

# PART 3 OUTCOME AND PROGRAM PERFORMANCE

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# PART THREE: OUTCOME AND PROGRAM PERFORMANCE

### CSIRO's outcome and program structure

CSIRO receives approximately 60 per cent of its operating revenue in appropriation funding through the Federal Budget. Our commitment to the parliament and people of Australia, set out in the 2010–11 Portfolio Budget Statements, is to contribute to the following outcome:<sup>1</sup>

Innovative scientific and technological solutions to national challenges and opportunities to benefit industry, the environment and the community, through scientific research and capability development, services and advice.

In pursuit of this outcome in 2010–11, CSIRO allocated funds across four Programs listed below and as outlined in Table 2.3, page 7:

- Program I National Research Flagships
- Program 2 Core Research and Services
- Program 3 Science Outreach: Education and Scientific Publishing
- Program 4 National Research Infrastructure: National Facilities and Collections

These Programs reflect the Organisation's focus on delivering scientific solutions to Australian industry and communities, while simultaneously helping to build Australia's science base to meet ongoing challenges and opportunities.

The following sections provide a report against the deliverables and key performance indicators specified for each Program in the Portfolio Budget Statements.

# **Program 1 – National Research Flagships**

### National Research Flagships - objectives and deliverables

Since the launch of the first three National Research Flagships in 2003, CSIRO has committed an increasing proportion of its resources to addressing major national challenges and opportunities through the National Research Flagships Program. In 2010–11, CSIRO devoted 44 per cent of its resources to ten Flagships: **Climate Adaptation; Energy Transformed; Food Futures; Future Manufacturing; Light Metals; Minerals Down Under; Preventative Health; Sustainable Agriculture; Water for a Healthy Country;** and Wealth from Oceans.

The Flagships address complex challenges by forming large-scale multidisciplinary research partnerships with Australian Universities and publicly funded research institutions, the private sector and selected international organisations. They target clearly defined goals, framed from a careful analysis of the needs of people and enterprises, and have a strong focus on adoption and impact.

<sup>&</sup>lt;sup>1</sup> The relevant section of the Portfolio Budget Statements can be viewed at www.innovation.gov.au. The Outcome is the formal legal statement of the purpose for which funds are appropriated to CSIRO.

### National Research Flagships – Program performance

The performance of the Program is assessed through five key performance indicators and a series of Flagship reviews. Table 3.1 provides a summary of progress. More detailed analysis and trend data follow the Table.

Key performance indicator	Target	Performance
Demonstrated adoption and impact of Flagship outputs.	Growing economic, social, environmental and intangible benefits	Independent assessments provide positive feedback on the impact and value of the two Flagships that were subject to external review in 2010–11 (see page 28). Recent achievements from each of the ten Flagships are reported on pages 30–49.
The number of refereed Flagship publications.	Maintain or increase	The Flagships published 584 journal articles and 1,204 publications in total in 2010 (the first year for which these data are separately available for Flagships).
Financial support by Flagship partners.	Maintain or increase	Flagship partners increased their financial support to the Flagships by \$29.9 million or 17 per cent in 2010–11.
Customer satisfaction.	Maintain	Implementation of a formal customer satisfaction measurement program was planned for 2010–11 but has been re-prioritised and deferred to 2011–12.
Investment of the Flagship Collaboration Fund (FCF).	On Plan	The FCF disbursed \$17.2 million in 2010–11, in line with the agreed budget.

# Table 3.1: Performance indicators for Program 1- National Research Flagships

#### Economic, social, environmental and intangible benefits

As an input to an external review of the Wealth from Oceans Flagship, the consultancy firm RMDSTEM was commissioned to conduct an economic analysis on 14 research areas representing around 50 per cent of the research funded by the Flagship. Taking a conservative approach (impacts were quantified only where reliable and logical evidence was provided), the 14 areas were calculated to have an expected value, taking into account risk factors on the path to adoption, in excess of \$4 billion. The present value of benefits from technical results already achieved at the time of the assessment was calculated to be in excess of \$2.6 billion.

Similarly, the consultancy firm ACIL Tasman was engaged to assess the likely impact and value of the Climate Adaptation Flagship. ACIL Tasman concluded that 'subject to continued careful management and focus on the issues of good science and good institutional arrangements for planning and adoption of options, the Flagship offers value that is well in excess of likely costs. Modelling of the Flagship as a whole suggests a present value across the period to 2030, as a result of Flagship activities in developing new options, and encouraging earlier and sounder use of existing cost-effective options, of the order of \$16 billion'.

### **Flagship publications**

In 2010, CSIRO's new electronic publications repository, 'ePublish', became operational, allowing us, for the first time, to identify Flagship publications as a subset of CSIRO's total publications. However, the repository is still in development and the numbers are subject to review.

Table 3.2 shows the number of Flagship publications, by type. Total CSIRO publications are shown in Table 3.4, page 51.

Publication type <sup>l</sup>	Number
Conference papers	420
Journal articles	584
Books / book chapters	61
Technical reports	139
Total	1,204

#### Table 3.2: Number of Flagship publications by type, 2010

See glossary page 205 for definition of publication types.

#### Financial support by Flagship partners

In 2010–11, the National Research Flagships Program earned revenue of \$201.7 million from external partners. This accounts for 38 per cent of the Program's total investment, up from seven per cent in 2003–04 and 32 per cent in 2009–10.

Figure 3.1 shows the growth in financial support from external partners in the last five years. The average amount of support received per Flagship also increased from \$6 million to \$20.2 million over the same time period.



#### Figure 3.1: Financial support for Flagships from external partners

#### **Customer satisfaction**

Implementation of a formal customer satisfaction measurement program planned for 2010–11 was delayed by other priorities. CSIRO will now establish a baseline rating of customers' 'willingness to recommend CSIRO' in 2011–12.

The continuing commitment of major customers to strategic levels of engagement with CSIRO – such as multi-year research alliances – is evidence that these customers see CSIRO as an essential partner in the success of their organisations. As recognition for more than 22 years of productive engagement, CSIRO was named 'Supplier of the Year' by Boeing in May 2011 (see case study page xix).

#### Investment of the Flagship Collaboration Fund

Investment in the Flagship Collaboration Fund<sup>2</sup> continued as planned with \$17.2 million disbursed to research in 2010–11. Overall \$108 million of the initial \$114.25 million has been committed (see Figure 3.2). The remaining \$6.25 million will be allocated to projects, visiting fellowships, or postgraduate scholarships to fully expend the \$114.25 million by 2013–14.

In 2010–11, three new clusters involving 14 national and international universities and industry partners were approved for funding. See Appendix 1 for a full list of Flagship Collaboration Clusters.

<sup>&</sup>lt;sup>2</sup> For more information, see page 172 and www.csiro.au/org/FlagshipCollaborationFundOverview.html



Figure 3.2: Flagship Collaboration Fund disbursements and commitments

#### Flagship reviews

To maximise the likelihood of achieving Flagship goals, CSIRO conducts a three-to-four year cycle of independent reviews of each Flagship by a panel of experts from Australia and overseas. Two Flagships, Climate Adaptation and Wealth from Oceans, were reviewed in 2010–11.

The panel reviewing the Climate Adaptation Flagship commented on the excellent progress made in its first two-and-a-half years, including a number of significant impacts on the Australian understanding and uptake of climate adaptation programs and projects. They noted that a 'strong and talented' team were leading a highly appropriate research program for CSIRO, and that the Flagship has the necessary research capabilities to deliver a very creditable program, but with some emerging capacity constraints. The panel recognised the uncertainty of many key external factors in planning and implementing the Flagship's research program and was impressed at the progress the Flagship has made in engaging with its clients and delivering results.

The panel for the Wealth from Oceans Flagship review were impressed with the talent, enthusiasm and commitment of the staff and the international standard of research leadership. They found that the inaugural (2003) Flagship goal – to position Australia by 2020 as an international benchmark in the delivery of economic, social and environmental wealth based on leadership in understanding ocean systems and processes – had been largely met by September 2010. The panel commented that innovative work was evident in all three research themes and that 'Flagship scientists have been very successful in applying and adapting new technology... that could revolutionise management of the coastal zone in Australia and internationally'. The panel further commented that the Flagship should seriously consider how it markets or promotes its innovative research and science to potential stakeholders to ensure greater adoption.



# RAFT: World-class technology commercialised

The challenge to develop new polymer materials with new and improved performance to meet industry and consumer needs has gone a long way to being solved by CSIRO's breakthrough polymer technology known as RAFT (Reversible Addition-Fragmentation chain Transfer).

Invented by CSIRO and developed in partnership with DuPont, the new technology provides control over the formation of polymer structures and offers the ability to tailor these materials for different applications. This technology allows us to make polymers that were impossible pre-RAFT.

Applications for the technology will include intelligent drug delivery; biocompatible materials; paints and coatings to meet stricter environmental guidelines; targeted personal care and cosmetics; additives to promote fuel efficiency; better synthetic rubbers; and new and improved agricultural delivery systems.

CSIRO has recently signed its fifteenth license agreement, the latest with a multinational organisation that controls a share in the healthcare products market worth billions of dollars.

Internationally, over 3,000 papers have been published on RAFT developments and there are over 450 patents that have been filed by research and commercial institutions globally. CSIRO's Dr Ezio Rizzardo, one of the key inventors of RAFT, was named as one of the Top 100 Chemists in the world, ranked at eighteenth by the United States information and analysis company Thomson Reuters.

More details about RAFT can be found at: www.csiro.au/products/RAFT



RAFT technology is a living radical polymerisation process that enables users to tailor polymer properties. Credit: Stuart Dunn

# **Climate Adaptation Flagship**

**Flagship goal:** Equip Australia with practical and effective adaptation options to climate change and variability and in doing so create \$3 billion per annum in net benefits by 2030.

### Overview

CSIRO's Climate Adaptation Flagship ensures Australia can effectively adapt to the impacts of climate change and variability. CSIRO's scientists are working in partnership with governments, industries and communities to address this urgent national challenge.

There is now wide scientific agreement that the world is heading for at least two degrees Celsius warming and quite possibly four degrees Celsius by 2070 as a result of human activities. Climate change is likely to exacerbate climate variability and extremes across Australia causing changes to wind, precipitation and weather extremes and exposing our coastline to rising sea levels.

The Flagship is supporting Australia to address the challenges of climate change through improving knowledge of climate change projections and pathways to adaptation which provide both an underpinning research base to our endeavours, and strong engagement into three priority sectors: cities and coasts, natural ecosystems, and primary industries with their associated enterprises and communities. Our research has a strong emphasis on applicability and on large-scale, integrated projects made possible by diverse partnerships.

## Achievements 2010–11

#### Climate change effects on concrete



Concrete is the basic building block of Australian buildings and infrastructure. Understanding how climate change could impact on the deterioriation of concrete is crucial to ensuring major assets such as roads, ports and buildings continue to perform up to expectations. A recent CSIRO report outlines major findings for the benefit of policy-makers, engineering designers, asset managers and other professionals and decision-makers in both public and private sectors. The report makes a number of recommendations on the design of new, and maintenance of existing concrete structures. It is hoped that the impact of corrosion in new structures can be countered at the design stage through new technologies and materials.

#### Conservation management under climate change



From 2008–11, CSIRO has authored a series of studies commissioned by the Australian Government to address the effects of climate change on Australia's biodiversity and how best to respond. Building on a previous report on the National Reserve System, this year the Flagship coordinated a national report on four major regional biomes across the continent. The report outlined how to plan conservation in an integrated way for these different exemplar regions and highlighted the need for a major revision of objectives for conservation and the role of protected areas. These results are being integrated into policy at the national and state level.

#### Attitudes to climate change: results of an online survey



Research into Australians' views of climate change – through 22 recent surveys conducted in Australia by groups including universities, media organisations and CSIRO – is informing policy recommendations through the 2011 Garnaut Review. While the studies asked a diverse range of questions about climate-related issues, they are clear in showing that most Australians believe the climate is changing – about 75 per cent. The surveys indicated that people are confused about the science of climate change and what are effective policies or actions for adaptation. The results have important implications for those trying to communicate the science of climate change or develop policy for responding to climate change.

#### Ocean warming detrimental to south-east Australia fish species



Researchers have identified forty-three species, representing about 30 per cent of the inshore fish families occurring in south-east Australia, exhibiting shifts in their territories thought to be climate-related. In another study, Australian scientists have published the first known detrimental impact of southern hemisphere ocean warming on a fish species

- the banded morwong. In response to requests by Tasmania's four major salmon companies, Flagship scientists will provide ocean temperature forecasts to assist marine farmers to plan for warmer water, which can have adverse effects on farmed fish.

#### **Climate Adaptation Flagship Roadmap**

Theme	Short term 1–3 years	5	Medium term 4–9 years	Long term 10+ years
Pathways to adaptation	Define new approaches to vulnerability and adaptation assessments.	Adaptive capacity of communities and industries assessed; innovative approache to climate projection	Identify social and economic adaptation outcome within different sectors and regions.	Biophysical social and institutional dimensions of adaptive capacity more effective for Australia.
Sustainable cities and coasts	Develop methods to ass vulnerability in cities and adaptive capacity and go	ess climate risk and coasts and community vernance.	Flexible models of utilities, social sciences and governance for climate adapted urban planning and management.	Planning, design infrastructure, management and governance solutions for Australia's cities and coasts responding to climate change.
Maintaining species and natural ecosystems	Studies of regions, single species and simple species interactions.	Greater model realisi Focus on threats and tools to assist natural resource managers.	m. Complex studies of biotic interactions and community ecology, Refine tools for ecosystems managers.	Deliver adaptation options to protect Australia's marine and terrestrial species, ecosystems from the impacts of climate change.
Adaptive primary industries, enterprises and communities	Improve analysis of interaction between climate drivers and managers' responses on farms.	Develop technologie and practices for loca industry adaptation.	Shifts in vulnerability to climate change understood. Identify when transformational options may be needed.	Adaptation strategies provide economic benefits and improve livelihoods from primary industries, enterprises and communities.

Current position

# **Energy Transformed Flagship**

**Flagship goal:** To develop, demonstrate and ensure deployment by 2020 of integrated low carbon pathways for Australia and alternative stationary and transport energy solutions that realise a reduction of Australia's  $CO_2$  e emissions greater than 20 million tonnes per annum by 2030 and greater than 50 million tonnes per annum by 2050.

### Overview

CSIRO's Energy Transformed Flagship is focused on developing renewable and alternative energy solutions to provide Australians with affordable, secure and sustainable electricity and transport fuels.

