South Coast Marine GIS Information and Resource Compilation Project

O4SC1-01k

Final Report
May 2009

A project supporting South Coast Regional Marine Planning

Ewan Buckley
Marine Information Officer

Marine Policy and Planning Branch
Department of Environment and Conservation

Suite 3, Level 3 Queensgate Building
10 William St
Fremantle WA 6160

Funded through South Coast Natural Resource Managment Inc. and South West Catchments Council with the support of Western Australian and State Governments, through the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality

SOUTH WEST CATCHMENTS COUNCIL

SOUTHCOAST NATURAL RESOURCE MANAGEMENT

Department of Environment and Conservation
Our environment, our future

TABLE OF CONTENTS

Summary

With funding support from South Coast Natural Resource Management Inc., a contract position was created within the Department of Environment and Conservation's Marine Policy and Planning Branch, to collate and manage the information required for the WA Government's South Coast Regional Marine Planning initiative. This would also contribute to several key investment areas of South Coast NRM's Regional Strategy. The South Coast Marine GIS Information and Resource Compilation project commenced with the appointment of Ewan Buckley to the GIS Project Officer position in January 2007. Later funding contributions were sourced from South West Catchments Council and DEC provided in-kind support throughout the project.

The project was initially divided into two phases, with a third phase developed later in the project. Phase 1 (January – July 2007) aimed to build the information system, review and acquire existing datasets, and identify gaps in knowledge required for South Coast Regional Marine Planning (SCRMP). Phase 2 (July 2007 – June 2008) was to build on Phase 1, by refining the data acquisition according to identified requirements for South Coast Regional Marine Planning, and by producing or commissioning the production of datasets to fill gaps in knowledge. Phase 3 (July 2008 – February 2009) was later initiated as an extension of Phase 2, to focus on the production of a spatially comprehensive marine benthic habitat layer across the south coast.

Datasets collated through this project have been acquired under data license agreements for use in this project, from various custodians with various levels of licensing requirements. It is the users' responsibility to abide by these data license agreements, and/or to seek custodian's approval for fitness-for-use, whether or not licensing agreements exist. Refer to the Outcome: Licensing of acquired datasets section of this report, individual data license agreements, metadata and licensing details as noted in the Acquisition Log.

Irrespective of data licensing, it is always best to contact data custodians prior to use, to check for licensing, fitness-for-use and any available updates.

Phase 1

Phase 1 (January – July 2007) of the project progressed as planned, beginning with the creation of a database to manage the spatial and aspatial information collated through the project.

Available broadscale information relating to south coast biophysical, cultural and socio-economic values was sourced, primarily through state and federal government agencies, but also from universities and other non-government organisations where required.

Datasets identified and/or acquired were documented within the database to allow easy access to metadata records and source contact information. Upon reviewing the available datasets, the main gaps in the information system were identified, relating to the distribution of marine recreational activities, commercial fishing values, physical coastal landform characteristics, and broadscale marine benthic habitat information.

Phase 2

Phase 2 (July 2007 – June 2008) acknowledged the information gaps identified in Phase 1, and further refined the information requirements for South Coast Regional Marine Planning through involvement in the planning process, particularly the SCRMP Community Workshop series and meetings with the SCRMP Planning Working Group (State Government agency staff) and Planning Advisory Group (stakeholder advisory group). Through the SCRMP process, key marine values and issues were identified across the region, for which adequate information was required to support the planning process.

Phase 2 then initiated the production of several new datasets to address the gaps in knowledge identified in Phase 1, as well as working with existing data to address information requirements for the SCRMP process, and production of the draft South Coast Regional Marine Strategic Plan.

The key datasets produced through Phase 2 include: the South Coast Community Recreational Marine Usage Survey, coastal landform mapping, coastal compartments mapping, the commission of composite satellite imagery enhanced for water penetration, commercial fishing values, and community-based habitat mapping. Phase 2 included an identification of the need for further work in integrating existing marine benthic habitat mapping which led to the development of Phase 3.

Phase 3

Phase 3 (July – December 2008) was developed through the recognition of a lack of spatially comprehensive benthic habitat mapping data across the south coast region. Phase 1 and 2 identified and acquired existing datasets, which varied in their accuracy, methods and spatial and thematic scale and extent. This left holes in benthic habitat mapping coverage of the south coast region, and it was difficult to compare data between different studies, due to their different methods and objectives.

Phase 3 integrated all available existing habitat mapping information into one dataset, and filled spatial gaps by desktop mapping using all available information sources collected through Phase 1 and 2, such as satellite imagery, charts, geological maps, etc. Where necessary, original spatial mapping was improved using more recent or better spatial data than the original, and original attributes were standardised across all input original data. New mapping of spatial data was attributed with the best available information, and where little information is available, habitat modelling methods, derived from previous studies were used to classify new mapping into broadscale habitat classes and associated information.

Introduction

The first Regional Marine Planning (RMP) process for Western Australian State waters is being conducted off the south coast, covering an area from Cape Leeuwin to the South Australian border (Figure 1). RMP is a process which:

> *provides a framework to integrate current and future sectoral planning and management of biophysical marine regions according to an agreed vision for sustainability*

As input to the RMP process, there was a need for an assessment of the bio-physical and socio-economic values that are important to the region - based on the best available information - from which the regional marine planning strategy is being derived. An assessment of such values is reliant on sound biophysical and socio-economic information, and whilst a considerable amount of spatial (Geographic Information Systems - GIS) and aspatial (research/reports) data existed, it was in various forms, published and unpublished, stored in different government and non-government organisations at varying jurisdictional levels (local to federal).

A common desire to collate and make readily available such information was identified between the South Coast Regional Marine Planning (SCRMP) Working Group (Ian Herford) and the south coast community-based regional Natural Resource Management (NRM) group, South Coast Natural Resource Management Inc. (SCNRM – Dylan Gleave). Funding from SCNRM was used to set up a Marine Information and Resource Compilation sub-project, to be delivered through the Marine Policy and Planning Branch of the lead SCRMP agency, the WA Department of Environment and Conservation (DEC). Later funding contributions were sourced from South West Catchments Council and DEC provided in-kind support throughout the project.

As well as assisting with the South Coast Regional Marine Planning process, the project was designed to contribute to several Key Investment Areas (KIAs) and Management Action Targets (MATs) of the South Coast NRM Regional Strategy, relating to the documentation of the region's marine environmental and socio-economic values.

Table 1: South Coast NRM Management Action Targets that the South Coast Marine GIS Information and Resource Compilation Project addresses. Extracted from the Project Schedule.

Management Action Targets (MATs)		
MAT Ref #	**Description**	**Related RCT**
Primarily:		
MAT C2	Regional database established documenting marine biodiversity by 2007	**RCT** C1, C2, B3
MAT C5	Regional framework established to support sustainable marine/aquaculture resource management by 2007	**RCT** C1, C2, C3, B1, B3, L5, L6
Also:		
MAT C8	Regional integrated coastal management planning framework in place by 2010	**RCT** C1, C2, C3, B1, B3
MAT C9	Marine reserve areas identified using CAR analysis by 2006 and marine conservation reserve system establishment commenced by 2010	**RCT** C1, C2, C3, B1, B2, B3

The cross-regional nature of the project, and the benefits that it brought to a project such as this was recognised by South West Catchments Council (SWCC) who also contributed funding to the project. SWCC includes part of the SCRMP study area, along the coast between Augusta and Walpole (Figure 1).

A Memorandum of Understanding for the Natural Resource Management responsibilities for the coastal area to the east of the South Coast NRM regional boundary (Figure 1) exists between Rangelands NRM and South Coast NRM, whereby South Coast NRM manage marine and coastal NRM activities this area on behalf of Rangelands NRM. Hence, Rangelands NRM were not directly involved in this project.

The SCRMP process involved all State Government agencies with responsibilities for marine planning and management, as well as other organisations such as the Department of Indigenous Affairs and South Coast NRM:

- Department of Environment and Conservation (lead agency).
- Department of Fisheries.
- Department of Industry and Resources.
- Department for Planning and Infrastructure.
- Tourism Western Australia.
- Albany Port Authority.
- Department of Water.
- Department of Indigenous Affairs.
- Goldfields-Esperance Development Commission (representing the three south coast Development Commissions).
- Western Australian Museum.
- South Coast Natural Resource Management Inc.

The multi-sectoral nature of SCRMP provided a cooperative platform for the acquisition and integration of information required for the process, where all agencies and organisations were committed to supporting the process and so by extension, this project. The appointment of Department of Environment and Conservation as the lead agency provided the expertise and experience of the Marine Policy and Planning Branch Marine Information Section to the direction of this project, and methods used in finding, acquiring and managing the resultant volume of data. The Marine Information Section (Ray Lawrie and Mark Sheridan) have over 10 years experience in sourcing multi-disciplinary datasets for marine reserve planning processes, which encompass many similar issues and data requirements of SCRMP, though often at different spatial scales.

To capitalise on this experience, the externally-funded contract position for this project was created within the Marine Policy and Planning Branch, and filled on January 15th 2007 by Ewan Buckley. DEC provided in-kind support of project supervision, hardware/software, and administration and office

costs, whilst South Coast NRM provided funding for salary, travel/accommodation and project operational costs. South West Catchments Council later provided additional funds as a contribution to the overall project cost (Table 2). Chris Nutt (DEC Marine Policy and Planning Branch) took over as project officer for Phase 3, in July 2008.

Table 2: Total budget outline for the South Coast Marine GIS Information and Resource Compilation Project, 15 January 2007 to 31 December 2008.

Source	**Amount**
South Coast NRM Inc.	$161,124
DEC (in-kind and funding)	$89,116
South West Catchments Council	$25,000
Total	$275,240

The project was initially set up in two phases, with a third phase developed later in the project:

- Phase 1 (15 January 2007 – 15 July 2007) aimed to build the information system, review and acquire existing datasets, and identify gaps in knowledge required for South Coast Regional Marine Planning (SCRMP).
- Phase 2 (16 July 2007 – 30 June 2008) was to build on Phase 1, by refining the data acquisition according to identified requirements for SCRMP, and by producing or commissioning the production of datasets to fill gaps in knowledge.
- Phase 3 (1 July 2008 – 31 December 2008) was later initiated as an extension of Phase 2, to focus on the production of a spatially comprehensive marine benthic habitat layer across the south coast.

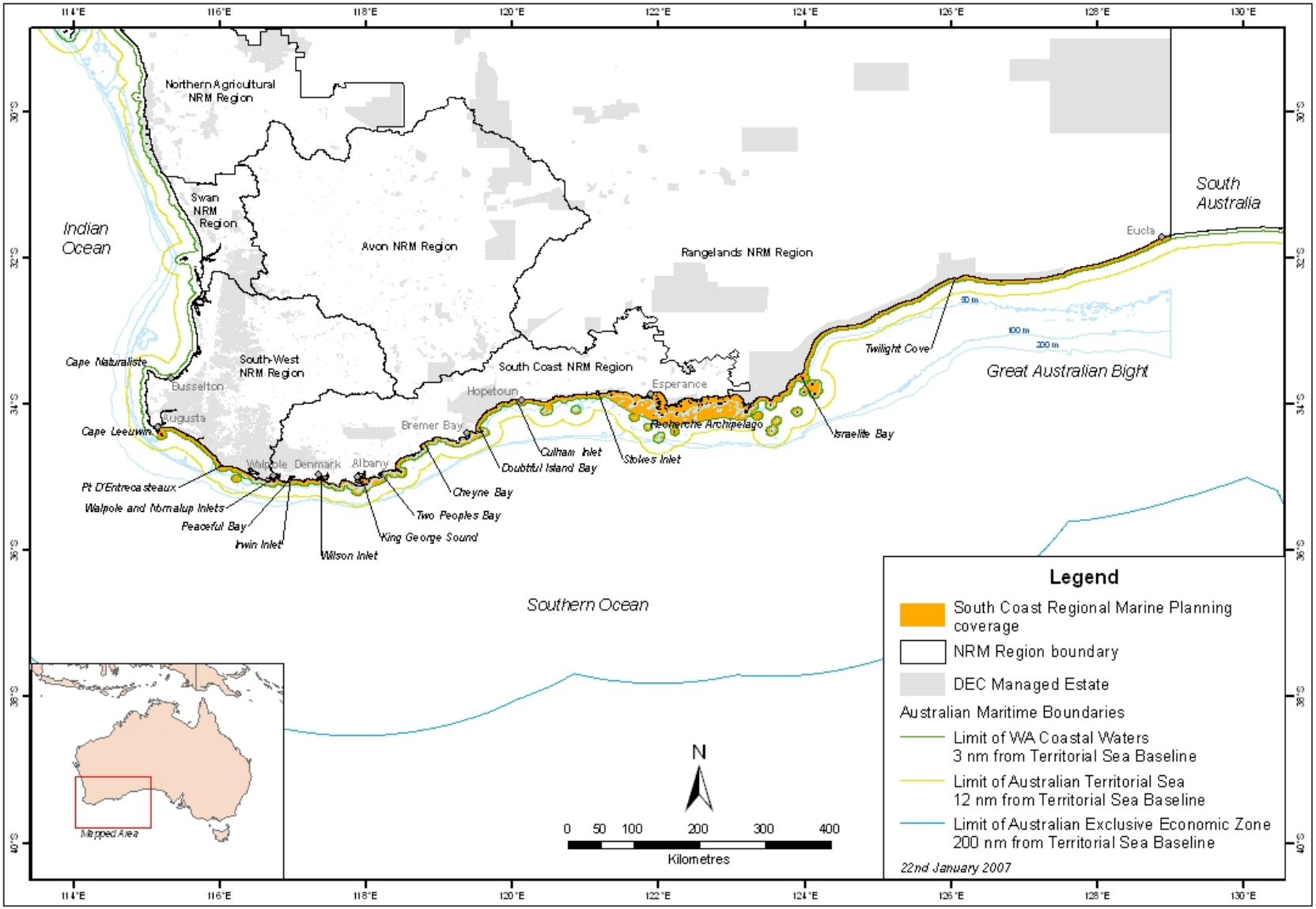

Figure 1: Map of the South Coast Regional Marine Planning Study area, and NRM regional boundaries.

