FINAL

An Impact Assessment of FRDC Investment in 2012-024: INFORMD2

Risk-based tools supporting consultation, planning and adaptive management for aquaculture and other multiple-uses of the coastal waters of southern Tasmania

Agtrans Research

August 2018

FRDC Project No **2016-134**

An Impact Assessment of FRDC Investment in 2012-024: INFORMD2 – Risk-based tools supporting consultation, planning and adaptive management for aquaculture and other multiple-uses of the coastal waters of southern Tasmania
Project 2016-134

2018

The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

Researcher Contact Details

Name: Talia Hardaker
Address: Suite 36, Benson House, Toowong QLD 4066
Phone: 07 3870 4047
Fax: 07 3371 3381
Email: talia@agtrans.com.au

FRDC Contact Details

Address: 25 Geils Court, Deakin ACT 2600
Phone: 02 6285 0400
Fax: 02 6285 0499
Email: frdc@frdc.com.au
Web: www.frdc.com.au

Contents

List of Tables

List of Figures

Acknowledgments

Agtrans Research and Consulting would like to thank Patrick Hone (Executive Director) and Nicole Stubing (Project Manager) of the Fisheries Research and Development Corporation for facilitating contact with relevant project personnel and for their guidance and feedback throughout the Impact Assessment process.

Scott Condie, Oceanographic Modeller, CSIRO Oceans and Atmosphere
Joshua Fielding, Senior Portfolio Manager, Fisheries Research and Development Corporation

Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
BCG	Biogeochemical
CIA	Cumulative Impact Assessment
CONNIE	Connectivity Interface
CRRDC	Council of Rural Research and Development Corporations
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	Department of Agriculture and Water Resources (Commonwealth)
DPIPWE	Department of Primary Industries, Parks, Water and Environment (Tasmania)
DST	Decision Support Tool
EIS	Environmental Impact Statement
EMS	Environmental Modelling Suite
EPA	Environment Protection Authority (Tasmania)
ERA	Environmental Risk Assessment
FRDC	Fisheries Research and Development Corporation
GVP	Gross Value of Production
INFORMD	Inshore Network for Observation and Regional Management: Derwent-Huon
MAREE	Marine Ecological Emulator
MIRR	Modified Internal Rate of Return
OCS	Office of the Chief Scientist
PVB	Present Value of Benefits
RD&E	Research, Development & Extension
UTAS	University of Tasmania
VMS	Virtual Monitoring Site
YMV	Your Marine Values

Executive Summary

What the report is about

This report presents the results of an impact assessment of a Fisheries Research and Development Corporation (FRDC) investment in *INFORMD2: Risk-based tools supporting consultation, planning and adaptive management for aquaculture and other multiple-uses of the coastal waters of southern Tasmania.* The project was funded by FRDC over the period July 2012 to July 2016.

Methodology

The investment was analysed qualitatively within a logical framework that included activities and outputs, outcomes and impacts. Impacts were categorised into a triple bottom line framework. Principal impacts identified were then considered for valuation. Past and future cash flows were expressed in 2017/18 dollar terms and were discounted to the year 2017/18 using a discount rate of 5% to estimate the investment criteria.

Results/key findings

The investment has likely contributed to improved effectiveness and efficiency of environmental impact assessments for the Tasmanian marine environment and associated aquaculture industries. Several economic, social and environmental impacts/potential impacts were identified. The most significant impact was considered the investments contribution to the maintenance of the Tasmanian aquaculture industry’s social licence to operate through the use of the suite of INFORMD2 decision support tools.

Investment Criteria

Total funding from all sources for the project was $2.12 million (present value terms) with FRDC investment in the project totalling $1.03 million. The investment produced estimated total expected benefits of $8.26 million (present value terms). This gave a net present value of $6.14 million, an estimated benefit-cost ratio of 3.9 to 1, an internal rate of return of 20.6% and a modified internal rate of return of 9.4%.

Conclusions

While several economic, environmental, and social impacts identified were not valued, the impacts were considered indirect, uncertain and/or minor compared with the impact valued. Nevertheless, combined with conservative assumptions for the impact valued, investment criteria as provided by the valuation may be underestimates of the actual performance of the investment.

Keywords

Impact assessment, cost-benefit analysis, INFORMD2, aquaculture, Tasmania, decision support tool, biogeochemical model, modelling, risk assessment, environmental impact assessment

Introduction

The Fisheries Research and Development Corporation (FRDC) required a series of impact assessments to be carried out annually on a number of investments in the FRDC research, development and extension (RD&E) portfolio. The assessments were required to meet the following FRDC evaluation reporting requirements:

- Reporting against the FRDC 2015-2020 RD&E Plan and the Evaluation Framework associated with FRDC's Statutory Funding Agreement with the Commonwealth Government.
- Annual Reporting to FRDC stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

The first series of impact assessments, that included 20 randomly selected FRDC investments, was completed in August of 2017. The published reports for the first series of evaluations can be found at: http://frdc.com.au/Research/Benefits-of-research/2017-Portfolio-Assessment

The second series of impact assessments also included 20 randomly selected FRDC investments. The investments were worth a total of approximately $5.62 million (nominal FRDC investment) and were selected from an overall population of 96 FRDC investments worth an estimated $21.32 million (nominal FRDC investment) where a final deliverable had been submitted in the 2016/17 financial year.

The 20 investments were selected through a stratified, random sampling process such that investments chosen spanned all five FRDC Programs (Environment, Industry, Communities, People and Adoption), represented approximately 26% of the total FRDC RD&E investment in the overall population (in nominal terms) and included a selection of small, medium and large FRDC investments.

Project 2012-024: *INFORMD2 – Risk-based tools supporting consultation, planning and adaptive management for aquaculture and other multiple-uses of the coastal waters of southern Tasmania* was selected as one of the 20 investments and was analysed in this report.

