# From competition to collaboration: Challenges for New Zealand science

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## Introduction

Science has long been based on a model of individual and institutional competition. The reforms of the sector in the 1990s led to the formation of the Crown research institutes (CRIs), which had responsibilities for specific economic or environmental sectors, independence and separate governance. The bulk of funding came via the Foundation for Research, Science and Technology, with often intense competition for resources. This was exacerbated by the openness of the investment processes to universities, research associations, and other research providers. Over the past decade there were various attempts to encourage interdisciplinary and collaborative programmes, manage overbidding and establish alternative models, such as outcome-based investments, but there were still significant transaction costs in the competitive bidding processes. Doubts remained as to whether the nation was maximising benefits.

A full analysis of the performance of the science system is beyond the scope of this article. However, we can provide some perspectives from a review of a large-scale global collaborative programme in marine biodiversity, the Census of Marine Life, and frame these within the context of how emerging policy settings for science in New Zealand may encourage more collaborative science. In 2010 the government initiated a process of reform of the sector, with an emphasis on expectations for performance of the CRIs. The reforms have given a greater proportion of funding decisions to the boards and management of the CRIs, based on more comprehensive and distinctive statements of core purpose. These statements give some national responsibilities for capability to specific CRIs, with expectations that collaborations will be developed across institutions and with end-users. This provides some challenges to the accepted system, to policy makers, and to the prevailing culture of science. Collaboration may be easy to say but hard to do.

Scientific research in New Zealand is dominated by significant government investments in the biological sciences, as befitting an economy with a base in biological enterprises. However, there is little experience in building large-scale international collaborations in the biological (including ecological) sciences. In contrast, the physical sciences, such as physics or astronomy, often require significant capital investments that can only be met by international collaboration. New Zealand's participation in the Australian Synchrotron facility and the bid for the Square Kilometre Array are but two of many examples. In biology we have more limited investment in global initiatives such as the Global Biodiversity Information Facility (GBIF). The Global Research Alliance for Agricultural Greenhouse Gases is also an emerging example of our leadership in a collaborative programme, which integrates biological and physical sciences to provide solutions for a key issue for the agricultural sector.

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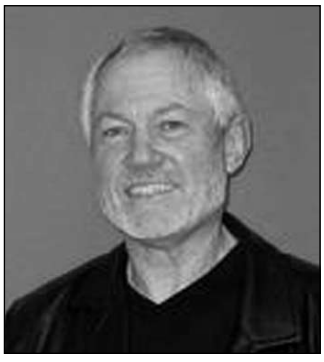
**Professor David Penman** has developed a strong interest in the development of large-scale collaborative science projects internationally, through his past chairmanship of the Global Biodiversity Information Facility, and nationally, through his leadership in the development and implementation of the Outcome Based Investments in biodiversity-related research at Landcare Research. David trained as an entomologist and has held senior roles in universities, Lincoln and Canterbury, and in senior management at Landcare Research.



**Andrew Pearce** has a long and distinguished association with the reforms of the science sector in New Zealand. From active research within the Forest Research Institute, he took on management roles, and leadership in the formation of the CRIs culminating in becoming the inaugural Chief Executive of Landcare Research. Dr Pearce has published widely on the structure and impacts of the reforms to science and is now an active director in a number of private and public sector organisations.

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We face challenges in moving from a competitive model towards greater collaboration, so we may be able to learn from how other large-scale collaborations have built new partnerships, capability, infrastructure and cultures. The authors of this article were commissioned by the Alfred P. Sloan Foundation (New York) to review the impact of the Census of Marine Life over their decade-long involvement and provide some lessons that might be relevant to other future collaborations in science. This article highlights some of the lessons of particular relevance to policy development and science management in New Zealand. The full report is available through Landcare Research (Penman *et al.* 2011).

