistics. "What would be more fitting to mark the centennial of the general theory of relativity?"

In the 1990s, Associate Professor Meyer and physicist colleague Nelson Christensen, now at Carleton College, Minnesota, developed techniques using Markov Chain Monte Carlo methods – a type of algorithm – to decipher the highly complex signals captured by the detectors. Essentially, she says, these techniques help researchers extract the signal from statistical "noise". "The signals are so tiny and extremely hard to detect," she says.

Their insights were adopted by the LIGO consortium, and have since been built on by the duo, their students, and by researchers all over the world. Associate Professor Meyer held a Marsden research grant from 2003-2006 to further develop the techniques, and brought a group of talented postgraduate students on board to help.

She says the discovery of gravitational waves is "stunning", adding that "it's great to see the data analysis methods we initiated prove so useful."

Physicists have concluded that the detected gravitational waves were produced during the final fraction of a second of the merger of two black holes to produce a single, more massive spinning black hole. This collision of two black holes had been predicted but never observed.

Associate Professor Meyer's Marsden grant that contributed to this work was UOA204: "Bayesian strategies for astrophysical data analysis".

NZ's little penguins are recent Aussie invaders: Otago research

(UOO1112; 2011; \$763,478; Contact PI Professor Jon Waters)



The little penguin species (popularly known as little blue penguins) found in southern New Zealand is a surprisingly recent invader from Australia, according to a new study led by University of Otago researchers.

Following the recent discovery that little penguins in Otago belong to an Australian species, a team of researchers from New Zealand and the United States set out to determine when the Aussies first arrived.

The Marsden and Allan Wilson Centre-funded study was carried out by Dr Stefanie Grosser as part of her PhD research, and led by Professor Jon Waters from Otago's Department of Zoology.

The researchers analysed ancient DNA from the remains of over one hundred little penguins: bones dating back to pre-human times, as well specimens from archaeological deposits and museums.

Dr Grosser says previous studies had concluded that the Australian species has been in New Zealand for hundreds of thousands of years. However, the new genetic study indicates that the Australian species arrived in New Zealand much more recently.

"Amazingly, all of the bones older than 400 years belong to the native New Zealand species," she says.

"Our results clearly show that the Australian penguin colonised Otago very recently, between 1500 and 1900 AD, apparently following the decline of the native New Zealand little penguin, which was hunted by early human settlers and introduced predators."

The researchers say that while the results are exciting, the finding of wildlife extinction and replacement in the aftermath of human arrival is not a completely isolated case.

"Many of New Zealand's animal species, birds in particular, have suffered at the hands of people. The really exciting thing about these findings is that they show how quickly nature can respond to human impacts," says Professor Waters.

The team's findings have been published today in the international biological research journal *Proceedings of the Royal Society B: Biological Sciences*.

The research was funded through Marsden contract UOO1112; "The biogeographic importance of historical contingency: extinction and recolonisation in coastal New Zealand".

Gene crowding affects cell development

(UOA1023; 2010; \$734,783; Contact PI Dr Justin O’Sullivan)



The crowding of genes inside the nucleus of a cell affects the way they replicate, and how they are turned on and off, according to a study led by the Liggins Institute at the University of Auckland.

The study is now published online in *Scientific Reports*, a journal from the Nature Publishing Group.

Liggins Institute molecular biologist, Dr Justin O’Sullivan, says the findings on how crowded genes behave are important for our understanding of development and disease.

The researchers developed 3D digital models of how the DNA is folded inside the nucleus of a yeast cell, and then mapped how genes encoded in the DNA are clustered inside the nucleus.

They found that the regions of DNA that control replication are crowded together. By mutating certain genes they could change the pattern of crowding and thus the timing of replication.

They also found that those genes that were turned on – or expressed – were physically separated from those that were turned off.

“The more we understand about what’s happening to the genes encoded in the DNA inside the cell nucleus, the easier it is to understand how that DNA structure responds to the environment outside the cell,” Dr O’Sullivan says.

“So these findings add to our understanding of epigenetics – the chemical process in which the environment modifies the DNA, switching the genes responsible for certain developmental processes on or off.

“Our next step is to investigate whether the development of common diseases is influenced by the way genes with mutations are crowded together and communicate with one another,” he says.

The researchers used a 3D digital model to examine the folding of the DNA inside the yeast cell nucleus. They verified the model using measurements from live yeast cells.

The Liggins Institute researchers collaborated with colleagues at the Rockefeller University in the United States and the Research Centre for the Mathematics on Chromatin Live Dynamics (RcMcD) at Hiroshima University in Japan.

The published paper can be accessed on the [Nature](#) website.

The research was partly funded through Marsden contract UOA1023: “Moving genes in genome structure and memory”.

