MARINE CONSERVATION BRANCH
DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

A STRATEGIC PLAN FOR OCEANOGRAPHIC INFORMATION REQUIREMENTS IN MARINE RESERVE IMPLEMENTATION, MANAGEMENT, POLICY AND CO-ORDINATION IN WESTERN AUSTRALIA

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SUMMARY

This report outlines generic oceanographic information requirements for the Department of Conservation and Land Management's marine reserve implementation, management support, policy and co-ordination programs and provides a strategic plan for the provision of this information. These programs are being administered by the Marine Conservation Branch (MCB).

Goals, objectives, constraints to achieving the objectives and a prioritised set of strategies to overcome the constraints are presented. Details of mechanisms to service the strategies are given.

The optimum framework for the provision of oceanographic information is considered to comprise an internal oceanographic capability, based within the MCB and incorporating CALM's Regions and Districts, complemented by externally generated information through collaborative and commercial arrangements with academic and commonwealth research groups, industry and State and Federal agencies. This arrangement would ensure CALM's capacity to provide the required oceanographic information at all required temporal and spatial scales, ranging from rapid intensive investigations in key localities (e.g., Monkey Mia), investigative responses to incidents (e.g., contaminant spills), base-line information for marine reservation and zoning, and longer-term requirements associated with management (e.g, natural variability and surveillance).

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Direction

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1 INTRODUCTION

The objectives of this document are to:

- outline the generic oceanographic information requirements of the Department of Conservation and Land Management's marine reserve implementation, management, policy and co-ordination programs, and

- provide a strategic plan to ensure the provision of required oceanographic information.

The marine reserve implementation, management, policy and co-ordination programs are core functions of CALM's Marine Conservation Branch (MCB) and this plan is linked with the MCB's principal planning document*: Strategic Plan (1997-2002) Marine Conservation Branch* (CALM, 1997).

An adequate understanding of the ecology of marine ecosystems, with the oceanography as a fundamental component, is required in order to effectively implement and manage marine reserves. It is important to understand the manner in which water and contained substances (desirable and undesirable) moves and mixes within and between marine ecosystems. Processes ranging from fine-scale turbulent mixing within small lagoons and embayments to broad-scale regional currents, such as the Indonesian Throughflow and Leeuwin Current, need to be understood in order to adequately understand the ecology of the State's marine environment. A key issue is to quantify the degree of inter-connectedness within and between marine reserves, and hence there is the need to resolve the hydrodynamics of the State's marine waters over a wide range of spatial and temporal scales.

For marine reserve implementation broad-scale circulation patterns are required in order to ascertain a region's characteristic flow directions and flushing characteristics, with this information primarily used to assist in preliminary zoning of multiple uses.

Marine reserve management generally requires oceanographic information that is of higher detail and spatial focus than for marine reserve implementation. This requirement generally reflects high levels of usage and associated impacts or threats to the conservation values of a particular region within a marine reserve, such as the Monkey Mia lagoon within the Shark Bay Marine Park.

Oceanographic information is also required in marine reserve policy formulation and in the co-ordination of marine activities within CALM. For example, policies relating to the impacts of moorings in marine reserves may draw on hydrodynamic principles, such as forces on structures, in determining design criteria for mooring designs. In the MCB's marine co-ordination role the oceanography assists in providing state-wide information on conditions likely to be encountered by vessels around the State's coastline, thereby assisting in the rationalisation of CALM's marine operational capability. Measurements may be required over a wide range of time scales in order to capture the influence of key forcings. Hence, data gathering programs may need to be structured to detail diurnal, synoptic, seasonal and inter-annual mechanisms.

Because of the remoteness and large size of many existing and proposed marine reserves (CALM, 1994) in Western Australia (see Figure 1) the acquisition of essential oceanographic information, including bathymetry, meteorological forces, wave climates, salinity-temperature-density fields, current fields and coastal discharges, can pose significant logistical difficulties. A range of mechanisms will need to be employed in order to service CALM's oceanographic needs, as outlined in this document. For example, CALM will need to maintain and develop an in-house oceanographic capability, form collaborative arrangements with academic and public research agencies, provide infrastructural support for oceanographic research in regional locations, provide direct funding for contracted oceanographic research, develop mechanisms for the opportunistic acquisition of oceanographic data through community involvement and foster academic research and training in oceanography as relevant to CALM's objectives in the marine environment. Through the Marine Conservation Branch, CALM is currently active in all of these areas and this document presents a way forward to further develop the potential of these various mechanisms for CALM's oceanographic needs.

2 RELATIONSHIP WITH THE MARINE CONSERVATION BRANCH STRATEGIC PLAN (1997-2002)

The Marine Conservation Branch's strategic plan (CALM, 1997) has identified the oceanography of the State's marine waters as a key component of the MCB's core programs in marine reserve implementation and management. The emphasis placed on the oceanography is motivated by an acknowledgment that biological processes and the

