

## **Introduction**

An introduction to IMOS has been published in the international Journal of Ocean Technology (Vol. 3, Number 3, pp 80-81, and is available on the IMOS website <http://imos.org.au/imosrev.html>). Readers may want to read the introduction before reading this overview of the Node Science and Implementation Plans. Very briefly, IMOS is a distributed set of instrumentation, data and information services covering the oceans around Australia. It was established as part of the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS), in partnership with ten universities and federal and state government agencies. The observations monitor the open oceans around Australia, the major boundary currents and their interactions with ecosystems over the continental shelf.

IMOS is just the beginning of the marine observing system that Australia needs. As such, coverage is incomplete, but will be enhanced in prioritized steps as needs are defined and resources become available.

The initial implementation plan was devised by the Australian marine community through five **Nodes**, in a process facilitated by NCRIS. Future development will also be guided by the Nodes. The Nodes are

- Great Barrier Reef Ocean Observing System
- South East Australian-Marine Observing System (was NSW-IMOS)
- Southern Australian IMOS
- Western Australian IMOS
- Bluewater and Climate Node

Each Node has prepared a detailed Science and Implementation Plan (available at <http://imos.org.au/nodes.html>), identifying the socio-economic context of their observations, the scientific background and rationale for observing, the relevant observations in existence before IMOS, the need for observations in their region and the implementation plan for new observations.

As a national capability supported by NCRIS, a major challenge for IMOS is to maintain a focus on a national approach to ocean observing. A strategic research objective of national significance, discussed below, and socio-economic applications of national extent promote a national approach.

## **Socio-economic context**

Observing the oceans around Australia has potentially many applications, the first and economically most important of which is managing the impacts of climate variability and change on the terrestrial environment. The ocean is the internal controller of the climate system and sets the speed of climate variation and change through complex,

multi-time and -space scale processes. It is an essential component of any system that predicts climate. The role of the ocean in the climate system and its terrestrial impact is well known in Australia and has been discussed in many planning documents. These ideas are summarized in the Bluewater and Climate plan.

Less well known are the marine applications of ocean observing, including

- Support for management of off shore industries (e.g. oil and gas, fishing)
- Safety at sea, search and rescue, management of oil spills
- Navigation and administration of ports
- Conservation of marine ecosystems
- Sustainable management of iconic marine ecosystems and marine parks
- Management of marine tourism and recreation
- Support for ocean races and other sporting events
- Military applications, and
- Support for marine research

The return from investing in ocean observations around Australia was estimated through an economic analysis undertaken in 2006 by the Australian Academy of Technological Sciences and Engineering and the Western Australian Global Ocean Observing System Inc. (*Economics of Australia's sustained ocean observation system, benefits and rationale for public funding*). That study, based on only a limited set of benefiting industries (agriculture, oil and gas, safety at sea) concluded that the cost:benefit to the Australian economy of investing in ocean observations was better than 1:20.

The details of many of the above socio-economic applications are discussed in the regional Node Science and Implementation Plans. Some of the highlights include:

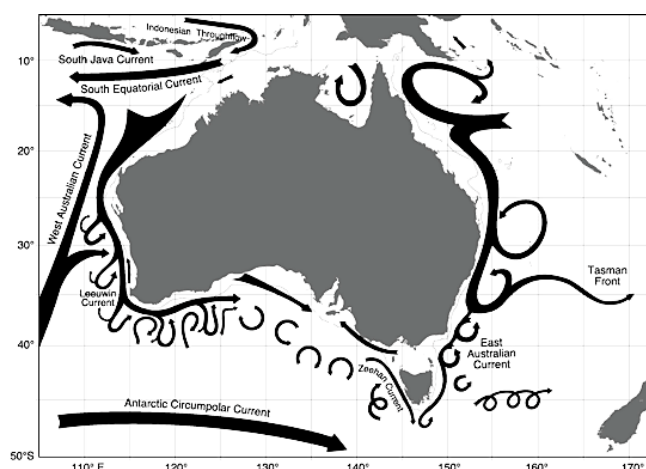
- future sustainability and tourism at the Great Barrier Reef, Ningaloo Reef and the famous beaches of Australia, in relation to the threats of global warming (coral bleaching), ocean acidification and invasive species
- management of commercial and sport fisheries in all regions
- preservation of unique biodiversity as the oceanic environment and boundary currents around the continent change.

### **Scientific background and rationale for observing**

Australia is a continent surrounded by major boundary currents (*see Figure 1*), all of which have changed over recent decades and are expected to continue changing, sometimes as a decadal or longer fluctuation and sometimes as a trend in response to human induced climate change.