## The Census of Marine Life

The Census of Marine Life was conceived as a science discovery programme to address significant information gaps in our knowledge of the biodiversity of the oceans. In 2010 a decade-long $US650 million programme was completed; this involved 2700 scientists from 80 nations and 640 institutions who spent 9000 days at sea on more than 540 expeditions, plus countless days in labs and archives. As one of the largest scientific collaborations ever conducted, the census produced over 3100 scientific papers and many thousands of other information products. The global community now has a legacy of a baseline of data on life in many of the ocean's realms that will shape policies and management of the oceans for decades to come.

The census pioneered a way to build scientific and community collaborations for the biological and ecological sciences. It was created with a simple and visionary goal: to understand the diversity, distribution and abundance of marine life.

The census emerged from a convergence of the need for information, largely expressed through the energy and advocacy of Dr Fred Grassle of Rutgers University in the United States, and the willing support of an initial investor in the idea, the Sloan Foundation (Ausubel 1997, 1999). The foundation provided funding to support initial workshops and proposal preparation, eventually culminating in a more than $US75 million investment over ten years. The foundation then supported the governance and secretariat functions of the whole programme, administration of each project, development of core infrastructure for data sharing, synthesis of overall results, and outreach. Several key elements coalesced around the census, including recognition of an identifiable issue; a lack of response from traditional funding agencies in the United States; a research community which was fragmented and used to small projects shaped within existing funding constraints; a limited culture of collaboration and data sharing; and no recognised open-access data portal for information sharing, while at the same time increasing demands were being faced for more integrated management of the oceans.

We interviewed over 60 people from around the world, and views were also gained from participation in, and observation of, a number of census-related meetings and review of relevant documents. The review did not analyse the impact of the science; these impacts will continue to expand once the science moves into new projects, policy development and management of the oceans. Instead, the review focused on the lessons from processes such as governance, leadership, management, collaboration, globalisation, data management, synthesis, education and outreach, and future legacies. We were able to compare our findings with the perceptions of the census leadership which have been published elsewhere (Alexander *et al.* 2011).

## Key lessons

### *Governance*

The census developed at a time when our understanding of effective models for governing science was rudimentary. The census had no real defined governance structure, but functional relationships evolved despite limited documentation of roles and responsibilities. The Sloan Foundation as the key 'investor' ensured its interests were maintained through a strong link with the scientific steering committee (SSC), which provided review and support for the various projects making up the census. The SSC was a de facto governing board. A complex programme such as the census required more regular oversight than the SSC meetings (usually three per year), so the later development of an executive committee with more defined functions provided better support for the delivery of the census. This included a more formal consideration of risks, especially as the programme neared completion. Many science projects appear to have limited views on true end-points, so there were challenges to governance in getting participants in the census to deliver results by the end of 2010. There was also no successional plan or process at the governance level, so the census missed the opportunity to develop new leaders to take the project forward beyond 2010.

Our full report more comprehensively examines the principles and function of governance and compares the census with other initiatives. Governance arrangements for institutions are often well documented around lines of responsibility and accountability, and governors, through some form of board structure, take responsibility for approving strategy, approving plans to deliver the strategy, allocating resources, assessing and managing risks, measuring performance, and appointing and assessing leadership.

More challenging is how governance might work in collaborative contexts where projects cross a range of boundaries (e.g. institutional, disciplinary, national, etc.). Such projects will have their own governance structures and performance expectations, and the challenge is how to link those to wider expectations for benefits from large-scale collaboration, and what might be an effective model for governance given the sometimes overlapping expectations of the boards of participating institutions. Such projects often have complexities arising from areas such as financial resources, differences in capability and capital assets, policies on internet protocol and data sharing, political realities, and social and cultural differences.