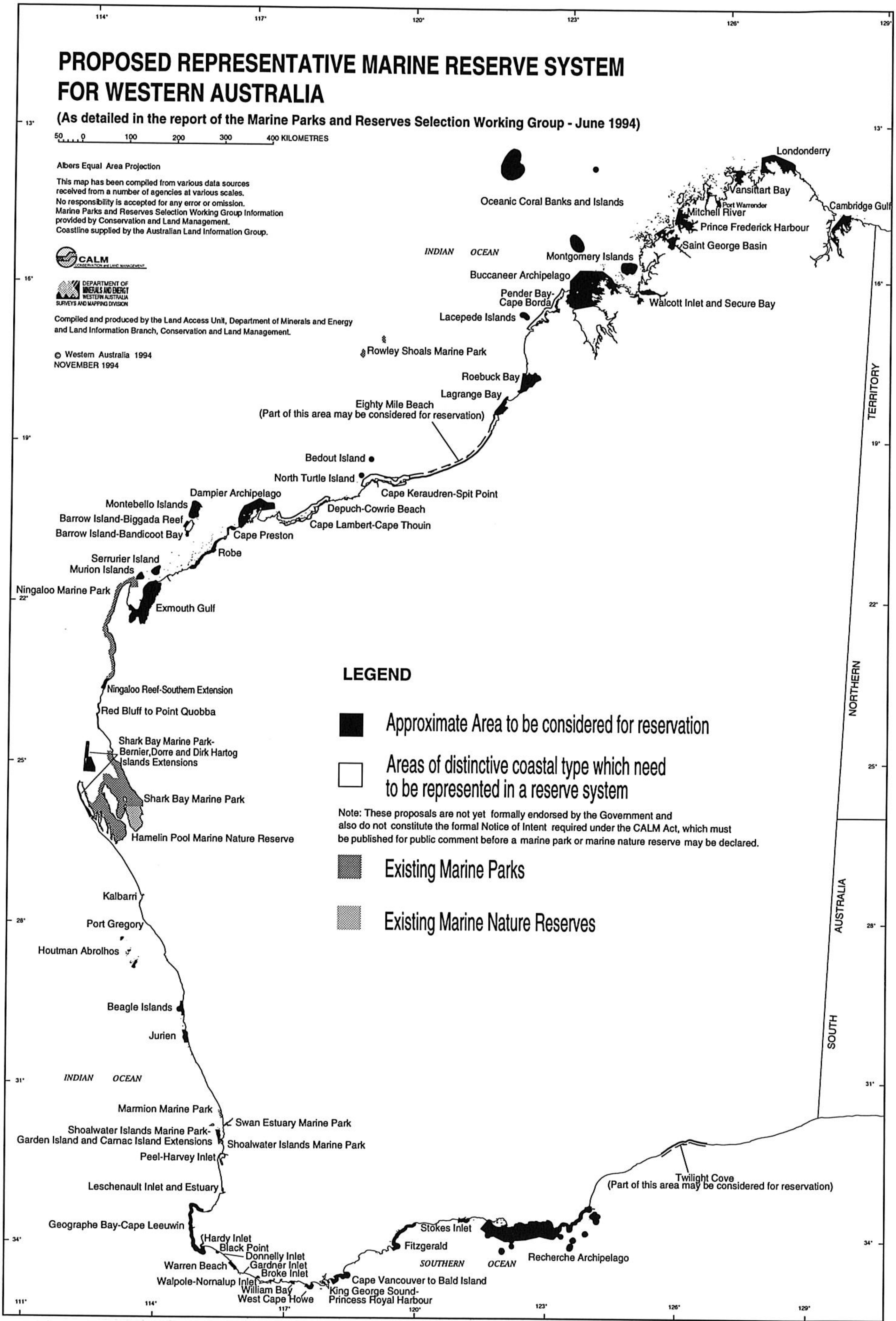

Figure 1 Existing marine reserves and areas noted as worthy of consideration for marine reservation in the Report of The Marine Parks and Reserves Selection Working Group (CALM, 1994)

Figure 1 Existing marine reserves and areas noted as worthy of consideration for marine reservation in the Report of The Marine Parks and Reserves Selection Working Group (CALM, 1994)

This plan links with the Marine Conservation Branch's strategic plan (CALM, 1997) by providing details of a strategy for the provision of oceanographic information to service the Marine Conservation Branch's core marine programs.

3 THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT'S ROLE IN MARINE RESERVE IMPLEMENTATION, MANAGEMENT, POLICY AND CO-ORDINATION

CALM's mission is "...to conserve and manage Western Australia's wildlife and the lands, waters and resources entrusted to the Department for the benefit of present and future generations", as specified in CALM's annual reports.

CALM's statutory obligations in the marine environment are delineated in the CALM Act 1984 and the Wildlife Conservation Act 1950. Amongst its range of statutory duties CALM has a responsibility to implement and manage marine nature reserves and marine parks in Western Australia, as defined in the CALM Act 1984. CALM is also responsible for conserving native plants and animals in marine waters throughout the state outside of the reserve systems, as defined in the Wildlife Conservation Act 1950.

The State Government recently released a strategy to implement a representative system of marine reserves for Western Australia (as outlined in a Government strategy document for marine management, released in November 1994 and titled *New Horizons in Marine Management*). As its foundation, this strategy proposed new marine legislation to create a Marine Parks and Reserves Authority (MPRA), a Scientific Advisory Group to the MPRA and a third category of marine reserve called a Marine Management Area (MMA). The philosophical foundation for usage within MMA's is similar to marine parks in that multiple uses will be allowed for. The Government's strategy also includes the creation of the now formed Marine Conservation Branch within CALM to provide scientific and technical support in the establishment of a representative marine reserves system for Western Australia.

The proposed legislation outlines a new procedure for marine reserve implementation which will involve an assessment of biological values, the establishment of indicative boundaries and an assessment of resources required to manage a marine reserve area. All of these steps require an understanding of the oceanography as key input.

The Marine Conservation Branch was formed in April 1996 from the amalgamation of the former CALM Marine Unit and staff transferred from the Department of Environmental Protection. The Branch is a specialist group within CALM's Nature Conservation Division and has the overall role of servicing CALM's strategic objectives in the marine environment of Western Australia, including the establishment of a representative system of marine reserves.

The MCB has as its vision "...to ensure the marine environment of Western Australia is conserved and managed on an ecologically sustainable basis for the benefit of present and future generations" and this will be accomplished through the establishment of "...a world-class system of representative marine reserves in Western Australia" and the provision of "...the highest quality professional service for the conservation, management and equitable use of the State's marine environment" (CALM, 1997).

The MCB has the following roles.

- To 'drive' CALM's marine reserve implementation program.
- To improve the scientific basis for the management of existing marine reserves and rare or threatened marine flora and fauna outside the reserve system.
- To provide policy advice to the CALM Executive and scientific and technical support to CALM's Branches, Regions and Districts.
- To co-ordinate marine activities within CALM .
- To provide a central focus for external liaison with CALM's clients in relation to marine conservation issues.

The MCB structure is based on the following programs.

- Marine Administrative Program.
- Marine Reserve Implementation Program.
- Marine Management Support Program.
- Marine Policy and Co-ordination Program.

An understanding of the oceanography of the State’s marine waters is of particular relevance to the Marine Reserve Implementation and Management Support programs but is also important for the Marine Policy and Co-ordination Program. The following section details the oceanographic requirements for these three programs.

4 GENERIC OCEANOGRAPHIC INFORMATION REQUIREMENTS IN MARINE RESERVE IMPLEMENTATION, MANAGEMENT, POLICY AND CO-ORDINATION

4.1 Marine reserve implementation

With respect to the technical information requirements in the marine reserve implementation process, an understanding of the hydrodynamics of candidate areas is required at broad spatial scales under typical forcings so that the general characteristics of the circulation and mixing of substances contained in the water can be considered in preliminary zoning for multiple uses. For example, flow fields are needed to provide guidance to the choice of sanctuary zones which provide pristine sources of biological material (e.g, eggs and larvae) within marine parks. These zones would generally be sited in the upstream region of a prevailing flow field and not within the pathways of contaminant streams. In addition, a marine park zoning scheme may need to consider existing pressures from marine developments such as the passage or accumulation of contaminants within and through a marine reserve. Errors in judgement relating to the siting of potentially threatening activities can be avoided given a sound technical understanding of the ecology which, by definition, includes the oceanography as a key component.

Regional scale oceanographic processes are important to consider in issues concerning inter-connectivity of marine reserves. Currents such as the Leeuwin Current, oceanic circulation patterns and the Indonesian Throughflow play significant roles in the regional scale transport of substances (such as larvae, phytoplankton) along and across the Western Australian continental shelf. The along-shore migration of certain marine fauna is also intrinsically related to regional scale currents, as evidenced, for example, by the occurrence of corals, tropical fish species and marine mammals such as loggerhead turtles off the southwest coast of Western Australia. Space and time scales relevant to these processes can exceed 1000 km and 1 year, respectively.