Project Aims

The aims of the South Coast Marine GIS Information and Resource Compilation Project were:

1) To identify the information requirements for South Coast Regional Marine Planning;
2) To identify and acquire available information (GIS and aspatial) relating to biophysical, cultural and socio-economic values across the south coast region as per the requirements above;
3) Where possible within time and budget constraints, to produce or commission the production of datasets to fill gaps in knowledge;
4) To review information gathered and produced for SCRMP and recommend further strategic data acquisition as required.

Phase 1 addressed Aims 1 and 2, with Phase 2 targeting Aims 3 and 4. Phase 3 also addressed Aims 3 and 4, but focussed in particular on gaps in knowledge of the extent and distribution of marine benthic habitats across the south coast region.

Phase 1 Objectives and Outcomes

Phase 1 (January 2007 – July 2007) aimed to:

1) identify the information requirements for south coast regional marine planning, and;
2) identify and acquire available information (GIS and aspatial) relating to biophysical, cultural and socio-economic values across the south coast region as per the requirements above.

In order to achieve the aims of Phase 1, the following Objectives were defined, leading to their related Outcomes, described below:

Objective: Database creation

- Create a database/data management system to record and store all the information relating to the data acquisition for the project, including details of datasets and their acquisition, a research bibliography and contacts database, and the acquired data itself.

Outcome: AcquisitiOn Log

A Microsoft Excel spreadsheet (\SouthCoast_GIS\Data\AcquisitionLog.xls) was created to log details of all identified datasets, and the progress of their acquisition from source custodians, as well as details of data contacts and resources. The log divides information layers into separate biophysical and socio-economic themes, for easy search and location of specific datasets within the spreadsheet.

The spreadsheet format was chosen as the Microsoft® Excel software is installed by default onto most computers and is widely used and understood by users of a wide range of technical expertise. On one worksheet, users are able to view details of many datasets at once, and can view basic details and acquisition status at a glance. Hotlinks to source webpages, background documents, metadata statements and log files allow rapid access to more detailed information about the data.

Information Themes in the Acquisition Log

Table 3: Information Themes

Category	Theme
Biophysical	Coastline
	Geology and Geomorphology
	Hydrology
	Climate
	Oceanography
	Bathymetry
	Elevation
	Marine Habitats
	Marine and Marine-dependant biota
	Terrestrial biota
	Water Quality
	Miscellaneous
Socio-economic	Administration and Tenure
	Infrastructure
	Demography
	Cultural values
	Commercial Fishing
	Aquaculture

	Recreational Fishing
	Tourism and non-extractive recreation
	Mining and Petroleum
	Community
	Miscellaneous
	Pollutants
	Aerial Photography
	Satellite imagery
	Digital charts
	Digital topographic maps
	Videography/photography

Contents of the Acquisition Log

The Acquisition Log contains 4 worksheets: LUT (Look Up Table); Project Contacts; Resources; Themes and Datasets, Data Contacts.

The 'LUT' worksheet contains the values for look up tables that supply choices for drop-down menus in the other worksheets of the Acquisition Log. This worksheet should not be modified unless necessary to change the drop-down menu items.

The 'Project Contacts' worksheet contains information about contacts for data acquisition and other people involved in the South Coast Regional Marine Planning project. Throughout the project various members of the community and government agencies are recommended for follow-up of data. Whilst not all are followed up, it is important to log the details for future reference. The 'Project Contacts' worksheet records information on the person's Name, Organisation, Role, Notes and who referred that person. Specific contact details are not recorded in this worksheet, but are recorded instead in Outlook contacts. Outlook can export contact details to Excel or other file formats – at the conclusion of the project, SCRMP data acquisition contacts will be exported and saved in the Acquisition Log for distribution to SCNRM.

The 'Resources' worksheet records information about online resources for data acquisition and background information for marine planning, mapping, and topics that come up through the project.

The 'Themes and Datasets' worksheet is the main page of the Acquisition Log. It lists the datasets identified through the project and their custodians, source information, data manager contact, acquisition status (i.e. whether is has been obtained and stored in the South Coast GIS system), file name, metadata file, licensing information, and completeness. Where datasets have been acquired, hyperlinks on the acquisition Status, File Name and Metadata values open the dataset's log file, storage directory and metadata, respectively.

The 'Data Contacts' worksheet contains an output from the Microsoft® Outlook contacts list put together through the project. This can be re-imported back into Outlook.

Outcome: Directory Structure

The directory structure has been designed to be as intuitive as possible to allow users who are not familiar with the data and the project in general to access data easily.

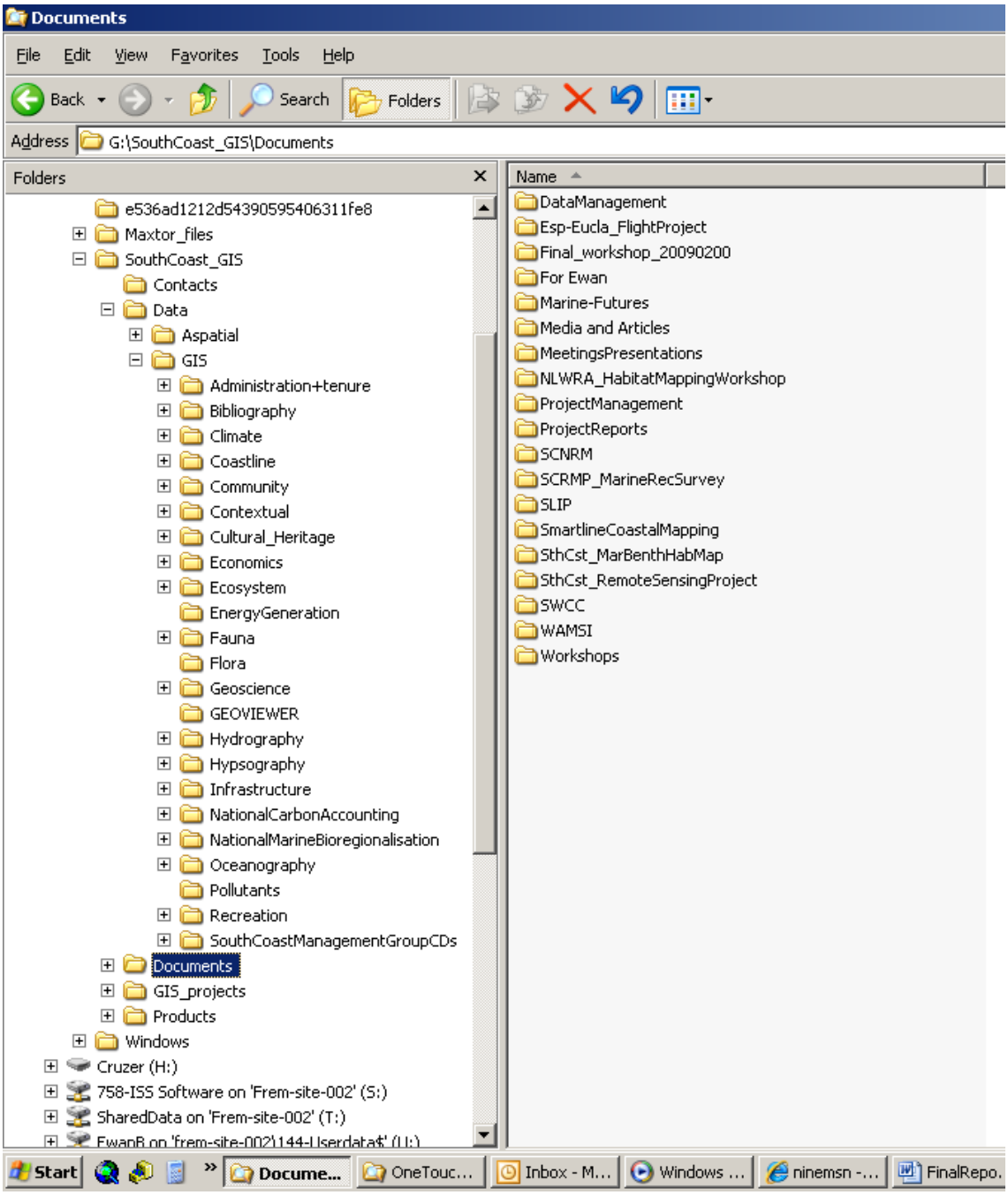

Figure 2: Directory structure.

SouthCoast_GIS

Contacts – data and other project contacts. Also noted in the Acquisition Log

Data – contains all data gathered in the project

Aspatial

Logos

Reports-Govt

Reports-NGO

Research-Articles

GIS

Various Information Themes

Documents – various documents relating to the project management, such as quarterly reports, draft reports, final reports, budgets, etc.
GIS_projects – ArcGIS projects created in the project
Products – map products produced through the project

The design of GIS data structures can be difficult, with many different points of logic to consider. For example directories could be organised by custodian, information theme or by geographic area, and different themes may be better organised differently to others. As the project progressed, directories evolved to accommodate new data and to better organise key data themes more logically.

Directory names match the Information Themes listed in the Acquisition Log as closely as possible to maintain a logical connection between the two. This is not always possible in order to maintain a manageable directory, and some suites of data are best left in the structure that they are acquired in, such as the National Marine Bioregionalisation project data (see directory folder in Figure 2), however hyperlinks within the Acquisition Log will direct the user to the appropriate directory from within MS Excel.

Outcome: Bibliography

Research articles and reports were logged using EndNote software, as it is considered the most efficient way of compiling bibliographies, and is commonly used. Thus bibliographies exist in EndNote libraries for which users must purchase EndNote licenses to use. In line with the goal of the project to make it as accessible as possible, at the completion of bibliographic work these libraries will be exported to worksheets in the Excel Acquisition Log. Where possible, copies of articles or reports are acquired and saved as PDF documents in the relevant \SCRMP\Data\Aspatial\ directory, with the PDF name also recorded as a link in the bibliography. Sub-directories of the aspatial directory are identical to those used in the GIS directory.

A DEC volunteer, Michael Higgins, worked on digitising the spatial extents of study areas of acquired research articles. These areas are saved in shapefiles which, through hotlinking, allow users to select the areas and have the PDF of the research automatically open. The shapefiles are attributed with publication details, as well as the subject of the articles, allowing users to search for research spatially or thematically. The shapefiles are saved in different research themes, for example, one shapefile for each of marine mammals, sea birds and marine habitat research. These GIS datasets are stored in the Bibliography theme folder of the GIS directory.

Objective: GIS data collation

- Collect spatial (GIS) data relating to marine natural resource management of the south coast region.
- Review information already held by DEC, and expand to identify and use resources in other government and non-government organisations, particularly WA Land Information System (WALIS – http://www.walis.wa.gov.au/) custodians and other key agencies involved in SCRMP.
- Store collated datasets in a logical system to allow easy access to planners and SCNRM for future work. GIS data requires high levels of ongoing maintenance, so the Project needs to document and store the available data within systems that are logical and transferable to SCNRM at its conclusion.