There are differing expectations for governance and accountability and it is clear that there is no single model that is likely to meet the diversity of funding instruments, partnerships and stakeholder demands. In our view, there is no single 'right' model of governance – every set of governance arrangements contains compromises that reflect particular organisational circumstances, and often each compromise has to be balanced by another action to offset potential negative consequences. Thus, the design of effective governance needs to reflect a core set of governance principles rather than a rigid set of rules. From our review of governance of the census and comparisons with other initiatives, we contend that the design of governing structures should note the following key aspects:

- A 'cornerstone' investor is critical, and the willingness of the Sloan Foundation to commit a substantial sum for a decade underpinned the development of the census community.
- The 'cornerstone' investor should establish goals and expectations, including preferred governance models, performance measures and reporting processes.
- A substantial degree of autonomy and trust should be given to the programme director/executive director to enable rapid decisions about early investments to be made.
- A clear strategic plan should be developed early in programme planning to ensure progress towards achieving the goals, outcomes and impacts. Progress can be assessed and alterations made during the course of the programme.
- There needs to be clarity on the respective roles within governance groups, including decisions on representative, skills-based or mixed memberships.
- Risk-assessment and management is an important part of project direction and needs to be explicit.
- Leadership should be regularly assessed and reviewed to ensure new leaders are developed to support ongoing activities.

### *Leadership*

Much leadership in science is individual, with the generation of ideas and hypotheses tested by experimentation or observation which then leads to peer-reviewed conclusions published in journals. Many scientific advances and societal benefits can be linked to this enduring process. However, occasionally some issues are so large and complex or require such a significant capital investment that they can only be addressed by a large collaborative initiative. The census had its inception in a visionary leader (Fred Grassle) who was able to convince a small group of colleagues of the need for such a project and find a like-minded individual (Jesse Ausubel of the Sloan Foundation), who saw the opportunity for the foundation to take a key role in bringing the census to fruition. This was not leadership that sought out problems to solve; it identified an issue that could not be addressed through conventional national funding mechanisms and could only be approached through a large-scale global collaborative endeavour.

We focus this article on public-good science, where the benefits of the research have wide societal outcomes and are not readily captured for direct private or commercial benefit. The traditional and linear view of science is that potential technologies emerge from basic research, and, with the assistance of institutional technology transfer and business development offices, new investors help to bring the ideas to commercialisation. Such a process recognises the role of the idea generator and his/her key role in the further development of the concept or product. However, it is now commonly accepted that the role of the 'inventor-scientist' should diminish as external investment increases towards 'product development'. Other professional managers and governors with different and wider business skills should then take increasingly significant leadership roles. The role of the 'inventor-scientist' (founder) becomes more one of a senior adviser, but with significant 'ownership' rights, which may, in turn, be diluted as more investors enter the project. We contend that this approach is equally valid in considering leadership of more public good-oriented projects.

The foundation was very clear that they would provide support (effectively as an 'angel investor') for a finite period to build the baseline in knowledge, the personal networks and the data infrastructure. Should the analysis of the results justify a positive business case, some new investor may take the census to the next phase. Scientists, as a rule, are not very good at such business decisions and disciplines. Comments from interviewees support the view that the SSC could have been more influential in recommending work to stop in some areas and enhancing investment in areas that promised a greater return – 'scientists are not very good at stopping things'. As a result, the census failed to generate a substantial and well-argued 'prospectus' on which to base a case for continuing some priority parts with new investors from 2010 onwards.

From our review, we contend that the following lessons are relevant to future collaborative projects:

- Apply the life-cycle model of 'inventor-scientist' followed by professional management and governance to the expected duration of the project, and form some initial views on the type of leadership that might be needed at different phases of the life cycle, and the approximate timing of any changes.
- Document roles and responsibilities for leadership at various levels and have processes in place for regular review and feedback.
- Consider term delineations, especially in advisory/leadership roles.
- Have a specific leadership development programme in place to develop the new echelon of leaders.
- Assign clear responsibility for completion of the initial phase of investment and for the preparation needed to obtain investment/investors for the next phase.
- Have a close understanding of the expectations of the lead investor.

### *Management*

Large-scale collaborative science projects often have very complex management issues to deal with. Stakeholders want systems that are low-cost but enable their voices to be heard. The challenge is to have the right degree of support for the higher levels of leadership but ensure that issues raised by those who largely conduct the programme can be heard. It is almost universal that some form of secretariat provides management services, but the scope is very variable. In some cases it is merely administrative support, including planning and logistics for meetings; in others the secretariat does a substantial amount of the work.