General Method

The impact assessments followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations, Cooperative Research Centres, State Departments of Agriculture, and some Universities. The approach includes both qualitative and quantitative descriptions that are in accord with the impact assessment guidelines of the CRRDC (CRRDC, 2014).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs, outcomes, and impacts. The principal economic, environmental and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. Where impact valuation was exercised, the impact assessment uses cost-benefit analysis as its principal tool. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, a high degree of uncertainty surrounding the potential impact, or the likely low relative significance of the impact compared to those that were valued. The impacts valued are therefore deemed to represent the principal benefits delivered by the project. However, as not all impacts were valued, the investment criteria reported for individual investments potentially represent an underestimate of the performance of that investment.

Background and Rationale

Background

Regional Context

Southern Tasmania includes the Huon and Derwent estuaries and the Bruny Bioregion. The region also includes the coastal and marine areas that immediately surround the Greater Hobart area (the major population centre in Tasmania).

The Derwent-Huon Region is fundamental to the cultural, natural and economic heritage of Tasmania. The region has significant cultural and natural heritage resources and supports a wide range of habitats and species. It also includes areas of major economic activity and infrastructure. The region contains a number of non-governmental organisations, from business and industry bodies to Indigenous organisations and community-based organisations focusing on the coastal areas.

Southern Tasmania is a microcosm of the issues facing coastal development globally and elsewhere in Australia; these issues include an increasingly diverse and intensifying range of human activities, technological change, and population growth, all within the context of climate change. The region also has a well-developed science and management infrastructure, making it an ideal location to develop and demonstrate how the key issues facing populated and environmentally significant coastal regions may be better addressed (Leith, Coffey, Haward, O'Toole, & Allen, 2012).

Aquaculture in Southern Tasmania

Tasmania’s aquaculture sector has expanded significantly over the past decade with a gross value of production (GVP) of approximately $730.7 million in 2015/16. This growth has largely been driven by the expansion of the Tasmanian salmonid industry, where production has more than doubled from 2005/06 to 2015/16, accounting for 98 per cent of Australian salmonid production in 2015/16 (ABARES, 2017).

Salmonid farming occurs predominantly in two locations in Tasmania, Macquarie Harbour on the west coast and south-east Tasmania including the Derwent Estuary, Huon River and D’Entrecasteaux Channel (Beven, 2015). The industry operates along a populated coastline, in waterways shared with a range of other industrial and recreational uses.

The aquaculture industry in Tasmania is highly regulated by the Department of Primary Industries, Parks, Water and Environment (DPIPWE) and the Environmental Protection Authority (EPA). Both government and industry recognise that maintaining high environmental standards is critical to maintaining a social licence to operate in Tasmania.

INFORMD

In 2008, CSIRO and the University of Tasmania (UTAS) undertook an initiative known as the Inshore Network for Observation and Regional Management: Derwent-Huon (INFORMD). The aim of the initiative was to provide quality modelling and monitoring outputs of biogeochemical flows and processes in south-eastern Tasmania. South-eastern Tasmania was chosen as the site for the project due to both the existence of numerous modelling products and knowledge of the system, and a stakeholder desire for system characterisation that the modelling could deliver.

The approach within the INFORMD project was to implement a near real-time hydrodynamic model to provide an indefinite archive of the ocean state that is always up-to-date. The archive then could be accessed for analysis or re-running scenarios including biogeochemistry and sediment transport. The scenarios could be run using either a full hydrodynamic model, or, for longer scenarios, by combining with a transport model (CSIRO, n.d.).

Rationale

Dalmer (2012) noted that major limitations have been identified in existing approaches to managing environmental risks and argued that the next generation of cumulative impact assessments (CIA) need to go beyond the approach of traditional environment impact assessments that involve site-specific 'project-by-project' reviews that are assumed to be additive in their cumulative effects.

New approaches would need to address cumulative, nonlinear and threshold effects, ecological interactions (both synergistic and/or antagonistic) and be undertaken at regional scales more relevant to spatially-explicit ecological processes. Also, they would need to accommodate interconnected social, economic and environmental issues and address future scenario analyses to assess the sustainability of risk management options.

Project 2012-024 was funded to build on the work conducted under the original INFORMD research program. The four-year project, undertaken by CSIRO and UTAS, developed decision support tools (DSTs) to address the impact assessment issues described above in the context of aquaculture and other marine uses in southern Tasmania. Further, the INFORMD2 project was designed to generate, and make accessible, key environmental information that would support improved, evidence-based decision making.

Project Details

Summary

Project Code: 2012-024
Title: *INFORMD2 – Risk-based tools supporting consultation, planning and adaptive management for aquaculture and other multiple-uses of the coastal waters of southern Tasmania*
Research Organisation: CSIRO
Principal Investigator: Scott Condie
Period of Funding: July 2012 to July 2016
FRDC Program Allocation: Environment (80%), Industry (20%)

Objectives

The project's key objectives were:

1. For the marine environment of southern Tasmania, characterise key environmental, social and economic values and aspirations from industry, government and community perspectives.
2. Relate these values to measurable indicators based on understanding of key biophysical and socio-economic processes.
3. Develop a framework to support spatial risk assessment for planning of future development within the systems, with an initial focus on aquaculture leases.
4. Develop a framework for evaluating spatial risk management strategies, with an initial focus on managing aquaculture leases.
5. Integrate the planning framework (Objective 3) and risk management framework (objective 4) into an online tool accessible to key stakeholders.

Logical Framework

The focus of INFORMD2 was on developing practical tools to support planning and management of aquaculture and other coastal and marine activities within a CIA framework. Table 1 provides a more detailed description of the project in a logical framework.