Electricity and transport contribute 69 per cent of Australia's greenhouse gas emissions. Furthermore, Australia's net petroleum imports could increase from \$14 billion today to \$70 billion by 2030. It is therefore vital to identify pathways and solutions that will help reduce greenhouse gas emissions and, at the same time, secure Australia's environmental, economic and social wellbeing.

This objective can only be achieved in close collaboration with industry, research organisations and government. The Energy Transformed Flagship, since its inception, has been a catalyst for this broad collaboration.

## Achievements 2010–11

#### New solar tower and research facility opened



A \$4.2 million international hub for developing and commercialising solar thermal technologies was opened on 18 June 2011 at CSIRO's National Solar Energy Centre in Newcastle, New South Wales. With a new 30-metre tower and 450 mirrors (heliostats), the facility will generate temperatures of up to 1,500° Celsius and will be used to develop new low-cost solar technologies that produce

power when people need it. The project has secured the interest of local and international energy organisations all eager to make solar power cheaper and more efficient (see: www.csiro. au/science/Solar-Brayton-Cycle.html).

#### Volunteers use 'Energymark' to reduce power bills



CSIRO led an initiative to help people across New South Wales and the Brisbane and Redlands City Council areas in Queensland to reduce their carbon footprint and lower their energy usage. Around 3,000 volunteers are taking part in 'Energymark', a program designed to help participants lower their power bills by providing tips and resources. On average, Energymark participants saved up to 20 per cent on their energy bills and reduced their carbon footprint by around 25 per cent. Gathering in small groups,

family, friends, neighbours and workmates got together to discuss energy, climate change, water and waste issues over eight sessions using CSIRO material (see: www.csiro.au/energymark).

#### Sustainable aviation fuels



CSIRO, working with Australia's major aviation players, produced a joint report, *Flight Path to Sustainable Aviation*, which outlines a range of possible future scenarios for the use of sustainable aviation fuels in Australia and New Zealand. The report supported the possibility of a local bio-derived jet fuel industry that, over the next 20 years, could generate more than 12,000 jobs, reduce Australia's reliance on fuel imports by \$2 billion per annum and decrease greenhouse gas emissions of the aviation

sector by 17 per cent. The report also identified the market, infrastructure and governance changes that will be required for success (see: www.csiro.au/science/Sustainable-Aviation-Fuels-Road-Map.html).

#### UltraBattery technology licensed to China



CSIRO has licensed its UltraBattery technology to one of the world's largest battery manufacturing companies to enable manufacturing in China for the automotive market. The rechargeable lead-acid battery, combined with a supercapacitor, delivers low-cost, long life, high-performance power. The licence will enable the CSIRO invention to be mass produced for conventional and hybrid-electric vehicles, making hybrid electric

vehicles cheaper, more powerful and quicker to recharge. The UltraBattery has already been licensed to enable manufacture in North America, Mexico, Canada, Japan and Thailand (see: www.csiro.au/science/Ultra-Battery.html).

#### Energy Transformed Flagship Roadmap<sup>1</sup>

Theme	Short term I-3 years	Medium term 4–9 years	Long term 10+ years
Carbon futures	Develop models and reports to inform policy, industry and research. Undertake social attitude mapping. Hold stakeholder energy forum.	Hold transport sector stakeholder forums. Undertake longitudinal and larger population social analysis studies; commercialise software. Initiate integrated carbon assessment service.	Deploy an integrated energy, water, food and carbon assessment service to help Australia identify the least cost and risk transition pathways to a prosperous and secure low carbon future.
Sustainable stationary energy and transport	Develop technologies for low- cost solar power production and energy storage. Prioritise potential fuel crops for large-scale, sustainable biofuels production.	Demonstrate significant technologies at pilot scale, with industry and government support	Drive the cost-effective take- up of renewable electricity and transport fuels in Australia to 2020 and beyond and maximise the long-term renewables uptake to 2050.
Local energy systems	Develop low-emission distributed energy technologies. Identify and begin engagement with partners.	Develop distributed generation and efficient options model to inform government and industry. Commercialise technologies.	Reduce greenhouse gas emissions by driving the uptake of distributed energy solutions, demand reduction and energy efficiency measures to 2020.
		Current position	

<sup>1</sup> In 2011, the Flagship refined the long-term goal for Carbon futures.

# **Food Futures Flagship**

**Flagship goal:** To transform the international competitiveness of the Australian Agrifood sector, adding \$3 billion in annual value, by applying frontier technologies to high potential industries.

### Overview

The Food Futures Flagship is a collaboration involving CSIRO, industry and research partners which will transform the Australian agrifood sector.

The Flagship's research programs cover the entire food supply chain linking our science projects with farmers, governments, the food industry and consumers. Our research teams are developing healthier ingredients, delivering higher quality food products and improving sustainability and food security for farmers, manufacturers and consumers both here in Australia and around the world.

The Flagship's research is adding value to primary products through innovative food design, providing new opportunities in domestic and foreign export markets, improving farm profitability and producing healthier and safer foods for consumers.

The Food Futures Flagship's work focuses on:

- future grains, grain based foods and feed
- breeding better Australian seafood and beef
- biosensor technology.

### Achievements 2010–11

#### New source of omega-3



The Flagship has initiated a \$50 million dollar research collaboration which will use leading-edge gene technology to develop and commercialise canola oil rich in the same high quality long-chain omega-3 oil that traditionally comes from marine plants and fish. CSIRO and partners have developed canola plants that produce long-chain omega-3 oils containing DHA (docosahexaenoic acid). Until now, this oil has only been available in beneficial quantities from ocean-based algae and the fish that eat it (see case study page 99).

#### BARLEYmax<sup>™</sup> cereals available in supermarkets



The success of CSIRO's new BARLEYmax<sup>™</sup> grain continues with a growing range of breakfast cereals and porridges now available on supermarket shelves. These new products can be found in most major Australian supermarkets and are securing a growing share of the Australian breakfast cereal market. A key factor in their success has been CSIRO's ten year multidisciplinary research and development program designed to understand and substantiate the grain's health benefits. BARLEYmax<sup>™</sup> can have a significant impact on preventing disease by delivering high levels of resistant starch and other dietary fibres and is a leading example of scientific and commercial success stemming from collaboration within CSIRO and with a range of external partners.

#### Using sensory evaluation to improve shellfish quality



The Flagship is working with the oyster industry to measure and map the regional differences in oysters grown in South Australia, New South Wales and Tasmania. By developing a sensory 'language' to describe the appearance, aroma, taste and texture of oysters, researchers can measure and analyse how oysters stimulate the senses. This sensory information can be used to guide growing, harvesting and processing to improve product quality and deliver the right product to the right consumers.

#### Breeding fish to boost sustainability



Researchers based in Tasmania are adopting selective breeding techniques traditionally used in land-based livestock animals to boost the sustainability of farmed seafood. Much of the aquaculture industry still relies on wild fish for its breeding stock, but the Food Futures Flagship is working to introduce domesticated fish stocks into the aquaculture production system. Enabling breeding technology that uses genetic markers to identify specific

desirable characteristics is an approach much the same as that used by sheep and cattle farmers for centuries. Their goal is to help the industry become more sustainable by reducing or removing the need to rely on catching wild fish every year for breeding purposes.

#### Food Futures Flagship Roadmap

Theme	Short term I–3 years	Medium term 4–9 years	Long term 10+ years
Future grains	Optimise carbohydrate in grains, optimise omega-3 oils in plants and investigate genetic traits for improved quality and nutrition.	Combine beneficial traits for farmers and consumers, breed and commercialise long chain omega-3 oils in plants and commercialise quality and nutrition traits.	Increase returns to Australia by \$550 million per annum through enhanced grain quality attributes and human health benefits.
Breed engineering	Animal management systems adopted and breeding technology developed with commercial partners.	Industry adoption of testes cell transfer techniques, success of aquatic breeds and novel feeds and optimal genetics in livestock and aquaculture.	Boost the value of Australia's animal-based food industries by \$350 million per annum for beet and \$550 million for seafood.
Quality biosensors	Development of test technology, odours predicting grape and wine quality identified.	Biosensor developed and adoption commenced in defence domain. Applications for food safety and quality in development. Flavour potential of wine grapes optimised.	Develop biosensors and improve current technology to optimise flavour in food and beverage value chain, adding \$750 million per annum.

#### Current position

The Food Futures Flagship research portfolio was reduced from four themes to three due to the transfer of the Designed Food and Biomaterials theme to CSIRO Food and Nutritional Sciences in March 2010.

# **Future Manufacturing Flagship**

**Flagship goal:** To create \$2 billion of additional annual value for Australia's manufacturing industry by 2025 through the development and application of resource efficient, clean and disruptive technologies.

### Overview

Australian manufacturing faces significant challenges surrounding resource efficiency, increased international competition and the need to move to clean sustainable products and processes. Innovative science and technology are essential to address these issues and support our ongoing economic sustainability in an increasingly resource and emissions constrained world.

The Flagship is helping to address these challenges and secure Australia's global competitiveness by creating the advanced materials and manufacturing technologies needed to transform existing industries and build future manufacturing opportunities.

These technologies will support employment and deliver economic and social benefits by contributing to technical solutions across a number of industry sectors including aerospace, automotive, renewable energy, defence, textiles, building infrastructure and packaging.

# Achievements 2010–11

#### Biodegradable shipping pallets



CSIRO scientists have been working with Australian company Biofiba Ltd to develop a sustainable alternative to timber shipping pallets targeted at the US\$90 billion global export pallet market.

Traditional timber export pallets are environmentally unsustainable as they are generally discarded after one use due to contamination risks and the high cost to treat and recycle them.

The revolutionary new bio-composite timber is derived from renewable resources that will break down at the end of the pallets' life to form mulch. The technology offers a sustainable alternative for pallet manufacture, freeing timber resources for high value-added uses.

#### Repainting aircraft with Paintbond SM-1



In collaboration with Boeing, CSIRO scientists have developed Paintbond SM-1; an innovative and effective solution to the complex ergonomic, safety and environmental challenge associated with both original equipment manufacturers painting and after-market repainting of aircraft. Traditional aerospace polyurethane topcoats become inert once they are cured and cannot form strong adhesive bonds to subsequent coating

layers without reactivation. The Paintbond SM-I spray-on treatment reactivates the existing coating's surface chemistry to provide strong and durable bonds with fresh paint layers, eliminating the need for time consuming and hazardous manual sanding. The technology is being used on all Boeing's current generation single and twin aisle aircraft and has seen widespread deployment on 737 and 777 aircraft.

#### New Automotive Australia 2020 Roadmap



CSIRO, working with the Cooperative Research Centre for Advanced Automotive Technology, has developed the new Automotive Australia 2020 Roadmap – a program to drive and guide the future development of Australia's automotive industry. The team analysed and considered input from 160 organisations across industries, universities and government to chart the automotive industry's capabilities, needs and commercial

potential. The Roadmap identifies four key directions for long-term opportunities: vehicle electrification, gaseous fuels, light-weighting and advanced data and communication systems. CSIRO's world-leading expertise in the field of green car technologies will be vital in achieving the Roadmap's objective of growing Australia's automotive industry and lowering its carbon footprint.

#### Olex fire resistant cables



CSIRO and Olex have partnered to develop an innovative ceramifiable insulation technology which has helped Olex secure a \$10 million contract to supply electric cables to the Brisbane Airport Link project. Olex's Alsecure fire resistant cables, which will be used in the project's road tunnels, contain ceramifiable polymers that form a solid protective and insulating ceramic layer at high temperature. In the event of a fire, this unique technology will significantly improve safety as the cable's ceramic shield

maintains the integrity and continuity of circuits for essential tunnel services such as alarms, pumps and fans that are vital for safe evacuation and fire fighting.

#### Future Manufacturing Flagship Roadmap

Theme	Short term I-3 years	Medium term 4–9 years	Long term 10+ years
Advanced engineered components	Materials and process development for sustainable transport solutions.	Commercialise emerging technologies.	Growth in the Australian advanced engineered components sector.
Advanced fibrous materials	Establish relationship clusters in filtration and defence, personal protection and environment sectors.	Commercialise first and second generation products.	Growth in the Australian advanced textiles manufacturing sector.
Flexible electronics	New materials discovery, device prototype optimisation and ruggedisation and scale-up.	Translate discoveries to create vibrant manufacturing industries based on flexible electronics.	Creation and growth of world- leading Australian companies in flexible electronics.
Sustainable materials	Develop technologies for economically and environmentally sustainable construction materials and processes.	Deploy new platform technologies in partnership with industry.	Sustainable environmentally conscious manufacturing in Australia.

#### Current position

The Future Manufacturing research portfolio underwent major expansion in 2010–11. Advanced engineered components, Advanced fibrous materials, and Sustainable materials themes were transferred from CSIRO Materials Science and Engineering (CMSE), Biomedical manufacturing moved to CMSE and Cleantech manufacturing merged with the incoming Sustainable materials theme.

# **Light Metals Flagship**

**Flagship goal:** To lead a global revolution in light metals, doubling export income and generating significant new industries for Australia by the 2020s while reducing environmental impact.

### Overview

The Light Metals Flagship commenced in 2003, one of the original National Research Flagships set up by CSIRO to focus on National Research Priorities. The Flagship was established to further the goals of the Government's Light Metals Agenda. Its focus was the stimulation of new industries to add value to developments of Australian reserves of titanium and magnesium ores, and the growth of existing alumina and aluminium industries with efficient low-carbon footprint technologies.

In 2011, it was decided to merge the Light Metals Flagship research into two larger Flagships which serve the mining and manufacturing sectors. During its eight year lifetime, the Light Metals Flagship had many achievements. The Flagship engaged successfully in technology transfer to a wide range of businesses, from Australian small-to-medium size enterprises such as T-Mag Casting Pty Ltd and o.d.t Engineering, to initiating and growing the international relationship with GE, which last year culminated in the announcement of the CSIRO-GE alliance.

The Flagship successfully attracted funding from commercial partners for both its novel processes for titanium metal powder and carbothermic magnesium production. The Flagship initiated and led projects in residue remediation and high-silica bauxite processing, through the Aluminium Taskforce of the Asia-Pacific Partnership on Clean Development and Climate.

The Flagship has partnered with many of the major aluminium producers – Rio Tinto Alcan, Alcoa, Tomago and Hydro Aluminium – in contract projects and collaborative initiatives. The Breakthrough Technologies in the Aluminium Smelting Collaboration Cluster has brought together Australasian researchers to develop low energy solutions for the aluminium smelting industry. The Flagship also hosted ground-breaking research in the measurement and mechanisms of atmospheric emissions, both in the aluminium industry and in alumina refining.

