NATIONAL MARINE SCIENCE COMMITTEE

National Marine Science Plan
Infrastructure Theme
White Paper

The International Ocean Discovery Program

A. Abstract

The International Ocean Discovery Program (IODP) is the latest iteration of 45 years of scientific ocean drilling, and is the world's largest international scientific geoscience program, with an operational budget of $US180 million p.a. and 27 participating nations. IODP is a wide-ranging international program that goes beyond any one country's marine science infrastructure. IODP deploys two large drilling vessels and other drilling platforms on expeditions that take continuous deep sea cores to address global scientific problems in the fields of climate and oceanographic change, the evolution of biota, planetary dynamics and natural hazards. Our ARC/LIEF funding gives us adequate access to the program, but this is time-limited funding as compared to the ten years of each phase of IODP. Longer term and more assured funding would ensure the full national benefit of our membership of this program. In the medium term we should look toward increased funding, giving increased participation.

B. Background

IODP provides a variety of drilling platforms that can take continuous cores in sediments and rocks in almost all ocean water depths and up to 6000 m below the sea bed (www.iodp.org). Its expeditions address global scientific problems in the fields of climate and oceanographic change, the evolution of biota, planetary dynamics and natural hazards. Proposals are internationally peer-reviewed and also reviewed by advisory panels and, because the cost of the average two-month expedition is about $US8 million, competition for expeditions is fierce. Nevertheless, there has been a disproportionate number of ocean drilling expeditions in our region in the last 45 years. The workhorse of IODP, the drill ship *JOIDES Resolution*, will be in our region for the next few years, due in no small part to the drive of Australian and New Zealand researchers in inspiring and leading, on occasions, excellent globally recognised proposals. We are cooperating at the highest level of international marine geoscience, and are clearly 'punching above our weight' in hosting a disproportionate number of expeditions in our region.

On the Australian continental margin, deep stratigraphic drilling is the best way to test our existing understanding of the many sedimentary basins. Drilling can constrain models drawn from seismic reflection surveys, and shallow coring and dredging from normal research vessels. IODP drilling has been and will be important in initial assessments of petroleum potential in frontier areas. Ocean drilling goes well beyond the capability of Australian and foreign oceanographic research vessels, or what can be inferred from satellite gravity information. Australia could never afford ocean drilling itself, but we and all our partners benefit greatly from being members of IODP.

IODP has 27 countries as partners, and 15 Australian universities and two Australian government research agencies are part of the ANZIC consortium, which also includes two government agencies and two universities from New Zealand (www.iodp.org.au). An extensive external review in 2013 of Australia's participation in IODP, by The Allens Consulting Group, is available at http://iodp.org.au/publications/independent-review-of-australian-participation-in-integrated-ocean-drilling-program/. Allens concluded that "The scientific outcomes from Australia's participation in ocean drilling are impressive in terms of productivity, quality and scientific impact".

Australia was a member of the Ocean Drilling Program, IODP's predecessor, from 1989 to 2013. We joined the first phase of IODP in 2008, and ANZIC is entitled to at least six shipboard positions per year. Since then 33 Australians have participated in the science party on expeditions and most have received ANZIC post-cruise funding for analytical work. In addition, 29 Australians participated in grants to work on ocean drilling material in 2012, and 23 in 2014.

When IODP is drilling in our region, there is a huge collateral benefit, with around 28 foreign shipboard scientists on each expedition working on 'Australian' problems for years. Further in this vein, the main IODP drillship, *JOIDES Resolution*, has been or will be involved in 8 confirmed and another 5 probable regional expeditions from 2010 to 2017, at an operational cost on $US64-$104 million. The cost benefit is enormous, when one considers that our membership payments for the period 2008-2017, when we were or hope to be members, would be about $15.6 million, and that sum also covers vessels other than *JOIDES Resolution* and many more exciting expeditions elsewhere in the world.

Over its long history, ocean drilling has led to about 13,500 peer-reviewed journal papers, many in top science journals, and Australian authors have been involved in many such papers even though there were long periods when Australia was not a member. Based on the Ocean Drilling Citation Database

(e.g. iodp.tamu.edu/publications/AGI_studies/AGI_study_**2013**.pdf), Australian scientists are authors of 9% of all scientific ocean drilling publications produced since IODP commenced in 2003. We are global leaders in terms of our impact: the average citation rate of Australian-authored ocean drilling papers on the SCOPUS data base (1996-2011) of 20 is significantly above the world average.

Australia's current ARC/LIEF funding of ~ $A2.655 million p.a. expires in 2015. With the present round of funding running out, it is very important that IODP feature prominently in the National Marine Science Plan, and the infrastructure theme is for us a key, although scientific ocean drilling is relevant to most NMSP themes, and aspects of its science are well covered in other white papers.