The East Australia Current (EAC) forms in the Coral Sea and flows southward along the Great Barrier Reef. It is strongest and closest to shore off northern New South Wales, then turns eastward near Sydney. The EAC extension and eddies flow southward as far as Tasmania. The Leeuwin Current forms off the Northwest Shelf and flows southward to Cape Leeuwin, then turns eastward into the Great Australian Bight. Extensions (e.g. Zeehan Current) reach as far as Tasmania. In the north the Pacific to Indian Ocean Indonesian Throughflow and in the south the Antarctic Circumpolar Current form critical ocean-interconnections that affect the heat budget

of the global climate system. There is evidence that the currents vary on all time-scales from days to years (Church and Craig, 1998; Holbrook et al., 2005).



**Figure 1:** Boundary currents around Australia

Multi-decadal variation and change in the currents has recently been documented. The EAC has increased in strength and penetrates further southward (Roemmich et al., 2006; Ridgway, 2007; Hill et al., 2008), consistent with models of human induced climate change (Cai, 2006). The Leeuwin Current and Indonesian Throughflow have weakened (Wainwright et al., 2008; Feng et al., 2008). Change in ecosystems over the continental shelf has been noted anecdotally but data are lacking to robustly document the changes. For example, the southward strengthening of the EAC has been associated with southward spread of species, which have resulted in the destruction of sea-bed flora on the rocky coasts of Tasmania (Craig Johnson, personal communication). The Leeuwin Current strongly affects shelf ecosystems at inter-annual time scales implying that its weakening over recent decades will have important consequences.

Observing, describing, understanding and modelling variability and change of the boundary currents around the continent, and the potential impacts on marine ecosystems, offshore activity and the climate system is the high level strategic objective of IMOS. Many regionally specific goals in the Node plans, including understanding of short term processes that control ecosystems, will contribute to the strategic objective, and provides the context for a national approach to ocean observing.

Examples of the regional science goals are:

- Understanding the influence of the Coral Sea on the Great Barrier Reef corals, larval trajectories and coastal fisheries by documenting the cross-shelf exchange of EAC water with the lagoon
- Understanding how coastal trapped waves and longer term fluctuations of the Great Australian Bight affect the upwelling dependent ecosystems off Kangaroo Island-Eyre Peninsula and the Bonney Coast
- Identification of the role of EAC eddies (and associated upwellings) in the marine ecosystems of the NSW coast
- Understanding the physical and biological processes that control the Leeuwin Current's impact on the Western Rock Lobster fishery, Australia's most valuable fishery, recognized internationally for sustainable management

- Validation that seasonal and multi-decadal climate prediction models correctly simulate the large scale, oceanic circulation around Australia.









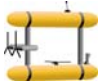


## Observations required by the Nodes

Each Node has identified a set of observations that will support research on a broad range of marine issues. IMOS does not have sufficient resources to fully satisfy all the requests in each case. The final allocations were decided through the NCRIS facilitated process. Details of the allocations are given in the Node plans (see <http://imos.org.au/nodes.html>).



**Figure 2:** An artistic representation of resources deployed in each Node. See the legend in Table 1 for the Facilities operating in each region.

**Table 1:** Legend of symbols used in Figure 2

Symbol	Facility	Symbol	Facility
	Argo Australia (Argo)		Australian Coastal Ocean Radar Network (ACORN)
	Enhancement of Measurements from Ships of Opportunity (SOOP)		Australian Acoustic Tagging and Monitoring System (AATAMS)
	Southern Ocean Time Series (SOTS)		Facility for Automated Intelligent Monitoring of Marine Systems (FAIMMS)
	Australian National Facility for Ocean Gliders (ANFOG)		eMarine Information Infrastructure (eMII)
	Australian National Autonomous Underwater Vehicle (AUV)		Satellite Remote Sensing (SRS)
	Australian National Mooring Network (ANMN)		

## Implementation plan

Implementation of IMOS is carried out by 11 Facilities. Facility-deployments in each Node are indicated in Figure 2, using symbols in the legend provided in Table 1. The measurements made by each Facility are discussed below and summarized in Table 2.