Marsden-funded Books published 2016-2017

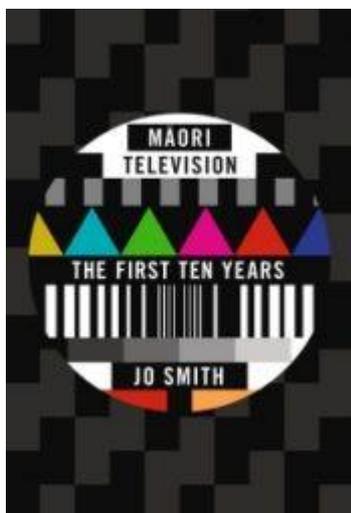
Māori Television: The First Ten Years

By Associate Professor Jo Smith

School of English, Film, Theatre and Media Studies, Victoria University of Wellington

Published by Auckland University Press, 2016

(VUW1104; 2011; \$669,565; Contact PI Associate Professor Jo Smith)



Māori Television was originally set up in 2004 to protect and promote te reo Māori me ngā tikanga Māori (Māori language and cultural practices), to inform, educate and entertain a broad viewing audience, and thus to 'enrich New Zealand society, culture and heritage'. Over the following decade, it had a major impact on the New Zealand media landscape. Based on kōrero with key stakeholders – staff, the board, other media, academics, politicians, funders and viewers – this book shines light on the complex dynamics underpinning state-funded Māori media. Offering five frameworks to help understand this Māori media organisation operating within a wider non-Māori context, this book is a deep account of Māori Television in its first ten years.

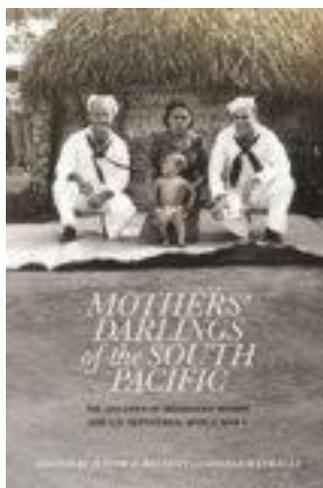
Mothers' Darlings of the South Pacific: The children of indigenous women and US servicemen, World War II

Edited by Judith Bennett and Angela Wanhalla

Department of History, University of Otago

Published by Otago University Press, 2016

(UOO0925; 2009; \$815,111; Contact PI Professor Judith Bennett)



Like a human tsunami, World War II brought two million American servicemen to the South Pacific where they left a human legacy of some thousands of children. *Mothers' Darlings of the South Pacific* traces the intimate relationships that existed in the wartime Pacific between US servicemen and indigenous women, and considers the fate of the resulting children.

The American military command carefully managed such intimate relationships, applying US immigration law based on race to prevent marriage 'across the colour line'. For indigenous women and their American servicemen sweethearts, legal marriage was impossible, giving rise to a generation of children known as 'GI babies'.

Among these Pacific war children, one thing common to almost all is the longing to know more about their American father. *Mothers' Darlings of the South Pacific* traces these children's stories of loss, emotion, longing and identity, and of lives lived in the shadow of global war. It considers the way these relationships developed in the major US bases of the South Pacific Command from Bora Bora in the east across to Solomon Islands in the west, and from the Gilbert Islands in the north to New Zealand.

The writers interviewed many of the children of the Americans and some of the few surviving mothers, as well as others who recalled the wartime presence in their islands. Oral histories reveal what the records of colonial governments and the military largely have ignored, providing a perspective on the effects of the US occupation that until now has been disregarded by historians of the Pacific war.

The book was launched on July 13th 2016, and has also been published by the University of Hawaii Press.

The Religious Worlds of the Laity in Late Antique Gaul

By Lisa Bailey

Faculty of Arts, University of Auckland

Bloomsbury Publishing, 2016

(UOA0819; 2008; \$157,988; Contact PI Dr Lisa Bailey)



Christianity in the late antique world was not imposed but embraced, and the laity were not passive members of their religion but had a central role in its creation. This volume explores the role of the laity in Gaul, bringing together the fields of history, archaeology and theology.

First, this book follows the ways in which clergy and monks tried to shape and manufacture lay religious experience. They had themselves constructed the category of 'the laity', which served as a negative counterpart to their self-definition. Lay religious experience was thus shaped in part by this need to create difference between categories. The book then focuses on how the laity experienced their religion, how they interpreted it and how their decisions shaped the nature of the Church and of their faith. This part of the study pays careful attention to the diversity of the laity in this period, their religious environments, ritual engagement, behaviours, knowledge and beliefs.

The first volume to examine laity in this period in Gaul – a key region for thinking about the transition from Roman rule to post-Roman society – *The Religious Worlds of the Laity in Late Antique Gaul* fills an important gap in current literature.