C. Relevance

Because ocean drilling covers such a wide field - climate and oceanographic change, the evolution of biota, the extreme biosphere beneath the sea bed, planetary dynamics, natural hazards, petroleum and mineral resources – its end users are many and varied. It informs us on how the Earth has operated in the last 200 million years, how it is operating at present, and how it may operate in the future. With its thousands of continuously cored drill holes in all the world's oceans it helped prove the theory of plate tectonics; it is the key information source for past changes in global oceanography and climate; it is a major information source for the processes that control oceanic volcanism, seabed mineralisation, and earthquake-producing processes at subduction zones, and all the various types of ocean basins; and addresses the formation of continental margins, island arcs and oceanic plateaus.

Paleoclimatic reconstructions based on deep ocean drill cores are used to estimate the sensitivity of the climate to CO_2 levels and other boundary conditions, a crucial set of variables needed to understand the possible extent of future warming of the planet as we formulate policies to limit dangerous warming. The paleoclimate record is our only means of seeing earth system changes of similar amplitude to those we anticipate in the coming century. Paleoceanographic data is used to calibrate climate models of the type used to predict future climate. Indeed, the most recent assessment by the IPCC (AR5) has for the first time included paleoclimate information in its evaluation of climate model performance. The IPCC reports inform national policy makers. Finally, paleoceanographic data can provide a benchmark against which to assess current and future changes in marine ecosystems, for example in response to ocean acidification, again valuable information for national policy makers.

Ocean drilling works uniquely to investigate subduction zones that generate earthquakes and tsunamis. For example the IODP vessel *Chikyu* drilled through and instrumented the fault that generated the enormous 2011 Japanese earthquake and tsunami, and showed that nearly all stress has dissipated and that another such earthquake is unlikely from that fault for another thousand years.

The external review of Australia's participation in IODP by The Allens Consulting Group came to the key conclusion "that the benefits to Australia of direct membership of the IODP consortium far exceed the modest costs of participation": http://iodp.org.au/publications/independent-review-of-australian-participation-in-integrated-ocean-drilling-program/.

Many ocean drilling expeditions have drilled deep stratigraphic core holes in sedimentary basins on continental margins for primarily scientific reasons, but the results are widely utilised by petroleum exploration companies and Geoscience Australia, which are interested in the petroleum potential of these basins. Where ocean drilling wells exist, Geoscience Australia includes the results in its reviews

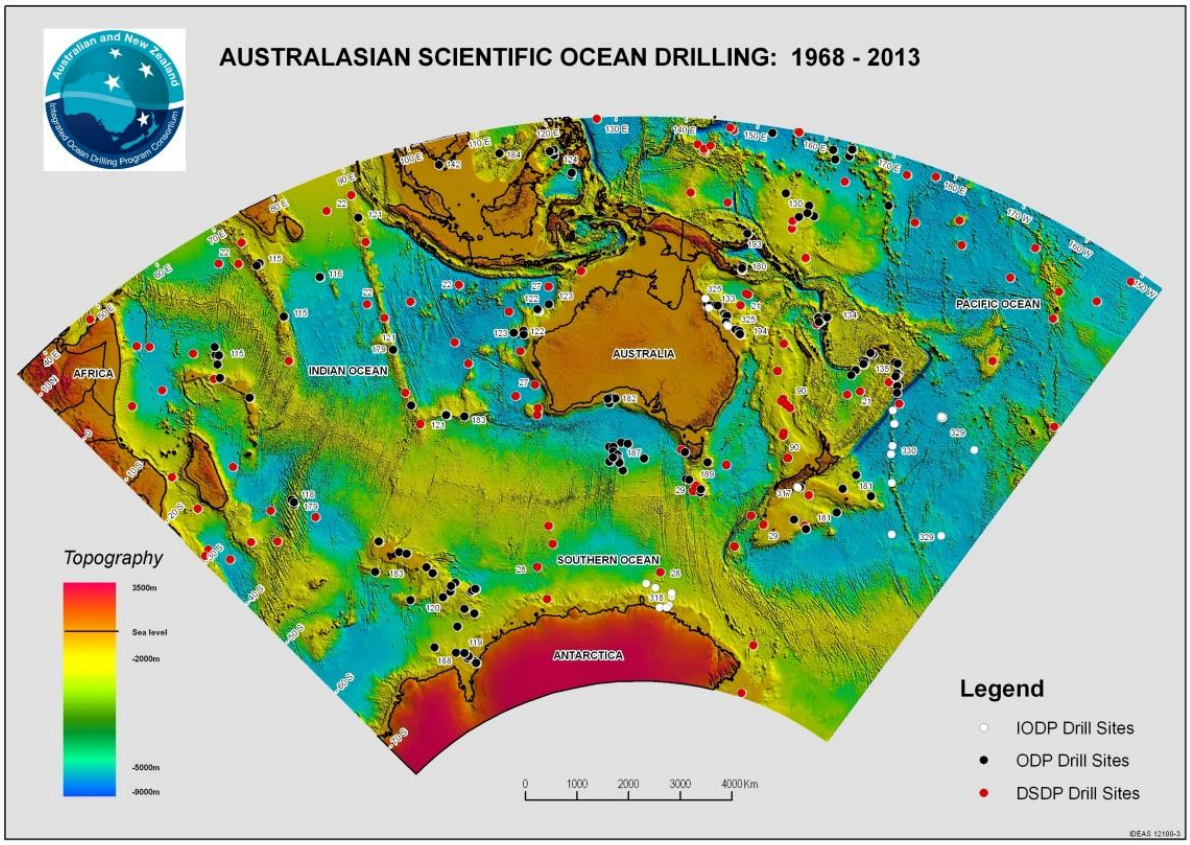
of petroleum prospectivity which accompany Federal/State offshore Petroleum Acreage Releases. It should be noted that our American partners at the US National Science Foundation want to keep this a scientific program with no direct links to the petroleum industry for various reasons. However, on occasions industry may provide data or research grant support for expeditions of interest to them.