Some of the Flagship's most notable successes have been in support of the Australian car industry. Flagship technologies for lightweight die casting have been used in the manufacture of steering wheel armatures for Australian cars and recently Flagship die casting expertise was critical in determining the award of a global manufacturing contract by Nissan Motors (Japan) to Nissan Casting Australia.

The Flagship has received recognition within CSIRO, winning two CSIRO Medals for Business Excellence – for the commercialisation of T-Mag<sup>™</sup> magnesium die-casting in 2007, and the novel titanium production technology, TiRO<sup>™</sup>, in 2009.

The Light Metals Flagship will be integrated into two other Flagships, Minerals Down Under and Future Manufacturing, from 1 July 2011.

## Achievements 2010–11

#### CSIRO helps clinch global car component deal



In 2011, Nissan Casting Australia was successful in their bid to manufacture components for the Nissan Motor Company's new LEAF electric car. The success of the bid, which provides job security for 146 Victorian workers, was due in part to CSIRO's advanced casting technologies. Nissan Motors' Japanese engineers were impressed with CSIRO's die casting expertise and the potential for future access to a suite of CSIRO process-efficient technologies, helping to influence the Nissan Motor's decision to award the casting contract to Nissan Casting Australia.

#### Keeping pedestrians safe in industrial environments



A CSIRO system that alerts vehicle operators to oncoming pedestrians around blind corners has the potential to reduce fatal collisions between pedestrians and vehicles and make work in mining, materials handling and construction industries much safer. The technology uses software which tracks moving objects, identifies them as pedestrians or vehicles, and predicts the likelihood of a collision. A flashing light alerts vehicle operators, preventing accidents at dangerous 'black spots'.

#### CSIRO's Titanium Challenge



CSIRO's inaugural Titanium Challenge produced innovative design submissions from Australian undergraduates, developed during the competition's one week timeframe. Students were challenged to create and submit a design to be made in titanium using additive manufacturing, which capitalised on the superior material properties of titanium. The winner, a design for a novel radiator, was created by a Swinburne University industrial design student (see case study page 107).

#### Refiners can cut costs by recovering soda



CSIRO researchers have developed technology to recover and re-use caustic soda from Bayer process residues (red mud). The technology has the potential to provide significant cost savings for alumina refiners, as well as environmental benefits by enabling simpler storage options for the residues. This work evolved from high silica bauxite processing research for the Asia-Pacific Partnership on Clean Development and Climate (see: www.asiapacificpartnership.org/pdf/Projects/Aluminium/ ATF-06-04.pdf).

# **Minerals Down Under Flagship**

**Flagship goal:** To assist the Australian minerals industry exploit new resources with an in-situ value of \$1 trillion by the year 2030 and to more than double the size of the associated services and technology sector to \$10 billion a year by 2015.

### Overview

The Minerals Down Under Flagship focuses on technical, social and environmental challenges facing Australia's minerals industry. This industry is central to the Australian economy, supplying raw materials, mining technologies and services around the world. However, Australia is facing mounting global competition while new deposits are not being found fast enough to replace those being extracted. Many of Australia's deposits are experiencing declining grades resulting in increased production costs, increased handling of ores with higher levels of impurities and increasing environmental pressure.

Working with numerous industry, government and research collaborators, the Flagship is helping to strengthen the economic and environmental performance of the Australian minerals industry and maximise the longer-term discovery and use of our national resource endowment. This research infrastructure positions Australia as a global leader of science and technology for this important industry.

## Achievements 2010–11

#### New data network provides a multitude of geological information



A new data network of geoscientific information and its supporting infrastructure – the Spatial Information Services Stack – will enable users to explore Australia's geology on a national scale. Developed by CSIRO and AuScope in collaboration with research organisations around the country, the new online network will allow users to gain a greater understanding of climate change,

sustainable energy, water and mineral resources and extreme geological activity such as earthquakes. They can view and filter data on user specific queries from multiple organisations, share information and incorporate it into their workflow.

#### Using saline water at mine sites



Using saline water in mining and mineral processing could lead to significant financial savings and an environmentally sustainable future for the industry. CSIRO researchers examined the use of saline water in physical processes such as crushing and flotation. While saline water can cause corrosion to pumps, pipes and other components at mine and mill sites, the advantages outweigh the disadvantages where fresh water is unavailable. Potential savings due to recycling and reduced consumption of water would accumulate over the lifetime of the mine.

#### Processing nickel without sulfuric acid



A new process that will improve the economic viability of nickel laterite processing has been successfully demonstrated on a laboratory scale by CSIRO and industry partner Direct Nickel. The reagent recycle process that uses nitric acid instead of sulfuric acid provides the opportunity for lower grade ores to be profitably treated, potentially converting millions of tonnes of Australian nickel laterite ores into economically attractive

material. This new approach promises to secure major economic and environmental benefits for the Australian and global minerals industry. Direct Nickel and CSIRO are working together on several R&D projects aimed at enhancing the technology and Direct Nickel leads its commercialisation.

#### Using groundwater to find mineral resources



CSIRO scientists have developed a new cost-effective exploration technique that uses groundwater to map underground geology and target new regions of mineral deposits. It can also be used to locate gold, nickel, copper/zinc, uranium and other highvalue resources. Known as hydrogeochemical exploration, the composition of groundwater is used to detect mineral deposits in the area – ground water displays a chemical halo when mineral

deposits are present. The technique is ideally suited to the Australian landscape and will provide the minerals industry with an effective exploration tool that is quick and easy to use.

Theme	Short term I-3 years	Medium term 4–9 years	Long term 10+ years
Driving sustainability through systems innovation	Develop concepts to reduce greenhouse gas and water use. Assess the implications of plausible futures.	Proof of concept for new eco-efficient technologies. New planning tools to support social licence to operate.	Demonstration of whole system approach. Social negotiation tools embedded in technology and project development.
Discovering Australia's mineral resources	Identify new exploration too Enable data interoperability Build multi-party collaborations.	New 3D exploration tools developed and applied to buried deposits and new Greenfield sites	3D visualisation, modelling and targeting embedded as an industry standard leading to new discoveries.
Transforming the future mine	Engagement with industry to develop innovative mining concepts and establish investment.	Field trials of novel automated continuous selective mining systems and integrated light weight drill systems.	Adoption of new drilling, rock extraction and sorting systems. A vibrant mining technology services sector.
Securing the future of Australia's carbon steel materials industry	Develop infrastructure for precision iron ore and coke characterisation. Build relationships with industry.	Beneficiation and agglomeration process improvements being commissioned with resulting efficiency gains.	Low grade iron ores gaining traction in the Australian export market.
Creating wealth through advanced processing technologies	Laboratory testing of new ore characterisation, ore concentration and mineral/ metal extraction techniques	Continuous improvements of existing plant. Pilot plant and field trials of new techniques.	New ore reserves on-stream. In-situ leaching viable. Australian mineral processing technology preferred.
Transforming productivity through on-line analysis	Collaborative projects for concept development. Technology trials with indus	Industry partnerships for platform development. Spin-offs and commercialisation.	On-line analysis embedded in Australian operations with significant efficiency gains and reduced cut-off grades.

#### Minerals Down Under Flagship Roadmap

#### Current position

Growing Australia's light metal industry will be a new theme for the Minerals Down Under Flagship effective from 1 July 2011. The theme will incorporate some of the research from the former Light Metals Flagship.

# **Preventative Health Flagship**

**Flagship goal:** To improve the health and wellbeing of Australians and save \$2 billion in annual direct health costs by 2020 through the prevention and early detection of chronic diseases.

### Overview

The Preventative Health Flagship's research addresses our national health challenges in areas such as colorectal cancer, gut health, neurodegenerative diseases, mental disorders and brain health.

In addressing these health challenges, the Flagship's research teams are focusing on the development of better screening methods and new techniques for the earlier detection of disease. They are also investigating the contribution of diet and lifestyle to disease and examining new approaches to disease prevention through the use of protective foods and personalised nutritional and lifestyle measures. Another area of research involves advanced methods for collecting and utilising health data to improve the way we monitor and measure our health.

## Achievements 2010–11

#### Solving the structure of Alzheimer's protein



Alzheimer's disease is associated with the development of a toxic protein in the brain known as amyloid beta. In the brains of Alzheimer's sufferers, the amyloid beta protein rapidly 'selfassembles' and clumps together, producing toxicity and harmful plaques. CSIRO and collaborators have solved the first structure of amyloid beta providing a vital step towards understanding why

the protein accumulates and creates these toxic plaques. It is thought that these plaques disrupt connections within the brain, causing reduced neuron function and memory loss. There is no cure for Alzheimer's disease, but this knowledge could result in the development of new treatments.

#### Improving early detection of colorectal cancer



The Preventative Health Flagship and the Ludwig Institute for Cancer Research have used a sophisticated mathematical algorithm to identify a combination of proteins in blood, which shows promise as a screening test for the early detection of colorectal cancer. The team are working to validate the test with groups of colorectal cancer patients and healthy volunteers. If successful, a simple blood test will provide an alternative to existing faecal tests, which suffer from poor compliance.

#### Biobank to aid disease prediction and diagnosis



CSIRO and collaborators are building a biobank of blood samples in an effort to predict diseases such as colorectal cancer and Alzheimer's disease in ageing Australians. Over a three year period, the ASPirin in Reducing Events in the Elderly (ASPREE) Healthy Ageing Biobank will collect, process and store blood samples from 10,000 participants in the clinical trail. When coupled with the matched clinical and lifestyle data being collected under the ASPREE trial, the biobank will enable researchers to conduct a broad range of biomedical research including biomarker discovery and validation for specific diseases.

#### Novel strategies for stroke prevention



Launched in September 2010, the STroke, imAging, pRevention and Treatment (START) cohort study will integrate imaging and analysis of biomarkers (biological early warning signs) to more quickly and accurately identify patients at risk of stroke. The study will collect information derived from brain images

and blood samples from 200 Australian victims of acute ischaemic stroke, caused by an interruption of blood flow to the brain. The aim is to discover and validate new diagnostic biomarkers to enable the early identification of patients at risk of recurrent stroke and post-stroke depression and use these strategies in the development of new measures to prevent stroke.

#### Theme Short term I-3 years Medium term 4-9 years Long term 10+ years Reduced morbidity and New knowledge, early Translation into marketable mortality from colon Colorectal cancer detection and prevention of colon and rectal cancer and diagnostics and protective and rectal cancer and and gut health inflammatory bowel disease foods. inflammatory bowel disease. in Australia. New knowledge about Delay the onset of Develop and commercialise Neurodegenerative the aetiology and early detection of neuro protective agents and biomarkers for early detection Alzheimer's and other diseases neurodegenerative diseases neurodegenerative disease. and prevention. in Australia by five years.

### Preventative Health Flagship Roadmap

Current position

The Preventative Health Flagship research portfolio was reduced from three themes to two due to the transfer of the Obesity and Health theme to CSIRO Food and Nutritional Sciences in July 2010.

# Sustainable Agriculture Flagship

**Flagship goal:** To secure Australian agricultural and forest industries by increasing productivity by 50 per cent and reducing net carbon emissions intensity by at least 50 per cent by 2030.

### Overview

A number of important challenges and opportunities face Australia's agriculture and forestry industries. The opportunities include the production of more food for a growing Australian and world population, the reduction of greenhouse gas emissions and the storage of carbon in rural soils and forests. Some of the challenges we face are increasing competition for Australia's water resources, the limited supply and rising cost of production inputs (such as water, fuels, fertilisers and chemicals) and competition from other land uses (such as mining and urban development) for agricultural land.

In partnership with industry, communities and government, the Sustainable Agriculture Flagship is addressing these opportunities and challenges by developing and implementing new and enhanced technologies and practices, delivering innovation in knowledge-based services, informing policy options, building capacity and supporting key institutions. Maintaining and enhancing soil health and agro-ecosystem function is fundamental to achieving the Flagship's goals.

Although research is primarily focused on national productivity and carbon, the Flagship is partnering with many countries across south-east Asia, Africa and the Pacific to contribute its science expertise as part of Australia's contribution to the global food and climate security challenges.

## Achievements 2010–11

#### Using water efficiently increases crop yield



CSIRO and the Grains Research and Development Corporation are working to improve the water use efficiency of grain-based farming systems. As part of the National Water Use Efficiency Initiative, CSIRO's research in southern Australia highlights the importance of pre-cropping factors including management of weeds, stubble and livestock as well as in-crop decisions about selecting the right variety, sowing time and fertiliser use (see: www.csiro.au/science/Water-Use-Efficiency.html).

#### Increasing yields and reducing emissions from farming



CSIRO is working with research partners, industry and government to reduce greenhouse gas emissions and increase carbon storage in rural lands. Using a combination of improved land use, better management practices and technology, the Flagship is leading research to measure, model and mitigate emissions. A range of projects funded under Australian Government programs explore soil carbon and biochar, as well as methane emissions from livestock, savanna fire management and carbon forestry (see: www.csiro.au/science/Carbon-Australianagriculture.html).

#### CSIRO leads Global Soil Map in Oceania



CSIRO is leading the Oceania Node of a global partnership to produce the first detailed, three-dimensional digital map of the world's soils. So far involving agencies from Australia, New Zealand, Indonesia and the Pacific Islands in Oceania, the *GlobalSoilMap.net* project will provide users around the world with vital information on key soil attributes critical to supporting agriculture, land use planning, biodiversity management and greenhouse gas abatement (see: www.csiro.au/partnerships/Global-Soil-Map.html).

#### Community-based forestry assists rural Vietnamese livelihoods



CSIRO has co-managed and created a community-based forest management system that provides sustainable livelihoods through agro-forestry while protecting the remaining native forests in remote regions of northern Vietnam. As a result of this research, four rural communities now own, manage and have responsibility for forest land. The outcome has been improved forest protection and elimination of illegal tree cutting. Farmers have also developed tree nurseries to diversify incomes (see: www.csiro.au/science/Indonesia-Vietnam-Sustainable-Plantations.html).