1. **Argo Australia** (Argo) – a fleet of ~200 profiling floats observing ocean physics to 2000m, part of a larger global program ([www.argo.int](http://www.argo.int)). The floats provide measurements of temperature and salinity profiles approximately every 3° Latitude by 3° Longitude. A small number of floats provide measurements of oxygen profiles.
2. **Enhancement of Measurements on Ships of Opportunity** (SOOP) – a set of underway observing systems for physical, chemical and biological oceanography on volunteer observing ships. The ships provide measurements of temperature profiles to a depth of 800 m. Some ships provide additional measurement such as radiometric sea surface temperature, pCO<sub>2</sub>, fluorescence, weather parameters.
3. **Southern Ocean Time Series** (SOTS) – a set of moored biogeochemical and ocean weather instruments in the Sub Antarctic Zone. In addition to a suite of weather parameters required to estimate air-sea exchange of heat and freshwater (evaporation), the mooring provides measurements of subsurface temperature, salinity, oxygen, pCO<sub>2</sub>, nitrate, fluorescence, transmissivity, particulate matter and other biogeochemical parameters
4. **Australian National Facility for Ocean Gliders** (ANFOG) – a multisensor system similar to a Argo float, which can traverse as well as profile, and is operated from a land base. The gliders provide measurements of temperature, salinity, oxygen, fluorescence, turbidity and dissolved organic matter.
5. **Australian National Autonomous Underwater Vehicle** (AUV) Facility – used for high resolution surveys of benthic habitats. The AUV provides high resolution video imagery of the sea floor and a suite of environmental properties.
6. **Australian National Mooring Network** (ANMN) – a network of national reference stations, plus regional moorings on shelves and slopes. The moorings provide measurements of temperature, salinity, oxygen, fluorescence, turbidity, dissolved organic matter and currents, as well as a basic suite of weather variables. Some sites will record ambient sound (e.g. whale song). One site will make a suite of measurements to calibrate satellite observed ocean colour. Water samples at the mooring sites will be analysed for dissolved inorganic carbon, alkalinity, nitrogen, silicon, phosphorus and salinity. Towed nets will sample phytoplankton and zooplankton.
7. **Australian Coastal Ocean Radar Network** (ACORN) – for high resolution mapping of coastal currents. Radar gives measurements of ocean current out to >150km from the coast.
8. **Australian Acoustic Tagging and Monitoring System** (AATAMS) – curtains of receivers to monitor movements of tagged marine animals. The system gives the location of tagged fish and basic environmental information at listening stations.

9. **Facility for Automated Intelligent Monitoring of Marine Systems (FAIMMS)** – a communications system on the barrier reef, facilitating the delivery of data from sensors to the scientists in real time. Virtually any type of sensor can be plugged into the networks established on seven islands and reefs. Temperature and salinity will be routinely measured.
10. **eMarine Information Infrastructure (eMII)** – responsible for hosting, managing, distributing and archiving IMOS data. All data will be available through a web based distributed archive.
11. **Satellite Remote Sensing (SRS)** – to make Satellite products to support research in Australia’s regional waters. The facility will initially provide sea surface temperature and ocean colour data.

*Table 2: IMOS data streams and the Facilities that provide each stream.*

<b>Parameter</b>	<b>Facility</b>
<b>Sea Temperature</b>	
<i>skin temperature</i>	SRS, SOOP
<i>surface temperature</i>	SOOP, ANMN
<i>sub surface temperature</i>	ANMN, FAIMMS, AATAMS, AUV
<i>vertical temperature profiles</i>	ARGO, SOTS, ANFOG, ANMN, SOOP
<b>Sea Conductivity/Salinity</b>	ARGO, SOTS, ANMN, ANFOG, SOOP
<b>Dissolved Oxygen</b>	ARGO, SOTS ANFOG, ANMN
<b>Radiation Flux</b>	SOOP, SOTS, ANMN
<b>Meteorology</b>	SOOP, <i>RV Southern Surveyor, RSV Aurora Australis</i> , SOTS, ANMN, FAIMMS
<b>pCO2</b>	SOOP, SOTS
<b>Optical, Fluorescence</b>	ANMN, SOTS ANFOG, AUV, SOOP
<b>Optical, Turbidity</b>	ANMN, SOTS, ANFOG, AUV, SOOP
<b>Optical, CDOM</b>	ANFOG, AUV
<b>Chlorophyll</b>	SOOP, SRS
<b>Optical, Clarity</b>	ANMN
<b>Current Measurement</b>	ANMN, ACORN, AUV, ARGO, ANFOG
<b>Biogeochemical</b>	ANMN
<b>Biological</b>	AATAMS, SOOP, ANMN
<b>Bathymetry</b>	AUV
<b>Stereo imagery and sizing</b>	AUV

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