Table 1: Logical Framework for Project 2012-024

Activities and Outputs	**Your Marine Values (YMV)** • The YMV component of the project commenced in 2012 with the aim of identifying what Tasmanians (local communities, marine industries, and managing agencies) valued most about the marine waters of southern Tasmania, with a specific focus on marine values affected by, and affecting, aquaculture activity. • A series of individual stakeholder workshops was held in regional locations, as well as an online survey. Community engagement was high, with the project team recording 137 responses from workshop and survey participants. • A cross-sector workshop was held. The workshop involved management agencies, researchers, aquaculture and commercial fisheries industry representatives, and community representatives. • The project identified 17 distinct ecological, social, and economic values. • Interactions between these values were grouped in terms of the ecological processes and human activities that were significant at the estuary and channel scale. • The project then characterised those values that were shared by government, the aquaculture industry, and community stakeholders and linked them to specific

	governing legislation and policy, relevant research and monitoring, and measurable indicators that provide information on the condition of those values. • The values identified provided guidance on the key elements that needed to be incorporated into the risk-based DSTs developed later in the project. • Water quality was the value identified by the largest number of YMV participants (68 per cent) and was found to be linked to almost every other identified value. • The YMV findings also were communicated to the broader Tasmanian community to highlight the critical links between the values identified, science and existing governance structures. **Biogeochemical (BGC) Model** • The CSIRO Environmental Modelling Suite (EMS) comprises a fully coupled hydrodynamic, sediment and BCG model[1]. • The BGC modelling was built on previous experience and model development in a Huon Estuary study and a Derwent Estuary Modelling study. • The BGC model expanded the geographical coverage to include both the Derwent and Huon/Channel systems. • The expanded BGC model was implemented on the Derwent-Huon-D'Entrecasteaux curvilinear grid and then used to provide detailed information on water quality parameters such as nutrients, sediments and dissolved oxygen. • The extended model combined hydrodynamic flows with sediments, nutrients, phytoplankton and zooplankton in various forms. • The model was then calibrated based on loads, boundary conditions, and observations from January to December 2009. Comparisons with observations were undertaken at 36 virtual monitoring sites (VMSs). • The BGC model was re-run using the 2009 forced conditions combined with four alternative scenarios for point source nutrient loads. • Government and industry representatives were consulted to identify the most relevant and useful scenarios. • Scenario modelling, based on past, recent, and future nutrient loads provided key inputs for the development of the DSTs within the project. **Dispersal and connectivity model: CONNIE3** • A previously developed online DST used to model and visualise dispersal and spatial connectivity (referred to as CONNIE3: CONNectivity InterfacE; www.csiro.au/connie/) was extended for southern Tasmania using currents generated by a hydrodynamic model of the southeast Tasmanian estuarine and marine waters including the Huon and Derwent Estuaries, D'Entrecasteaux Channel and Storm Bay. This was the third generation of the tool. • The southern Tasmanian implementation of CONNIE3 has a spatial resolution of approximately 200 metres and is automatically updated in near-real-time (monthly) to create an expanding archive. • The graphical user-interface includes key data layers of interest to government and industry, such as aquaculture leases and monitoring sites, with the potential to include habitat layers in the future. • Outputs from the model included sea-level and three-dimensional distributions of water velocity, temperature and salinity. • CONNIE3 provides estimates of the dispersal of any contaminant (e.g. nutrients, sediments, oils, debris) through the marine system of southern Tasmania and was designed to be used to identify waterborne interactions between aquaculture and other marine activities and assets. • CONNIE3 requires minimal training to use and is publicly available. **Marine Ecological Emulator**

[1] The CSIRO EMS can be found at: http://www.emg.cmar.csiro.au/www/en/emg/software/EMS.html

	• A water quality DST (known as MAREE: MARine Ecological Emulator) was developed. • MAREE combines physical dispersal information from CONNIE with a simplified representation of BGC transformations. • MAREE is capable of generating outputs for the 36 VMSs that were selected in consultation with government and industry stakeholders. Most VMSs correspond to existing field monitoring or high value marine sites. • Dispersal envelopes upstream of all VMSs were computed using CONNIE and stored in a database. Impacted VMSs then can be identified using the overlap of dispersion envelopes with sites of new nutrient inputs selected by the user (e.g. salmon pens). • Changes in conditions at the VMSs associated with new nutrient loads then are estimated from the dispersal envelopes scaled by empirical BGC transformations. • Results from the period modelled are then combined into a statistical description of the impacts of the new nutrient loads and visualised within the emulator. • The MAREE graphical user interface allows users to define new point sources of nutrients representing new coastal discharges or facilities such as sewage treatment plants or aquaculture pens. • The tool was developed specifically for government and industry for rapid assessment of the impacts of marine and coastal activities on local water quality. For example, the impacts of nutrient and sediment loads associated with stocking of salmon leases; sewage treatment plants and other industrial discharges; and altered land-use in local catchments. • While the tool's outputs contain limited spatial and temporal information (as compared to the biogeochemical model), the outputs are specifically targeted at the needs of managers and can be generated online by non-expert users. **Other** • The models and DSTs, developed and extended by the project, integrate a diverse body of information and understanding relating to the marine environment of southern Tasmania. • The Project Advisory Committee (with members from government, industry peak bodies, aquaculture companies, and the research community) held regular internal meetings and workshops that contributed to refinement of the project outputs and their subsequent adoption. • A series of small, informal workshops also was conducted with the Tasmanian Government (DPIPWE and the EPA), regional partnerships (the Derwent Estuary Program and the D'Entrecasteaux and Huon Collaboration), and Huon Aquaculture and Tassal, to train individuals within the participant organisations to use CONNIE3 and MAREE for their specific needs. • Communications undertaken as part of the project included numerous presentations, several published journal and periodical articles, radio interviews and digital media. • The project recommended that the models and tools developed as part of INFORMD2 be extended to include the Storm Bay region due to the expansion of salmon aquaculture in the region. • Also, it was suggested that management of aquaculture along the Tasmanian East Coast, and within Macquarie Harbour on the west coast, would benefit if INFORMD2 was further extended to incorporate these regions. Decision support tools in such regions could be tailored to provide a stronger focus on key issues such as algal blooms or dissolved oxygen dynamics.
Outcomes	**YMV** • The YMV workshops and surveys facilitated a more informed engagement process and greater trust between participants. • The YMV process helped to establish a shared understanding of ongoing priorities for major stakeholder groups of the southern Tasmanian marine resource.