Outcome: Documentation of available spatial data resources

In recent years, much effort has been made by information management government agencies at the state and federal level, to make information available or at least lodge metadata records in searchable online systems. The WA Land Information System (WALIS) and federal Australian Spatial Data Directory (ASDD) in particular have metadata search engines which connect with information portals of many government agencies at all levels across Australia.

Resources such as these, and the individual portals used in this project are logged in the 'Resources' worksheet of the Acquisition Log. Web addresses are included in the records, along with brief descriptions of the resources. This will be a valuable resource to aid future users with finding more information.

Of particular value have been:

- WA's Shared Land Information Platform for Natural Resource Management,
- WA Dept of Mines and Petroleum (formerly Dept. of Industry and Resources) Data and Software Centre,
- Commonwealth Department of Environment and Water Resources Discover Information Geographically website,
- Geoscience Australia's Online Mapping and Databases,
- CSIRO's Marine Laboratories Information Network (MarLIN),
- The National Ocean's Office Neptune Data Directory.

Outcome: Logging and acquisition of identified datasets

A total of over 300 GIS datasets have been acquired through this project, out of approximately 400 so far identified, covering the themes described above (Table 3). Due to the very large documentation workload in gathering and documenting these data, datasets have been gathered on a priority basis. Thus there are datasets logged in the Acquisition Log that are not yet acquired but which are likely to be of interest in the future.

Upon acquisition, datasets are reviewed and stored in the system, entering details of the acquisition into a '.txt' log file which is saved with the dataset, with the same filename. An example of the text file is provided in Appendix A.

Datasets are renamed to a convention applied by the DEC Marine Information Section of <what>_<where>_<when> which provides information at a glance about the dataset subject (what), its spatial extent (where) and its date of production/extraction (when).

Outcome: Licensing of acquired datasets

When acquiring datasets, Data Licensing Agreements have been arranged for DEC, SCNRM and SWCC users, where possible. This has so far been achieved for many of the datasets that require licensing. Highly sensitive information such as locations of threatened fauna and flora species, or cultural heritage locations etc are often subject to special licensing arrangements, or are limited to simplified versions of the data. Assessments of requests for full access to such data are often made on a project-by-project basis.

Data licenses are stored as Word documents or PDF files, with the dataset/s in the same place in the directory structure. This ensures that licenses are readily available when transferring or moving data. Licenses are typically generic, therefore are not linked to in the Acquisition Log; however, **it is important to review data licensing agreements before use or transfer, particularly for potentially sensitive or commercially confidential information. Many licenses stipulate that products of the information must bear some acknowledgement of the information source. If unsure, contact data custodian/s.**

Data acquired through this project are available for use in regional marine planning activities – for use in other projects, data custodians/licensors should be contacted for permissions. Regardless of licensing considerations, it is always best to contact the licensor to enquire about the status of the dataset, whether any updates are available, and it's fitness for use. In general, WA state government agency custodial data is available to NRM groups via the standard WALIS agreement.

A general Data License Agreement covering the whole database is saved in \SouthCoast_GIS\Data\ and \SouthCoast_GIS\Documents\DataManagement\DataLicensing\

Outcome: Metadata

Accurate metadata statements to accompanying datasets are extremely important in giving users context to the data, providing information on data sources, currency, accuracy, suitability for use and contact details.

Metadata statements have been sourced for all acquired datasets where available, and are hotlinked to the Acquisition Log. In cases where metadata were not available from the custodian, acquisition log files serve to give basic information on the data source and licensing details. Due to the very high documentation workload in researching and producing metadata statements for non-custodial data, this task will be done only for those datasets which are of importance through the SCRMP process. For the remainder, Acquisition Log and log file details will serve to give future users the source details to find out more about datasets.

Outcome: Documentation of work required

Once data have been acquired and stored in the system, they were reviewed for useability and relevance to the project. Often, datasets require some modification, of formats, datums, or linking of tables to the spatial data, for example. Such modification is commonly done upon receipt, and logged in the acquisition log file, but often the processing involved would require much work and was judged to be a lesser priority at that stage of the project. Details of work potentially required are logged in a column of the Acquisition Log for future reference. It is expected as the project progresses and datasets are required to be used and processed together, that further data processing work will be a higher priority.

Objective: GIS data standardisation

- Maximise the interoperability of the various datasets collated through this project, by storing in common GIS formats. ESRI shapefiles have been selected as the most desirable formats due to their widespread usage and acceptance in the GIS community. The .dbf file that contributes to a shapefile is also accessible outside of GIS software thus enhancing its accessibility.
- Check metadata to ensure it complies with current Australian (ANZLIC) and international (ISO) standards. Standardisation work was prioritised and undertaken as time permits. If standardisation work was necessary but not done, then outstanding work was documented.

Outcome: GIS Formats

Most datasets are received as ESRI Shapefiles in geographic GDA coordinates, which are the standards set for this project due to their common usage, thus most datasets received have not required standardisation. However, data are also often received in non-GIS formats such as Microstation Design files, or in formats that would not be easily useable without specialist software, or which would take substantial interpretation. Where necessary to evaluate the relevance of the data, these datasets have been converted to shapefiles in GDA coordinates, with basic attribution. Further work that could be done is recorded in the Acquisition Log, but in-depth processing has been avoided unless required.

Similarly, many datasets are provided from custodians in non-spatial formats such as MS Excel or MS Word files containing spatial descriptions such as coordinates or locations. Where required for mapping or GIS analysis purposes, these have been converted to GIS data.

File types such as gridded data (for example, modelled national average temperatures) can store very large amounts of data (depending on grid cell size) which can be very computer-intensive to work with and be of relatively limited value. Where necessary for use in the SCRMP, these datasets have been processed to give smaller, more useable vector datasets. For example, a gridded dataset of average temperatures could be processed to produce a ‘contour’ map of isotherms.

Outcome: Metadata

In the initial stages of the project it was proposed to standardise all metadata statements into a common format. As the project progressed it became apparent that this would not be a worthwhile use of resources, as the very large majority of metadata statements, whilst being saved in various file formats, have been produced to the basic ANZLIC metadata standard. Metadata statements have been stored as supplied, which may be as .XML, .HTML, .PDF, .DOC or .TXT files. Where metadata statements were produced through the project, they are created using DEC’s ArcGIS tools which use ANZLIC standards, and saved as .HTML files.

XML files are automatically generated by ArcGIS when it processes data. XML files describe key basic metadata such as the coordinate system and extent of datasets, the kind of features the dataset contains (grid, polygon, point or line), its attributes and data types for those attributes, any GIS processing steps and their parameters, modification dates and other such information. Some GIS operators exclusively use the XML metadata functionality to store additional descriptive information about the dataset, such as an abstract, custodial and contact information, lineage and other such details. XML files are viewable in Internet Explorer or Word, but are best viewed using ArcCatalog, by selecting the dataset and clicking the ‘Metadata’ tab of the viewing window of ArcCatalog. For more information about the metadata authoring, viewing and exporting functions of ArcGIS, consult ArcGIS Help documentation.

Objective: Aspatial (non-GIS) data collation

- Collect aspatial data, in the form of research products (peer reviewed articles, reports, theses etc) and governmental and NGO reports (from local, state and federal agencies) relevant to South Coast Regional Marine Planning. Document other information sources.
- Where possible, digital copies of documents will be obtained and stored in the SCRMP data management system, with bibliographical records, and document sources stored in the Acquisition Log database described above.
- Where research/reports are based on a study or focus area, the spatial extents of the study area will be recorded as a polygon in an index GIS dataset.

Outcome: Aspatial data storage

Whilst the focus of data acquisition was on GIS information, aspatial information such as planning reports, data reports, research articles, etc are also of interest in marine planning.

Due to the very large numbers of reports available from government and non-government organisations, acquisition of reports and other documents was done as they were needed, referred to, or found through GIS data acquisition processes.

Aspatial reports are stored in the ..\..\Data\Aspatial directory, organised primarily by their source – Government Reports, non-Government organisation reports, and academic research articles.

Outcome: Collection of Government reports

Coastal planning reports from the WA Planning Commission, strategic planning and statistical reports from Tourism WA, reserve planning and research reports from DEC, fisheries management and research papers from Department of Fisheries have been acquired so far.

Outcome: Non-Government organisation reports

Organisations such as NRM groups (SCNRM, South West Catchments Council, Rangelands) are also valuable sources of information for marine planning. Such organisations undertake bibliographical work, literature reviews and other such work of direct relevance to this project, as well as producing comprehensive NRM Strategy and Investment plans for NRM of the marine environment. These documents are available via internet download and have been acquired where available.

Outcome: Academic research

Primary literature on biophysical values in particular, was a valuable resource for use in SCRMP. Research on the distribution of fauna and flora, habitats, environmental characteristics, and research on ecological systems and processes guide the characterisation of the south coast marine environment and the pressures on its functioning.

Bibliographies of research on coastal and marine geology/geomorphology, oceanography, marine mammals, sea birds and marine habitats research have been compiled and documented as described above (Database creation – Bibliography).

Many other research report/papers/articles were sourced for usage in this project. Whilst not all were entered into a reference tool such as EndNote, they were stored as PDF's in the \SouthCoast_GIS\Data\Aspatial\Research-Articles\ folder. **Subject to copyright laws, these should not be reproduced or redistributed for any non-educational purpose.**

Objective: Lodge data with SLIP NRM

The Shared Land Information Platform (SLIP http://www.walis.wa.gov.au/slip) is a WALIS project that is compiling all the key datasets used by WA state government agencies in 4 key areas, Emergency Management (SLIP EM), electronic Land Development Process (SLIP eLDP), property Interest Enquiry (SLIP ROI) and Natural Resource Management (SLIP NRM).

SLIP NRM houses datasets relevant to Natural Resource Management, making them available online via a GIS data/map viewer to the public, for use in natural resource management projects.

- GIS data collated in this project to be stored within the SLIP NRM infrastructure, with the cooperation of dataset custodians, thus ensuring the ongoing maintenance and availability of the data to SCNRM and Government agencies in the longer term.
- GIS data produced through this project to be lodged with SLIP NRM.

Outcome: Future lodgement of datasets with SLIP NRM Info

As the project progressed it became apparent that not all of the datasets acquired are for lodgement into SLIP NRM. This is mostly due to the duplication of effort required by the custodial agencies responsible for managing the datasets, as many are already available through online delivery infrastructures. Furthermore, lodgement with SLIP requires satisfying rigorous, long-term data custodianship requirements that are the responsibility of the custodial organisation.

However, several key planning layers are likely to be lodged with SLIP NRM, to be made available to the NRM community via the internet. Fisheries and DEC information (aquaculture, fishery license areas, marine habitats, DEC tenure, coastlines) are already available on SLIP, and it is expected that several other WA government agency custodial datasets will be lodged with SLIP as they are identified as key datasets through the SCRMP process.

Information created in Phase 2 and 3, of marine habitats and marine user information will also be lodged on SLIP through normal data management processes following the completion of the project. Discussions with the Department of Agriculture and Food (the custodians of SLIP NRM) resulted in a specific South Coast topic in the mapping interface where south coast marine planning information will be easily accessible as it is provided to the SLIP NRM project. There may also be the potential for 'live' maps of marine habitat information, as provided by the community, to be updated online by community members as they have further information on the distribution of habitat and other biodiversity values. SLIP NRM have demonstrated that this capability exists; however, the management of the system would require a dedicated, long-standing project. This could also be extended to include marine usage information.

Since the beginning of this project, considerable developments have been made in the planning for a dedicated marine data portal within the WALIS and SLIP NRM data infrastructures. At the time of this report, it was considered best to wait for the implementation of such a portal before lodging datasets created through this project.

Upon delivery to South Coast NRM, the Community Recreational Marine Usage Survey will become the custodial responsibility of SCNRM, as it is likely that the survey will be continued and managed by SCNRM.

Objective: Marine information gap analysis

- Identify the key information layers required for the SCRMP process
- Assess the information available/collected through Phase 1, against the requirements for regional marine planning.
- Provide recommendations for priority data capture/creation for SCRMP (leading to Phase 2) and beyond.

Outcome: Identification of information requirements for regional marine planning

It is important to ensure that spatially comprehensive information is available, of all the key marine sectors/stakeholder groups active on the south coast. For regional planning, it is important for the datasets to describe the values across the entire region. Table 4 lists key sectors and the datasets/information so far acquired to describe them.