The ages and nature of the sediments, the wide set of physical and chemical data, and the industry-style wire-line logs provided by IODP are part of a petroleum explorer's tools of trade. As the many hundreds of kilometres of ocean drilling cores are accessible to all, not only do explorationists read ocean drilling reports, but they visit the core repositories or obtain samples for further studies. The 1989 ocean drilling in the Exmouth Plateau still attracts company interest and IODP drilling on Australia's Northwest Shelf in 2015 will be based on company seismic data.

Petroleum exploration companies have provided embargoed 3D seismic reflection data (worth many millions of dollars) to help our scientists prepare the scientific arguments that have led to next year's IODP Expedition 356, dealing with past oceanography and climate on the northwest margin of Australia. Companies are also considering providing $10 million to Adelaide University to support IODP scientific drilling of Cretaceous black shales in a huge delta in the Great Australian Bight. The shales are representative of global marine anoxic events and therefore of great interest to the academic community, but also are potential petroleum source rocks that would never be drilled by industry. This delta could become a major oil province for Australia, and the IODP drilling will provide insight into the formation of any petroleum resources.

Past ocean drilling program expeditions have investigated deep-sea polymetallic sulphide deposits, including those in the Manus Basin of PNG, one of which will soon be mined. Since many onshore ore deposits formed in past oceans in similar environments, the marine studies have informed onshore exploration. It is hoped that an Australian-led scientific proposal will lead to another Manus Basin expedition to help understand the genesis of the richest known offshore polymetallic sulphide deposit (Solwara1) in 2017 or 2018. This purely scientific proposal is supported by Nautilus Minerals, a Brisbane-based marine mining company, which holds the Solwara1 lease and has carried out all the necessary exploration work, and plans to start mining in 2017.

In summary, involvement in IODP enables our scientists to build a fundamental understanding of long-term societal issues in areas such as climate and oceanographic change, extremophile microbiology, sea level rise, tsunami hazards, and petroleum and mineral deposits. They also help us to understand our world's planetary dynamics, and better understand and manage the biodiversity and potential resources of the Australian marine jurisdiction. Thus end users include a wide variety of scientists around the world, and science and resource planners in this country. The map below indicates how much valuable ocean drilling has been carried out in our region in the last 45 years.



D. Science needs

Much of Australia's huge marine jurisdiction is unexplored and unknown. It is our responsibility under the UN Convention on the Law of the Sea to manage our jurisdiction, and that can only be done if we understand what lies within it. Naturally, it is also in our own interest to methodically explore our marine estate, in order to better understand our own environment and its changes, and our living and non-living resources. More than 80% of our marine jurisdiction of 14 million square kilometres lies beyond our comparatively well-known continental shelf, in water depths of 120m to 6000 m, and exploring that area is an important long-term national task.

The geoscience capabilities of the new Australian Research Vessel *Investigator* include seabed mapping, geophysical surveying to predict the nature of the sediments and rocks beneath the sea bed, seabed rock dredging and sediment coring to about 25 m below the sea bed. IODP complements these capabilities in ways not attainable with conventional research vessels. Indeed, its deep coring capability provides geoscience information in our region, and around the world, which cannot be obtained in any other way. Geophysical and deep drilling information is available in some areas from the publicly released results of petroleum or minerals exploration companies, but the petroleum companies do not take many cores in their deep holes. Sections of the text below, dealing with major topics, are drawn directly from IODP's excellent 2013 Science Plan, *Illuminating Earth's, Past, Present, and Future* (http://www.iodp.org/science-plan-for-2013-2023).

1) Climate and oceanographic change and sea level rise

Among the global challenges set out in the IODP Science Plan are to investigate 1) how our climate system responds to increased atmospheric CO_2 levels, 2) how ice sheets and sea level respond to global warming, 3) what controls regional patterns of precipitation, such as those driven by monsoons and El Nino, and 4) how resilient the ocean is to chemical perturbation.