#### Sustainable Agriculture Flagship Roadmap

Theme	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Radusian and	Assess mitigation practices and technologies in key industries, regions and systems.	Develop 'breakthrough' mitigation practices and technologies.	Profitable agricultural practices that contribute to greenhouse gas abatement are adopted by land managers.
greenhouse gas emissions while increasing storage of new carbon in our	Develop greenhouse gas measurement, accounting and bio-sequestration support packages.	Total system greenhouse gas outcomes for different management, history, climate and soil combinations quantifie- with defined uncertainty and co-benefit assessment.	New carbon sinks created giving net increase in carbon sequestration with environmental and production benefits.
lands.	Support national policy decisions and international frameworks on land use management for carbon storage and greenhouse gas mitigation.	Conduit for science and integration for industry and government.	National dialogue, policy and action are informed by robust science.
Advancing agricultural productivity and environmental health.	Identify challenges and prospects for food and fibre productivity increases in key industries, regions and systems.	Direct links between genetics, breeding and farming systems research underpin accelerated improvements in food and fibre productivity.	Step-change in productivity achieved via industry adoption of agro-ecological innovations for 'smart' food and fibre production systems.
	Characterise resource and labour-use, soil and water constraints to sustained productivity.	Integrated whole-farm analyses support diverse sustainable enterprise options for efficient resource management.	More sustainable production practices adopted with gap between farm and benchmark resources-use efficiency significantly narrowed.
	Evaluate agro-ecological tradeoffs in farming systems for potential to improve productivity and natural resource management outcomes.	Assess environmental impacts of emerging productivity and mitigation practices, technologies and policies.	New markets developed and in use for effective on-farm environmental and biodiversity stewardship schemes.
Informing land use planning, policy and natural resource management.	Observation of current status and historic change in key land management drivers.	Develop life-cycle based sustainability assessments for agri-food value chains.	Multi-scale temporal assessment of land use change.
	Enhance national soil and terrair data systems.	Triple bottom line modelling framework for land use systems.	International system for forest and carbon tracking.
Addressing global food and fibre security challenges through partners at home and abroad.	Deliver enhanced science and impact via an integrated approach to international project portfolio.	Deepen partnerships with international R&D institutions leading to enhanced capacity building.	Monitoring and evaluation confirm realised sustainable livelihood benefits in target regions.

DUTCOME AND PROGRAM PERFORMANCE

Current position

# Water for a Healthy Country Flagship

**Flagship goal:** To provide Australia with solutions for water resource management, creating economic gains of \$3 billion per annum by 2030, while protecting or restoring our major water ecosystems.

### Overview

The Water for a Healthy Country Flagship is addressing one of Australia's most pressing natural resource issues, the sustainable management of our water resources. The Flagship is Australia's largest research partnership focused on water in Australia. As demand for water increases, climate changes, and as economically and environmentally viable storage sites dwindle, Australia is looking to new strategies that manage demand, increase efficiency, re-use wastewater and allow water to be traded. Our science is informing the decisions on where and how to best invest in these options and is providing enabling technologies.

CSIRO's research is informing some of the major water policies and strategies at national and regional scales including the National Water Initiative, the Reef Water Quality Protection Plan, the Living Murray Initiative, the Water for the Future Program and the Murray-Darling Basin Plan.

## Achievements 2010–11

#### Seasonal streamflow forecasts help manage water



Using CSIRO research, the Bureau of Meteorology has launched an online seasonal streamflow forecasting service. It will give water managers and planners a better idea of how much water is expected to flow into selected rivers and catchments up to three months ahead, allowing them to plan for irrigation or potentially mitigate floods. The forecasting service has been developed for 13 river sites and eight storages

in the south-east Murray-Darling Basin and will gradually expand to other locations in Australia over the next 12 to 24 months.

#### Changing climate in south-eastern Australia



Despite recent rainfalls on the east coast of Australia due to one of the strongest La Niña events on record, the findings of the South Eastern Australian Climate Initiative (SEACI) indicate long-term, below-average rainfall and runoff into streams, and drier conditions into the future in south-eastern Australia. Results from the SEACI are being used by water managers to make decisions about future water use and planning

and the research is being used in Victoria's approach to regional water planning including the Northern Victorian Sustainable Water Strategy.

#### Reducing the cost of desalination



In desalination, membranes are used as a barrier to separate unwanted particles including salt, organisms and other substances from the water. However, pollutants can foul membranes by attaching themselves to the membrane surface, blocking membrane pores and decreasing water flow. This reduces the life of the membrane and increases treatment costs. Coagulants are commonly used to prevent this occurring. CSIRO has developed a

new coagulant that is more effective than conventional coagulants in ensuring residual pollutants do not attach to membranes, thereby reducing fouling. As membrane replacement, cleaning and use account for up to 70 per cent of operation and maintenance costs. The coagulant designed by CSIRO will deliver significant cost savings to desalination treatment plants.

#### Assessing water availability in major water systems



CSIRO has undertaken a comprehensive scientific assessment of current and future water availability in four major water regions across Australia: the Murray-Darling Basin, northern Australia, south-west Western Australia and Tasmania. The results are being used by governments and water managers to make decisions about future developments for these regions, including decisions on new irrigation schemes. The updated modelling for the Murray-Darling project has been used in developing the Basin Plan. In late 2010, CSIRO began assessing the water resources of the Great Artesian Basin, which underlies about one-fifth of the Australian continent.

#### Water for a Healthy Country Flagship Roadmap

			Medium term	
Theme	Short term I-3 years		4–9 years	Long term 10+ years
Urban water	Develop new tools and technologies for sustainable integrated management of water systems and infrastructure from city/regional to household level.	Inform state and national urban water policy through applied research of integrated urban water systems technologies.	Decision support systems, system performance knowledge, and new water management technologies to plan and deliver sustainable integrated urban water services.	To provide socially acceptable, affordable environmentally beneficial management solutions for Australia's urban water systems.
Integrated water information systems	In partnership with the Bureau of Meteorology, develop water reporting and forecasting tools. Develop sensor networks to improve real-time monitoring.	Enable water information interoperability through research investments in standards development, web service integration, semantic web and model interoperability.	Widely accessible national water information network based on open standards. Reporting and forecasting tools used in water demand regions.	Establish the platform for an Australia-wide network of integrated water information systems that deliver water accounts, assessments and forecasts.
Healthy water ecosystems	Establish a network of integrated models and evaluation tools and embed these in the adaptive management of high priority water ecosystems.	Inland and coastal water ecosystems managed through the use of integrated knowledge platforms.	Significantly reduced long-term impacts of pollutants and changed flow regimes in priority water ecosystems.	To provide the knowledge to protect or restore Australia's major water ecosystems while enabling sustainable use of water resources.
Regional water	Enable water savings in irrigation systems, and establish improved water efficiency and sustainability through improved surface and ground water management options.	Develop options for improved institutional water use arrangements and evaluation of their economic, social and environmental consequences.	Achieve greater water supply certainty, enhanced substitution options, and improved productivity through integrated management of river basins and aquifers.	To provide systems knowledge and analysis tools for river basins and aquifers to ensure water security for all users.

DUTCOME AND PROGRAM PERFORMANCE

Current position

# Wealth from Oceans Flagship

**Flagship goal:** To provide Australia with the knowledge and tools to protect coastal and ocean environments, increase their value to society and create a net economic benefit of \$3 billion per annum by 2020.

### Overview

CSIRO's Wealth from Oceans Flagship focuses on understanding Australia's oceans and their biodiversity, resources and relationships with the climate system. The Flagship delivers practical science that enables governments, industries and communities to make informed decisions about the sustainable management of marine and coastal resources. It provides CSIRO's contribution towards national challenges where oceans play a central role.

The Flagship's core partners are government – federal, state and local – where our science informs policy development and assists policy implementation across various sectors, such as oceans, environment, energy, fisheries and tourism. The Flagship also partners with industry and national and international universities, and participates in global collaborations such as the Census of Marine Life and the Global Ocean Biodiversity Initiative.

During 2010–11, the Flagship has been working to refocus its science strategy, resulting in new goals for each of the Flagship's themes. This new direction will see CSIRO lead a transformation in ocean information management, which will enhance Australia's capacity to address national ocean-related information challenges and opportunities. Implementation of this ambitious initiative will commence in 2011–12.

## Achievements 2010–11

#### One year on from the Gulf of Mexico oil spill



In May 2010, CSIRO scientists were deployed to the Gulf of Mexico to help monitor a massive oil spill. Using our prototype hydrocarbon sensor array to map the location and movement of the oil, CSIRO provided United States authorities with information about the quality of surface waters, which is helping them make important decisions about fisheries. Engaged by BP, the CSIRO team surveyed more than 8,000 nautical miles (see case study page 73).

#### First broad-scale maps of life on the sea-shelf



Marine scientists from five research agencies have compiled a directory of life on Australia's continental shelf. The new maps of biodiversity are guiding marine bioregional planning and the design and monitoring of marine reserves. The Commonwealth Environment Research Facilities Marine Biodiversity Hub mapped I,868 square kilometres of seabed with multibeam sonar, recorded 171 km of underwater video, and collected nearly I,000 samples. New statistical modelling approaches predicted

and mapped biodiversity across two million square kilometres from survey records dating back to the 1960s. The maps highlight complex patterns of biodiversity and emphasise how much remains unknown.

#### The Census of Marine Life



For the past decade a network of 2,700 scientists in more than 80 nations has been involved in the world's first comprehensive stocktake of marine life in the global ocean. The Census of Marine Life was officially released on 4 October 2010. CSIRO contributed to the Australian section of the census along with the Australian Institute of Marine Science, museums, government agencies and universities. CSIRO played a significant role in the

Australian section by developing approaches to predict life on the seabed and pioneering the genetic barcoding technique. Results of the census are already being used by government agencies to improve marine biodiversity management in Australia (see: www.coml.org).

#### Iceberg movements reveal new species of marine life



A CSIRO-led team of 40 Australian and international scientists visited east Antarctica after a 78-kilometre piece of Mertz Glacier tongue broke off, exposing a section of the Southern Ocean previously covered in hundred of metres of ice. Scientists deployed underwater cameras where the glacier tongue used to be. In addition to discovering new species of marine life, they found the salinity of the ocean around the glacier has decreased. Over time they hope to learn how this natural event will affect ocean currents and use that information to make predictions about climate change.

#### Robotic glider maps flood plume in Queensland



Research agencies joined together at short notice to track the massive flood plume that flowed from the Brisbane River in January 2011. Measurements from a robotic glider deployed by CSIRO were used to generate three-dimensional maps illustrating the impacts of the flooding. Initial results showed that flood waters travelled mostly northwards with a layer of freshwater evident to a depth of more than ten metres in surface waters off Caloundra. The exercise led to an improved capacity to predict the impacts of flood events.

#### Wealth from Oceans Flagship Roadmap<sup>1</sup>

Theme	Short term I–3 years	Medium term 4–9 years	Long term 10+ years	
The dynamic ocean	Synoptic forecasting system for major marine industries delivered (BLUElink 3).	Deliver littoral zone forecasting system for defence and industry applications.	National, seamless near- real ocean prediction and forecasting system operationalised.	
Our resilient coastal Australia	Coastal management strategy evaluation system implemented and operational in three regions nationally.	Integrated observation modelling and visualisation system (eReefs) guiding management of the Great Barrier Reef Marine Park.	National shelf-scale hydrodynamic model (BROWNlink) nationally implemented and used for oceanographic services.	
Sustainable ocean ecosystems and living resources	CSIRO R&D underpinning marine bioregional plans and National Representative System of Marine Protected Areas.	Adoption of CSIRO marine incident emergency response system.	Operationalisation of a National Ocean and Coastal Information System, as part of Australia's National Environmental Information System.	

#### Current position

<sup>&</sup>lt;sup>1</sup> As a result of the Flagship's impact review in 2010 – which found that the existing goal had been largely achieved – the Flagship has been working to refocus its science strategy, resulting in new goals for each of the Flagship's themes. Direct comparison of theme progress against last year's roadmap is therefore not possible.

# Program 2 – Core Research and Services

# Core Research and Services – objectives and deliverables

CSIRO's Core Research and Services Program covers a range of non-Flagship research portfolios which target improvements in industry, the environment and community wellbeing through the provision of advice, information and solutions.

In 2010–11, CSIRO's five Research Groups managed twelve such portfolios that delivered new and improved technologies, management systems, intermediate and final products, catalyst services for business, advice relevant to policy development, and new knowledge and skills. These twelve portfolios accounted for 44 per cent of total resources. The Research Groups are also responsible for the development and nurturing of research capability, ensuring the excellence of CSIRO's science and its relevance to current and emerging needs.

The work and achievements of each Research Group is showcased on pages 52–61.

# Core Research and Services – Program performance

The performance of CSIRO's Core Research and Services Program is assessed through four performance indicators. Table 3.3 provides a summary of progress. More detailed analysis and trend data are provided where indicated.

# Table 3.3: Performance indicators for Program 2 –Core Research and Services

Key performance indicator	Target	Performance
Demonstrated adoption and impact of Research Group outputs.	Growing economic, social, environmental and intangible benefits	Recent achievements from each of the five Research Groups are reported on pages 52–61.
The number of refereed publications.	Maintain or increase	The number of journal articles produced by CSIRO increased by five per cent from 2,542 in 2009 to 2,679 in 2010. However, the total number of publications fell by 11 per cent from 4,659 to 4,140. See page 51 for details.
Customer satisfaction.	Maintain	Implementation of a formal customer satisfaction measurement program that had been planned for 2010–11 has been re-prioritised and deferred to 2011–12. See page 27 for details.
Proportion of research capabilities rated as benchmark or strong.	Maintain or increase	There was a small increase in the proportion of capabilities rated 'benchmark' or 'strong' in Round Two assessments compared with Round One. See page 11 for details.

#### Number of refereed publications

The nature of the Organisation's matrix structure means all publications by CSIRO Divisions are accounted for in Program 2 – Core Research and Services, and a subset is attributed to the National Research Flagships Program (see page 26). Table 3.4 shows the number of publications, by type, produced by CSIRO, for the past five years.

Publication type <sup>1</sup>	2006	2007	2008	2009	2010
Journal articles	2,198	2,239	2,542	2,542	2,679
Books/chapters	227	234	363	237	184
Conference papers	1,830	1,525	1,911	1,664	1,034
Technical reports	676	613	145	216	243
Total	4,931	4,611	4,961	4,659	4,140

#### Table 3.4: CSIRO publications by type

<sup>1</sup> See glossary page 205 for definition of publication types.

The total number of publications produced by CSIRO fell by 11 per cent in 2010, due to a fall in the number of conference papers and books/book chapters. Preliminary investigations suggest the decrease in conference papers is associated with the introduction of the new publication repository, ePublish and with an increased emphasis on producing journal articles rather than other types of publications (in line with recommendations from Divisional reviews). The number of journal articles increased by five per cent in 2010. The figures for 2010 are subject to revision.