The census established a secretariat based at the Center for Ocean Leadership in Washington, DC. This was independent from any research institution and provided access to politicians. The secretariat did not have full oversight of the financial status of the census, as the Sloan Foundation controlled its investments and the requirement for substantial leverage funding from participating institutions/countries to carry out much of the research meant that gaining a full understanding of the financial position of the census proved to be challenging. However, the secretariat did an outstanding job of project coordination and support; but the effective role of executive director was subsumed into the role of Jesse Ausubel as the representative of the Sloan Foundation. It was only in latter years that the executive committee be-

gan to provide some additional support to the interface between the management and expectations of the funders.

In designing a management structure for collaborative programmes, participants should consider the following:

- Design a programme management structure that has clear roles, responsibilities and accountabilities.
- Consider the use of collaborative information-sharing tools from the start of the project. Some uses can lead to closed teams, not shared systems.
- Managing risks is a key role of governance and management. The more complex the project, the greater the risks.
- Build an exit strategy to keep the community together. There is a risk participants may drift apart unless some secretariat functions can be sustained.

### *Data management*

A critical innovation at the initiation of the census was the establishment of a means to share data. Grassle's promotion of the establishment of the Ocean Biogeographic Information System (OBIS) (Grassle & Stocks 1999) and the investment by the Sloan Foundation in establishing some core infrastructure was very forward-looking at the time. OBIS has been central to the delivery of primary data to a wide community, including researchers, policy makers and the wider public, and has been a crucial data portal for marine biodiversity data with links into GBIF.

Biologists and ecologists in many countries have been slow to recognise the value of data sharing. The census played a critical role in changing cultures among a community which had been resistant to making primary data more widely accessible. OBIS has become a key infrastructure project, but its future is not entirely secure and, while its move to come under the umbrella of the International Oceanographic Commission gives some institutional security, obtaining funds to maintain the infrastructure and build links to other organisations remains a challenge. These are issues which should receive more serious consideration as we examine how to make research data more widely available within the context of the open government and e-research policies.

Other issues relative to data management include:

- Having an explicit data-sharing policy at the outset of the programme, including standard protocols for metadata, data quality, intellectual property, etc. that meet best international practice.
- Ensuring that projects and individuals have specific expectations for data sharing and attribution, with appropriate sanctions; encouraging institutions to recognise data sharing as part of their individual reward systems.
- Considering having an advisory committee with specific responsibility for data management and ensuring the infrastructure is supported within an appropriate organisation.

### *Collaboration*

Census participants who were interviewed were universal in their view that being involved in such a big programme enabled them to work across disciplines, institutions and countries in ways that were not previously possible. They built new research teams, and the funding available to support face-to-face meetings early in the formulation of ideas and the subsequent development of proposals was critical to working together. The groups built trust, with an ability to articulate some big goals and build ownership of a strategy to achieve them.

Collaboration in the census had no theoretical framework; instead, it was pragmatic and involved people who were willing to be engaged in a new sharing culture to achieve some challenging goals. Collaboration within projects led to innovative science, resulting in many publications in a wide range of journals. Questions were answered that would be beyond a more disciplinary and small-project approach. However, there were many other personal benefits from building a collaborative environment. Early-career scientists gained enormously from the census through building relationships with highly credible scientists and institutions. This has led to invitations to publish together and conduct joint research, while late-career scientists who had established their status were delighted to be able to put their work into a wider context and find a way to share data and ideas.

As previously outlined, building the census programme committed participants to data sharing. This was a significant challenge for scientists who have operated in a more competitive environment. The initial workshops were critical for developing a culture that shared data and ideas, and most census-aligned scientists have undergone a significant change in their culture and views towards the benefits of data sharing. This has not been without its challenges, such as institutional barriers towards internet protocol and data ownership, concerns about misuse of data, such as drawing unjustified conclusions, lack of recognition for data sharing, issues of data quality and coverage, etc.