Apart from ice core research, which is limited to the last million years and gives a general picture of what has happened in the atmosphere but not the ocean, research into climate change is done largely by studying outcrops or sediment cores on land, and marine sediment cores offshore. In the marine domain most information comes from the included debris of plants that are swept offshore, and from the study of dust derived from the land. Because continuous sequences are much more common offshore, it is much easier to get a full picture there. Naturally, oceanographic changes are readily studied offshore, where detailed information on long-term conditions in various offshore settings is available. The data used include sediment character for current strength, and the nature and geochemical (isotopic) study of fossilised surface plankton for sea surface temperatures, and of benthic organisms for bottom water temperatures. Sea level fluctuations are commonly studied from the location, age, and character of sequences within fossil reefs. Recently such an IODP Expedition (325) was carried out in the Great Barrier Reef and its results are being published now. Much of the key information in all these areas has come from the continuous cores up to 1000 m long taken by ocean drilling vessels, and covering all time periods for the last 200 million years.

More such expeditions will occur in our region in the next few years, two of which deal with climatic changes in the last 5 million years. In 2015, IODP Expedition 356, on Australia's Northwest Shelf, will investigate the history of the Indonesian Throughflow Current and of the climate of Northwest Australia including the onset of the Australian monsoon. In 2016, Expedition 363, in the Western Pacific Warm Pool, will investigate the history of El Nino and the monsoon.

2) Ecosystems and biodiversity through time

The history of the organisms on the Earth is a major part of ocean drilling's investigations, with especial emphasis on the fossilised microorganisms that are especially well preserved in marine sediments. The evolution of many organisms over the last 200 million years is already reasonably well known, partly from ocean drilling, and the changes of these organisms through broad climate change and from sudden mass extinctions is now quite well documented. Mass extinctions can be generated by sudden changes in temperature, light or marine acidity, and these changes have been documented by ocean drilling as being due to volcanic eruptions, meteorite impacts, or sudden releases of methane from submarine gas hydrates. However, much is still unknown, and a better understanding of the changes and their drivers is a high IODP priority, and will be addressed in our region in the near future.

3) Extremophile microbiota

It is now known that a wide variety of living extremophile microorganisms (largely bacteria and Archaea) are present deep below the sea bed, in both sediments and basaltic rocks, and make up a significant part of Earth's biomass. Their origin, composition and global significance are major research questions. Other questions are the limits of life below the sea floor, and how sensitive these ecosystems are to environmental changes. Scientific ocean drilling has a major program for investigating this biosphere, and this will be addressed on various expeditions in our region in the next

few years. There are potential medical uses for compounds that can be developed from the chemistry of extremophile organisms, and such compounds could be of societal importance.

4) Planetary dynamics

The global challenges set out in the IODP Science plan in this area are to address 1) the composition, structure and dynamics of the upper mantle, 2) the relationship of seafloor spreading and mantle melting to the ocean's crustal architecture, 3) the mechanisms, magnitude and history of chemical changes between the oceanic crust and sea water, and 4) how subduction zones are initiated and how they cycle volatiles and generate continental crust.

To quote directly: "Geochemical exchanges among the solid Earth, ocean and atmosphere have influenced the Earth's surface environment through its history. The dynamic processes that create and destroy ocean basins, shift the positions of continents, and generate volcanoes and earthquakes extend from the Earth's core to its atmosphere are fundamental for understanding global change within the context of planetary evolution."

Within our region there is great interest in the formation and structure of the passive continental margins and adjacent continental plateaus of Australia; the ongoing separation of Australia and Antarctica; the subduction zones, island arcs and oceanic basins of the Southwest Pacific and the Indian Ocean; and large igneous plateaus, such as Kerguelen Plateau and the Ontong Java Plateau. Basic questions relating to the Sumatran (Expedition 362) and Hikurangi (northeast New Zealand) subduction zones, and the tectonic history of the Lord Howe Rise and adjacent basins, are the subjects of proposals that are already scheduled, or likely to be drilled by IODP in the next few years.

5) Geological hazards

IODP investigates the geological processes and hazards that can affect humanity in the foreseeable future. The challenges outlined in the IODP Science Plan include investigating 1) the mechanisms controlling destructive earthquakes, landslides and tsunamis, 2) the properties and processes that govern the flow and storage of carbon in the sub-seafloor, and 3) how the movement of fluids link sub-seafloor tectonic, thermal and biogeochemical processes. To this list can be added volcanic eruptions like those that have affected Indonesia and New Zealand in the last few hundred years, and Australia in the last 5000 years.

The planned expeditions to the Sumatran and Hikurangi subduction zones are designed to better understand and perhaps to predict future earthquakes and tsunamis. A proposed expedition to the Brothers Volcano north of New Zealand will investigate the flow of hot subsea fluids.