An adequate understanding of the ecology of one region could involve an appreciation of the hydraulic and consequent biological connections with other more distant regions, such as occurs between northern and southern Western Australian waters during the flow of the Leeuwin Current. The central west coast region of Western Australia, focussed around Jurien Bay, is an example which highlights the importance of along shelf connectivity; this area has been highlighted as a unique zone of biological overlap between tropical and temperate flora and fauna due to the seasonally periodic influence of warm tropical waters (which bathe the region during the southward flow of the Leeuwin Current in autumn, winter and spring) and cooler temperate waters driven into the area from the south under prevailing southwesterly to southeasterly winds during late-spring and summer. At another scale, which connects international waters, the Indonesian Throughflow forms a physical and biological connection between the waters of northwest Australia and those of Indonesia and surrounding countries.

For marine reserve implementation the nomination of a candidate area for marine reservation can be governed by political and social factors which, in some cases, requires a rapid assessment of the biological resources and processes of the area. This will require that oceanographic information is acquired at similarly rapid time scales and strategies need to be implemented to ensure that these time frames can be adequately met. Chapter 5 deals with this issue.

4.2 Marine reserve management

The oceanographic information requirements for marine reserve management are fundamentally similar to those for implementation except that there is often a higher level of scientific detail and spatial focus required for management. Once a reserve has been implemented the management emphasis switches to monitoring in order to provide data from which to assess activities that could potentially threaten management objectives for the marine reserve. Potential impacts will mostly be confined to localised sub-regions within a marine reserve, reflecting the tendency for activities such as tourism and commercial usage to be highly focussed geographically. As such, the spatial resolution at which usage patterns and ecological processes need to be monitored will also be high and the temporal repeatability of monitoring needs to be consistent with the time scales of natural ecological processes, environmentally threatening activities and activities that could threaten management objectives. Commensurately, the oceanographic detail will

As an example, within the Shark Bay Marine Park the number of visitors to the Monkey Mia lagoon is orders of magnitude higher than at many of the other popular sub-regions of the park (such as fishing and diving sites) and, considering the economic and conservation values of the dolphins that form the major attraction at Monkey Mia, the area warrants a relatively intensive level of environmental monitoring, including the hydrodynamics. Issues related to the physical accumulation or flushing of contaminants are critical in this area because of their relationships to the physiology and general health of the dolphins. It is worth noting that over 80000 visitors per year come to Monkey Mia with the primary objective of observing and interacting with the dolphins. Hence, monitoring needs to be pro-active with respect to the potential threats to the fauna of this area and this necessarily means intensive investigations at appropriate spatial and temporal scales.

A need for broad-scale surveillance of natural biological processes and impacts that may emanate from broad-scale usage, such as the spread of foreign organisms and basin-scale contaminant dispersion, may also be required and hence oceanographic monitoring will also need to capture these wider time and space scales. Furthermore, there may be physical relatedness between broad-scale processes (such as regional currents) and the hydrodynamic characteristics of localised areas. For example, shelf-scale flows such as the Leeuwin Current can impinge on coastal areas and influence their salinity-temperature patterns. Localised upwellings on the shelf can also be related to shelf scale flow patterns which are themselves driven by meso-scale wind patterns. Larval, nutrient and contaminant transport processes within marine reserves may be linked to these broad scale physical mechanisms and hence monitoring programs will need to consider these broader scales. Natural variation of biological processes will be linked to oceanographic processes and hence oceanographic monitoring strategies will need to incorporate long-term time frames, such as seasonal and inter-annual.

4.3 Marine policy and co-ordination

Marine policy and co-ordination issues will also require technical support from the oceanography program. An adequate network of monitoring stations for meteorological (e.g., wind, pressure, air temperature, solar radiation) and hydrological (e.g., waves, tides, river discharges) parameters is an essential baseline requirement from which broadly applied marine policies can be based. For example, oceanographic forces due to waves (sea and swell) and currents (tidal, wind-driven and oceanic) may be an intrinsic consideration in a state-wide mooring policy that considers the structural integrity and scouring of moorings from conservation and safety perspectives. Another example is the evaluation of issues relating to the siting, safety and environmental impacts of marine structures, such as jetties, boardwalks and other coastal structures that fall within CALM's management jurisdictions.

For marine co-ordination within CALM an understanding of broad-scale oceanographic processes, such as the Leeuwin Current, Indian Ocean Current, cyclonic effects and the Indonesian Throughflow, may be required in the formulation of state-wide marine policies. For example, issues concerning environmental risks associated with statewide shipping routes (e.g., the potential environmental consequences of an oil spill) will have a strategic broad-scale component to them and site specific studies may not be adequate in these instances. As a further example, the oceanography can assist in providing state-wide information on meteorological and oceanographic conditions likely to be encountered by vessels around the State's coastline, thereby assisting in the rationalisation of CALM's internal marine operational capability and in the formation of strategic alignments with other marine agencies that have operational capabilities.

4.4 Essential data requirements for an oceanographic information base

The generic data requirements that are needed to service the oceanographic program for marine reserve implementation, management, policy and co-ordination, at all relevant spatial and temporal scales, can be summarised as follows.

Bathymetry The bathymetry is a fundamental input to numerical hydrodynamic models and is required so that depth variations and physical obstructions to flows can be properly represented in the simulation of circulation fields and mixing characteristics. For example, flow past a promontory, island or inter-tidal reef may cause flow diversion or eddying and consequent trapping of matter either in the lee of the mean flow or within the region of the eddy. It is common to have vertical overturning of flow fields when a surface current meets a barrier and is forced to downwell. Often, because of the basin-like shape of nearshore embayments currents near the bottom are significantly weaker than those nearer the surface and the effective residence time for bottom waters can be relatively large. The formation of dense pools of high salinity and/or low temperature water at the bottom of basins can occur during relatively calm conditions when there is poor mixing and minimal flushing due to bathymetric trapping and vertical stratification of density due to salinity and/or temperature gradients. An accurate representation of the bathymetry is also important

Meteorology Meteorological information is a key requirement because it provides forcing data for numerical and analytical models relating to the movement and mixing of water (e.g., wind-driven advection and turbulent mixing) and to the formation of physical structure by solar radiation, evaporation, heating and cooling of the water (e.g., salinity, temperature and density gradients).

Water level variations (tidal and barometrically induced) The vertical variation of water level due to astronomic factors (tides) or barometric factors (e.g., wind and pressure) can drive currents and mixing processes.

Waves Swell and sea waves drive currents and cause mixing. For example, the breaking and passage of waves over reefs can cause wave pumping through lagoonal areas thereby causing significant currents and vigorous mixing.

Salinity-temperature-density fields The manner in which water moves and mixes can be strongly influenced by density gradients, which are set up by salinity and/or temperature gradients. For example, a vertically layered basin that has dense water near the bottom may resist complete vertical mixing by winds if the density difference is strong enough. Flushing currents may be forced to over-ride deeper denser water and as a consequence the relative flushing time of near-bottom water may be large leading to an accumulation of contaminants at depth. Salinity-temperature-density fields can be tracked in time to indicate broad-scale water movements and mixing characteristics.