The census built a new community which recognised the value of collaboration to address some big questions in biology and ecology. New technologies were deployed and some of these promise significant commercial opportunities, and, through OBIS, there is an infrastructure to support data sharing. The challenge is how to sustain the community, the technologies, and the infrastructure in any future initiative.

### *Delivering benefits*

The census was conceived as a science discovery programme. A key driver was the development of the baseline of information of life in the oceans that might then be used for future policy development and management of marine resources. Providing information in a format relevant to policy and management was not an initial objective. As the census progressed and expanded in depth and breadth of coverage, the debate on potential relevance also grew.

Building links where the science becomes 'relevant' to a stakeholder or end-user can be challenging to some scientists. Many participants in the census were comfortable in doing the 'science we always wanted to do' but were more challenged when their results were being placed in a policy or management context. While the census did develop significant baselines of information on marine species, there are still many gaps. Policy makers cannot wait for the definitive science but must use current information and integrate this with other economic, environmental, social and cultural considerations.

However, the census had a simple message with clear goals. It was understood by funding agencies, institutions and researchers, and by stressing 'baselines, baselines and baselines'

the basis for developing future policy and management options became possible. The census provided 'additionality' by bringing multiple funding sources together. It was held together by the innovative funding from the Sloan Foundation, which supported the development of trust and collaboration, built a culture of data sharing within a supporting infrastructure, and built a public profile and 'brand' by a very active outreach and education project. Our analysis provides the basis for programme design for any similar initiatives that might emerge. Such developments should include consideration of:

- Developing a governance structure that endorses an early investment strategy, supports proposals to potential funders with collaboration as a key objective, and supports some long-term planning for future legacies.
- Identifying a business model that will best facilitate programme delivery and ongoing support.
- Having a specific leadership development programme and successional processes.
- Having a globalisation and collaboration strategy that builds early links and capability with key countries, institutions and individuals.
- Seeking support for an independent secretariat to coordinate the programme.
- Having clear expectations for data sharing, attribution and storage.
- Building early links with potential end-users of the research.
- Identifying and supporting specific capability needs.

## Conclusions

The Census of Marine Life challenged marine biologists and ecologists to find new ways of working together and it succeeded in building a new commuity which values collaboration and data sharing. A conventional process of competitive bidding would be unlikely to achieve such outcomes. Rather, it took the willingness of an investor (the Sloan Foundation) to facilitate the development of a culture committed to the sharing of data and the generation of widely accepted research questions, the development of compelling proposals, supporting secretariat services, and funding an outreach programme. The Foundation did not ask for these activities to be funded from existing individual or institutional resources. Instead, it provided funding on top of existing or proposed grants. This was very innovative and enabled a true competition for ideas rather than a competition between individuals and institutions.

The reforms to the CRIs in New Zealand, the emergence of core purpose statements and funding, and the merging of policy and investment processes within the Ministry of Science and Innovation provide the basis for some innovative development of large-scale collaborations, both nationally and internationally. There will be challenges, especially in bringing universities and other agencies with different funding streams and drivers into such programmes, but New Zealand does have opportunities in being able to embrace transdisciplinary approaches to research on key issues more readily than many other countries. It is essential that we provide funding over and above the core institutional resources if we are to develop effective collaborations.

Through the review of the Census of Marine Life we have identified some of the key issues relevant to any collaborative programme design, especially for governance, leadership and management. There is no one 'right' answer, but we contend that, with the right incentives, we can overcome any existing reticence to share data and ideas, especially in biology and ecology. This will require ongoing commitments to open access, especially to public-good data and research, to improved links to key end-user agencies, and to support of the key infrastructures to share data.

Finally, to quote Ian Poiner, chair of the scientific steering committee of the Census of Marine Life: 'The Census changed our views on how things could be done. We shared our problems and we shared our solutions.'

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