The Thomson Reuters/ISI Essential Science Indicators database provides another view of CSIRO's publication performance. It shows a 12 per cent increase in the number of CSIRO-authored journal articles (based on a ten-year rolling total for journals indexed in the database). CSIRO is the eighth ranked Australian institution in terms of journal articles and its world ranking is 185 of 4,381 institutions as at May 2011 (compared with 218 of 4,122 as at May 2010).

The new CSIRO strategy reaffirms the ongoing importance of scientific publications to the Organisation's future and we are committed to improving our performance in terms of quantity and quality across all publication types.

# **Energy**<sup>1</sup>

**Research group aim:** To develop and apply leading-edge energy research that reduces greenhouse gas emissions; ensures energy supply; maximises Australia's wealth from its energy resources; and derives increased, sustainable benefits from Australia's marine resources while ensuring conservation of our marine biodiversity and coastal habitats and settlements.

### Overview

Australia is endowed with rich energy resources and a massive ocean territory. To help tackle Australia's energy and ocean opportunities and challenges, CSIRO is building nationally integrated carbon-pathways and ocean-management models. We are also working with industry, governments, the community and our research partners to demonstrate new low-emissions energy technologies that address unique Australian needs and advantages.

Our energy research portfolio aims to accelerate large-scale emission cuts while ensuring a smooth transition to a prosperous, low-carbon future. It covers emerging stationary and transport energy technology options including solar, geothermal, smart grids, energy storage and biofuels.

Our research also emphasises the importance of cleaner fossil energy – coal, gas and oil – in providing energy security and wealth, as well as supporting and enabling the path towards a clean energy future.

CSIRO's ocean research seeks to understand ocean systems, processes, biodiversity, resources and technologies, and the ocean's role in driving the climate system. We take a whole-of-system approach to marine science, focusing on national challenges where oceans play a central role. We deliver data, knowledge, tools and approaches that directly support sustainable ocean and coastal management.

## Achievements 2010–11

#### Extinguishing the danger of coal mine fires



Gas and fire in underground coal mines are significant safety hazards for the mining industry. To prevent coal from heating, gas must be drained from the mine and inert (non-reactive) gas strategically injected. This lowers oxygen concentrations (shown in red) limiting the possibility of heating and fire. CSIRO, in collaboration with the Australian coal industry, has improved gas drainage by 50 to 100 per cent in different coal mines. By implementing optimum strategies to make the atmosphere inert, miners' safety has been greatly increased.

#### First carbon capture in Queensland



Low-emissions coal research has reached an important milestone in Queensland with the first capture of carbon dioxide  $(CO_2)$  using post-combustion capture (PCC) technology. In partnership with Tarong Power Station, the CSIRO pilot plant has successfully demonstrated the technology and shown it can capture more than 85 per cent of  $CO_2$  emissions from coal-fired power stations. The research has reduced the energy required for the PCC process by ten per cent, an important step towards making the technology more efficient and affordable.

See Appendix 6, page 198 for the structure of each Research Group.

#### Cleaner, synthetic transport fuels



Industry, in collaboration with CSIRO, is creating cleaner synthetic transport fuels through Australia's first fully automated, around-the-clock, synthetic fuels research facility, SynCat. The new facility is developing less costly, more efficient processes with lower environmental impact, to convert natural gas, biomass and coal into liquid fuels. Reducing the costs and carbon footprint of these processes will provide Australia with an alternative to importing oil, increasing our energy security. These processes add value to our conventional and unconventional gas resources, while producing cleaner fuels.

#### Repairing subsea pipelines with PIPEASSURE™



CSIRO and PETRONAS, Malaysia's international oil and gas company, have developed and completed comprehensive laboratory testing on a new composite material that will rejuvenate damaged risers (vertical pipelines), reduce production downtime and enable industry to perform safer maintenance and repairs. The lightweight and flexible product that functions like a bandage, named PIPEASSURE<sup>TM</sup>, can be applied to complex shapes and has been trialled in Malaysia to restore damaged risers on a remote petroleum platform.

#### Detecting oil in the Perth Basin



CSIRO has helped local exploration companies find evidence of former oil accumulations in the underexplored offshore northern Perth Basin. Using CSIRO's fluid inclusion and quantitative fluorescence techniques, researchers examined tiny droplets of oil trapped within mineral grains of rocks, giving clues for oil exploration and drilling targets. This will greatly assist companies in their bids for recently released acreage and improve future success rates for oil discoveries in the Perth Basin.

#### Turning methane emissions into energy



CSIRO's Ventilation Air Methane Catalytic Turbine (VAMCAT) technology can capture and burn fugitive methane emissions from underground mining operations and harness them as an energy source. A 25 kilowatt prototype unit has been tested successfully in CSIRO laboratories and is being installed at a coal mine in China for a series of field trials. CSIRO is leading research into increasing the accuracy of measuring fugitive methane emissions and their contribution to Australia's greenhouse footprint.

# **Environment**<sup>1</sup>

**Research group aim:** To develop and apply leading-edge environmental research that will underpin the economic, environmental and social future of Australia.

### Overview

Australians have stewardship of a beautiful, diverse and unique environment. The cumulative consequences of the last 200 years of development of natural resources leave us with a legacy of environmental challenges. The future of Australia, the Asia-Pacific region, and indeed the whole world, is also being re-shaped by the forces of climate change and variability, natural resource quality and security, technological revolution, trade reform, poverty alleviation and national security concerns.

CSIRO's response to these challenges and opportunities involves the application of enhanced systems understanding as well as the development and deployment of new technologies, processes and services. CSIRO's Environment Group is doing this by boosting our understanding of the operation and interaction of entire ecosystems, regional economies, and societies. We aim to deliver the highest quality scientific research that will result in a more internationally competitive and sustainable Australia.

## Achievements 2010–11

#### Latest climate change information captured in new CSIRO book



*Climate Change: Science and Solutions for Australia* highlights the importance of climate change as a matter of significant economic, environmental and social concern in Australia. The new book from CSIRO draws on the latest peerreviewed literature contributed by thousands of researchers in Australia and internationally. It provides a bridge from the peer-reviewed scientific literature to a broader audience of society, while providing the depth of science that this complex issue demands. It provides the latest information

on climate change science and potential adaptation and mitigation responses in non-technical language. *Climate Change: Science and Solutions for Australia* can be downloaded for free at: www.csiro.au/Climate-Change-Book.

#### Testing air quality in Australian homes



A CSIRO study of the quality of air inside the typical Australian home is the most comprehensive examination to date of air pollutants in Australian houses. Fine particles, carbon monoxide, carbon dioxide, formaldehyde, benzene, nitrogen dioxide, ozone, fungi and mould were measured inside and outside 40 Melbourne households.

There were no surprise results in the study, which reflects the way Australians live – how we cook and warm the

home, the cleaning agents, building materials and finishes in the home, and the proximity to roadways and parklands. The project establishes a benchmark against which future changes in the mix of chemicals and pollutants can be measured, and can improve house design and air flow-through.

<sup>&</sup>lt;sup>1</sup> See Appendix 6, page 198 for the structure of each Research Group.

#### Old diving tank air extends greenhouse gas record



CSIRO maintains an archive at its Melbourne laboratory of air collected at the Australian Bureau of Meteorology's site at Cape Grim in Tasmania. The Cape Grim Air Archive, from which CSIRO has produced the longest direct record of greenhouse gases in the Southern Hemisphere, dates from 1978 to the present. This record has been extended back to 1968 using a recent find of a very old air sample contained in a long-disused SCUBA compressed air tank. Analysis of the air sample has generated new trace gas data on aerosol propellants, refrigerants and aluminium smelter emissions present in the global background atmosphere of 1968, but not widely used

in Melbourne at that time. Following publicity about the new air source several people contacted CSIRO offering old containers sealed with air.

#### Investigating Asian bee threat



CSIRO-led research is investigating the scale of the threat posed by Asian honeybees and associated varroa mites. Scientists are studying whether a new deadly strain of varroa mite that has jumped from Asian to European honeybees in Papua New Guinea could also enter Australia on new incursions of Asian Bees. So far Asian honeybee outbreaks in Australia have been free of varroa mites. If bees carrying this new mite break into Australia they will decimate wild and managed populations of

European honeybees and significantly affect growers of crops such as almonds, stone fruit, avocadoes, pumpkins and melons which rely on managed-honeybee pollination.

#### Identifying exotic pests through new technologies



New digital technologies have been developed by CSIRO and partners to enable the easy, rapid identification of damaging exotic pests and diseases such as mealy bugs or myrtle rust. Users are able to access our network of experts by utilising existing hand-held microscopes and new mobile devices to make identifications. The technology is a leap forward for Australia's efforts to rapidly identify and respond to exotic

pests and diseases, potentially reducing the need to implement expensive eradication and control programs.

#### The Atlas of Living Australia engages citizen scientists



The Atlas of Living Australia is a national initiative focused on making biodiversity information about Australian species more discoverable and useable online. The Atlas has developed its core tools in support of research, policy and management and will continue to develop more tools and datasets, improve the existing tools and complete key projects. By June 2012, the Atlas will deliver the most comprehensive, current and authoritative checklist of Australian species ever produced. It is collaborating

with 60 biological collections around Australia to digitise and mobilise their information. In addition, the Atlas has developed software to enable citizen scientists to record, share and analyse sightings of species.

# Food, Health and Life Science Industries<sup>1</sup>

**Research group aim:** To achieve outcomes for Australia along the value chain of food and fibre production, from 'paddock to plate', for economic, social and environmental benefits. The Group strives for excellence in animal, plant and microbial sciences to deliver profound impact in agriculture, food, health and the environment.

### Overview

The problems and issues facing Australia and the world are directing our research focus towards science-based solutions for major global challenges such as food security, increased agricultural productivity and sustainability, human disease prevention, biosecurity and the development of sustainable sources of energy and bio-materials.

Through the application of our life sciences research capability across CSIRO, the Group is delivering key outcomes in four important areas for Australia and the world.

We are significantly and sustainably enhancing food and agricultural yield and productivity in the face of increasing constraints on natural resources and carbon. Our research is helping improve the health and wellbeing of Australians throughout life via the prevention, early detection and treatment of serious diseases, combined with comprehensive modelling of the health system. We are also creating an inclusive and integrated national biosecurity system to respond to new challenges from increasing global interconnectivity, open access trade and climate change.

In the course of achieving these outcomes, our fourth goal is to enhance Australia's economy by building new industries based on the life sciences and increasing the competitiveness of existing industries in this domain.

## Achievements 2010–11

#### The low methane Tammar wallaby



CSIRO scientists have discovered gut microbes unique to Australia's Tammar wallaby that may be responsible for its remarkable 'low methane' digestion of plant material. Compared with cattle and sheep, Australian kangaroos and wallabies produce very little of the greenhouse gas methane when digesting plants because they have fewer methane-producing microbes in their digestive system. One of the ultimate aims of this research is to help develop novel technologies that will enable agriculture to reduce its environmental footprint, while maintaining animal health and productivity.

#### Experimental vaccine stops Hendra virus in horses



Researchers at the Australian Animal Health Laboratory have shown that a new experimental vaccine will help protect horses against the deadly Hendra virus. Trials have found the vaccine prevents horses developing the disease, thereby reducing the likelihood of transmission to humans. A horse vaccine is crucial to breaking the cycle of Hendra virus transmission from flying foxes to horses to humans.

See Appendix 6, page 198 for the structure of each Research Group.

#### Reducing production costs for the prune industry



The Australian prune industry is the first industry to benefit from CSIRO research that leads to a 60 per cent reduction in the energy required for prune processing. Using power sourced from solar and other alternative energy sources, combined with sophisticated computational modelling techniques, major environmental benefits and cost savings for food companies have been achieved. The techniques greatly reduce energy, money and greenhouse gas emissions while, at the same time, increase production rates. This work can be applied across a wide range of food and other processing industries.

#### Breeding the horns out of cattle



CSIRO scientists discovered a genetic marker that has been developed into a new DNA test to help the cattle industry end the painful practice of dehorning beef cattle. Australian beef cattle are routinely dehorned to prevent major injuries caused by horns. However, this procedure is labour intensive and has implications for animal welfare. Under the leadership of the Beef Cooperative Research Centre, a DNA marker for the absence of horns, identified by CSIRO researchers, has been developed into a commercial test that has proved to be accurate in trials involving several Australian cattle breeds.

#### Genetic archetype of sheep revealed



An International Sheep Genomics Consortium, co-led by CSIRO, has revealed the genetic archetype, or reference genome for sheep. This will help scientists develop tools for breeding sheep with more efficient production of meat, milk and wool. The results will allow researchers to start answering the question 'What makes a sheep

a sheep and not a cow?' The answer, from a genetic viewpoint, is not as obvious as it might first appear because sheep and cattle have very similar genomes.

#### **Diabetes Diet and Lifestyle Plan**



To assist Australians living with diabetes, CSIRO, the Baker IDI Heart and Diabetes Institute and Penguin Publishing have released a book covering every aspect of type 2 diabetes prevention and control. *The CSIRO and Baker IDI Diabetes Diet and Lifestyle Plan* explains what diabetes is, how people develop it and how its severity can be reduced. It also includes comprehensive plans to support a healthy lifestyle, expert advice on optimal diets and ideas for increased physical activity.

#### Controlling when grapes ripen



CSIRO has discovered a way to control when grapes ripen without affecting wine style. Grapes are ripening earlier and the harvest season is becoming shorter, possibly due to climate change. This causes wineries considerable difficulty in accurately scheduling harvest time to maximise the wine-making potential of some grape varieties. By applying particular plant-growth regulators, berry ripening can be delayed to enable more timely and cost-efficient harvesting.

# Information Sciences<sup>1</sup>

**Research group aim:** To work with partners to solve national challenges, drive the productivity of Australian industries, and deliver public good outcomes through the innovative application of mathematical, statistical, information and communication sciences and technologies, and to build Australia's role in developing the next generation of space sciences.

### Overview

The Information Sciences Group contains the core of CSIRO's research focus in the dataintensive sciences and services. It provides Australia with world-class capabilities in Information and Communication Technologies (ICT), mathematical sciences, and astronomy and spacecraft tracking that are deployed through a collaborative partnering approach. The Group plays a key role in enabling CSIRO's multidisciplinary science across Flagship programs and other portfolios.