Current fields The direct measurement of currents provides important information on circulation patterns and can be used as forcing, validation and calibration data from which to run, check and tune models, respectively.

Coastal discharges This is a particularly important parameter when the amount of freshwater or heat that enters the coastal zone is sufficient to create strong salinity and/or temperature gradients (vertically and horizontally). These gradients can alter the influence of other forcings in producing currents and/or mixing patterns. For example, the vertical stratification of salinity in a partially enclosed basin, such as Cockburn Sound, due to local river inputs is known to significantly alter the manner in which water is mixed vertically and the manner and depth that external water enters and resides within the basin. In coastal regions, the potential influence of buoyancy fluxes (freshwater and heat) must be assessed in order to be able to choose the appropriate type of hydrodynamic model for a particular application. In addition, river discharges can introduce nutrients or other contaminants into a coastal region and hence the spreading and mixing of river discharges may also be directly linked to water quality issues.

4.5 Mechanisms for the acquisition of oceanographic information

It is clear that oceanographic information will be required at a wide range of spatial and temporal scales for the marine reserve implementation, management support, policy and co-ordination programs. A number of mechanisms could be employed to achieve this and these are summarised as follows.

Analytical

First, in the absence of any data or modelling, a combination of existing oceanographic knowledge (local or general) complemented by simple analytical calculations can be made on the basis of known fundamental hydrodynamic principles. Typical values for meteorological (e.g., wind) and hydrological (e.g., tide and wave) forcings can be taken from historical records (such as can be found in year books and departmental data archives) and these data can be used in the application of classical analytical techniques. However, the areas to be addressed in Western Australia are often remotely located, generally large (having spatial scales of order 10-1000 km) and the hydrodynamics are driven by forcings over a wide range of temporal scales (from days to seasons, and in some instances inter-annual) and hence this approach is unlikely to arrive at a sufficiently comprehensive understanding of the hydrodynamics. Analytical techniques will result in largely theoretical or speculative results and there will inevitably be a requirement for field and/or model validation of analytical results. However, there may be times when an analytical approach is the only one possible.

Field measurements

Second, direct measurements of currents and mixing patterns can be obtained by field surveys. The main problem with relying solely on this approach is one of resourcing and logistical constraints. In order to adequately cover large marine reserve areas and capture relevant time scales monitoring grids would need to involve a large number of sites and the data collection would need to be carried out over long time periods. The cost of infrastructural support (vessels, instruments, workshops etc) and personnel effort required to adequately resolve the temporal and spatial characteristics of oceanographic processes in large and/or remote areas will in most instances be prohibitive. As an completed Southern Metropolitan Coastal Waters Study (1991-194), covered an area of about 30 X 100 km^2, involved two full time oceanographic coordinators and the supporting technical assistance of up to 40 personnel operating from five vessels during the individual field surveys of the study. Although the field site was near Perth, the value of the field component of these oceanographic studies totalled well in excess of one million dollars.

Modelling, field and analytical methods combined

The third and most widely adopted method is the use of hydrodynamic numerical models combined with one or more of the techniques described above. A range of public domain numerical models capable of simulating hydrodynamic behaviour inclusive of density effects are now available. Contemporary models range in sophistication and complexity, with the most elegant capable of simulating circulation and mixing patterns for large areas in three-dimensions and at fine-scale grid resolutions while incorporating the effects of all the key forcings and physical water conditions. The limiting factors will generally relate to the quality of input data (e.g., bathymetry, meteorology, wave, tide and salinity-temperature fields), validation/calibration data (e.g., currents, salinity-temperature fields) and the processing power of the host computer. Many good models are now freely available and relatively inexpensive to run. The level of field data required to achieve an adequate broad-scale oceanographic understanding is significantly reduced in comparison to relying solely on field-based techniques. One particularly relevant virtue of this approach is that the models can be run for either broad-scale or intensive investigations of the hydrodynamics by adjusting the grid size, time step and forcing inputs to suit. Hence, a model may initially be applied at broad spatial and temporal scales for reserve implementation purposes to provide the general features of broad-scale circulation and mixing patterns but may then be re-applied to sub-localities of the marine reserve at more intensive spatial and temporal scales to provide focussed hydrodynamic results motivated by management objectives.

The oceanographic information that CALM requires will need to be acquired by using a combination of internal and external mechanisms. A strategy is required to ensure the adequate acquisition of the essential oceanographic information, including bathymetry, meteorology, tides, wave climates, salinity-temperature-density fields, current fields and coastal discharges, in order to service and complement modelling exercises for existing and proposed marine reserves and this issue is addressed in Section 5, below.

5 A STRATEGY FOR THE PROVISION OF OCEANOGRAPHIC INFORMATION

5.1 Overview

The important questions that now arise relate to *how to ensure that the required oceanographic information is obtained*. The answer to this will lie somewhere between relying entirely on the results of external oceanographic studies and relying entirely on a self-sufficient internal oceanographic capability within CALM. Both of these mechanisms have inherent shortcomings.

Relying solely on external agencies for the provision of oceanographic information could leave CALM in an insecure position in terms of its ability to adequately meet all of its oceanographic information requirements. For example, in environmentally sensitive areas or important conservation zones within CALM managed waters, such as the Monkey Mia lagoon and Hamelin Pool Nature Reserve, there may be a need for rapid management-related information to prevent or ameliorate threats to conservation values that could arise at short notice due to factors such as catastrophic pollution incidents or indeterminate deteriorations in environmental values. Unless rigid arrangements (such as memoranda of understanding) can be set in place, it would be unwise to rely solely on external agencies or organisations for a rapid mobilisation of scientific monitoring equipment, vessels, field personnel, numerical modelling, remote sensing facilities, computing and scientific expertise. Research organisations generally have programs planned at yearly or longer time frames and, in general, will not always be able to accommodate externally driven requests for oceanographic studies at relatively short notice.

The development of a fully self-sufficient oceanographic capability (field, remote sensing, modelling and analytical) within CALM would be both prohibitively expensive and introduce duplication with the large number of oceanographic functions already performed by other agencies and institutions that have been set up to service the community's oceanographic requirements. There a number of well-equipped and highly capable oceanographic research facilities within and outside of Western Australia (e.g., AIMS, CSIRO, universities, industry) in addition to certain government agencies that routinely collect data pertinent to the oceanography of the state's marine environment (e.g., Bureau of Meteorology, Departments of Transport, Land Administration and Fisheries). Hence, there should be no need for a fully self-sufficient oceanographic capability to be developed within CALM.