	• Values identified by the YMV process were used as inputs into the DSTs developed and extended within the project. **BGC Model** • The main applications of the BGC model to date have been running various scenarios used to set background levels and calibrate MAREE, and to estimate nutrient budgets for the southern Tasmanian marine system. • The BGC model also has been used by stakeholders to test scenarios for planning and water quality impact assessment. **CONNIE3** • There was strong user uptake of CONNIE3 over the course of the project, particularly within government and among salmon companies. • CONNIE3 was adopted as a major element in the development of Environmental Impact Statements (EISs) for the proposed expansion of salmon aquaculture into Storm Bay. • A standard parameterisation for representation of dissolved nutrients in CONNIE3 has been agreed between the regulators (DPIPWE and EPA) and relevant salmon companies. This will allow all parties to generate consistent model runs that are directly comparable. • DPIPWE also commissioned CONNIE3 runs that combine the proposed nutrient loads from all lease sites and made results available to each of the salmon companies for inclusion in their individual EISs. • CONNIE3 also has been used to assess risks to abalone grounds at the southern end of the D'Entrecasteaux Channel, to identify impact zones around salmon leases from dispersals of fish faeces and biofouling, and to identify risks of Pacific Oyster Mortality Syndrome infecting new leases during the first Tasmanian outbreak in early 2016. **MAREE** • MAREE has been used to compare background nutrient levels under current and future climate flow scenarios in the Huon River and D'Entrecasteaux Channel. • MAREE also has been used to model the effects of changing aquaculture loads in the Huon River and D'Entrecasteaux Channel to compare nutrient exceedance levels, and to investigate the effects of changing land-use in the Huon Valley on nutrient loads. **General** • Uptake of project outputs has been rapid and widespread, reflecting strong demand for targeted information to support environmental risk assessment (ERA). • The Tasmanian government (through DPIPWE and the EPA) have adopted the BGC model, CONNIE3 and MAREE as key inputs into their planning, assessment and regulation processes. • Modelling using the INFORMD2 DSTs now is a requirement of the Tasmanian government when considering aquaculture industry expansion in the regions covered by the models (Joshua Fielding, pers. comm., 2018). • Use of the models has already underpinned expansion of the Salmon aquaculture industry in the Southern Region of the D'Entrecasteaux Channel. This region represents a major lease for Tassal and is predicted to produce more than 2,000 tonnes of Salmon per annum (Joshua Fielding, pers. comm., 2018). • The capabilities provided through INFORMD2 support testing of alternative management strategies and regulatory frameworks. Within the CONNIE3 and MAREE frameworks, alternative strategies can be rapidly specified and compared by non-expert operators with immediate results providing managers and other stakeholders with an improved and shared understanding of how the southern Tasmanian marine system responds to alternative management actions. • It is expected that the INFORMD2 risk-based management tools may help to reduce the potential for conflict between users of the southern Tasmanian marine system. For example, many conflicts are based on perceived risks and the ability to

	address concerns quickly and cost-effectively using online tools may allow managers to focus on key issues that pose significant, quantifiable risks. • A suite of three RD&E proposals following on from the INFORMD2 investment and focussing on the Storm Bay region have been developed. To date, one has been approved by FRDC and a further proposal, focussed on BGC modelling in Macquarie Harbour, also has recently been funded (Scott Condie, pers. comm., 2018)
Impacts	• Reduced costs associated with improved efficiency of the EIS process through the use of a standard set of tools (Scott Condie, pers. comm., 2018) • Improved effectiveness of risk assessments as a result of better quality ERAs that capture the cumulative impacts of all aquaculture developments in Tasmanian marine environments (Scott Condie, pers. comm., 2018). • Contribution to the expansion of salmon aquaculture in the D'Entrecasteaux Channel as well as to the potential future expansion of the industry into Storm Bay (Joshua Fielding, pers. comm., 2018). • Potential contribution to avoided future aquaculture industry losses through a reduced risk of events that negatively affect industry (e.g. disease outbreaks) (Scott Condie, pers. comm., 2018). • Some contribution to the maintenance of the Tasmanian aquaculture industry's social licence to operate through the investments contribution to a reduced risk of loss of social licence to operate. • Contribution to potentially improved environmental sustainability of the Tasmanian aquaculture industry. For example, potential for improved environmental outcomes for the Storm Bay region through improved decision making with regard to the expansion of the salmon industry. • Maintained and/or improved regional community well-being as a spill-over from improved sustainability and a maintained social licence to operate for the Tasmanian aquaculture industry. • Increased scientific knowledge and research capacity.

Project Investment

Nominal Investment

Table 2 shows the annual investment (cash and in-kind) in project 2012-024 by FRDC and others. 'Other' investors included CSIRO and UTAS.

Table 2: Annual Investment in the Project 2012-024 (nominal $)

Year ended 30 June	FRDC ($)	OTHER ($)	TOTAL ($)
2013	281,459	252,461	533,920
2014	55,421	219,698	275,119
2015	111,239	210,195	321,434
2016	226,881	186,831	413,712
2017	75,000	0	75,000
Totals	750,000	869,185	1,619,185

Program Management Costs

For the FRDC investment the cost of managing the FRDC funding was added to the FRDC contribution for the project via a management cost multiplier (1.122). This multiplier was estimated based on the share of 'employee benefits' and 'supplier' expenses' in total FRDC expenditure (5-year average) reported in the FRDC's Cash Flow Statement (FRDC, 2013-2017). This multiplier then was applied to the nominal investment by FRDC shown in Table 2.

For the CSIRO and UTAS investment (other), it was assumed that program management and administration costs were already included in the nominal amounts shown in Table 2.

Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2017/18 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2018). No additional costs of extension were included as the project included a high level of consultation with key stakeholders, including Government and Tasmanian aquaculture industry participants, and extension through workshops, presentations and published project findings.