E. Perspective

As set out in Section D above, IODP's Science Plan outlines a deep coring program to investigate global questions of fundamental interest to Australian science. Some of its goals could be regarded as pure science activities, but nearly all of them have spinoffs in applied science terms. The existing IODP Science Plan has a ten-year horizon, but scientific ocean drilling has been strongly and continuously supported for 45 years, and is a hugely successful global program that is highly likely to continue further into the future. At present it has two large drill ships, whose replacement value is around $US1.1 billion, access to other vessels under contract, supports three large core repositories open to all scientists, and has an annual operational budget of around $US180 million. The annual operational

costs of the three types of platform average out at about $US60 million for *JOIDES Resolution*, $US110 million for *Chikyu*, and $US10 million for alternative platforms Through our annual subscription of $US1.8 million, Australia and New Zealand have access to all these facilities, which we could never afford ourselves. Locally, they allow us to build on information that we and our partners can gather through *Investigator*, foreign research vessels, and the petroleum and minerals exploration industry.

As a minor partner, we have little influence on the global IODP science framework, but we do have considerable influence in attracting expeditions that address global problems to our part of the world. The Southern Hemisphere is a key region in studies of past global climate and oceanography, and there are good reasons to bring other types of expedition to this region. Expeditions in our region address global problems, and they bring a dedicated team of 30 scientists from around the world to study our geoscience, not just for the two months of an expedition but for years to come.

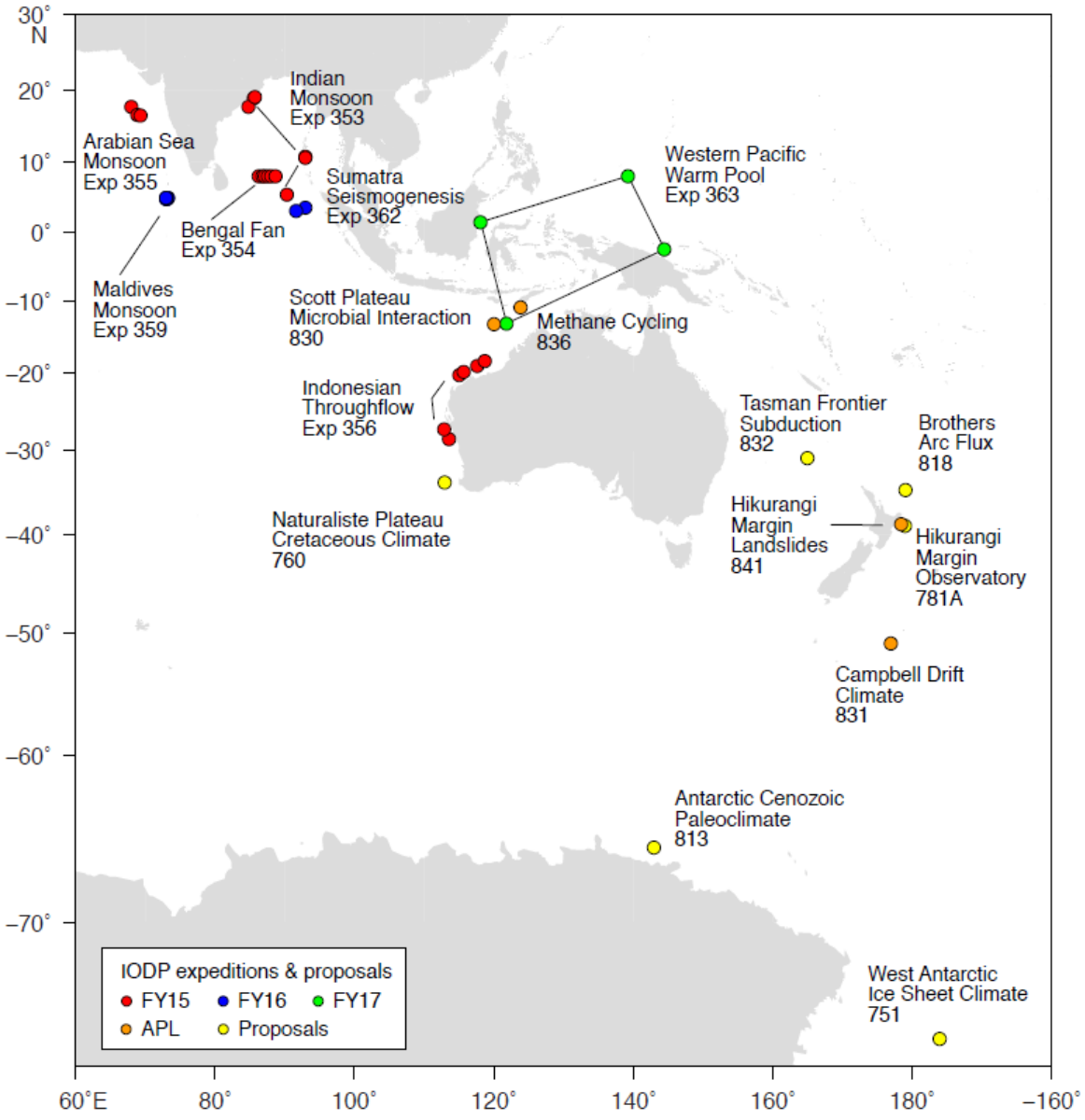
In the next five years, several expeditions will certainly be carried out in our region and others are the subject of highly ranked proposals (see map), and other strong proposals will be submitted by 1 October 2014. We expect drilling of the *JOIDES Resolution* to continue in this region until 2018 and there may also be drilling expeditions using other platforms. Each *JOIDES Resolution* expedition costs about $US8 million to mount which is a great return on our membership costs of $US1.5 million p.a. The research program beyond early 2017 will depend on the quality of proposals, and the program in our region also depends on proposals. Under the current program, we expect exciting expeditions to continue at least until 2023 and probably beyond, and a substantial number of them will be in Australasia.