In view of the above arguments, a limited internal capability with collaborative links to other oceanographic research

MCB, cognisant of the branch's co-ordinating role in CALM's marine reserve programs. In addition to the MCB's oceanographic expertise and resources the development of a complementary Regional/District oceanographic capability is also highly desirable. This may include, for example, the provision of research infrastructure including logistical support in the field, accommodation, laboratory facilities, vessels and the availability of personnel for technical and scientific roles in oceanographic studies. As a department CALM should have the resources to (i) collate, analyse and interpret existing oceanographic information for its own objectives, (ii) collect and analyse oceanographic information (through field, analytical and modelling techniques) that cannot be adequately sourced from other agencies and organisations and (iii) develop strategies and mechanisms to facilitate integration of the State's (and Commonwealth, where relevant) net oceanographic capability as pertinent to marine reserve implementation, management, policy and co-ordination.

The establishment of formal integrating mechanisms, both internally and with external research organisations, will be pivotal in facilitating collaborative alignments for oceanographic research. For example, within CALM the recent re-establishment of the Marine Co-ordinating Group is a good example of a mechanism that will enable integration of CALM's marine capability as a contribution to achieving its oceanographic objectives. The formation of external co-ordinating mechanisms will allow CALM the opportunity to have key input at the strategic planning level in oceanographic research organisations, thereby enabling the identification of areas of mutual interest and alignments to be established in research directions at the appropriate times in their planning cycles. The recent formations of the Western Australian Physical Oceanography Co-ordinating Group and the Marine Working Group of the State Liaison Committee on Remote Sensing are important steps in this process.

Other important sources of information for CALM's oceanographic programs will be via the opportunistic acquisition of oceanographic data through community involvement programs and data collection programs appended to other marine studies (internal and external). For example, commercial and recreational fishers could provide sea temperature data for satellite calibration purposes (using onboard echosounders or temperature meters) and oceanographic data collection could be incorporated into CALM's regional/district marine monitoring efforts. A working model for 'piggy-back' type studies exists within the CSIRO's *RV Franklin* national oceanographic programs for which opportunities for compatible adjunct studies are offered to external agencies and organisations as a matter of routine.

Drawing on the rationale of the preceding sections the goals and objectives of CALM's oceanographic program along with constraints and strategies to overcome constraints are now presented.

5.2 Goal

To ensure the provision of oceanographic information required in CALM's marine reserve implementation, management support, policy and co-ordination programs.

5.3 Objectives

Marine reserve implementation program

- The provision of broad-scale oceanographic information on circulation and mixing patterns within proposed marine reserve areas as required in the zoning phase of the statutory marine reserve implementation process, including an adequate understanding of the influence of regional scale transport processes that drive or influence physical communication between proposed reserve areas and adjacent or remote waters.

Marine management support program

- The provision of oceanographic information at spatial and temporal scales consistent with the scales of key ecological processes and anthropogenic pressures which threaten management objectives within marine reserves. This will involve intensive investigations and longer-term monitoring to detail oceanographic processes within marine reserves at spatial scales < 0.1 km to > 10 km and at temporal scales < 1 day to > 1 yr in order to capture and resolve the effects of relevant environmental forcings and threatening activities.

Marine policy and co-ordination program

- The provision of state-wide base-line oceanographic information as relevant to the formulation of generic marine conservation policies and internal co-ordination of marine conservation activities within CALM.

5.4.1 External

The following constraints identify the difficulties and short-comings of an option based around total reliance on externally generated oceanographic information.

- Difficulties in reconciling the relatively long time frames required for the planning and mobilisation of oceanographic resources by external oceanographic facilities and the relatively short time frames at which CALM requires oceanographic information in the initial phases of the statutory marine reserve implementation process.

- Difficulties in reconciling the relatively long time frames required for the planning and mobilisation of oceanographic resources by external oceanographic facilities and the relatively short time frames at which CALM requires oceanographic information for management in response to threats to management objectives that arise due to indeterminate pollution incidents, indeterminate water quality deteriorations or deleterious changes to ecological processes and/or behavioural patterns in marine communities (such as rare or endangered species, or flora and fauna with a particularly high conservation and/or commercial value).

- Difficulties posed by the relatively rapid and unpredictable nature of reserve candidate area selection and associated management information requirements when trying to reconcile the oceanographic research that is required for marine reserve implementation with the short-mid term planning cycles of external oceanographic agencies and institutions.

- Restricted internal capacity for CALM to conduct rapid focussed in-house oceanographic investigations in response to situations which threaten conservation values in the marine environment, such as pollution incidents and indeterminate deteriorations in the health of marine fauna and flora.

- The prohibitive cost associated with full commercial outsourcing of oceanographic research and monitoring due to the preclusion of CALM’s infrastructure and logistical resources that could otherwise be used for collaborative studies.

- Non-alignments between the strategic objectives of external oceanographic agencies and institutions and those of CALM’s marine reserve programs.

- A restricted capacity for CALM to ensure that, with respect to marine reserve information requirements, current deficiencies in the state-wide oceanographic data base are addressed at the required temporal and geographical scales, in order to provide for the selection, validation and calibration of numerical hydrodynamic models and for the provision of direct information on circulation and mixing patterns.

- Lack of internal resources and oceanographic expertise to ensure adequate quality control of outsourced oceanographic studies.

- Lack of CALM representation in technical oceanographic forums and on oceanographic committees of external oceanographic agencies and institutions resulting in a reduced capacity to contribute to priority setting for external oceanographic research.

- Inability to keep abreast of funding opportunities for oceanographic research available through state and federal funding agencies.

- Inability to keep in touch with contemporary oceanographic research initiatives which could provide information relevant to CALM’s marine reserve program objectives.

- Inability to inform the wider oceanographic research community of CALM’s objectives and requirements for oceanographic information in relation to its marine reserve programs.

5.4.2 Internal

The following constraints identify the difficulties and short-comings of an option based around total reliance on internally generated oceanographic information.

- The prohibitive cost of developing and maintaining a fully comprehensive oceanographic equipment base, including capital purchases, housing, maintenance facilities, depreciation, replacement and technical support.

- The introduction of duplication in research areas and directions currently embellished in the research programs and strategic objectives of external oceanographic groups active in the Western Australian marine environment.

- The prohibitive cost of supporting the large number of technical, administrative and scientific personnel that would be required to service a fully self-contained oceanographic research capability having a spatial and temporal brief that covers the state's marine waters at time frames relevant to CALM's short, mid and long-term marine reserve implementation and management support objectives.

- The logistical complexities which would be encountered in the acquisition of oceanographic data due to the remoteness of many proposed marine reserve areas which will require base-line oceanographic information such as bathymetry, meteorology and hydrology.

- A restricted capacity to form links and collaborations with external projects being conducted through industry, academia, research institutes, State and Commonwealth government agencies.

- The large infrastructural requirements that would be associated with an oceanographic program that aimed to cover the State's entire coastal zone. These requirements would include vessels, accommodation, transportation, workshop and laboratory facilities.

- The large personnel effort, both technical and scientific, that would be required to service a state-wide oceanographic monitoring program and to ensure high quality control in data collection, processing and interpretation.

- Data processing and modelling resources that would be required to maintain and run large and varied data sets, sophisticated data processing software packages, numerical models and information technology support for software and hardware maintenance.