Table 4: Key marine planning sectors, information required and acquired, gaps in knowledge, and information gathered for South Coast Regional Marine Planning

Marine Planning Sector	Key information required	Key Datasets acquired	Notes	Main Information Gaps or limitations of existing data	Gaps addressed through South Coast GIS project (Phase 2 and 3)
Biodiversity Conservation	Bioregions	Integrated Marine and Coastal Regionalisation of Australia (IMCRA) - Provincial and meso-scale bioregions version 4	Three meso-scale bioregions are defined for the south coast - Eucla, WA South Coast, and Leeuwin-Naturaliste		
	Sub-bioregions			Sub-regionalisation/characterisation of the south coast, as described by IMCRA *micro-scale* (see IMCRA Report 3.3, 1998)	mapping of coastal compartments/sediment cells, as a geomorphic input to a sub-regionalisation; integrated/standardised existing habitat mapping; some new habitat mapping (manual digitising and remote sensing); enhanced satellite imagery coverage
	Existing marine and terrestrial reserves	DEC tenure, Shire and other reserves tenure, Commonwealth Marine Parks	Walpole/Nornalup Inlets Marine Park, numerous coastal reserves		
	Areas to be considered for Marine Conservation Reserves	Marine Parks and Reserves Selection Working Group (1994) areas - the 'Wilson Report'	These areas represent approximate areas for consideration or investigation into their suitability for marine reservation, as described in the report.	Biodiversity surveys of all recommended areas have not been completed. Areas that have been surveyed to some extent include: the Recherche Archipelago, the Fitzgerald coast, Walpole/Nornalup Inlets, Albany harbours.	

Marine Planning Sector	Key information required	Key Datasets acquired	Notes	Main Information Gaps or limitations of existing data	Gaps addressed through South Coast GIS project (Phase 2 and 3)
	Marine Benthic Habitat mapping	Marine Futures areas; seagrass - Albany to Israelite Bay (CSIRO/Kirkman); Fitzgerald coast (DEC/Coleman); Fish Habitats of the Recherche Arch. (FRDC/UWA), C. Leeuwin to C. Naturaliste (DEC); geomorphic habitat mapping of estuaries (GA); Seascapes (GA)	With the exception of the Marine Futures study areas, these surveys are relatively broad-scale. Marine Futures data are delivered to NRM groups via their own delivery mechanisms	Spatial gaps between Eucla and Israelite Bay, and Albany to Augusta; most habitat mapping is coastal/shallow water mapping only. Different projects capture and classify information differently. CSIRO dataset has little groundtruthing or classification	integrated/standardised existing habitat mapping; some new habitat mapping (manual digitising, and remote sensing); enhanced satellite imagery coverage; collection of community knowledge
	Threatened and priority fauna distributions	DEC's Threatened, Endangered and Priority Fauna database	captures the locations of sightings or deaths of TEP fauna	dataset limited to sightings or deaths, not systematically surveyed	
	Marine fauna distributions	Whale breeding areas, whale migration movements in the Recherche Archipelago, seal and sealion breeding islands, seabird breeding islands, WA Museum sponge collection sites		few species have comprehensively mapped distributions	contributed to Commonwealth Govt project to characterise whale breeding areas, for SW Marine Bioregional Planning
	Marine and coastal geology and geomorphology	auSEABED and MarSed marine sediment databases; geology mapping (500K); OSRA coastline classification; DPI *Coastal Environs*; Galloway Coastal Lands (1984); Geoheritage (DOIR); Seascapes (GA)		consistently classified coastline/beaches; detailed coastal landform classification/mapping; sediment dynamics; coastal compartments/sediment cells; marine geology	supplied data to Dr Chris Jenkins' AuSEABED database - received AuSEABED; new mapping and classification advice to Dr Chris Sharples' Smartline project - received Smartline; new mapping of coastal compartments of the south coast; undertook oblique aerial photography of Esperance-Eucla

Marine Planning Sector	Key information required	Key Datasets acquired	Notes	Main Information Gaps or limitations of existing data	Gaps addressed through South Coast GIS project (Phase 2 and 3)
	Bathymetry	DPI soundings data for south coast harbours; Australian Bathymetry Grid (2005); isobaths digitised from charts	the Australian Bathymetry Grid (2005) is modelled bathymetry, Most useful at regional scales of mapping.	comprehensive, region-wide systematic bathymetric mapping at anything other than very course scale. Some areas have no data available at all.	
	Oceanography – waves, temperature, chlorophyll	National Marine Bioregionalisation datasets: Mean wave heights/periods; wind curl; tides; average monthly gridded sea surface temperatures, chlorophyll-*a;* nutrients and others			
	Estuaries and catchments/rivers	Hydrographic catchments; Geoscience Australia geomorphic estuary habitat mapping; OzEstuaries database (NLWRA/Geoscience Australia); Australian River Assessment sites and database (AusRivAs - DEWHA)			produced SCRMP Estuarine Characterisation
Fishing and aquaculture	Commercial fishing administration	Fishery licence areas, closed areas, bioregional management boundaries			
	Commercial fishing production (catch and effort reporting)	2000-2005 catch data (tonnes and $ value) for all WA fisheries	reported in 60 nautical mile grids	very coarse spatial resolution (60 x 60 nm grid reporting) - cannot tell where within the block is being fished. Data available as spreadsheet database extracts - not GIS data	produced GIS datasets of fishery catch reporting (2000-2005) from non-GIS data
	Commercial fishing values			no data to describe important areas to fishers, such as safe harbours, vital infrastructure, important fishing	requested WAFIC assistance for workshopping south coast fishers, digitised workshop

Marine Planning Sector	Key information required	Key Datasets acquired	Notes	Main Information Gaps or limitations of existing data	Gaps addressed through South Coast GIS project (Phase 2 and 3)
				areas/seasons	results as GIS data
	Aquaculture leases	Aquaculture lease areas and licenses	licenses not available publicly		
	Aquaculture planning	Recherche Archipelago Aquaculture Plan (DOF 2000)	report only, no spatial data available	no aquaculture planning datasets	
	Recreational fishing	Australian National Recreational and Indigenous Fishing Survey 2001; Recherche Archipelago Recreational fishing/spearfishing	2001 survey was a broad randomised telephone survey and follow-up questionnaire	very coarse spatial resolution, and inconsistent scale of mapping for the national telephone survey	created and ran the SCRMP Community Recreational Marine Usage Survey
	Customary (indigenous) fishing	Australian National Recreational and Indigenous Fishing Survey 2001		very coarse spatial resolution, and inconsistent scale of mapping for the national telephone survey	
Shipping and Ports, Marine Safety	Port Authorities	Port Authority boundaries	Esperance and Albany PAs		
	Maritime Legislation	Shipping and Pilotage Act areas, Marine and Harbours Act areas, Proclamations Areas, Navigable Waters Act areas	various datasets, regulations change often, but spatial areas are generally well defined		
	Ports and boating infrastructure/facilities	DPI coastal infrastructure; DPI boat ramps; Navigation Aids	DPI maintain a coastal infrastructure database		
	Port servicing infrastructure (e.g. road and rail links)	roads, railways			
	Marine Safety facilities	Navigation aids; sea rescue groups		no spatial data available for Silent Sentry placements	Sea Rescue Groups; Silent Sentry locations
	Shipping movements/volumes/types	AusRep - Australian 24 hr Ship reporting	voluntary ship location reporting		

Marine Planning Sector	Key information required	Key Datasets acquired	Notes	Main Information Gaps or limitations of existing data	Gaps addressed through South Coast GIS project (Phase 2 and 3)
Mineral and Petroleum	Mining and petroleum lease areas	Mining Tenements, Petroleum titles	live database, can take a 'cut' of it. Should refer back to this		
	Mining and Petroleum exploration areas	MINEDEX, WA Petroleum release and application areas, exploration areas	database for new info		
	Mineral deposits	MINEDEX			
Recreation and Tourism	Coastal access	Recherche Archipelago Socio-Economic Study		limited to Recherche Archipelago study site	some mapping of coastal access points was done whilst interpreting aerial and satellite imagery for coastal landform types for Smartline
	Recreational areas	Recherche Archipelago Socio-Economic Study; Dive wrecks (HMAS Perth and Cheynes III); DEC Recreation sites		RARES study was comprehensive and detailed, but limited to Recherche Archipelago study site; DEC recreation sites were unattributed - map production only	created and ran the SCRMP Community Recreational Marine Usage Survey
	Camping areas	DEC Recreation and Tourist Information System		limited to the Black Pt to Walpole area	
	Visitation rates	Marine-based tourism statistics (By Local Government Authority)	collected by Tourism Australia	coarse scale of spatial and thematic information, provided as GIS data	converted to spatial dataset
Cultural interests	Cultural Heritage sites	Heritage Council sites; Register of the National Estate			
	Indigenous Heritage sites	Aboriginal Heritage Sites	contains confidential or sensitive sites, which are not mapped accurately or described in detail in publicly available datasets		

Marine Planning Sector	Key information required	Key Datasets acquired	Notes	Main Information Gaps or limitations of existing data	Gaps addressed through South Coast GIS project (Phase 2 and 3)
	Shipwrecks	WA Shipwrecks database	contains both known locations, and unknown location wrecks	not originally in GIS format	converted to GIS format
	Maritime Archaeology	Maritime Archaelogical sites			
	Aboriginal cultural values	Restoring Connections (David Gilfour/SCNRM)	some mapping has been attempted in the SW region by Noel Nannup/DEC. collected by Norman Tindale through the 1950's and 1960's - some debate exists about accuracy	no information readily available to describe indigenous cultural values across the region (in spatial format)	
	Aboriginal Language Groups	Tindale language groups		possibly inaccurate, not completed in consultation with Aboriginal people	
Management of adjacent lands and waters	Govt adminstrative boundaries	Various administrative/management boundaries			
	Native Title Claim registrations and determinations	National Native Title Tribunal Claims and Determinations	these are periodically updated and often change, should be re-checked for each use		
	Coastal tenure	State cadastral database			
	Commonwealth administration boundaries	Australian Maritime Boundary Information System (AMBIS)			
Research and Education	Research areas	Securing WA's Marine Futures study areas	Marine Futures data are delivered to NRM groups via their own delivery mechanisms		
	Research articles				spatial bibliography created

Marine Planning Sector	Key information required	Key Datasets acquired	Notes	Main Information Gaps or limitations of existing data	Gaps addressed through South Coast GIS project (Phase 2 and 3)
	Research organisations				

Outcome: Identification of key gaps in information required for regional marine planning

Most of the identified gaps in knowledge were related to a limited spatial extent of existing information for regional marine planning purposes (Table 4). For example, the Recherche Archipelago has benefited from numerous and varied studies which have documented and spatially described most of the important marine bio-physical and socio-economic values in that area. However, this level of thematic and spatial detail is rare across the rest of the south coast, particularly east of the Recherche Archipelago across to Eucla, and between Albany and Augusta.

Marine planning sectors that have a legislated or other special requirement for spatial data capture and management, such as shipping and ports, minerals and resources and administration and management sectors, tend to have well organised and easily accessible data.

The main requirements for more information for regional marine planning are in the areas of marine bio-physical description and human uses such as commercial fishing and recreational activities.

In particular there was an identified lack of spatially comprehensive information describing:

- Marine benthic habitat information across the region. Several existing datasets were identified and acquired, but gaps still exist. Additionally, it was recognised that the different objectives and technology/methodology used in the production of those existing data made it difficult to integrate and compare marine environmental values between/amongst them;
- Moderate/high resolution bathymetry across the region, a fundamental dataset for a wide range of applications;
- Suitable resolution coastal landform mapping. Existing mapping of the coastal types across the region was thematically and spatially coarse and not continuous across the region;
- Sub-IMCRA regionalisation of the region. It was recognised that there is significant diversity of ecosystems within south coast IMCRA regions which were undescribed/undefined;
- Marine recreational activities. Little or no information existed to describe the types and distribution of marine recreational activities comprehensively across the region.
- Commercial fishing values/important areas. Existing Catch and Effort Reporting data were considered too spatially coarse (60 nm grid blocks), and consider only tonnage and $ value of catches. It was recognised that there are many other factors involved in what makes an area favourable to commercial fishers.
- Indigenous cultural values. Little information was readily available to describe Aboriginal cultural values (other than sites in the Aboriginal Heritage Register) in a spatial or otherwise comprehensive format across the region.