JOIDES Resolution expeditions in our region (each two months)

353: Indian monsoon history, December 2014, one Australian will be aboard
354: Bengal Fan history, February 2015, one Australian will be aboard
355: Arabian Sea monsoon history, April 2015, one Australian will be aboard
356: Indonesian Throughflow Current on NW Australian margin, August 2015, four Australians will be aboard including a co-chief scientist
359: Maldives monsoon history, October 2015, we expect one ANZIC scientist aboard
362: Sumatra seismogenesis, August 2016, we expect one ANZIC scientist aboard
363: Western Pacific warm pool, October 2016, we expect one ANZIC scientist aboard

We then expect some of the proposals shown on the map (751 to 841) to be scheduled, with several more strong proposals to be added, before *JOIDES Resolution* heads eastward some time in 2018.

Planned and proposed *JOIDES Resolution* IODP Expeditions in the Australasian region



Note that the US Fiscal Year begins in August, so FY15 begins in October 2014

F. Realisation

In the IODP program, the coring platforms and core repositories are provided by foreign entities, and we obtain access to them by paying membership contributions. Our present contributions mean that ANZIC has at least one position on each expedition. Present plans are for the same situation to apply at least until 2023. The platforms are in three categories: the workhorse vessel *JOIDES Resolution*, the deep drilling vessel *Chikyu*, and alternative platforms provided by the European consortium. Details are set out below.

Very large leverage is exerted by the relatively small investment of Australia in IODP membership, a total of $US12 million in the eight years from 2008 to 2015, when at least $US1.2 billion was expended on IODP operations, excluding many millions of dollars' worth of scientific expenditure. This gets us access, among other things, to two major drill ships, whose replacement value is about $1.1 billion. Even if one constrains one's attention to our region, there will have been 9 expeditions in areas of prime interest to ANZIC in 2008-2015, at an operational cost of $US80 million. Looking forward to 2016 to 2018, with many strong proposal in the ANZIC region, an investment of $US4.8 million should get us access to five or more regional expeditions, with operational costs of at least $US40 million. Overall return on investment is very high, both in monetary and scientific terms.

JOIDES Resolution (provided by the US National Science Foundation), with its state-of-the-art laboratory facilities and scientific crew of about 30 scientists and 30 technicians, is provided for eight months per year. It is capable of drilling in water depths of up to 5000 m and depths of up to 2000 m below the sea bed. It takes up to 5000m of continuous cores in sediments and rocks on a typical expedition. It cannot drill where a flow of oil or gas could be a hazard. Details are provided in iodp.tamu.edu/labs/ship/ship_brochure.pdf.

Chikyu (provided by the Japan Agency for Marine-Earth Science and Technology - JAMSTEC) is a very large drill ship that is provided for 4-5 months per year. Its scientific facilities are similar to those of JOIDES Resolution, but it can drill much deeper, up to 6000 m below the sea bed, and it has the safety equipment to drill where a flow of oil or gas could be a hazard. Details are provided in www.ship-technology.com/projects/**chikyu**/.

European alternative platforms are provided by the European IODP consortium, ECORD. Where *JOIDES Resolution* or *Chikyu* are not suitable, ECORD charters alternative coring platforms for an average of one two-month expedition per year. These vessels operate in shallow water, polar waters, or in deep water where coring of less than 200 m below the seabed is adequate. Details are provided in www.**ecord**.org/about/j/wp2-final.pdf.