The Group is the national leader for e-enabling scientific research endeavours through a data-intensive approach. Through implementation of the eResearch Strategy, the way we conduct research at CSIRO is changing, enabling researchers to actively collaborate and share resources globally, and engage in cross-disciplinary research. The eResearch strategy supports research tackling 'big science' challenges and associated data management requirements.

The Group operates world-class national facilities in astronomy and spacecraft tracking on behalf of the Australian Government.

### Achievements 2010–11

#### Wireless broadband for rural Australia



CSIRO is developing wireless broadband technology for people living in rural and regional Australia. CSIRO's Ngara technology aims to bring wireless broadband access to people living beyond Australia's planned fibre network using existing broadcasting infrastructure, such as that left behind after the switch-over to digital TV. The technology uses devices attached to existing broadcasting towers and slightly modified ordinary TV antennas to 'beam' broadband to and from homes, offering people in the bush the benefits of 21<sup>st</sup> century services. It can operate using barely a quarter of the number of transmission towers required by current systems.

#### Astronomers unravel how pulsars work



CSIRO and international colleagues are close to solving a 30-year-old puzzle as to why 'cosmic clocks' called pulsars are not perfect. Pulsars are small spinning stars that emit a beam of radio waves and are often used as clocks given their highly regular rotation. When the beam sweeps over the Earth we detect a 'pulse' of radio waves. Scientists observed 366 pulsars over several decades and found that a pulsar's magnetosphere (its 'cocoon' of magnetic fields) switches back and forth between two different states, subtly affecting the pulsar spin.

Armed with this understanding, astronomers will find it easier to compensate for errors in their pulsar 'clocks' when used as tools – for instance, in trying to detect gravitational waves.

<sup>&</sup>lt;sup>1</sup> See Appendix 6, page 198 for the structure of each Research group.

#### Improving communication for animal disease experts



Responding to outbreaks of deadly animalborne diseases is now quicker and easier with new CSIRO-developed technology. Installed at the Australian Animal Health Laboratory in Geelong, Victoria, the interactive system provides high-definition video conferencing and a shared workspace that offers secure, real-time access to critical technology such as microscopy, pathology and software applications. The

technology allows disease experts both inside and outside a high security biocontainment area to work in real-time with chief veterinary officers across Australia.

This will greatly improve the management of emergency animal disease outbreaks in Australia.

#### Exercising while playing computer games



CSIRO has developed software that aims to encourage children to be more active when playing computer games. It works by exploiting the children's desire to win. Using the game 'Neverball', that is usually played sitting down, players must guide a ball through a maze within a time limit. Researchers modified the game by shortening the time allowed and making players get up and jump around before being able to proceed to the next level. Every jump earns a second of game time.

Modified and unmodified versions of the game were tested on 270 primary school children, and found that children playing modified games spent 25 per cent of their gaming time being active, whereas those playing unmodified games were active for

just three per cent of the time. Physical activity is an essential part of a healthy lifestyle, and CSIRO is now investigating if programs such as this can improve children's health.

#### Helping Centrelink respond to customer needs



CSIRO is developing sophisticated technologies to help Australia's largest human services provider Centrelink understand and respond to trends in demand for social worker services. Figuring out how and where to invest social worker resources is difficult. Not only are there huge demands, but as customers' needs change over time, resource allocation must

also change in response to where services are needed most. The project will allow early detection of unexpected increases or decreases in demand for social worker services, identify where current services are not meeting needs, and help Centrelink respond to changing issues and demographics of customers.

# Manufacturing, Materials and Minerals<sup>1</sup>

**Research group aim:** To help grow Australia's wealth by fostering increased efficiency and supporting business and job creation in an environmentally and socially responsible manner.

### Overview

The focus of the Manufacturing, Materials and Minerals Group is to assist industry become more sustainable. We innovate in partnership with local and multinational organisations to deliver technologies, products and processes for their sustainable competitive advantage. We work with companies in aerospace, automotive, renewable energy, defence, textiles, building infrastructure, health, chemicals, plastics, packaging, mineral exploration, mining, mineral processing, and metals production market segments.

The Group delivers major initiatives in: sustainable and fibrous materials; flexible electronics and advanced engineered components; innovative technologies for advanced mineral processing; mineral exploration; improvements to mining productivity; systems innovation; and works across the entire light metals value chain from aluminium, titanium and magnesium production to manufactured products and components.

The Group's research will deliver economic benefits including the development of new and improved products processes and services, new companies and employment opportunities; environmental benefits as we create new products and services which have a lighter environmental footprint; and social benefits through increased employment and wealth creation for Australia.

## Achievements 2010–11

#### LANDTEM<sup>™</sup> finding difficult-to-detect ores across the globe



LANDTEM<sup>™</sup>, is a portable exploration tool that uses highly sensitive magnetic sensors known as SQUIDs (Superconducting Quantum Interference Devices). Licensed to Australian start-up company Outer-Rim Exploration Services, the LANDTEM<sup>™</sup> system enables the minerals industry to 'see through the ground' in search of the next generation of resources to underpin the future of our minerals industry. It represents a major innovation in our ability to unearth mineral deposits worth hundreds of millions

of dollars. In the past eight years, ten LANDTEM<sup>™</sup> systems have been built and deployed successfully on four continents helping to unearth around \$6 billion of new mines worldwide. The underpinning SQUIDS technology has been applied to oceanography, security and defence applications, and is a great example of science teams working across boundaries to deliver impact to multiple industry sectors.

<sup>&</sup>lt;sup>1</sup> See Appendix 6, page 198 for the structure of each Research Group.

#### Repairing flood damaged buildings



In response to the 2011 floods in Australia, CSIRO developed extensive documents and interactive tools to provide information and advice to the Australian public dealing with flood damaged buildings. Information on the effects on different building materials and how they should be repaired was widely referenced and republished throughout the national

media. Details about extreme weather events and the causes and impacts of floods and tropical cyclones formed part of the rich package of information.

#### **GE-CSIRO** Research Alliance



GE and CSIRO have signed a \$20 million strategic Research Alliance that will allow the organisations to benefit from complementary capabilities and achieve mutual long-term objectives. The alliance, which is a five-year commitment to collaborative research and development, will include projects around the key themes of energy, healthcare, materials and water. The partnership with GE will link CSIRO to the global innovation system, position Australia as a development

market for new innovations with global potential and will enable CSIRO to create impact both within Australia and on a global scale.

#### International Centre of Excellence to open in Chile



CSIRO has been selected by the Chilean Government to develop the *International Centre of Excellence in Mining and Minerals Processing.* The world-class centre will address current and future challenges common to both the Australian and Chilean mineral industries, including processing lower grade and complex ores, improving mining safety and efficiency and reducing energy and water use. It will also tackle the chronic global skills shortage by opening up postgraduate

training opportunities and it will support greater linkages between the vital mining equipment, technology and services sectors.

# Program 3 – Science Outreach: Education and Scientific Publishing

# Science Outreach – objectives and deliverables

Communicating scientific research helps raise the profile of science and CSIRO within the community. CSIRO conducts a range of science education programs for primary and secondary school students and their teachers and the public, and hosts the CSIRO Discovery Centre in Canberra.

CSIRO operates **CSIRO** PUBLISHING as an independent science and technology publisher with a global reputation for quality products and services covering a wide range of scientific disciplines, including agriculture, chemistry, the plant and animal sciences, and environmental management. **CSIRO** PUBLISHING operates within CSIRO on a commercial basis on behalf of authors and customers in Australia and overseas.

CSIRO also runs an honours and postgraduate scholarship program which provides opportunities in science and engineering for outstanding graduates who enrol at Australian tertiary institutions as full-time postgraduate students for research leading to the award of a PhD. PhD students at CSIRO are co-supervised by a university, allowing students to maintain and develop their university connections while being exposed to research in a working environment. The number of students fluctuates due to uneven intakes each year and a reduction in student numbers is often seen when a cohort moves through the program (see Table 3.5).

Some CSIRO Divisions have collaborative arrangements with universities to foster PhD studies in particular areas – for example, CSIRO Marine and Atmospheric Research and the University of Tasmania run a joint PhD Program.

	2006–07	2007–08	2008–09	2009–10	2010-11
Sponsored postgraduates <sup>(a)</sup>					
PhD	256	241	338	375	333
Masters	4	18	9	13	24
Honours	16	13	17	25	19
Total	276	272	364	413	376 <sup>(b)</sup>
Supervised postgraduates <sup>(a)</sup>					
PhD	582	523	629	733	655
Masters	31	48	56	47	59
Honours	61	63	58	60	77
Total	674	634	743	840	791
Postdoctoral Fellows	294	301	304	330	333

#### Table 3.5: Science outreach – CSIRO's postgraduate students

(a) As at 31 May each year. A student may be either sponsored, supervised or both. The total number of individual students sponsored and/or supervised as at 31 May 2011 was 815, including more than 53 supervised in collaboration with CRCs and 57 through the Flagship Collaboration Fund. See glossary page 205 for definition of sponsorship and supervision.

<sup>(b)</sup> Includes 121 students fully sponsored and 255 students partially sponsored by CSIRO.

#### Science Outreach - Program performance

The performance of CSIRO's Science Outreach Program is assessed through six performance indicators. Table 3.6 provides a summary of progress. More detailed analysis and trend data follow the Table.

#### Table 3.6: Performance indicators for Program 3 – Science Outreach

Key performance indicator	Target	Performance
Utilisation of science outreach	Increasing	Overall participation in CSIRO Education Programs increased.
programs.		The Canberra Deep Space Communication Complex and the CSIRO Parkes radio telescope continue to attract large numbers of visitors.
Awareness of science by CSIRO stakeholders.	Increasing	Data not available. <sup>1</sup>
Success of participants in the Science Outreach Programs.	Evidence of success	Independent evaluations and surveys confirm the success of CSIRO's Science Outreach Programs and visitor centres.
International reach and impact of published journals.	Increase	International submissions increased by 15 per cent and global readers downloaded over 2.6 million papers.
		Journal impact factors as measured by the Institute for Scientific Information are generally increasing.
New book titles.	50	48 new book titles were published during the year.
Net profit from <b>CSIRO</b> PUBLISHING.	Positive	A net profit of \$624,000 was delivered.

<sup>1</sup> The community awareness survey was not undertaken in 2010–11.

# Utilisation of science outreach programs

CSIRO Education continues to offer a range of valued programs to teachers and students. Table 3.7 shows there was a small increase in the number of visitors to CSIRO's Science Education Centres and Science by Email continued to increase its readership. In 2010, the Maths by Email program was launched, with the number of subscribers reaching 9,255 by December 2010. The Scientists in Schools program reached 1,850 teacherscientist partnerships and the number of Mathematicians in Schools partnerships reached 163. *SCOPE*, the national weekly science TV program broadcast on Saturday mornings, continues to reach an increasing number of viewers. However, participation in the Double Helix Science Club dropped by 20 per cent. A new program of promotion is being undertaken to address decline in membership. After the success of the pilot program reported last year, CarbonKids gained funding to expand its reach.

CSIRO's Discovery Centre had great success with their National Science Week event, 'The Canberra Family Science Spectacular', which drew 11,000 guests in three days. The national science film festival SCINEMA, run by CSIRO Discovery, played to an audience of 30,000 at 300 venues across Australia. The SCINEMA Jury awarded the Festival's Directors Award to *Honeybee Blues*, a film which highlighted the work of CSIRO's Denis Anderson. The Canberra Deep Space Communication Complex (CDSCC) has attracted significant public and education interest in a year highlighted by significant space exploration activities and the expansion of the Complex which has new antennas under construction. The complex welcomed over 70,000 visitors, including a record 12,000 school students and the CDSCC Space Open Day was well attended by the public.

The CSIRO Parkes radio telescope remains extremely popular with visitors. Visitor experience has been improved through the installation of a new astronomy and space science exhibition and increase in summer vacation student presentations. The Pulse@Parkes program allowed 200 high school students to observe pulsars using the Parkes telescope remotely. The program increased its international reach with twenty students in the Netherlands participating.

Program	2006	2007	2008	2009	2010
CSIRO Education Programs					
CSIRO Science Education	369,919	383,499	390,947	386,500	389,287
Centres (visitors)					
CSIRO Discovery	60,581	73,772	80,555	94,365	100,920
Centre (visitors)					
Double Helix Science	18,945	19,545	20,253	19,656	15,821
Club (members)					
Science by Email (subscribers)	20,689	28,516	29,560	34,933	38,156
Maths by Email* (subscribers)					9,255
Creativity in Science and	6,509	5,999	8,355	8,801	9,668
Technology (CREST)					
(participants)					
BHP Billiton Science	2,677	4,103	2,568	3,114	3,658
Awards (participants)					
Other Visitor Centres					
Parkes radio telescope (visitors)	94,305	104,783	92,369	112,342	95,104
Canberra Deep Space	65,467	62,162	67,538	67,582	70,044
Communication Complex					
(visitors)					

#### Table 3.7: Science outreach

\* Launched in 2010

# Awareness of science by CSIRO stakeholders

No formal survey of community awareness was undertaken in the reporting year. However, CSIRO continues to reach a wider audience through its expanding online presence.

Podcast downloads increased by over 40 per cent with CSIROpod holding the number one spot in the iTunes Natural Science category on more than one occasion. Downloads of CSIRO's video podcasts 'CSIROvod' also increased by 63 per cent and for the first time, captured the number one position on iTunes in the Natural Sciences video podcast category in June.

CSIRO expanded its social media portfolio to include a Twitter account, @csironews, which attracted 3,028 followers by June 2011.

Fans of CSIRO's Facebook Fan page increased by 136 per cent. During the year, CSIRO launched the inaugural Titanium Challenge, which aimed to engage fans in understanding titanium, additive manufacturing and CSIRO's titanium research (see case study on page 107).

CSIRO added 20 videos to its YouTube channel and views of its channel increased by 58 per cent.

# Evidence of success in the Science Outreach Programs

CSIRO uses a variety of methods to demonstrate the success of its Science Outreach Programs, including independent evaluations and surveys. An external evaluation of Maths by Email was highly complimentary of the difference it was making to students in its target 9–12 age group. An evaluation of Science by Email is underway. Reader surveys are regularly undertaken of *The Helix* and *Scientriffic*  magazines with content and style being modified in response. Two student finalists from the BHP Billiton Science Awards attended the Intel Science and Engineering Fair in the USA with one student receiving an award from the United States Patent and Trademark Office Society.