Impacts

Table 3 provides a summary of the principal types of impacts from the suite of new and extended models and DSTs delivered by the INFORMD2 investment. Impacts have been expanded from those listed in Table 1 and categorised into economic, environmental and social impacts.

Table 3: Triple Bottom Line Categories of Principal Impacts from Project 2012-024

Economic	• Reduced costs associated with improved efficiency of the EIS process through the use of a standard set of tools (Scott Condie, pers. comm., 2018) • Improved effectiveness of risk assessments as a result of better quality ERAs that capture the cumulative impacts of all aquaculture developments in Tasmanian marine environments (Scott Condie, pers. comm., 2018). • Potential contribution to avoided future aquaculture industry losses through a reduced risk of events that negatively affect industry (e.g. disease outbreaks) (Scott Condie, pers. comm., 2018). • Contribution to the expansion of salmon aquaculture in the D'Entrecasteaux Channel as well as to the potential future expansion of the industry into Storm Bay through provision of relevant modelling and information to the Tasmanian Government (Joshua Fielding, pers. comm., 2018).
Environmental	• Contribution to potentially improved environmental sustainability of the Tasmanian aquaculture industry. For example, potential for improved environmental outcomes for the Storm Bay region through improved decision making with regard to the expansion of the salmon industry.
Social	• Some contribution to the maintenance of the Tasmanian aquaculture industry's social licence to operate through the investment's contribution to a reduced risk of loss of social licence to operate. • Maintained and/or improved regional community well-being as a spill-over from improved sustainability and a maintained social licence to operate for the Tasmanian aquaculture industry. • Increased scientific knowledge and research capacity.

Public versus Private Impacts

Both public and private impacts were identified for the project. Private impacts include the maintenance of the Tasmanian aquaculture industry's social licence and improved efficiency of risk assessments associated with commercial activities and developments in the southern Tasmanian marine environment. Minor public impacts may be delivered, including environmental impacts through improved sustainability of the Tasmanian aquaculture industry, and social impacts in the form of regional community spill-overs.

Distribution of Private Impacts

Private impacts will primarily be captured by individual aquaculture organisations operating in southern Tasmania. There also may be some positive impacts to operators along the aquaculture supply chain, including input suppliers and processors. Impacts will be distributed according to associated supply and demand elasticities.

Impacts on other Australian industries

It is possible that some other Australian industries may benefit from the INFORMD2 investment. For example, the tourism industry may benefit from improved environmental outcomes in southern Tasmania achieved, in part, through the use of the suite of DSTs developed by the project.

Impacts Overseas

No significant impacts to overseas parties are expected.

Match with National Priorities

The Australian Government's Science and Research Priorities and Rural RD&E priorities are reproduced in Table 4. The project findings and related impacts will contribute primarily to Rural RD&E Priorities 1 and 3, and to Science and Research Priorities 1 and 7.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities (est. 2015)	**Science and Research Priorities (est. 2015)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

Sources: (DAWR, 2015) and (OCS, 2015)

Valuation of Impacts

Impacts Valued

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria.

Two key impacts of the project were valued. One was the social impact of a maintained social licence to operate for a proportion of the Tasmanian aquaculture industry because of improved risk-based management of marine resources in southern Tasmania. This impact was considered the primary and most significant impact stemming from the INFORMD2 investment.

The second impact valued was a contribution to the expansion of salmon aquaculture in the D'Entrecasteaux Channel through the provision of relevant modelling and information to the Tasmanian Government.

Impacts Not Valued

Not all impacts identified in Table 3 could be valued in the assessment. Social and environmental impacts were hard to value because of a lack of evidence/data, difficulty in quantifying the causal relationships and pathways between the INFORMD2 investment and the impacts, and the complexity of assigning monetary values to the impacts. Also, potential economic impacts including improved efficiency and/or effectiveness of risk assessments and avoided future industry losses were not value due to insufficient data and uncertainty regarding the pathways to impacts.

The economic impacts identified but not valued included:

- Reduced costs associated with improved efficiency of the EIS process through the use of a standard set of tools.
- Improved effectiveness of risk assessments as a result of better quality ERAs that capture the cumulative impacts of all aquaculture developments in Tasmanian marine areas.
- Potential contribution to avoided future aquaculture industry losses through a reduced risk of events that negatively affect industry (e.g. disease outbreaks).

The environmental impact identified but not valued included:

- Potential contribution to improved environmental sustainability of the Tasmanian aquaculture industry; for example, potential for improved environmental outcomes for the Storm Bay region through improved decision making with regard to the expansion of the salmon industry.

The social impacts identified but not valued included:

- Maintained and/or improved regional community well-being as a spill-over from improved sustainability and a maintained social licence to operate for the Tasmanian aquaculture industry.
- Increased scientific knowledge and research capacity.

Valuation of Impact 1: Maintained Social Licence to Operate

The INFORMD2 investment produced a suite of up-to-date, validated models and DSTs that allow stakeholders, including government and industry, to test alternative management strategies and regulatory frameworks for various component areas of the southern Tasmanian marine resource. The targeted information produced by project outputs supports environmental risk assessments and facilitates improved decision making by managers of marine resources (including aquaculture companies and government agencies such as DPIPWE and the EPA). This improved, risk-based decision making is expected to contribute to the maintenance of the social licence to operate for a proportion of Tasmania's aquaculture industry.

It was assumed that 50% of the GVP for Tasmanian aquaculture ($730.7 million) is at risk of some form of loss of social licence. Further, it was assumed that profits are represented by 10% of the GVP. The risk was then assessed as a 10% reduction in the profitability of these marine farms without INFORMD2 investment. Given the availability of the INFORMD2 models and DSTs, it was assumed that the risk may fall from 10% to a 7.5% reduction in the profitability of the applicable aquaculture farms.

Specific assumptions for valuing Impact 1 are provided in Table 5.