Outcome: Recommendations for gap-filling work – Phase 2

Phase 2 was initially planned to run for 6 months from July 2007, but was later extended to 12 months. Given this initial timeframe, and with resources limited to one FTE employed officer with modest operational funds, there was no capacity for field surveys or to engage scientific or cultural consultants to assist with the capture of new information.

Given these constraints, an assessment was made to focus Phase 2 of the project on projects that could leverage the South Coast Regional Marine Planning community consultation process, and to utilise existing contacts made through Phase 1, in the production of:

- Collection of community recreational marine usage data;
- Coastal landform mapping;
- Sub-regionalisation of the south coast;
- Satellite remote sensing of marine benthic habitats;
- Commercial fishing values mapping, and;
- Data management for production of the SCRMP Strategic Plan;

Objective: Reporting

- Progress to be reported weekly/fortnightly (as required) to the Project Manager Ian Herford.
- Complete Quarterly progress and financial reporting obligations for SCNRM, reporting progress against milestones/timeline.
- In July, at the end of Phase 1, a report detailing SCRMP information and requirements, as identified by the SCRMP team through Marine Working Group meetings, etc, against the information that had been acquired by then during this project, was prepared. This report also included an analysis of possible future data collation work.

Outcome: Quarterly reports

Quarterly reporting to SCNRM was completed as required, all final reports are stored in \SouthCoast_GIS\Documents\SCNRM\ALL_FINAL_QR_REPORTS\

Outcome: Progress reports

Several progress reports were completed as required, stored in \SouthCoast_GIS\Documents\ProjectReports\ProgressReports\

Outcome: Phase 1 report

A summary report for Phase 1 was completed, stored in \SouthCoast_GIS\Documents\ProjectReports\ProgressReports\

Phase 2 Objectives and Outcomes

Phase 2 aimed to:

1) where possible within time and budget constraints, produce or commission the production of datasets to fill gaps in knowledge;
2) review information gathered and produced for SCRMP and recommend further strategic data acquisition as required.

It was recognised that a paucity of high-quality data available for marine planning is common, often due to the high cost or difficulty involved in producing such data across large areas of ocean. With limited time and funding resources, it was necessary to limit new data creation projects to desktop mapping or through community input via the SCRMP consultation process. Thus an analysis of what new data creation was feasible during Phase 2, within the given constraints, was required.

The following objectives were defined to address gaps in knowledge within the given timeframe and available budget.

- Collection of community recreational marine usage data;
- Coastal landform mapping;
- Sub-regionalisation of the south coast;
- Satellite remote sensing of marine benthic habitats;
- Commercial fishing values mapping;
- Data management for production of the SCRMP Strategic Plan;
- Recommendation of further data acquisition.

Objective: Collection of community recreational marine usage data

The SCRMP process recognised the high importance the south coast and broader WA community places on marine recreational activities in the south coast region, and the many socio-economic benefits that flow from these activities. Despite this high value, there was very little spatial information available which covered the region consistently, and for all different kinds of marine activities. Several reports and datasets were identified, but these typically either focussed on only a few activities, or a small study area (see Buckley 2009).

The objective was to gather indicative information about the spatial distribution of the most highly valued marine recreational activities across the south coast region. The information gathered must be spatially and thematically comprehensive, covering the whole region and all marine recreational activities.

Outcome: The SCRMP Community Recreational Marine Usage Survey 2007-2008

A significant opportunity was identified, to use the community consultation process of SCRMP, for data collection about the participants' recreational usage of the south coast marine environment.

A survey was designed to capture spatial information about the types, distribution and values of various marine recreational activities, to be presented as part of the SCRMP Community Workshop series, and then later modified and extended out via various distribution points as a reply-paid postal survey.

The survey report **FinalSCRMP_RecMarineUse_Survey_report.pdf** is contained in \SouthCoast_GIS\Documents\SCRMP_MarineRecSurvey

A guide to using the database which stores the data collected through the survey was also produced and should be referred to by anyone who intends to continue the survey, or to analyse or view the results.

The database guide **SCRMP-RecMarineUse_survey_DatabaseGuide.pdf** is contained in \SouthCoast_GIS\Documents\SCRMP_MarineRecSurvey

The database **SCRMP_RecMarineUsageSurvey-FINAL.mdb**, and accompanying spatial data layer files are found in \SouthCoast_GIS\Data\GIS\Recreation\SCRMPSurvey

SUMMARY FROM THE SURVEY REPORT

"From October 2007 to March 2008, as part of the South Coast Regional Marine Planning process, this survey was run to capture information about the distribution and types of marine recreational activities that the south coast marine user community participate in. The study area was from Eucla in the east to Cape Leeuwin (Augusta) in the west.

The survey was distributed principally in conjunction with the South Coast Regional Marine Planning process Community Workshop series, held Augusta, Manjimup, Kojonup, Denmark, Albany, Bremer Bay, Hopetoun, Esperance, Kalgoorlie and in Perth. The survey was also available to download from the Regional Marine Planning website, and was stocked in numerous distribution points such as Department of Environment and Conservation, Department of Fisheries and Department of Planning and Infrastructure offices, marine-oriented shops, accommodation centres and telecentres.

262 responses were received in the survey period, which provided indicative information about the most popular activities, and the distribution of those activities across the coast. The 10 most popular activities reported were Fishing, Swimming, 4WDing, Camping/picnicking, Walking/Hiking, Diving/Snorkelling, Beachcombing, Surfing, Whale-watching, and Other Wildlife-watching. The areas that these activities were undertaken tended to coincide with major population centres, as well as where the coast was particularly accessible or suitable for those activities.

The survey was considered to be successful in providing indicative information; however, there were too few responses received to be able to draw detailed statistics about the average number of days people would spend doing an activity in an area, or how much they valued different areas for the different activities.

The format of the survey successfully enabled respondents to complete it unsupervised, and suitable information was captured to allow spatial display and interpretation of the results in GIS (Geographical Information Systems) format. It is recommended that the survey be continued for as long as possible to increase the value and useability of the database, and to allow more detailed analyses to be undertaken from a greater population sample size. "

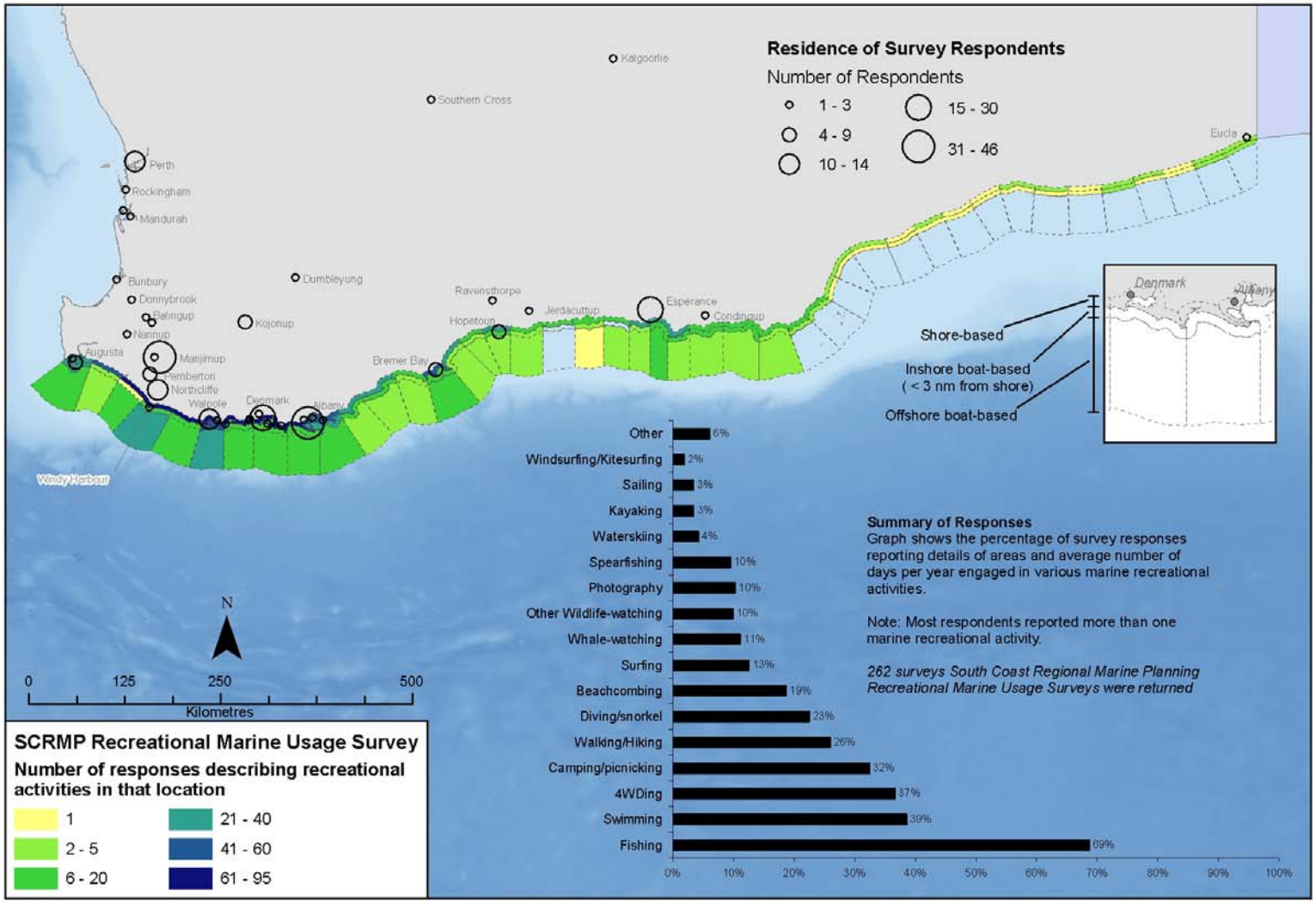

Figure 3: Map of summarised outcomes of the SCRMP Community Recreational Marine Usage Survey.

Objective: Mapping of Coastal Landforms

It was recognised that quality coastal landform mapping was useful for many marine planning and management applications, from coastal/intertidal habitat mapping to oil spill response management and first-pass coastal vulnerability assessments. Existing data were either coarsely mapped, both spatially and thematically, or had limited uses outside of their original purpose. These datasets included:

- *Coastal Environs* mapping by Patrick Hesp and Ian Eliot for DPI (2002, state-wide scale mapping of broad coastal types, see http://www.planning.wa.gov.au/Plans+and+policies/Publications/312.aspx
- Oil Spills Response Atlas (OSRA) mapping. Variable scale resolution, updated as required from various source linework. Simple classification scheme for the purpose of managing oil spills responses.

The objective was to use the best, most accurate and detailed spatial data available (most recent High Water Mark mapping, satellite imagery, orthophotography, and geological mapping) to map coastal landforms using a standardised, hierarchical classification scheme that could be used with different scales of mapping and interpretation possible across the region. It was recognised that more remote areas, such as the Recherche to Eucla coast, would likely have less, or lower quality available information.

Outcome: Smartline – high resolution desktop mapping using a nationally-recognised classification scheme

In order to produce a nationally-consistent dataset of coastal landforms, contact was made with Dr Chris Sharples of the University of Tasmania, who was creating a national classification scheme for coastal landform types. The Australian Coastal Smartline Geomorphic and Stability Mapping project was funded by the Australian Greenhouse Office to deliver a 'first-pass' dataset to identify coastal types around Australia, for the primary purpose of identifying areas at risk of sea level rise. His coastal mapping system, Smartline, was identified as being suitable for a very wide range of applications, and the cross-regional study area provided by this project assisted Dr Sharples in his classification development.

Thus a joint project was formed where original mapping work would be done through the South Coast GIS project, and the data delivered to Dr Sharples for further classification and integration into the national dataset. The objective was to produce a fine-scale dataset of coastal landforms which included the classification of intertidal, near-shore subtidal and back-shore environments, as well as underlying geology and backshore profiles.