5.5 Strategies

The following strategies are listed in order of priority. Full details of these strategies, including mechanisms to achieve them, are detailed in the Appendix of this report. The items listed within the strategies are regarded as high priority unless otherwise indicated as desirable items by an asterix.

- *Develop a strategic oceanographic capability within the Marine Conservation Branch comprising:*

Personnel (1 senior oceanographer, 1 oceanographic research officer*, 1 part-time oceanographic technical officer).
A three-dimensional baroclinic numerical model.
Computer hardware and software for modelling and data processing.
Training of MCB oceanographic staff in the use of software.
Oceanographic monitoring equipment:

- 1 conductivity-temperature-depth profiling probe
- 1 salinity-temperature profiling meter
- 2 temperature meters
- 15 temperature loggers (for shallow and deep water applications)
- 10 Drogues
- 1 Portable weather station
- 1 ocean-going vessel
- 1 Acoustic Doppler Current Profiler*
- 4 Fixed point current meters*

A discretionary budget for equipment and model maintenance and upgrades, baseline data collection, data processing and training.

- *Develop an operational oceanographic capability in CALM's Regions and Districts to complement the Marine Conservation Branch's capability comprising:*

PC support for oceanographic field requirements and data processing.
Logistical/infrastructural support including field stations and accommodation for research personnel.*
Vessel support.
Transport support.

- *Develop collaborative links with external oceanographic groups through:*

Participation on relevant coordinating and integrating committees (e.g., Western Australian Physical Oceanography
Co-ordinating Group and the Marine Working Group of the State Liaison Committee on Remote Sensing).
Initiation and support of undergraduate and post-graduate oceanographic research.
Regular liaison with external groups to promote opportunities for research and baseline data programs.
Representation on external committees such as industry and professional representative bodies.

· *Develop a strategy to acquire public (State and Commonwealth) or industry funding for oceanographic research by:*

Identifying relevant funding sources.
Systematically applying for relevant funding.

· *Develop a strategy for the opportunistic acquisition of oceanographic information through internal (CALM) and external collaborative initiatives by:*

Regular communication and liaison with Region/District staff to identify and initiate internal oceanographic studies.
Regular communication and liaison with industry, academia, research institutions, State and Commonwealth government agencies, through the development of collaborative links, to identify and initiate external oceanographic studies.

· *Develop a strategy to improve the spatial coverage of Western Australia's baseline oceanographic information by:*

Liaison with relevant government agencies to identify opportunities to improve the State's spatial and temporal oceanographic baseline data coverage.
Encouraging the establishment of a wider network of stations for oceanographic baseline data coverage.

· *Develop a strategy to maintain scientific and operational oceanographic expertise for CALM staff through:*

Incorporation of this objective in the training component of the Marine Conservation Branch strategic plan.
Direct training provided by the Marine Conservation Branch oceanographic staff to Region/District staff involved in the oceanographic program.

· *Develop a communication strategy for CALM's oceanographic program through:*

The incorporation of the communication needs of the oceanographic program in the Marine Conservation Branch communication plan.

6 FUTURE REVIEWS OF THIS PLAN

The MCB is a newly formed group and as such a plan of this nature will need regular review to keep abreast of changes in branch structure and funding (internal and external). It is therefore recommended that this plan be reviewed on a yearly basis.

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APPENDIX 1 DETAILS OF STRATEGIES FOR THE PROVISION OF OCEANOGRAPHIC INFORMATION

Goals, objectives, constraints to achieving the objectives and a list of strategies to overcome the constraints were given in Section 5. The details for these strategies, including mechanisms to achieve them are now given.

A.1 CALM internal oceanographic capability

A.1.1 Marine Conservation Branch

The discussion in Chapter 5 presented a rationale for the consolidation of a limited oceanographic capability within CALM to enable it to acquire information as a complement to oceanographic information that is or may be available through external oceanographic groups. An evaluation has been made of what is considered to be an ideal set-up within the MCB as part of CALM's internal capability and this is now presented in two parts: first, a set of relatively high priority items; second, items considered to be desirable and worth acquiring to improve CALM's oceanographic capability as resources become available.

High priority

Personnel

The following personnel are required in addition to core MCB managerial and administrative support.

- One full-time senior oceanographer with at least 10-15 years experience in the oceanography of Western Australia's shelf and regional scale environment, with the primary responsibility of ensuring the provision of oceanographic information required in CALM's marine reserve implementation, management support, policy and co-ordination programs. This will involve strategic planning, coordination of the oceanographic program and involvement/supervision of the MCB's oceanographic activities including modelling, field surveys, data processing, interpretation, reporting and supervision of technical and professional staff. An important function of the senior oceanographer is to liaise with external oceanographic groups and with CALM's Regions/Districts (via the Western Australian Physical Oceanography Co-ordinating Group [WAPOCG], the Marine Working Group [MWG] of the State Liaison Committee on Remote Sensing and the CALM Marine Co-ordinating Group [MCG], training programs with Region/District staff and general forms of print, electronic and verbal communication).

- One part-time (25%) technical officer with primary duties comprising vessel navigation (minimum Master Class 5 qualification), equipment maintenance, field survey logistics (planning and coordination) and having at least 5 years operational experience in oceanographic field studies conducted in Western Australian coastal sea conditions.

Numerical hydrodynamic modelling capability

- ***3D numerical hydrodynamic model*** A fully three-dimensional numerical hydrodynamic numerical model capable of simulating barotropic and baroclinic hydrodynamic behaviour within the Western Australian shelf zone, at fine to broad spatial scales and for regions having varying degrees of bathymetric complexity and topographic enclosure. One example of an appropriate model would be the Princeton Ocean Model, which is available as public domain and which has recently been applied with success to Perth's coastal waters as part of the Department of Environmental Protection's *Southern Metropolitan Coastal Waters Study 1991-1994* (Simpson *et al*., 1996).

- ***Computers*** Computers capable of effectively running 3D hydrodynamic numerical models include highly specified present day PC's and mainframe computers. The computing power required will depend on the particular application and relate to grid resolution, time stepping and simulation periods. Hence, the ideal scenario would be for the model to be installed on MCB PC's and on CALM's mainframe computing network in order to allow flexibility in the device used for specific applications.

- ***Computer support for modelling*** A service agreement between CALM's Information Management Branch and Marine Conservation Branch to provide a mechanism for software/hardware support relating to the installation and maintenance of models on CALM's mainframe system, similar to the agreement for the marine GIS software and air dispersion models within CALM.

- ***Training*** Initially, training would be required to instruct MCB oceanographic personnel on the use of the model and thereafter ongoing training would be required for future model developments.

- ***Graphics*** Hardware and software to plot model output would be required. Any one of a number of commercially available plotters would be adequate for graphical output of model results. There are a number of commercially available software packages that would provide an adequate graphics capability. Alternatively, a locally designed oceanographic data processing package exists at the University of Western Australia (Centre for Water Research) and this has been successfully utilised for the processing and analysis of oceanographic data collected as part of the Department of Environmental Protection's recent *Southern Metropolitan Coastal Waters Study 1991-1994* (Simpson *et al*., 1996).