Core storage facilities

All cores are kept in cool conditions (4°C) in three repositories: one in Texas, one in Germany, and one in Japan. Most cores from our region are stored in Japan. More than 200 km of drill core, the result of 45 years of ocean drilling, is stored in each repository. Once the one-year moratorium for each expedition is over, access to core and other relevant material is provided to any *bona fide* scientist on the basis of a high-quality research proposal. People can either visit the repository to examine and/or select material, or order it on the basis of online reports and images.

Publications

The aim of IODP is to study global scientific questions and publish all the work and ideas arising from each expedition. IODP itself publishes exhaustive volumes of *Initial Reports* and *Scientific Results* for each expedition, but most of the results are published in peer-reviewed scientific journals including *Science* and *Nature*. At last count about 13,500 papers had been published in peer-reviewed journal articles on ocean drilling since 1968.

Governance

This, the world's largest geoscience research program, is dominated by the three platform providers, the USA, Japan and the European IODP Consortium. Scientific and safety issues are looked after by the Science Evaluation Panel (SEP) and the Environmental Protection and Safety Panel (EPSP) on both of which ANZIC is represented.

Once highly ranked and safe programs have been sent forward for potential scheduling, the *JOIDES Resolution* Facility Board, the *Chikyu* IODP Board, or the ECORD Facility Board consider which of them will be drilled and when. ANZIC is represented on all these bodies.

Within ANZIC, a Governing Council provides broad control, a Science Committee deals with purely scientific questions, and a Program Office at ANU facilitates all activities.

Australian input to IODP expeditions through the 'Investigator'

For Australia to work toward IODP expeditions, one major pre-requisite is the ability to collect the necessary baseline data to develop a scientific concept of global significance, and to accumulate the necessary site survey data to develop a suitable drilling program. Australia was a member of the Ocean Drilling Program (ODP), the predecessor of IODP, from 1989 to 2003. During most of this time the Australian geoscience community had access to AGSO's superb seismic reflection and dredging vessel, *Rig Seismic*, leading to the development of many excellent ODP drilling proposals, a number of which led to very successful drilling expeditions. When *Rig Seismic* was retired in 1998, there were problems in developing drilling proposals, which were met in part by using the Australian marine national facility vessels, *Franklin* and *Southern Surveyor*. However, these vessels lacked seismic capability, which is absolutely essential in building ocean drilling proposals. This problem was overcome in some areas by using existing seismic data from *Rig Seismic* or from the petroleum exploration industry, new data acquired by Geoscience Australia for other purposes, and data acquired by foreign research vessels.

The new National Facility vessel, *Investigator*, will be important for developing new ideas and IODP proposals because it has excellent seabed mapping sonar systems, a coring capability of 25 m below the sea bed, dredging capability to sample rocky outcrops, a sub-bottom profiler capable of imaging strata up to 50 m below the seabed, and a reconnaissance seismic profiling system which will be adequate for most site survey work. The vessel would also be capable of handling a more powerful containerised seismic system, should one be available from a foreign institution for cooperative research with an IODP proposal in mind.

The present situation, with the *Investigator* funded for only 180 days at sea is clearly a problem, as there will be fierce competition for access to it by scientists from many disciplines.

Australian funding arrangements

IODP currently has 27 countries as partners, and 15 Australian universities and two Australian government research agencies are part of the ANZIC consortium involving New Zealand (www.iodp.org.au). Australia's funding is covered under the ARC/LIEF program and amounts to $1.8 million p.a. from ARC and $855,000 p.a. from our partners; New Zealand provides $US300,000 p.a. to ANZIC and has a partnership of two universities and two government agencies. ANZIC pays the US National Science Foundation $US1.5 million p.a., and JAMSTEC $US300,000 p.a., for our participatory rights in the program, the most important of which is access to the three types of drilling platform

being used. We normally receive one position on each expedition, but more in many cases, especially for expeditions in our waters or led by an ANZIC co-chief scientist. These positions are allocated to Australia or New Zealand in rough proportion to their financial inputs.

ANZIC covers all travel costs for shipboard attendance and official post-cruise meetings. Analytical funding from our partners (outside of ARC funds) is provided on the basis of applications to the Science Committee or a sub-committee. In recent years ANZIC shipboard scientists have applied for up to $40,000 of post-cruise funding, and up to $25,000 has been provided to Australian groups for work on legacy ocean drilling material. This funding is crucial for our scientists to maintain international competitiveness and for Australia to have collaborative equity with our overseas partners.

The ARC/LIEF grant expires at the end of 2015, and Australia plans to bid for another 5 years of funding at a similar level. New Zealand also intends to continue in the ANZIC consortium. A more certain, longer-term mechanism to cover this style of international collaboration, where we pay for access to foreign IODP facilities, would provide long-term stability for our own scientific community and more confidence for our partners.