Dr Ian Eliot, a coastal geomorphologist volunteering in the Marine Policy and Planning Branch, assisted with the classification of coastal landforms for detailed mapping by GIS volunteer Michael Higgins. Ian Eliot also attended the Australian Coastal Smartline Geomorphic and Stability Mapping Project Workshop, where the structure and contents of the classification system were discussed. The project workshop report **CoastalGeoMap_Workshop_Report.pdf** is stored in \SouthCoast_GIS\Data\GIS\Geoscience\Geomorphology\Coast_Characterisation\AustCoastSmartlineProject

Michael Higgins used the most recent available (Nov 2007) Mean High Water Mark from Landgate coastline data as a base line to split and classify, based on the coastal environments interpreted either side of that line. Orthophotos and high-resolution satellite imagery, as well as GoogleEarth® scenes were the main contextual layers for information to justify splitting the line. For a large portion of the coastline, Michael also recorded any visible coastal access points, such as 4WD tracks. This dataset **CoastalAccessPts_sthcst_20070907.shp** is stored in \SouthCoast_GIS\Data\GIS\Recreation

Linework was interpreted at scales of 1:10,000 to 1:250,000, depending on the availability of orthophotography or satellite imagery. Mean High Water linework was split where a change in either the subtidal, intertidal, or backshore geology or geomorphology was observed in the available imagery, or where a change in exposure

was identified. Characteristics used to split the line were provided by Dr Chris Sharples through the development of his Smartline classification hierarchy, described in the associated Smartline manual.

The first-pass detailed interpretation was completed by Michael Higgins, using the classifications provided by Dr Chris Sharples, which were then reviewed by Ian Eliot and Ewan Buckley, prior to delivering the work to the University of Tasmania team. The Smartline team then integrated the raw data into the national dataset and added attributes of backshore profile, and underlying geology, based on available elevation and geological mapping data.

At the time of publication of this report, the Australian Coastal Smartline Geomorphic and Stability Mapping Project datasets and reports were available only in draft form. Updates on the progress of the project are available via the Ozcoasts website http://www.ozcoasts.org.au/

The draft Australian Coastal Smartline Geomorphic and Stability Mapping Project manual **ACVGeo_Manual.doc** is contained in \SouthCoast_GIS\Data\GIS\Geoscience\Geomorphology\Coast_Characterisation\AustCoastSmartlineProject

The beta-version dataset **auscstgeo-v1-beta5_wa_20080505.shp** is stored in \SouthCoast_GIS\Data\GIS\Geoscience\Geomorphology\Coast_Characterisation\AustCoastSmartlineProject

The original dataset, interpreted by Michael Higgins, Dr Ian Eliot and Ewan Buckley is **SmartlineCoast_sthcst_20080107.shp** stored in \SouthCoast_GIS\Data\GIS\Geoscience\Geomorphology\Coast_Characterisation

The significant contribution of both Michael Higgins, and Ian Eliot, working as unpaid volunteers on this project, is gratefully acknowledged. Michael spent several weeks on the detailed GIS work required for this project, and Ian Eliot contributed weeks to the review process.

This project also initiated the engagement of Dr Julie Bowyer, employed as a contractor by the University of Tasmania, to extend the mapping project around the rest of the WA coast. This enabled the extension of the Smartline classification for all available coastal mapping for WA – a significant achievement. Julie was supervised by Ian and Chris, with GIS support provided by the DEC Marine Policy and Planning Branch Marine Information Section.

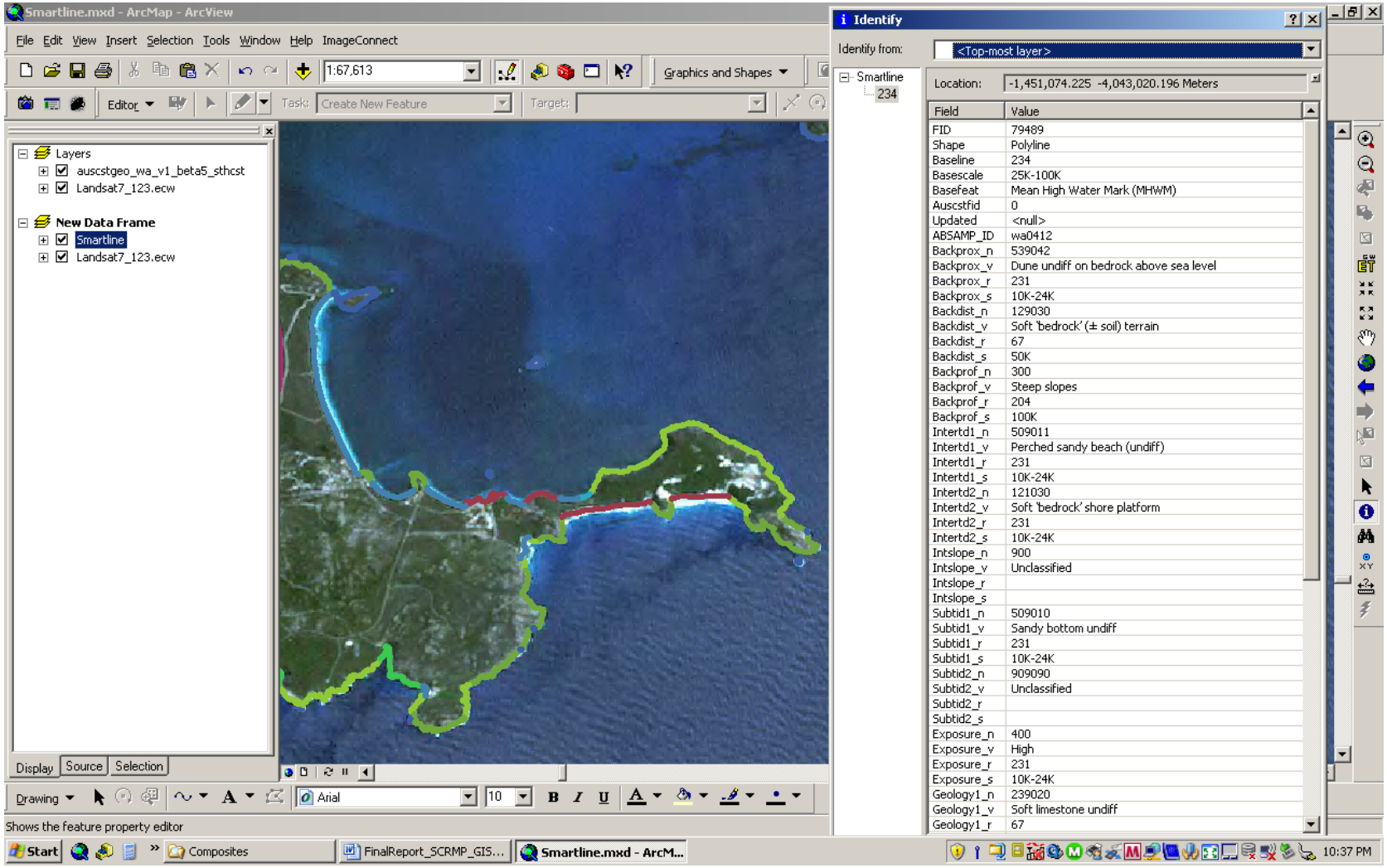

Figure 4: ArcMap screenshot showing the area near Bald Head, Albany, with Smartline symbolised by different intertidal coastal types. The Identify results box shows the key attributes contained in the data, for one selected line segment.

Objective: Investigate a sub-regionalisation of the south coast

Broadscale geological and geomorphological processes are a major factor in the distribution of biodiversity, and human uses of the marine environment. These processes can be summarised and characterised with the concept of coastal compartments and sediment cells.

Extract from Eliot *et al.* (2009, in prep.)

"Coastal sediment compartments are large, regional scale features of the coastline. They are comprised of a complex array of physical landforms and coastal processes in which the state of the environment is highly dynamic, varying over space and time. The array of landforms differs between adjacent compartments with respect to characteristic landforms, coastal processes or some combination thereof.

A coastal sediment compartment is a natural management unit for the conservation of sediment and ecosystems as well as development of strategies for mitigation of environmental risks. Potentially, managing the coastline through an approach based on sediment compartments provides focus on management of change. It facilitates recognition of components within each compartment that are subject to different levels of susceptibility to change and provides scope for proactive adaptation to changing environmental conditions.

A sediment cell is a reach of coast, including the nearshore terrestrial and marine environments, within which movement of sediment is readily identifiable if not largely self-contained. As defined in the literature (Komar 1996), sediment cells are segments of the coast in which sediments that are being or have been derived from a common origin or source can be traced along transport paths to a sink where they are temporarily or permanently lost to the coast. For example calcareous sands originating as skeletal material from animals growing on an offshore reef near Mandurah in South Western Australia may be moved landward to comprise part of the beach at Secret Harbour and ultimately be blown into a dune in Warnbro Sound or moved into deep water off the continental shelf seaward of Rottnest. Exchange of sediment across boundaries between adjacent cells may occur, although it may be limited and highly variable. In this respect a sediment cell provides a natural unit for estimation of a coastal sediment budget (Dolan et al 1987; Komar 1996; Rosati 2005) as well as identification of areas undergoing erosion or accretion and the linkages between them."

New work in defining coastal compartments at various hierarchical levels was seen as an opportunity to begin a sub-regionalisation of the south coast, based on broadscale geomorphological units. Such mapping can provide ecosystem-based planning and management units, which for some applications, such as coastal infrastructure, marine reserve or fisheries and aquaculture planning, could augment or replace traditional administrative or jurisdictional boundaries that often have little or no relationship to important environmental processes.

The objective was to map coastal compartments at a variety of spatio-temporal scales/hierarchical levels, and to instigate further research into the applicability of this methodology across a wide range of marine and coastal planning processes.

Outcome: Preliminary mapping of Primary, Secondary and Tertiary coastal compartments, sediment cells, sinks and sources.

Desktop mapping of south coast coastal compartments was originally undertaken by Ian Eliot, Michael Higgins and Ewan Buckley, and research into the applicability of this methodology across a wide range of marine and coastal planning processes was initiated.

Extract from Eliot *et al.* (2009, in prep.)

"Boundaries of the compartments were identified on the basis of the following:

Priority	Feature	Examples

1	Changes in bedrock geology	Metamorphic to sedimentary rocks; lithified to unconsolidated sediments
2	Rock structures (topography)	Rocky capes, peninsulas, termination of extensive cliffs
3	Geomorphic features (morphology)	Large cuspate forelands and tombolos; extensive sandy beaches
4	Change in aspect of the shore	Bald Head at the entrance to King George Sound

The following steps were used to identify primary coastal compartments:

Major changes in lithology along the coast were identified from the 1:500 000 Geological Map. These provided the first approximation of boundaries for identification of 10 primary compartments between Cape Leeuwin and the border with South Australia (Figure 6).

The primary compartment boundaries were then adjusted with reference to the 1:250 000 Geological Map, the 1:100 000 Topographical Map Series and satellite imagery available on Google Earth 2008 ®. The adjustment was made to accommodate apparent change in the orientation of the coast, as occurs close to as well as to incorporate complete landforms of regional significance broadly in accord with the scheme proposed by Semeniuk (1986), such as the De Grey River delta (Pilbara)."

Further to the identification of primary and secondary compartments, Eliot *et al.* (2009, in prep.) identify regions (also known as sub-regions), at a hierarchical level above primary cells, and tertiary cells (also known as sediment cells), at a level below secondary cells (Figure 5). At the time of writing this report, secondary and tertiary cells were being reviewed as part of the ongoing DPI/DEC funded project.

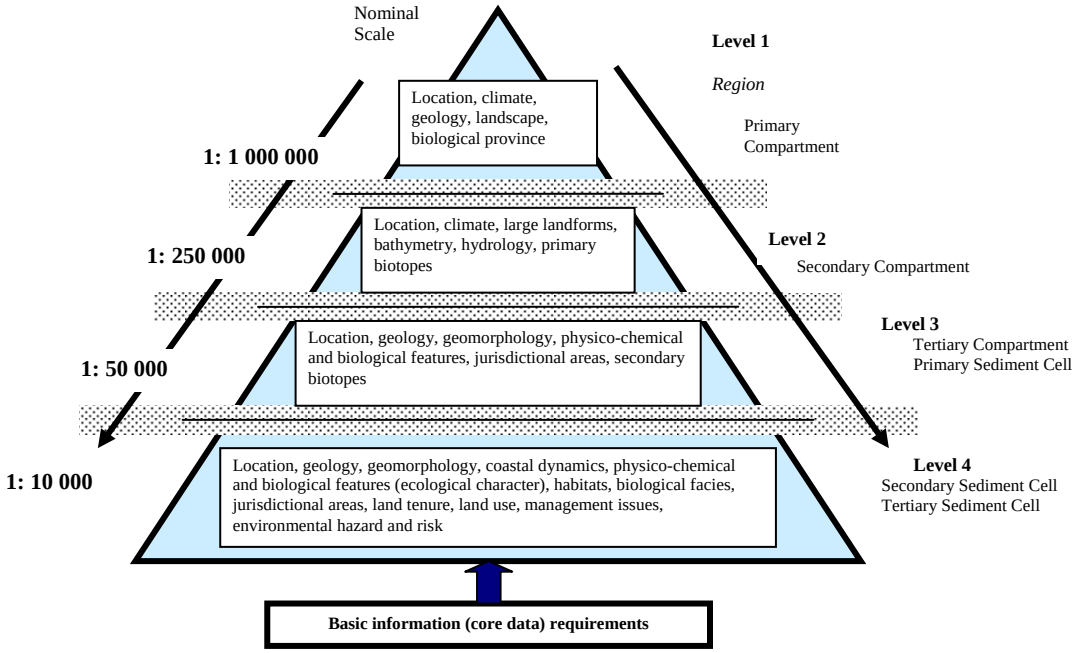

Figure 5: The hierarchy of compartment sizes, nomenclature, nominal scale and characterising information.