Field capability

- ***Conductivity-temperature-depth (CTD) profiling probe*** CTD probes are used to map salinity-temperature-density fields to assist in choosing models for particular applications and also to assist in model validation and calibration. CTD data are also used to track water movements by identifying salinity (S), temperature (T) or density (D) fields that can be followed in time. Furthermore, the details of vertical mixing in stratified systems can be revealed by vertical profiling with sufficiently accurate CTD probes. A probe that resolves to better than about 0.01 pss, ^{o}C and kg m^{-3} for salinity, temperature and density, respectively, would be suitable. Ideally, the probe should be free-falling, easily deployable by hand-operated winches and provide real time data acquisition to allow field programs to be adjusted in-situ according to prevailing physical processes and scientific considerations. A sampling rate allowing vertical data to be collected at better than about 0.1 m resolution with descent speeds of faster than about 0.20 m per sec would be required. The probe should be equipped with communication cables to allow collection to depths of 200-300 m for cross-shelf surveys. Ideally, the probe should be capable of having additional biological sensors appended (e.g., dissolved oxygen, pH, flourometry). A review of available instruments and sources indicates that suitable CTD probes are only available from overseas manufacturers. Although there are a limited number of suitable probes available for hire locally, experience indicates that availability is uncertain when instruments are required at short notice or when there are conflicting demands, hence compromising the ability to plan around the use of such instruments.

- ***A manually deployable salinity-temperature (ST) meter*** This is required as a back-up for the CTD probe. In certain field applications for which relatively small amounts of ST data at low resolution are required these meters offer a quick, easy and cost-effective method of collecting ST data. Suitable ST meters are available in Australia

- ***Temperature meters*** Low cost battery operated temperature meters can be used to measure water temperatures from bucket samples in most field situations and their use requires no specific training. For example, they can be used to gather opportunistic sea-surface temperature measurements for satellite image calibration purposes.

- ***Temperature loggers*** Self-recording temperature loggers are required to complement CTD data for surveys of basin-scale STD fields. Continuous records of temperature at fixed points capture broad-scale water movements and allow physical mechanisms driven by intermittent periodical meteorological events, such as upwelling, to be reconciled over relatively long time periods. Loggers that can be deployed in deep offshore waters and requiring relatively little maintenance are ideally suited. Temperature logger arrays can be deployed on vertical strings to provide long-term records of vertical mixing as indicated by changes in vertical temperature stratification. The ideal complement would comprise 10 nearshore loggers (< 20 m) and 4 deep water loggers (20-200 m). Suitable temperature loggers are available from within Australia.

- ***Drogues*** Drogues provide a simple, convenient and cost-effective method of measuring current speeds and flow patterns. With the advent of highly accurate differential GPS (DGPS) the tracking of drogues has been made much easier and cheaper than in the past, when trigonometric position-fixing, relying on shore-based reference stations, was necessary. A complement of 10 drogues deployed from a vessel capable of operating in coastal waters in winds of up to about 25 knots can provide current data for numerical model validation and calibration.

- ***Weather station*** For much of Western Australia's coastline meteorological information is collected either at relatively low frequencies or not collected at all. This is a major constraint in the oceanographic program. A portable weather station that monitors wind, air temperature, relative humidity, solar radiation and barometric pressure is required. Such a system could be assembled locally using components available in Australia.

- ***Vessel*** Ideally the oceanographic capability would include a vessel from which to mount field surveys at relatively short notice and with the following specifications: capable of operating in nearshore coastal conditions under typical winds and seas (wind < 25 knots and swell <2-3 m); capable of supporting a field crew of up to 5 and instrumentation such as a CTD probe, current meters and drogues; equipped with GPS and capable of night navigation; having a dry cabin to house electronic equipment such as computers; equipped with a heavy duty winch for the deployment of items such as current meters and associated moorings. The MCB vessel *Bidthangara* is an example of a suitable vessel.

Budget

- The above components will require both a capital budget (to set up the oceanographic capability) and a discretionary budget to allow for ongoing expenses relating to model upgrades, computing support, computer upgrades, equipment maintenance and replacement and training expenses.

Desirable items

- ***Acoustic Doppler Current Profiler*** Oceanographic surveys of the type which are necessary in CALM's marine reserve implementation and management programs would generally utilise Acoustic Doppler Current Profilers (ADCP's) to gather rapid basin-scale information of current velocity patterns. Such an instrument provides the facility to obtain current fields through the water column and can be towed along transect paths (for example, with the ADCP fixed to a vessel and transmitting its signal vertically downwards). The ADCP is connected to a PC and data are acquired in real time and viewed instantaneously. The current data returned from a relatively rapid 'criss-cross' traversal pattern can yield a three-dimensional current velocity field. For many applications, such an instrument would eliminate the need for intensive drogue tracking and fixed point current metering and would increase the ability to quickly acquire hydrodynamic process information for model validation and calibration purposes. Combined with an appropriate CTD probe, as described above, this would provide an ideal field capability for the type of oceanographic investigations required by CALM.

- ***Fixed point current meters*** Self-recording fixed-point acoustic current meters provide the capability to capture a continuous flow history driven by periodic or inter-mittent meteorological and oceanographic forcings over long time spans (up to six months at 5-10 minute intervals). They are of particular value in validating numerical models designed to simulate long-term hydrodynamic processes (> 10 days). Their relative shortcomings are that they cannot record vertical current profiles (in contrast to ADCP's, which are capable of recording vertical current profiles at 0.5 m vertical resolution). Between four and eight acoustic fixed-point current meters would provide a good working complement for CALM's oceanographic capability. There are presently over 10 fixed point acoustic current meters residing within the State's public and private sectors.

- ***Personnel*** One full-time oceanographic research officer with at least 5 years experience in coastal oceanography, including the application of oceanographic information to biological process studies. Responsibilities will include the custodianship of the oceanographic field capability (scientific instrumentation, maintenance, calibrations, coordination of survey equipment), and planning, preparation and involvement in field surveys, data monitoring programs, numerical modelling, data processing, data archival, hydrodynamic analyses and report writing.

A.1.2 Regions and Districts

Because of the vastness and remoteness of this State's marine environment the success of CALM's oceanographic program will rely on the formation of good internal collaborations between the MCB and the coastal Regions and Districts. This will primarily involve the acquisition of field data and the maintenance and consolidation of a logistical and infrastructural network from which to base oceanographic studies conducted by CALM or external groups.

Personnel

- Ideally, each of CALM's coastal regions would contain 1-2 professional or technical staff with a working knowledge of oceanographic processes and experience in baseline oceanographic field studies, including experience in working from seagoing vessels. Involvement in oceanographic studies, such as assisting in the planning, preparation and data collection in addition to the provision of a local focus for administration, liaison and planning of surveys would be important roles for Regional staff. In addition, important tasks to be performed at a Regional level would include maintenance and checking of oceanographic and meteorological instruments during long-term deployments (e.g., temperature loggers, current meters and weather stations). Data processing could also be incorporated as part of a Region's contribution to joint MCB/Regional studies. Training of Regional staff to provide the necessary skills in oceanography could be provided by the MCB and could also be acquired through technical and further training available at TAFE and tertiary institutions.