'[Maths by Email] is desperately needed and I am delighted to have it as a teaching tool. It gets kids interested in maths, as they still discuss its ideas and their findings outside the classroom!' Teacher

CSIRO's Discovery Centre supports science communication and education activities by promoting an understanding and appreciation of research. School children from every state and territory in Australia visit the centre – the number is growing annually, as many schools make multiple repeat visits. Discovery's unique and very popular 90 minute minds-on, hands-on program gives students an insight into CSIRO's work and the value of research to Australian society. During 2010–11, a major new exhibition was completed to showcase our research into functional foods.

'I love *The Helix*! It is a perfect way to see the many current science discoveries and science events. *The Helix* also has contests which is a great way to get kids excited about science. Plus all the experiments *The Helix* explains to everyone are great. Without *The Helix* I would be lost in science.' Cassidy, Double Helix Science Club member Feedback from visitors to the CDSCC's Visitor Outreach Centre was positive regarding the exhibition, narrative and level of information provided. Schools were extremely eager to ensure they rebooked for future years.

Visitor experience at the CSIRO Parkes radio telescope improved through 2010. Visitor feedback collected in exit surveys highlighted the quality of the astronomy and space science exhibition, the science garden and the enthusiastic staff as the contributing factors. Visitors' comments included:

#### 'Inspirational - leading edge information.'

'One of Australia's best kept secrets – truly inspiring.'

'Makes me proud to be Australian. Keep up the good work CSIRO.'

# International reach and impact of published journals

The reach and impact for the 25 Journals published by **CSIRO** PUBLISHING in partnership with the Australian Academy of Science and other societies continues to grow. International submissions increased by 15 per cent and global readers downloaded over 2.6 million papers (see Table 3.8). The drive for quality was generally rewarded with positive impact factor trends, as measured by the Institute for Scientific Information. The market expectation that we should open our print archives was met with *AJ Biological Sciences* and *AJ Physics* archives dating from 1948 digitised and published under an open access model.

ECOS, CSIRO's 'science for a sustainable future' magazine shifted to a digital only magazine, enabling it to reach a wider audience in a more timely fashion and to open more quality content to a mainly Australian readership by digitising archives back to 1974.

#### Table 3.8: CSIRO PUBLISHING

	2006	2007	2008	2009	2010
<b>CSIRO</b> PUBLISHING journal (downloads)	1,143,573	1,432,024	1,686,320	2,092,283	2,633,703
ECOS story (downloads)	101,267	168,262	204,225	200,740	241,525

#### New book titles

Forty-eight new book titles were published, highlighted by *Climate Change: Science and Solutions for Australia* released in hard copy and as an open access eBook. Other key titles included *Capturing the Essence*, a book for artists, *Scientific Writing = Thinking in Words* and the critically acclaimed *Living Architecture: Living Roofs and Walls*. While eBook versions of new books are now standard practice, **CSIRO** PUBLISHING continued to digitise backlist, out-of-print titles with over 300 eBooks now available on a variety of platforms.

#### Net Profit from CSIRO PUBLISHING

The business was able to withstand market challenges including economic pressures faced by international research libraries and a strong Australian dollar that reduced export income. While revenue was down at \$10.3 million, the bottom line profit target of \$624,000 was achieved.



# **Scientists in Schools**

It's not often that teachers and their students have the opportunity to use the latest technology when devising their experiments. But thanks to CSIRO's Scientists in Schools program, the staff and students at The Hutchins School in Hobart, Tasmania are using a CSIRO-developed sensor network to conduct research into plant water usage.

With CSIRO's assistance, Year 8 students set up a mini Sensor Web in a small plot of land at the school to measure soil water tension. The students developed a mobile telephone sensor network to read the water meters.

With the plot established, Years 11 and 12 environmental science students used the Sensor Web to monitor water usage. They measured how plants reacted to different soil moisture conditions and irrigation treatments in near real-time. They gained valuable insight into plant physiology, soil properties, the influence of weather/climate on evaporation-transpiration, and how sensor networks can help conserve water.

The environmental science teacher saw this as an invaluable opportunity to engage students in real-world science and capture their imagination by using emerging technology.

The Scientists in Schools program creates and supports long-term partnerships between scientists and teachers. It makes science appealing to students, especially those who are considering their career options. CSIRO also benefits from this deployment as it serves as another test bed for trialling its ideas.

Scientists interested in becoming involved can register at www.scientistsinschools.edu.au



Student from The Hutchins School examines the sensor technology. Credit: CSIRO

'I am keen to use this technology to reduce the school's ecological footprint....' Peter Crofts, teacher



ECOS, after 37 years of print, evolves to become an online magazine. Cover design by James Kelly et al.

Capturing the Essence offers techniques for a broad audience of bird artists. Cover design Andrew Weatherill based on artwork from William Cooper.

Climate Change: Science and Solutions for Australia reaches out to readers through hand-held devices. Credit: Robert Kerton. Cover design Andrew Weatherill using photos from Gregory Heath, Willem van Aken and Nick Pitsas.

# Program 4 – National Research Infrastructure: National Facilities and Collections

### National Research Infrastructure – objectives and deliverables

CSIRO manages two types of national research infrastructure on behalf of the nation; National Research Facilities and National Biological Collections. In addition, CSIRO hosts 30 other research facilities, such as the Australian Resources Research Centre (Perth) and the High Resolution Plant Phenomics Centre (Canberra) and over thirty national reference collections, including the National Tree Seed Collection, the National Soil Archive and the Cape Grim Air Archive.

#### National Research Facilities

CSIRO operates a range of specialised laboratories, scientific and testing equipment, and other research facilities which are available for use by both Australian and international researchers. The three major National Research Facilities, classified as landmark facilities, are:

• The Australian Animal Health Laboratory (AAHL) – located in Geelong, Victoria, is a national centre of excellence in disease diagnosis, research and policy advice in animal health and human diseases of animal origin (zoonoses). It is Australia's front line defence, helping to protect Australia from the threat of these exotic and emerging animal diseases. In recent years, CSIRO has been managing engineering upgrades, the provision of expanded facilities to support the work in zoonotic diseases and expansion of new microscopy capability.

- The Australia Telescope National Facility (ATNF) – operated and managed by CSIRO's Division of Astronomy and Space Science, is made up of radio telescopes at three observatories, near the towns of Parkes. Coonabarabran and Narrabri in New South Wales. A fourth telescope, the next generation Australian Square Kilometre Array Pathfinder (ASKAP) is currently being built at the Murchison Radio-astronomy Observatory in Western Australia and will consist of 36 antennas. Once fully complete, the ASKAP will also be operated by CSIRO as part of the Australia Telescope National Facility.
- The Marine National Facility (MNF) - is made up of a 66 metre blue-water research vessel, Southern Surveyor, a package of unique scientific equipment and instrumentation, and a collection of 26 years of marine data. It has the scientific, technical and administrative expertise required to safely and effectively manage an ocean-going research platform. The Southern Surveyor is particularly suited to multidisciplinary research projects in the deep oceans surrounding Australia. CSIRO is managing a major project to design and build a new stateof-the-art research vessel, Investigator, to replace the Southern Surveyor and is scheduled to be operational in 2013.

#### National Biological Collections

CSIRO is the custodian of several collections of animal, plant, fungal and microbial specimens that contribute to the discovery, inventory, understanding and conservation of Australia's plant and animal biological diversity. These include the:

- Australian National Insect Collection (ANIC), specialising in Australian terrestrial invertebrates. The ANIC also supports a remote microscopy service to enable virtual identification of species for the Australian Quarantine Service.
- Australian National Wildlife Collection (ANWC), specialising in land vertebrates
- Australian National Fish Collection (ANFC), specialising in marine fishes
- Australian National Herbarium (ANH), specialising in native plants and weeds.

Together, these collections support an important part of the country's taxonomic, genetic, agricultural and ecological research. These vital resources provide correct identification of species for biosecurity, conservation and the development of sustainable land and marine management systems.

### National Research Infrastructure – Program performance

The performance of CSIRO's National Research Infrastructure Program is assessed through seven key performance indicators. Table 3.9 provides a summary of progress. More detailed analysis and trend data follow the Table.

# Table 3.9: Performance indicators for Program 4 –National Research Infrastructure

Key performance indicator	Target	Performance
Utilisation of the National Research Infrastructure.	Variable	Availability and use of the National Research Infrastructure by Australia and the international scientific community has been maintained at the target levels for National Research Facilities and increased for National Biological Collections.
Maintenance and operation of National Research Infrastructure.	International standard	Management arrangements are progressively being strengthened to ensure they continue to be maintained and operated to relevant international standards.

Key performance indicator	Target	Performance
Proportion of National Biological Collections	Increase	The proportion of specimen level material digitised in the four collections is highly variable across collections and little changed from last year.
digitised and available to the public.		Public availability has been enhanced with the launch of <i>The Atlas of Living Australia</i> (ALA) (see: www.ala.org.au), which provides open and free access to biodiversity data held by the collections.
Coverage of National Biological Collections.	Increase	The coverage of Australian species increased marginally in the year, with coverage of fish species increasing by five per cent.
Response to national events.	Timely response	AAHL continues to respond to national events in a timely manner. All 39,000 tests on 25,000 samples sent for diagnostic testing for exotic diseases were completed in 24 hours or less.
The AAHL Collaborative Biosecurity Research Facility.	Facility built and operated in accordance with the NCRIS*/CSIRO agreement.	The collaborative Biosecurity Research Facility was completed this year. However, hand over was delayed until June 2011, due to refinements and modifications to one of the main laboratories (the PC4 laboratory for microbiological containment).
Scientific contributions in support of research.	Demonstrated high-quality contributions.	CSIRO's National Research Infrastructure continues to provide significant support to Australian and international scientific communities. Achievements this year are described on pages 78–81.

\* NCRIS is the National Collaborative Research Infrastructure Strategy.

#### Utilisation of National Research Infrastructure

Statistics relating to the use of the National Research Facilities are provided in Table 3.10. Use of the facilities has been relatively steady in recent years but is expected to increase as each expands its operation with the introduction of new laboratories for AAHL, new telescopes for ATNF and a new research vessel for MNF.

Access to National Research Infrastructure	2008–09	2009–10	2010-11
Australian Animal Health Laboratory			
Hours operating per day	24	24	24
Days operating per week	7	7	7
Australia Telescope National Facility			
Time allocated to observations (%)	76	75.3	72.4
Time lost to equipment failure (%)	3	2.9	3.1
Time allocated to CSIRO staff (%)	20	24	24
Time allocated to other Australian researchers (%)	30	23	25
Time allocated to international researchers (%)	50	53	51
Marine National Facility			
Ship time grants (days)	99	177	158

#### **Table 3.10: Utilisation of National Research Facilities**

<sup>1</sup> More information can be found in the ATNF's Annual Report (see: www.atnf.csiro.au/AR2010).

During the financial year, the Australian Animal Health Laboratory (AAHL) installed a new PC4 laboratory, which provides the highest level of microbiological containment. This additional laboratory will enable AAHL to undertake research on serious diseases that affect both animals and humans and for which there is no current vaccines or treatment, such as the Hendra virus, which can be fatal for both horses and humans.

Another new laboratory, the PC3 insectary, which is for use with animal or human pathogens that pose a medium risk to the environment, is expected to be operational in October 2011. This additional facility within AAHL will enable both diagnosis of and research into those emerging diseases transmitted by insects and that affect both animals and humans. For example, this year saw a significant increase in Murray Valley Encephalitis and Ross River Fever associated with heavy rains throughout eastern Australia. The facility will enhance our ability to both understand and respond to such outbreaks. Work also continued on the development of a horse vaccine for the Hendra virus.

#### The Australia Telescope National

Facility (ATNF) continues to be the most productive and powerful radio astronomy facility in the Southern hemisphere. Demand for its use from internationally prominent astronomers within and outside Australia remains high. The ATNF exceeded its target of 70 per cent of time allocated for astronomical observations on the Australia Telescope Compact Array and Parkes Telescope. Time lost during scheduled observations due to equipment failure was below five per cent. Performance targets were also met on the Mopra Telescope and Long Baseline Array.

The **Marine National Facility** (MNF) provided 158 days of ship time out of 240 days requested by scientists, and a further 11 research charter days. Participants included scientists from 29 Australian institutions including CSIRO, the University of Western



# Tracking the Gulf of Mexico oil spill

CSIRO scientists have been playing an important role in monitoring the extent of the oil spill in the Gulf of Mexico. In May 2010, researchers from CSIRO's Wealth from Oceans Flagship were engaged by BP Exploration and Production Inc on behalf of the Unified Area Command (UAC), to help map the oil's location and movement.

A team of scientists worked around the clock using CSIRO's new hydrocarbon sensor array system to build a picture of the surface water's hydrocarbon composition. Researchers onboard the vessel *Ryan Chouest* surveyed over 8,000 nautical miles of surface waters in the Gulf, gathering data about the water conditions just below the slick.

The hydrocarbon sensor system detects and analyses different types of hydrocarbons, including oil and gas. The original application of the hydrocarbon sensor was for petroleum exploration. The deployment of the sensors to the Gulf is a new, innovative application that enables real-time environmental monitoring.

The data obtained helped BP and the UAC to better understand the movement of the oil and assisted them to make important decisions, such as when fisheries should be closed. It also provided the CSIRO team with the opportunity to trial their technology and systems in a real life scenario, while making a valuable contribution to understanding the surface water's hydrocarbon content and composition.

Preliminary results showed that the condition of the Gulf water was better than anticipated. Contamination was not as severe as first thought, and did not exceed the United States Environmental Protection Agency limits. The team is currently in the final stages of verifying the results.



CSIRO scientists taking oil mousse samples from a water hose used on the underway hydrocarbon sensor system. Credit: Andrew Ross, CSIRO

Australia, the South Australian Research and Development Institute, the Antarctic Climate and Ecosystem Cooperative Research Centre, the University of New South Wales, the Australian National University, the University of Sydney and the Bureau of Meteorology and collaborating scientists from institutions in Canada, France, Germany, New Zealand, South

Africa and the USA. The MNF fostered the development of next generation marine researchers by enabling 17 students to experience scientific work at sea.

Use of the National Biological Collections has increased over the last three years (see Table 3.11).