Valuation of Impact 2: Increased salmon production

The findings of the INFORMD2 project have been used to underpin expansion of the Tasmanian salmon aquaculture industry in the D'Entrecasteaux Channel. Modelling using the INFORMD2 suite of models/tools is now a Government requirement and the Tasmanian Government currently uses INFORMD to inform expansion decisions and salmon stocking determinations (N. Stubing, pers. comm., 2018).

The average gross value per tonne of Tasmanian Atlantic Salmon is approximately $13,053 (ABARES, 2017). It was assumed that profit represents 10% of this gross value for salmon aquaculture producers and that information provided to Government through the use of the INFORMD2 models/DSTs contributed 20% to the salmon industry expansion decision making process.

Specific assumptions for valuing Impact 2 are provided in Table 5.

Attribution

The INFORMD2 investment built on previous RD&E from the original INFORMD initiative undertaken by CSIRO and UTAS. Investment in the original INFORMD initiative was estimated at $1.62 million (nominal dollars) over four years (2008/09 to 2011/12) (Scott Condie, pers. comm., 2018). The initial investment was therefore estimated to be $1.78 million in 2017/18 dollar terms. Given a total investment in INFORMD2 of $1.78 million (2017/18 dollar terms), an attribution factor of 50% was used for the valuation of the impact of the investment in Project 2012-024.

Counterfactual

CSIRO and UTAS can only undertake these types of RD&E projects with significant external investment. Without the FRDC investment it was assumed that the research providers would have focused their efforts elsewhere, where investment partners were available (Scott Condie, pers. comm., 2018). Therefore, it was assumed that, if the INFORMD2 project (2012-024) had not been funded, the benefits for impact 1 estimated in this analysis would not be realised.

Further, in the case of Impact 2 (contribution to the expansion of the salmon aquaculture industry into the D'Entrecasteaux Channel) in the absence of the Project 2012-024 investment, it was assumed that, given the projected growth of the Tasmanian salmon aquaculture industry and increasing community pressure for environmentally conscious decision making, additional investment (of a similar level to Project 2012-024) to improve the models/DSTs for the D'Entrecasteaux Channel region would likely have been undertaken but delayed by five years.

Summary of Assumptions

A summary of key assumptions made for valuation of the impacts is shown in Table 5.

Table 5: Summary of Assumptions

Variable	Assumption	Source
Impact 1: Maintained social licence to operate		
GVP of Tasmanian aquaculture	$730.7 million	ABARES, 2017
Percentage of marine farms assumed affected	50%	Joshua Fielding, pers. comm., 2018
GVP for farms affected	$182.68 m	25% x $730.7 million

First year of impact	2016/17	Based on year of release of project findings
Aquaculture profits as a proportion of GVP	10% ($18.27 m)	Agtrans Research
Risk of reduction in profitability as a result of a loss of social licence – without INFORMD2 investment	10%	
Risk of reduction in profitability – with INFORMD2 investment	7.5%	
Expected profitability benefit	$0.457 m p.a.	($18.27m x 10%) – ($18.27m x 7.5%)
Impact 2: Increased salmon production in the D'Entrecasteaux Channel		
WITH investment in Project 2012-024		
Farm gate value of Tasmanian Atlantic salmon	$13,053 per tonne	3-year average derived from ABARES, 2017
Estimated percentage of profit per tonne of additional Atlantic Salmon farmed	10%	Agtrans Research
Contribution of INFORMD DSTs to salmon aquaculture expansion decisions	20%	
Additional annual production of Salmon in the D'Entrecasteaux Channel	2,000 tonnes	Joshua Fielding, pers. comm., 2018
First year of impact	2017/18	Based on completion of project 2012-024
WITHOUT investment in Project 2012-024		
Investment required to improved modelling for the D'Entrecasteaux region	$1.78m over 5 years	Based on the total investment in Project 2012-024
First year of investment	2017/18	5 year delay
First year of impact	2022/23	
Level of impact	See 'with investment' assumptions above	
Attribution of Benefits/Other Considerations		
Attribution of benefits to the INFORMD2 investment (Project 2012-024)	50%	Based on relative, real investment costs as described above
FRDC Program Allocation	Environment 80%; Industry 20%	FRDC

Results

All costs and benefits were discounted to 2017/18 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the project investment period plus 30 years from the last year of investment (2016/17) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2014).

Investment Criteria

Tables 6 and 7 show the investment criteria estimated for different periods of benefits for the total investment and the FRDC investment respectively. The present value of benefits (PVB) attributable to FRDC investment only, shown in Table 7, has been estimated by multiplying the total PVB by the FRDC proportion of real investment (49.2%).

Table 6: Investment Criteria for Total Investment in Project 2012-024

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.48	2.96	4.59	5.86	6.86	7.64	8.26
Present Value of Costs ($m)	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Net Present Value ($m)	-1.64	0.84	2.47	3.74	4.74	5.53	6.14
Benefit-Cost Ratio	0.23	1.40	2.17	2.77	3.24	3.61	3.90
Internal Rate of Return (%)	negative	12.3	18.3	19.9	20.4	20.6	20.6
MIRR (%)	negative	7.7	11.0	10.9	10.4	9.9	9.4

Table 7: Investment Criteria for FRDC Investment in Project 2012-024

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.24	1.45	2.26	2.88	3.37	3.76	4.06
Present Value of Costs ($m)	1.03	1.03	1.03	1.03	1.03	1.03	1.03
Net Present Value ($m)	-0.80	0.42	1.22	1.85	2.34	2.72	3.03
Benefit-Cost Ratio	0.23	1.41	2.18	2.79	3.26	3.63	3.93
Internal Rate of Return (%)	negative	12.7	18.6	20.2	20.7	20.9	21.0
MIRR (%)	negative	7.9	11.2	11.2	10.6	10.1	9.5