Implications of funding not continuing

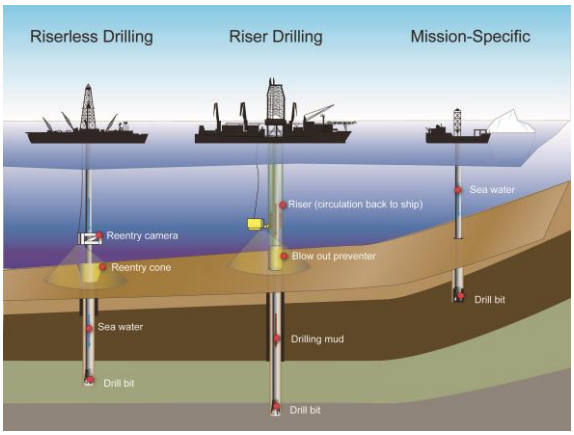
IODP is a wonderful international geological research partnership, which greatly increases the amount and quality of offshore geoscience information and geoscience understanding, locally and internationally. Should Australian funding not continue after 2015, we would lose all the advantages of membership in 2016 to 2018, when *JOIDES Resolution* will be working in our region (see Section E, ***Perspective***). We could no longer influence the program, and we would have no co-chief scientists, although we would have limited access to those expeditions in our marine jurisdiction. This would be an unproductive and completely illogical development just at the time when we could expect a major scientific pay off for our long term investment, scientifically and financially, in IODP.

At the time of writing, petroleum exploration companies are planning to provide $10 million toward a scientific IODP drilling program in the Great Australian Bight under a cooperative funding arrangement, known in IODP as a CPP. This program would investigate black shales laid down during periods of global anoxia in the world's oceans in the Cretaceous. These formations are of interest to a large academic community, but also to the companies as oil source rocks that they would not otherwise drill. This arrangement could lead to an expedition which would provide valuable money to IODP and our scientific researchers. It would also guarantee the presence of *JOIDES Resolution* in our region, facilitating other expeditions here. Were we not members of IODP, this CPP arrangement would not be possible.

The longer time frame

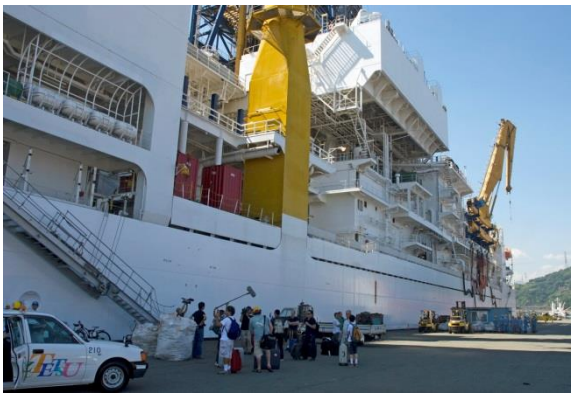
The present IODP program will end in 2023 (although ocean drilling is expected to continue beyond then), and we would hope to increase our input to the IODP membership fees after 2015, and hence our rewards from membership. The present total annual ANZIC budget of about $A3 million allows us an average of one shipboard participant per expedition. We should aim at doubling our shipboard participation in the longer term future which, at present exchange rates and under existing arrangements, would require a total annual budget of about $A6 million.

G. IODP Vessels and Equipment



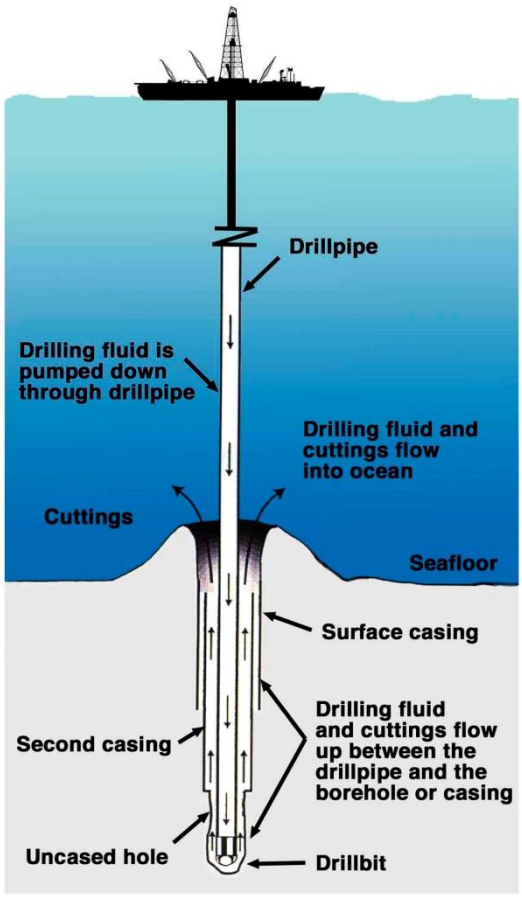
Three platforms with different capabilities

The deep riser-drilling *Chikyu*



***Chikyu* up close**

The globe trotting *JOIDES Resolution*



Riserless drilling – *JOIDES Resolution*

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