The South Coast Region incorporates four geomorphic sub-regions. From west to east these are Flinders, Baudin, Thijssen and Giles, and ten primary coastal compartments, as shown in Figure 6. The sub-regions, primary compartments and secondary compartments are further described in Appendix B.

Note the anomalous small size of the Albany Primary coastal compartment in Figure 6. Preliminary assessments of this area highlight the unique geology and geomorphology combining with an abrupt change in coastal aspect/orientation and a unique set of climatic and oceanographic conditions to create this transitional zone between the Nullaki and Cheyne compartments. Seasonally dominant SW and SE wind-driven current systems appear to converge in this area, and persistent Leeuwin Current eddies offshore, driven by a change in the aspect of the Continental Shelf and interactions with the Albany Canyons further emphasise the unique character of the area. Discussions with fishery researchers indicated the possibility of locally isolated populations of mulloway *Argyrosomus japonicus* and pilchards *Sardinops sagax* in the Albany harbours, whereas populations of these species tend to be more genetically diverse in other areas (pers. comm. Dan Gaughan (DOF), and Bryn Farmer PhD candidate).

These factors combine to indicate a uniquely small compartment where a variety of geologically inherited environmental conditions enhance a localised character and suite of coastal processes, which may influence the breeding and recruitment of important fish species.

If validated, this example would demonstrate the value of coastal compartment mapping in establishing a framework to assist in the planning and management of fish species, and which would likely relate to other fisheries, biodiversity values, and coastal planning involving sediment budgets/dynamics (such as dredging plans, spoil dumping, coastal infrastructure developments and invasive species dispersal).

The datasets describing primary and secondary compartments are:
CoastalComp-Regions_wa_20090518.shp
CoastalComp-Primary_wa_20090518.shp
CstlCompts-primry_sthcst_20080512.shp
CstlCompts-secnd_sthcst_20080512.shp, stored in
\SouthCoast_GIS\Data\GIS\Geoscience\Geomorphology\CoastalCompartments\

Following this preliminary mapping work for the south coast, a state-wide project was initiated, funded by the Department of Planning and Infrastructure and Department of Environment and Conservation, which builds on the work originally done for the South Coast GIS project, and will further develop the approach and will integrate the south coast project into a state-wide dataset and report.

The draft preliminary report (Eliot *et al.* 2009) is currently in production, describing the application of coastal compartment mapping to planning and management, and summarises the methods used to delineate compartments and other features.

The draft report **DRAFTSouthCoast_CoastalCompartments_SCRMP-GIS_20090530.doc is stored in \SouthCoast_GIS\Data\GIS\Geoscience\Geomorphology\CoastalCompartments**

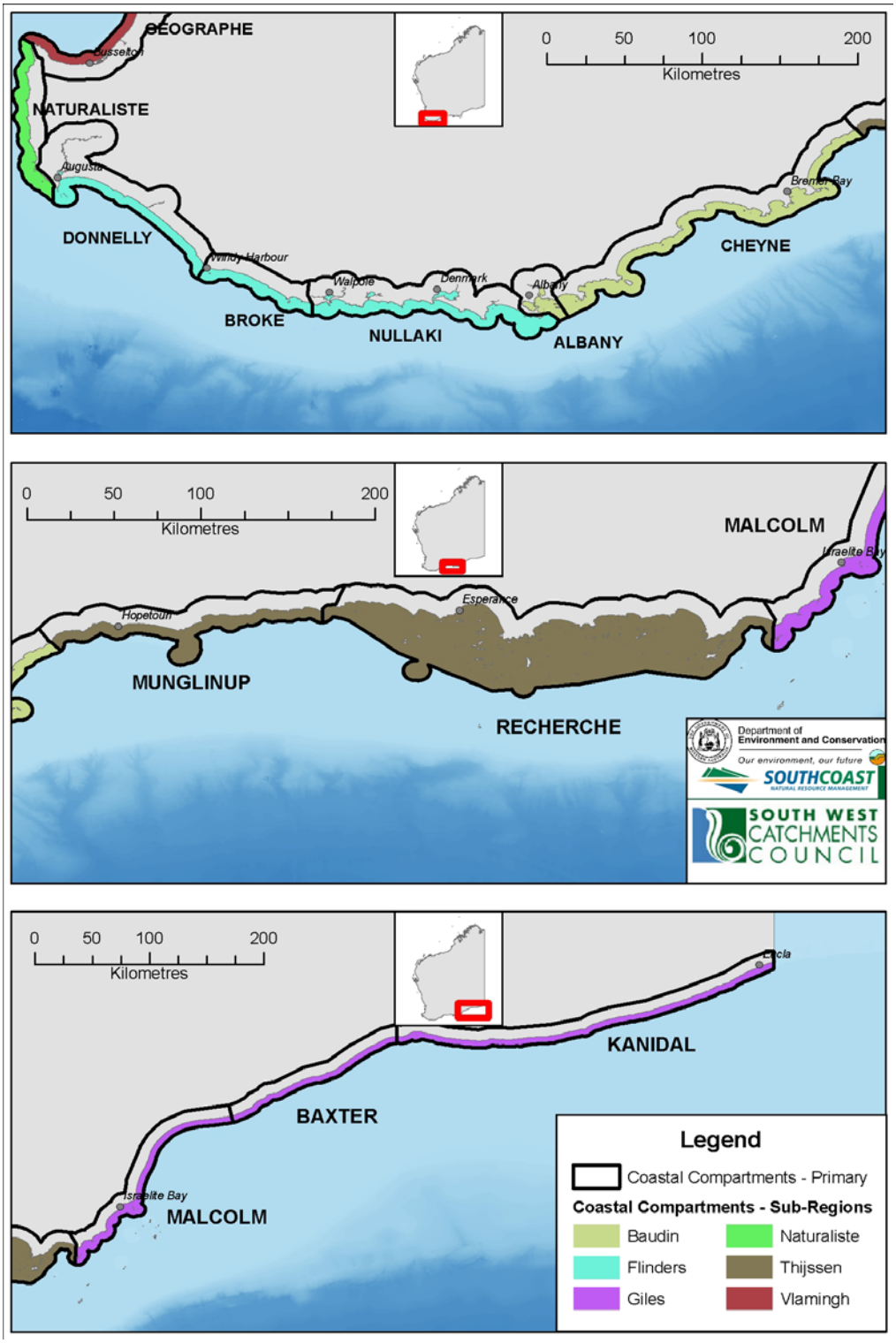

Figure 6: Regions (sub-regions) and primary coastal compartments of the south coast

Outcome: Instigation of state-wide mapping and research into planning and management applications

Following the completion of preliminary coastal compartment mapping for the south coast, a project was initiated to extend the work around the state, with an emphasis placed on researching the applicability of the coastal compartment concept to state-wide marine and coastal planning and management. At the time of writing, this was a joint project, funded by DPI Strategic Planning and DPI Marine (Charlie Bicknell) with in-kind support from DEC engaging Ian Eliot and Chris Nutt (DEC Marine Policy and Planning Branch) to supply primary and secondary coastal compartment mapping from the Kimberley to Eucla. Ian Eliot is working with Departments of Environment and Conservation, Planning and Infrastructure, and Mining and Petroleum on the potential application of coastal compartments for marine and coastal planning and management, including its relevance to the State Coastal Planning Policy (SPP 2.6).

Objective: Satellite remote sensing of marine benthic habitats

Satellite imagery can provide highly valuable contextual data for the identification of marine environmental values, however is rarely suitable for this purpose in its raw form, or when it has been gathered for land management purposes. Due to the absorption of light through the water column, the effects of turbidity and sea-surface interference from breaking waves and sunglint, imagery needs to be specially selected or enhanced for water penetration.

As well as for a simple visual contextual application, satellite imagery can be analysed more specifically to reveal more detailed information about benthic substrates. With suitable imagery and using latest techniques, it is possible to classify remotely sensed images for benthic habitat mapping, even to genus or species levels under perfect conditions.

One objective was to commission DEC Remote Sensing to process available catalogues of imagery for water penetration, and to produce a single image layer covering the south coast region for use in identifying benthic substrate features.

A second objective was to investigate the applicability of advanced remote sensing techniques for broadscale habitat mapping of remote, inaccessible areas of the south coast region.

Outcome: Satellite imagery enhancements

Satellite imagery can provide valuable contextual marine information over large areas, showing the locations of different benthic biophysical features as a continuous surface, as do aerial photographs over terrestrial areas. However, for marine and coastal applications, images are often limited for this application by the presence of sun-glint due to the reflectance of sunlight by waves, by turbidity in the water column, or by cloud cover. To identify which images out of a series are most suitable for use as a contextual layer can be a very time consuming process, and furthermore, parts of one image may be suitable whilst other parts of the same image are not. Thus it can be difficult to identify and collect images that span several image scenes for use in displaying the marine benthic features at a regional scale.

To address these problems, a time series of Landsat satellite imagery (multispectral, 25m resolution) was processed to enhance the visibility of marine benthic features in the shallow-water coastal zone across the south coast. DEC Remote Sensing (Kathy Murray) undertook the work, at a minimal cost of $3,000, utilising existing archives of satellite imagery and a new technique for the rapid production of enhanced imagery.

In this technique, in development by DEC Remote Sensing for marine applications, multiple images of the same areas are processed to extract the pixels with the minimum (darkest) value of the set, pixel-by-pixel over the extent of the images. Therefore, this ignores any pixels with sun-glinting, waves breaking, or with turbidity in the water column, due to suspended sediment such as sand in the surf zone, for example, as pixels with these sources of interference tend to have higher reflectance values (i.e. are brighter in colour). This technique also assumes that the darkest pixel of the set is the one with the greatest water penetration, i.e. the pixel that is ‘seeing’ the deepest. The ‘blue’ band of the Landsat imagery (Band 1) is primarily used for this technique, as it achieves the highest water penetration.

The resultant image is then created by the composition of all of the extracted ‘darkest’ pixels of the time-series – thus it is a composite image, where each pixel has been taken from any image of the set in which it had the lowest reflectance value. This composite is then adjusted to provide the greatest contrast between different coloured areas – thus providing a contextual layer of darker and lighter areas of the visible benthos. These different shades can then be interpreted as reef, seagrass, sand, and/or deep and shallow areas, for example. An example of the enhancement, compared with a single Landsat image, is shown in Figure 7.