Use of National Biological Collections	2008–09	2009–10	2010–11
Number of specimens dispatched	7,800	29,300	25,925
Outward going loans	138	147	193
Tissue samples sent	3,300	3,800	4,447
Tissue sample grants	79	44	40
Number of visitors hosted	155	186	336
Total visitor research days	403	713	551
Number of tours hosted	47	57	70
Total number of visitors on tours	535	597	1,266

#### Table 3.11: Combined utilisation of National Biological Collections

# Maintenance and operation of National Research Infrastructure

During 2010–11, AAHL completed a four year engineering upgrade with a refocus on routine maintenance and preventative activities. AAHL continues to operate at the highest level of biosecurity and biosafety, ensuring the physical containment of highly pathogenic organisms. The safety of staff is paramount at all times. The laboratory has retained full national accreditation for laboratory services (ISO 17025), and environmental management (ISO 140001). In keeping with the previous year, compliance with the Australian Quarantine Inspection Services, the Office of the Gene Technology Regulator and those regulations concerning Security

Sensitive Biological Agents has been achieved. Many of these regulations have been enhanced and expanded in response to maximising effective risk management in these areas. Auditing of the new facilities (the PC4 laboratory and the insectary) by the various regulators has been successful with only minor modifications required to ensure full compliance.

The **ATNF** is installing new instrumentation to maintain performance at the standard of comparable international facilities. A high rate of availability for astronomy was maintained despite undertaking several significant performance and reliability upgrades of the Parkes Telescope and the Australia Telescope Compact Array during the year, demonstrating the excellent maintenance and operation of the facility. Over one hundred papers using ATNF data were published in refereed journals in the last year. In 2008, (the latest year for which the analysis has been made) the ATNF ranked second internationally for radio astronomy papers in major journals.

CSIRO is overseeing the building of a new state-of-the-art research vessel, Investigator, to replace the current **MNF** research vessel, Southern Surveyor. The new vessel will be 89 metres in length, and represents a step-change in blue-water research capability available to the Australian marine research community. With accommodation for up to 40 scientists, RV Investigator will undertake multidisciplinary voyages up to 60 days duration to the further reaches of Australia's marine estate, from the Antarctic sea ice to the equator. The added capability will allow marine scientists to address national research challenges in ways not possible previously. Activities will include deploying and servicing deep water moorings systems to monitor ocean-atmosphere interactions, mapping and characterising the ocean floor out to deep waters, geological sampling, oceanic water sampling for physical, chemical and biological characteristics and deploying

meteorological sampling systems. Work has also commenced to facilitate the transition of support systems in readiness for commissioning of RV *Investigator* in 2013. Until then, the 40-year-old *Southern Surveyor* is being maintained to international standards with \$1.8 million allocated in 2010–11 for enhanced maintenance work. More information can be found at: www. csiro.au/science/Future-Research-Vessel

All National Biological Collections are housed in purpose-built facilities and are stored, curated and managed according to international standards. CSIRO's Information Management and Technology Group is building a data management system to support the storage, discovery and access of research data, including the natural history collections. As part of this, the ANIC is trialling in 2011 a new open-source product especially designed for natural history collections. The ANIC began a program to expedite curation through high-quality images of specimen drawers.

#### Proportion of collections digitised and available to the public

The proportion of specimen level material digitised in the four collections ranges from five to 100 per cent, (see Table 3.12).

Collection	Proportion of collection digitis	
	2009–10	2010–11
Australian National Herbarium	76	76
Australian National Fish Collection	100	100
Australian National Insect Collection	2.9	5
Australian National Wildlife Collection (excluding sound collection)	86	91

#### Table 3.12: Digitisation of the National Biological Collections

Overall, the majority of specimens are available through a range of internal or externally run databases. A concerted effort is focused on making all the collections available online through a single portal, *The Atlas of Living Australia* (ALA).

Efforts to increase availability in the past year have focused on adjunct material such as images, sounds and genetic information. The sound library of Australian birds is being transferred to digital recordings and images of collection drawers in the ANIC are being provided as digital meta-data records. DNA barcodes and images for most Australian moths have been released on-line this year.

The majority of Australian specimen records in the **ANH** are digitised, other than a small proportion of recent acquisitions. All digitised material is available through Australia's Virtual Herbarium (www.ersa.edu.au/avh/) and soon through the ALA (www.ala.org.au ). Images of Australian plants are also available via the Australian Plant Image Index (www.cpbr.gov. au/photo/), a comprehensive collection of over 65,000 images. Undatabased collections are predominantly of non-Australian origin.

The **ANFC** specimen data (48,669 records) is 100 per cent digitised and approximately 60 per cent is available publicly through the Online Zoological Collections of Australian Museums (www.ozcam.org.au/) and is searchable through the Australian National Data Service (ANDS) (www.ands.org.au/), the ALA and the Ocean Biogeographic Information System (www.obis.org.au) part of the Census of Marine Life. The Photographic Index of Australian Fishes is the largest collection of images of Australasian fishes, and more than 2,000 images covering about 1,600 species or 33 per cent of the described Australian species, are available to the public via Scienceimage (www.scienceimage.csiro.au/) and through ANDS.

Approximately five per cent of the **ANIC** invertebrate collection is digitised (about 500,000 records out of a possible 12 million). Of these, around two per cent are currently available for use and download through the ALA. However, all are still publicly available through the ANIC specimen database, OZCAM , the Global Biodiversity Information Facility (GBIF) (www.gbif.org) and Zipcode Zoo (www.zipcodezoo.com).

Ninety-one per cent of the **ANWC** vertebrate collections have been digitised, although this falls to 60 per cent when the sound collection is included. All specimens can be accessed through OZCAM on a manual provision basis, while around seven per cent have become available through the ALA.

#### Coverage of National Biological Collections

The National Biological Collections provide a moderately high-level of coverage of Australian Species (see Table 3.13).

Collection	Proportion of diversity covered (%)
Australian National Herbarium	70
Australian National Fish Collection	54
Australian National Insect Collection	70
Australian National Wildlife Collection	Vertebrate – 55
	Birds – 100

#### Table 3.13: Coverage of the National Biological Collections

Two projects, based on material held by the ANIC, have increased the list of known Australian moths: a recent book by a Finnish author has identified and named 137 new species of Australian leaf-mining moths. A new DNA study of all Australian moth species as part of the Barcode of Life Initiative (www. bolinfonet.org) has revealed the possibility of other new, as yet unnamed, species.

# Demonstrated response to national events

During 2010–11, AAHL responded to a major outbreak of equine encephalitis in horses in a number of eastern states that resulted in an increase in the number of samples from horses being tested for Hendra virus. Whilst all cases were negative for Hendra virus, many tested positive to the mosquito born virus infections (Murray Valley virus, Kunjun virus and Ross River Fever virus). Most of this was associated with an increase in vector populations due to heavy rains. Following this, major outbreaks of Hendra have occurred in Queensland and New South Wales. AAHL has been involved in confirmatory diagnosis activities, in causative agent isolation and identification and in undertaking further research to assist decision-making in the face of this significant outbreak.

Research continued on a range of viral infections of animals and humans. Work on a horse vaccine against Hendra virus infection progressed well and it is hoped that a vaccine will be available within two years. Studies on viral infection in bats had focused on a deeper understanding of the bat immune system and how this may have adapted to allow virus infection without any clinical manifestations in the bat. Early indications are that the bat's innate immune system may have some unique characteristics that allow for this non clinical co-existence. Work commenced overseas on studies with live foot and mouth disease virus to better understand the infection in cattle, sheep and pigs that is specifically relevant to Australia.

#### The AAHL Collaborative Biosecurity Research Facility

Further refinements and modifications to the new Biosecurity Research facility delayed hand over of this capability to scientists at AAHL until June 2011. Whilst this has postponed the occupation of this facility under the National Collaborative Research Infrastructure Strategy/CSIRO agreement, it has ensured that maximum use can be made of the space once operational.

A particularly challenging component of the refinement and modification to the PC4 laboratory for microbiological containment is the remote management of the live-cell imaging capabilities that will be established at PC4. This is a world first that requires some innovative technical solutions. Arrangements for training, for priority setting and for access arrangements and fees have all been completed. All the above have provided a timely capability to respond to the national call for additional work on the Hendra virus, most of which must be done at PC4 level.

# Scientific contributions in support of research

This section highlights some of the highquality scientific contributions made by the National Facilities and Collections in 2010–11, in support of the National Research Flagships, CSIRO's core research portfolios and external users.

## Achievements 2010–11

#### Australian Animal Health Laboratory



Recent investments in AAHL by the National Collaborative Research Infrastructure Strategy are ensuring that cutting-edge technologies linked to effective bio-containment attract scientists worldwide to partner with AAHL. Further investments in data management and communications are ensuring that research conducted within the secure area of AAHL can be effectively shared with collaborators worldwide. The development of the

Biosecurity Collaborative Platform is now being routinely used to conduct meetings across the secure barrier at AAHL. As an example, new research partnerships with scientists at Deakin University and the new Medical School in Geelong have utilised the new live cell imaging capabilities at AAHL to visualise the processes of viral entry into cells. In the case of the recent outbreaks of Hendra in Australia, these capabilities have been used to confirm outbreaks of the disease, further characterise the causative agent, harmonise testing across various States and territories, undertake targeted studies in close contact colonies of bats and estimate risks from affected species (horses and dogs). These activities have been crucial in providing science based decision-making in the face of an unprecedented level of disease, and the occurrence in a new species.

#### Australia Telescope National Facility



During 2010–11, pulsar astronomy research data from the Australia Telescope National Facility (ATNF) was made public in conjunction with the Australian National Data Service (ANDS). A key outcome of the project is to make large research datasets easily accessible. This will enable researchers to easily discover, download and reuse research data from anywhere in the world. Among the many benefits are the opportunities for collaboration and the potential for increased citation of associated publications.

Original data from 4,500 observations of pulsars (small stars that produce a regular train of radio pulses) observed with the ATNF's Parkes radio telescope is now available to researchers worldwide as a part of this initiative. This substantial new archive enhances over twenty years' of observations with ATNF telescopes already available through the Australia Telescope Online Archive (http://atoa.atnf.csiro.au/).

Notably, more than half of all currently known pulsars, including the only binary pulsar system, have been discovered via the Parkes Telescope, which continues to be a front-rank instrument in the field of radio astronomy.



# The Atlas of Living Australia

The Atlas of Living Australia (ALA) is a national initiative between the CSIRO, over sixty museums, herbaria and other biological collections, the Australian Government, and the community. The ALA project brings together a huge array of information on Australia's biodiversity, accessible through a single website.

The ALA launched its website in November 2010. During 2010–11, it has developed new software for recording and managing biodiversity data and photos in the field. The software is being used in research projects, urban biodiversity surveys, museum outreach activities, science education, biosecurity monitoring, natural resource management and reporting.

The ALA and its partners have made significant progress on digitising the information held in biological collections and delivered a suite of powerful mapping tools with national data for more than 350 environmental measures. The ALA has established national databases for identification keys, images and biodiversity literature, and has made substantial progress on a national species names list. Through these capabilities, the ALA is helping to make Australia a world leader in biodiversity informatics.



A Praying mantis, found during a Bushblitz survey in south-western Victoria. Credit: Julian Finn, Museum Victoria

#### Marine National Facility



During 2010–11, the Marine National Facility (MNF) supported a diverse range of science. The MNF was used to research the sustainability of a significant but declining rock lobster fishery and to improve the understanding of the Leeuwin Current off Western Australia which impacts marine productivity and the climate experienced in Australia. Researchers investigated the diversity of animal communities on the Park's ocean floor to inform the management of the Great Australian Bight Marine Park.

Deep water moorings in the Southern Ocean were serviced to ensure robust empirical data are available to improve the understanding of climate change and evaluate model projections. Ocean productivity in eastern Australian waters and the Tasman Sea was also investigated. More information can be found at www.marine.csiro.au/nationalfacility.

#### Australian National Insect Collection



A major revision of the ecologically dominant Australian meat ants (*Iridomyrmex*) was released. This was based on over 30,000 examined specimens of 79 recognised species. A collaborative DNA-sequence based study of relationships of the world's Dipterans (flies) has clarified the evolutionary history of this economically important group. As part of its digitisation efforts, ANIC has imaged more than 250 drawers of specimens and made them available for web-based viewing. The Remote Microscope Diagnostic Network has continued to grow and was recently recognised in 2011 with an Excellence in Innovation

Award presented by the Australian Research Council. The Network aids speed and accuracy of biosecurity decision-making and on-the-spot quarantine decisions are possible in 80 per cent of cases.

#### Australian National Wildlife Collection



The ANWC has continued to provide innovative linkages between present-day ecology and longer-term evolution of the Australian biota. This enhances our understanding of conservation significance and management needs. An example is in our improved understanding of the complexity of the evolutionary history of the iconic Australian and New Guinean parrots. We better appreciate now that the birds we so often simply call 'Australian parrots' are several distinct lines of evolution that all need conservation planning. Acquisition of a Micro CT scanner has contributed to a revolution in our understanding of native Australian mammal diversity and the names we need to apply to those mammals. This in turn helps the fundamental planning or conservation of this newly appreciated mammal diversity.

#### Australian National Fish Collection



The ANFC has provided major contributions to the worldwide knowledge of the marine fishes of our region through the Wealth from Oceans Flagship and international initiatives including the recently completed tenyear international Census of Marine Life by providing information, taxonomic identification of new specimens and analytical information to the marine research conducted in Australia as part of the Census (www.coml.org/).

ANFC data contributed to research in the Wealth from Oceans Flagship developing a new hierarchical framework to classify seabed biodiversity. The framework used in Australia's Regional Marine Planning is a significant step towards the ecosystem based management of marine systems. Its use in Australia and application in a global context is reported in a paper published in *Biological Conservation (2010, 143, 1675-1686)*.

The ANFC's historical data were essential in the Climate Adaptation Flagship's research assessing the impact of climate change on the marine biodiversity of south-eastern Australia – a known climate change hot spot. A paper in *Global Ecology and Biogeography (2011, 20, 58-72)* demonstrated major distributional shifts in 45 species of fishes thought to be climate related.

#### Australian National Herbarium



The ANH coordinates and manages the Australian Plant Census (www.anbg.gov. au/chah/apc/about-APC.html), a national, collaborative census of Australia's flora, aimed at providing a unified, agreed list of scientific names for all native and naturalised Australian flowering plants. Over 50,000 plant names have been considered and treated for the project, with another

13,000 to be treated before completion of the first stage of the project in late 2011. Along with the Australian Plant Name Index and the Australian Faunal Directory, the APC forms the 'taxonomic backbone' of another important, authoritative biodiversity information resource, *The Atlas of Living Australia* (www.ala.org.au).