Computing

- Ideally, Regional/District offices should be equipped with PC's capable of data storage and basic manipulation of oceanographic data for on-site processing. Modern day PC's carrying EXCEL/WORD applications would be adequate.

Infrastructure and logistical support

- ***Field stations*** CALM's marine reserves programs, including the oceanographic program, would benefit greatly from the provision of a network of field stations from which field surveys in regional locations could be based. For example, this might comprise an enclosed compound containing a workshop/laboratory for data analyses, equipment preparation and storage with access to essential services (e.g., water, power and communications). The provision of accommodation would also be of value to house research and operational personnel during field surveys for extended periods. Some of the benefits that would be associated with the creation of Regional research facilities include: the ability to add significant in-kind value by CALM in grant applications and in collaborations with external organisations; the provision of infrastructure and logistical support as a means of attracting external oceanographic research initiatives in regions that would otherwise pose prohibitive logistical and infrastructural constraints to external groups.

- ***Vessels*** A regional complement of vessels within CALM for marine investigations would significantly facilitate both internally and externally generated oceanographic research. The advantages of having vessels stationed within the Regions will reflect those given above in relation to infrastructural and logistical facilities. A review of CALM's boating capability is currently underway through CALM's MCG and this will consider the relative merits of a self-contained boating capability compared to full or partial out-sourcing of CALM's boating requirements.

- ***Transport*** CALM's Regional and District offices can greatly facilitate oceanographic field studies in remote locations through the provision of vehicles for equipment and personnel transport during field surveys. The cost of sourcing vehicles from Perth is often a constraining economical factor in planning for field surveys in remote locations.

A.2 Maintenance of expertise within CALM

A.2.1 Marine Conservation Branch

- ***MCB professional officers*** Expertise should be maintained by: yearly attendance and participation in an applied oceanography conference that covers topics including numerical modelling, analyses, field techniques, instrumentation and theoretical analyses; attendance at post-graduate academic courses, as required; attendance at local oceanographic seminars and workshops, as relevant; regular liaison within the local oceanographic community through visits, discussions and internet; regular (1-2 per year) meetings of the WAPOCG.

- ***Principal MCB technical officer*** Maintenance of operational and data processing skills through appropriate technical and further training. This could comprise post-graduate courses, liaison with other research groups active in applied oceanographic surveys and data processing, attendance at relevant workshops and seminars, biennial attendance at an appropriate conference that covers topics in field techniques, instrumentation and operational procedures relevant to applied oceanography.

A.2.2 Regions and Districts

- ***CALM Regional/District staff***. Training would be provided by the MCB in oceanographic field techniques, instrumentation and data processing and through attendance at short courses to acquire or improve operational and/or scientific skills, as appropriate.

A.3 Opportunistic studies

A.3.1 Internal (CALM Regions and Districts)

- It is important that communication within CALM is sufficiently effective to allow the identification of opportunities where existing or proposed field activities in the Regions and Districts could potentially easily accommodate addended data collection objectives as may be relevant to CALM's broader oceanographic information requirements. The MCG is an appropriate vehicle for the identification of such opportunities. A strategy to ensure adequate information exchange should also be included in the MCB's communication plan.

newsletters. Data collection opportunities would include monitoring or familiarisation tours on vessels to islands or remote marine regions within existing or proposed marine reserves which would provide a platform for MCB or regional staff to increase their familiarity with physical and biological characteristics, perform sea temperature measurements (for sea-surface satellite imagery ground-truthing), salinity-temperature profiling or instrument deployments (e.g., temperature loggers, meteorological stations). Regular surveillance activities performed by regional/district offices could provide similar opportunities.

A.3.2 External (industry, academia, research institutions, State and Commonwealth government agencies)

- It is important that communication with external groups (industry, academia, research institutions, State and Commonwealth government agencies) is sufficiently effective to allow the identification of opportunities where existing or proposed field activities could potentially easily accommodate addended data collection objectives as may be relevant to CALM's broader oceanographic information requirements. A strategy to ensure adequate information exchange should be included in the MCB's communication plan. The WAPOCG, MWG and the mechanisms identified within the communication plan will be important vehicles for this objective.

A.4 Baseline data

Limitations in the State's baseline oceanographic data, as relevant to CALM's marine reserve programs, requires that a strategy be developed and implemented to improve the data base. This will primarily involve liaison with state agencies responsible for the acquisition of oceanographic data. The WAPOCG and MWG will be important forums for these issues to be addressed.

A.5 Student research

A strategy for this objective should include the development of a yearly list of student topics relevant to CALM's short, mid and long-term oceanographic information requirements and the distribution of the list to relevant academic institutions. Ideally, the MCB discretionary budget should include a component to support a limited number of student projects and research funding applications should include provision for student involvement.

A.6 Co-ordinating and integrating mechanisms

The MCB should maintain representation on both the WAPOCG and MWG. The WAPOCG has recently been formed and is currently chaired by the MCB to facilitate liaison, collaboration and communication within the Western Australian oceanographic community and this will be a key forum for the identification of collaborative opportunities and facilitation of integration between CALM and external groups in relation to research as relevant to CALM's marine reserve programs. The MCG is an important vehicle for co-ordination and integration of the oceanographic capability between the MCB and Regions/Districts within CALM. The MWG provides a forum to identify collaborative opportunities in remote sensing.

A.7 Funding

An inventory should be developed identifying state, commonwealth and industry funding sources for oceanographic research in marine conservation. For example, funding for fundamental and applied research in the environmental sciences are available through various schemes administered by the Department of Employment, Educations, Training and Youth Affairs, Department of Industry, Science and Tourism, Department of Environment, Sport and Territories and Department of Primary Industries and Energy. It is important for CALM to keep abreast of funding opportunities through these sources and initiate either individual funding applications or applications in collaboration with other agencies, industry groups and/or research institutions.

A.8 CALM representation on external committees

The MCB should seek representation on relevant committees (e.g., Coastal and/or Environmental panels of The Institution of Engineers, Australia) and associations (e.g., Australian Water and Wastewater Association) that include representation by professional groups active in oceanographic research.

A.9 Oceanographic data inventory

An inventory should be developed that details the nature of existing oceanographic data in Western Australia and in national data repositories. The inventory should also include information on the availability and accessibility of existing data.

A.10 Communication

The communication requirements of the oceanographic program should be incorporated into the MCB communication plan (Osborne, in prep) with the objective of ensuring appropriate dissemination of oceanographic information within and external to CALM. For example, communication mechanisms could include the creation of a MCB oceanography web site, initiation of information dissemination channels on the internet, dissemination of this strategic plan via post and internet, seminar presentations (in technical, education and community forums), CALM newsletters, contributions to external newsletters and bulletins and the publication of research in CALMScience, scientific journals, Landscope and MCB Technical Reports.