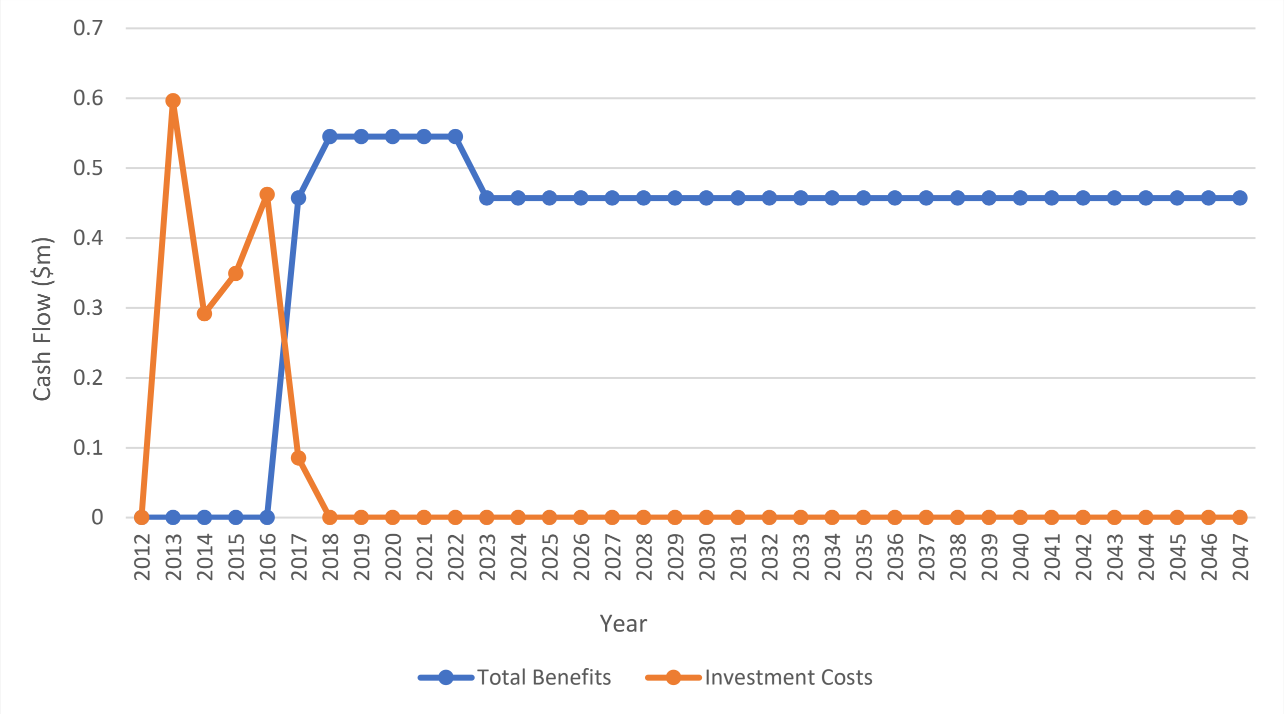
The annual undiscounted benefit and cost cash flows for the total investment for the duration of the INFORMD2 (FRDC project 2012-024) investment plus 30 years from the last year of investment are shown in Figure 1.

Table 8 shows the contribution of each impact to the total PVB.

Table 8: Contribution of Benefits

Impact	**PVB ($m)**	**% of Total PVB**
Impact 1: Maintained social licence	7.86	95.2%
Impact 2: Increased production of salmon aquaculture	0.40	4.8%
Total	8.26	100.0%

Figure 1: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs



Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 9 presents the results. The results showed a moderate sensitivity to the discount rate.

Table 9: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	14.61	8.26	5.61
Present value of costs ($m)	1.78	2.12	2.50
Net present value ($m)	12.83	6.14	3.11
Benefit-cost ratio	8.19	3.90	2.24

A sensitivity analysis was then undertaken for the assumption of the proportion of marine farms at risk of loss because of a loss of social licence as this was a key driver of the results and was a variable with relatively high uncertainty. Results of this sensitivity analysis are reported in Table 10.

Table 10: Sensitivity to the Proportion of Tasmanian Aquaculture Farms Assumed at Risk of Loss of Social Licence (Total investment, 30 years)

Investment Criteria	**Proportion of Tasmanian Aquaculture Farms at Risk of Loss of Social Licence**		
	10%	**25%**	**50% (base)**
Present value of benefits ($m)	1.97	4.33	8.26
Present value of costs ($m)	2.12	2.12	2.12
Net present value ($m)	-0.15	2.21	6.14
Benefit-cost ratio	0.93	2.04	3.90

A break-even analysis also was conducted on the assumed proportion of Tasmanian aquaculture at risk of loss of social licence. Results indicated that, given all other assumptions at their base, best-bet levels, investment criteria were positive with a proportion of industry at risk of approximately 10.9%.

A sensitivity analysis also was undertaken for the assumption of the change in risk of loss of social licence associated with the INFORMD2 investment. Results of this sensitivity analysis are reported in Table 11.

Table 11: Sensitivity to the Change in Risk of Loss of Social Licence because of the INFORMD2 Investment (Total investment, 30 years)

Investment Criteria	**Risk of Loss of Social Licence with the INFORMD2 Investment (10% without investment)**		
	5.0%	**7.5% (base – with investment)**	**9.5%**
Present value of benefits ($m)	16.12	8.26	1.97
Present value of costs ($m)	2.12	2.12	2.12
Net present value ($m)	14.00	6.14	-0.15
Benefit-cost ratio	7.61	3.90	0.93

A break-even analysis also was conducted on the assumed reduction of the risk of loss of social licence. Results indicated that, given all other assumptions at their base, best-bet levels, investment criteria were positive with a change is risk of approximately 0.55% (10% without investment, down to approximately 9.45% risk with the INFORMD2 investment).

Finally, a sensitivity analysis was undertaken for the assumption profit as a proportion of gross value for both Impact 1 and 2. Results of this sensitivity analysis are reported in Table 12. The results showed a moderate to high sensitivity to the profit proportion assumed as this was a key variable particularly in reduced risk of loss of social licence impact.

Table 12: Sensitivity to the Assumed Profit as a Proportion of GVP for Salmon Aquaculture (Total investment, 30 years)

Investment Criteria	**Profit as a Proportion of GVP**		
	5.0%	**10% (base)**	**30%**
Present value of benefits ($m)	4.21	8.26	24.45
Present value of costs ($m)	2.12	2.12	2.12
Net present value ($m)	2.09	6.14	22.33
Benefit-cost ratio	1.99	3.90	11.54

Confidence Ratings and other Findings

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 13). The rating categories used are High, Medium and Low, where:

High:	denotes a good coverage of benefits or reasonable confidence in the assumptions made
Medium:	denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
Low:	denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 13: Confidence in Analysis of Project

Coverage of Benefits	**Confidence in Assumptions**
Medium-Low	Low

The coverage of benefits was assessed as medium to low as only one of seven impacts/potential impacts identified was quantified as part of the assessment. The direct potential economic impacts associated with the investment's contribution to improved efficiency and effectiveness of risk assessments, and to potentially reduced future industry losses could not be valued due to a lack of data and high levels of uncertainty related to the project's contribution to these impacts and/or the specific pathways to such impacts. However, the impact valued (reduced risk of loss of social licence to operate for the Tasmanian aquaculture industry) was considered the most significant impact of the INFORMD2 investment.

Confidence in the assumptions, used for valuation of the impact, was assessed as low as two of the key assumptions were speculative (i.e. the proportion of Tasmanian aquaculture at risk, and the extent of the risk reduction due to the INFORMD2 investment) and there was limited evidence to suggest that the impacts assumed due to the INFORMD2 investment have actually occurred. Assumptions made therefore were conservative in nature.

Conclusions

The investment in INFORDM2 project has likely resulted in more efficient and effective environmental impact assessments for the Tasmanian marine environment and associated aquaculture industries. The investment also has likely contributed to improved environmental sustainability and, importantly, maintenance of the Tasmanian aquaculture industry's social licence to operate.

Funding for the project totalled $2.12 million (present value terms) and produced estimated total expected benefits of $8.26 million (present value terms). This gave a net present value of $6.14 million, an estimated benefit-cost ratio of 3.9 to 1, an internal rate of return of 20.6% and a modified internal rate of return of 9.4%.

While several economic, environmental, and social impacts identified were not valued, the impacts were considered indirect, uncertain and/or minor compared with the impact valued. Nevertheless, combined with conservative assumptions for the impact valued, investment criteria as provided by the valuation may be underestimates of the actual performance of the investment.

Glossary of Economic Terms

Cost-benefit analysis:	A conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless of to whom they accrue.
Benefit-cost ratio:	The ratio of the present value of investment benefits to the present value of investment costs.
Discounting:	The process of relating the costs and benefits of an investment to a base year using a stated discount rate.
Internal rate of return:	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits = present value of costs.
Investment criteria:	Measures of the economic worth of an investment such as Net Present Value, Benefit-Cost Ratio, and Internal Rate of Return.
Modified internal rate of return:	The internal rate of return of an investment that is modified so that the cash inflows from an investment are re-invested at the rate of the cost of capital (the re-investment rate).
Net present value:	The discounted value of the benefits of an investment less the discounted value of the costs, i.e. present value of benefits - present value of costs.
Present value of benefits:	The discounted value of benefits.
Present value of costs:	The discounted value of investment costs.

References

Australian Bureau of Agricultural and Resource Economics and Sciences. (2017). Australian Fisheries and Aquaculture Statistics. Canberra: Australian Bureau of Agricultural and Resource Economics and Sciences. Retrieved from http://data.daff.gov.au/data/warehouse/9aam/afstad9aamd003/2016/AustFishAquacStats_2016_v1.0.0.pdf

Australian Bureau of Statistics. (2018, January 31). 5204.0 - Australian System of National Accounts, 2016-17. Retrieved from Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5204.02016-17?OpenDocument

Beven, F. (2015, April 27). Tasmanian series: Insight into Tasmania's aquaculture industry. Retrieved from Deloitte: http://blog.deloitte.com.au/tasmanian-series-insight-into-tasmanias-aquaculture-industry/

Council of Rural Research and Development Corporations. (2014). Impact Assessment Guidelines. Canberra: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/wp-content/uploads/2016/04/CRRDC-Impact-Assessment-Guidelines-V.1-070514.pdf

CSIRO. (n.d.). Project Description. Retrieved from CSIRO - Coastal Environmental Modelling Team: https://research.csiro.au/cem/projects/completed-projects/tasmania/informd/project-description/

Dalmer, D. (2012, November). Cumulative Impact Assessment: Is It Just a Fancy Way of Identifying and Managing Risk? Environment and Energy Bulletin, 4(6), pp. 1-6. Retrieved from http://www.bcbc.com/content/659/EEBv4n6.pdf

Department of Agriculture and Water Resources. (2015). *Agricultural Competitiveness White Paper.* Canberra: Commonwealth of Australia. Retrieved from http://agwhitepaper.agriculture.gov.au/SiteCollectionDocuments/ag-competitiveness-white-paper.pdf

Fisheries Research and Development Corporation. (2013 to 2017). Annual Report. Canberra: Fisheries Research and Development Corporation.

Leith, P., Coffey, B., Haward, M., O'Toole, K., & Allen, S. (2012). Improving science uptake in coastal zone management: principles for science engagement and their application in south-eastern Tasmania. In R. Kenchington, D. Wood, & L. Stocker, Sustainable Coastal Management and Climate Adaptation: Global Lessons from Regional Approaches in Australia (pp. 135-156). Clayton, Victoria: CSIRO Publishing.

Office of the Chief Scientist. (2015). *Strategic Science and Research Priorities.* Canberra: Commonwealth of Australia. Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/STRATEGIC-SCIENCE-AND-RESEARCH-PRIORITIES_181214web.pdf