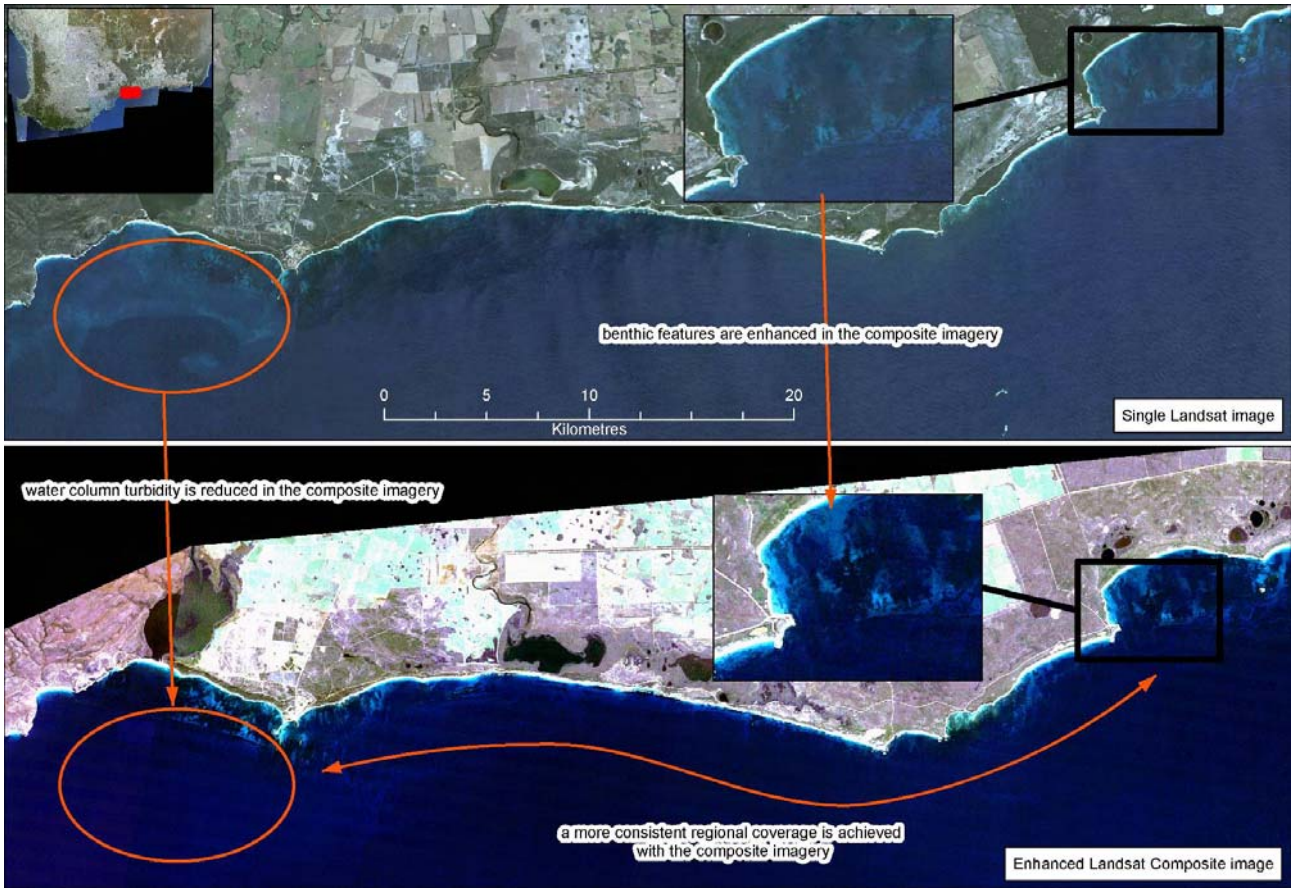

Figure 7: Map showing some differences between the enhanced composite Landsat imagery and a single Landsat image.

Images produced through this method are useful for background display, manual digitising of benthic features (as was done in Phase 3 of this project), study area identification, and may be of use in automated image classification, such as the object-oriented image classification techniques of software such as eCognition. Such software uses object shapes/textures as one input into a classification system, along with spectral reflectance properties. The enhanced shapes produced by this technique may assist such classification processes.

Whilst the imagery produced using this technique does provide an apparently enhanced view of the benthic features in shallow waters, there are several limitations to its use in marine benthic habitat mapping:

- Due to the nature of the composites being created from multiple image sources, each pixel could be from a different original image. Therefore neighbouring pixels may have different spectral properties and radiometric calibrations, even though they appear to show the same kind of feature. Thus, automated image classification techniques that analyse image pixel spectra, such as the SAMBUCA technique described further below, would be confounded by such variations in pixel statistics.
- The 'dark' features highlighted by the technique represent a maximum-extent view, over the time series of the images used. For example, if in a particular year, a larger than 'normal' extent of seagrass or algal growth is observed over what would usually be a lighter sandy area, then this would persist in the resultant composite, as the darker pixels of the maximum vegetation extent would be selected for the creation of the composite.
    - Conversely – the lighter areas in the composites would likely represent areas that persistently have a sandy, or lighter, substrate over time.
    - This effect also has advantages in assessing basic change detection, which can assist in the discerning the difference between, for example, static macroalgal/reef habitats, and seagrass habitats which may be more subject to expansion or contraction of their extents over time.

This technique also has potential applications in substrate change detection, where comparisons are made between images taken at different times, in order to analyse the differences between the two (or more) images. In the simplest form, this kind of analysis can be done qualitatively by comparing the composite imagery with any single image that shows the substrate with some clarity. If it is assumed that the composite shows a maximum-extent of features over the time series of images used in its production, and a particular feature is different to the same feature identified in the single image, then this difference can be used to ascertain the likelihood of that feature being a more dynamic seagrass meadow rather than a static reef, or example.

DEC Remote Sensing is investigating the application of more quantitative change detection using this and other similar techniques, which would yield rapid, low cost results which may provide information to trigger more in-depth analysis. The most robust change detection analysis would come from more detailed analyses involving field work and image corrections, such as the SAMBUCA processing described below. Such correction techniques allow any atmospheric, sea surface or water column variability between two images to be 'removed', thus leaving only substrate variability for the analysis.

The report **Landsat-Composites_sthcst_20071114.doc** outlines the enhanced composite imagery project and the output image files produced. The report and the images are stored in \SouthCoast_GIS\Data\GIS\Contextual\SatelliteImagery\Landsat\Composites

Outcome: Investigation into satellite remote sensing of marine benthic habitats

Information (as georeferenced images) gathered by high-resolution multi- or hyper-spectral satellite or aircraft mounted sensors can be analysed using advanced image processing techniques to yield information about the marine benthos and water column properties, such as substrate/habitat type, bathymetry and water quality characteristics.

Remotely sensed images of optically-shallow coastal waters represent the reflectance of incident sunlight from a combination of atmospheric, water surface, water column and marine substrate sources. Using the known physical light absorbing/reflecting properties of these sources, and with high quality imagery, models of the relative contribution of each of these to the total measured reflectance can be produced. From these models, the 'interference' caused by atmospheric and water column parts of the model can effectively be removed, leaving a model of the reflectance of light spectra of the marine benthic substrate only. These spectra can then be compared against known reflectance values of various substrate types to produce maps of marine benthic habitats.

Until recently, these techniques have been limited to research applications, but increasingly, marine planners and managers are using such techniques for broadscale habitat mapping and habitat change detection. CSIRO Environmental Earth Observation (Theme Leader: Dr Arnold Dekker) is researching the application of standardised procedures to marine and coastal baselining and marine environmental monitoring operations around Australia, with the end goal of having a suite of standardised tools and methods available nation-wide, for marine management authorities or natural resource management groups to use to produce comparable, standardised information. Currently, many different projects are using different image sources and techniques, yielding different habitat/substrate classification results, which are then very difficult to compare between projects.

Advanced physics-based remote sensing habitat mapping techniques have several advantages:

- large areas can be mapped continuously, at the resolution of the image source;
- the techniques are objective and repeatable, thus can be used for baselining and change detection;
- depending on the image source, substrate/habitat mapping can be relatively cheap on a per-hectare basis;
- inaccessible areas can be mapped
- shallow areas (inaccessible to boats) can be mapped
- with very high quality imagery, vegetated cover of substrates can be mapped to family or genus level (e.g. *Posidonia* seagrasses, *Ecklonia* macroalgae, etc)

But also can have several limitations:

- 'success' is dependant on the procurement of high quality imagery, with little or no interference such as sun-glint or turbidity;
- Mapping is limited to the optical depth of the water, which varies with water quality and sun angles, but is generally less than 25 m, and usually most accurate in < 10 m;
- Hyper-spectral imagery typically yields better results, but is currently only readily available using aircraft, which adds significantly to the cost of image acquisition;
- The south coast climate, with many cloudy, windy, or high swell days, makes it very difficult to acquire suitable high-quality imagery.

Of particular use in investigating these techniques is the Coastal Remote Sensing Toolkit hosted by the University of Queensland which explains common image formats and specifications and remote sensing techniques and requirements
http://www.gpem.uq.edu.au/CRSSIS//tools/rstoolkit/default.html

And these and other habitat mapping techniques are comprehensively covered on the OzCoasts website
http://www.ozcoasts.org.au/

Other information can be found on the Geoscience Australia Remote Sensing website
http://www.ga.gov.au/remote-sensing/basics/index.jsp.

Landgate and DEC also provide remote sensing services through the Leeuwin Centre for Remote Sensing
http://www.rss.dola.wa.gov.au/leeuwin/

WA Universities Curtin, Murdoch and the University of Western Australia in particular have significant marine remote sensing expertise. For more details see the WA Marine Remote Sensing Workshop Proceedings **MarRemSensWshop_20081113_proceedings.doc** stored in
\SouthCoast_GIS\Documents\SthCst_RemoteSensingProject

Outcome: Involvement in national satellite image acquisition and processing project (NLWRA)

Through contacts developed whilst researching remote sensing of benthic habitats (Dr Arnold Dekker - CSIRO, Dr Richard Mount – University of Tasmania/NLWRA) for the South Coast GIS project, DEC was asked to coordinate the identification of WA priority areas for the acquisition of high-resolution satellite imagery for the National Land and Water Resources Audit project *Remote Sensing for Coastal Habitat Extent, Condition and Trend Assessment*.

See the project report **Remote_Sensing_Sub_Project_2_221107_Short.doc** in
G:\SouthCoast_GIS\Data\GIS\Contextual\SatelliteImagery\QuickBird\NLWRA_priority-areas

This project resulted in the purchase of several images (QuickBird and ALOS) covering south coast marine waters and estuaries, which are available for marine habitat classification work for a nominal fee. Details about this National Land and Water project can be viewed at http://www.auricht.com/Coasts/index.html. More details, including the digital catalogue of imagery, information about remote sensing, and how to obtain the data, are found on Geoscience Australia's website http://www.ga.gov.au/remote-sensing/index.jsp, and the OzCoasts website has comprehensive information about habitat mapping techniques and applications, available data, conceptual models and a range of other information http://www.ozcoasts.org.au/

Objective: Commercial Fishing values mapping

Existing data describing commercial fishing activities was limited to license and management area boundaries, and the Catch and Effort reporting data, captured in 60 nm grids. It was determined that this resolution of data was too coarse for meaningful usage in regional marine planning, and that tonnage and $ values do not necessarily capture all the values of the commercial fishing community. For example, a single grid block that appears to yield a high tonnage or $ value may only be fished on certain environmental conditions or times of year, whereas other areas that appear to be of lower economic value may be sustaining fishers at other times of the year when environmental conditions limit their fishing ranges.

Furthermore, it was recognised that the commercial fishing community is a valuable information resource for other biophysical information, such as observations of non-targeted species, climatic and oceanographic observations and trends in other environmental and human usage values. Engagement with fishers in data-gathering exercises is one method to better engagement in planning processes.

The objective was to capture finer-scale spatial information about commercial fishing values across the south coast, where those values were defined and reported by the fishers themselves.

Outcome: Commercial fishing workshops held by WAFIC

In March 2008, workshops were held by the WA Fishing Industry Council (Felicity Horn - WAFIC), in order to meet with invitees from the various south coast fisheries to discuss commercial fishing values, as defined by the fishers themselves. The goal was to capture information spatially, where possible, in order to describe different fishing areas, safe havens, important access points, vital infrastructure and other such values.

The workshops yielded valuable information regarding the spatial distribution of some key target species, their seasonality, and the fishing strategies of the fishers, as well as information about other marine life and physical factors. The information from the workshops was captured in a brief workshop report, authored and owned by WAFIC, which was then given to DEC for the purpose of information gathering for the SCRMP process.

IMPORTANT – THIS INFORMATION IS OWNED BY THE Western Australian Fishing Industry Council, ON BEHALF OF THE CONTRIBUTORS LISTED THEREIN. USAGE OF THIS INFORMATION MUST BE APPROVED BY WAFIC.

WAFIC CONTACT: FELICITY HORN.

The workshop report **WAFIC CommercialFisher RMP outcomes 12-3-08.pdf** is stored in \SouthCoast_GIS\Data\GIS\Economics\WAFIC. This PDF document is locked to prevent modification or printing. The password to unlock the document to allow printing or editing is ***SCRMPGIS***; this should not be unlocked/printed/distributed without approval from WAFIC.

Outcome: Mapping of commercial fishing values - according to fishers

Some of the information contained in the WAFIC workshop report described above had a spatial context which could be interpreted using dataset collected through the South Coast GIS project. With approval from WAFIC, DEC interpreted this information into several GIS datasets, generally describing the notes recorded about different fisheries or species.

These datasets are stored in \SouthCoast_GIS\Data\GIS\Economics\WAFIC

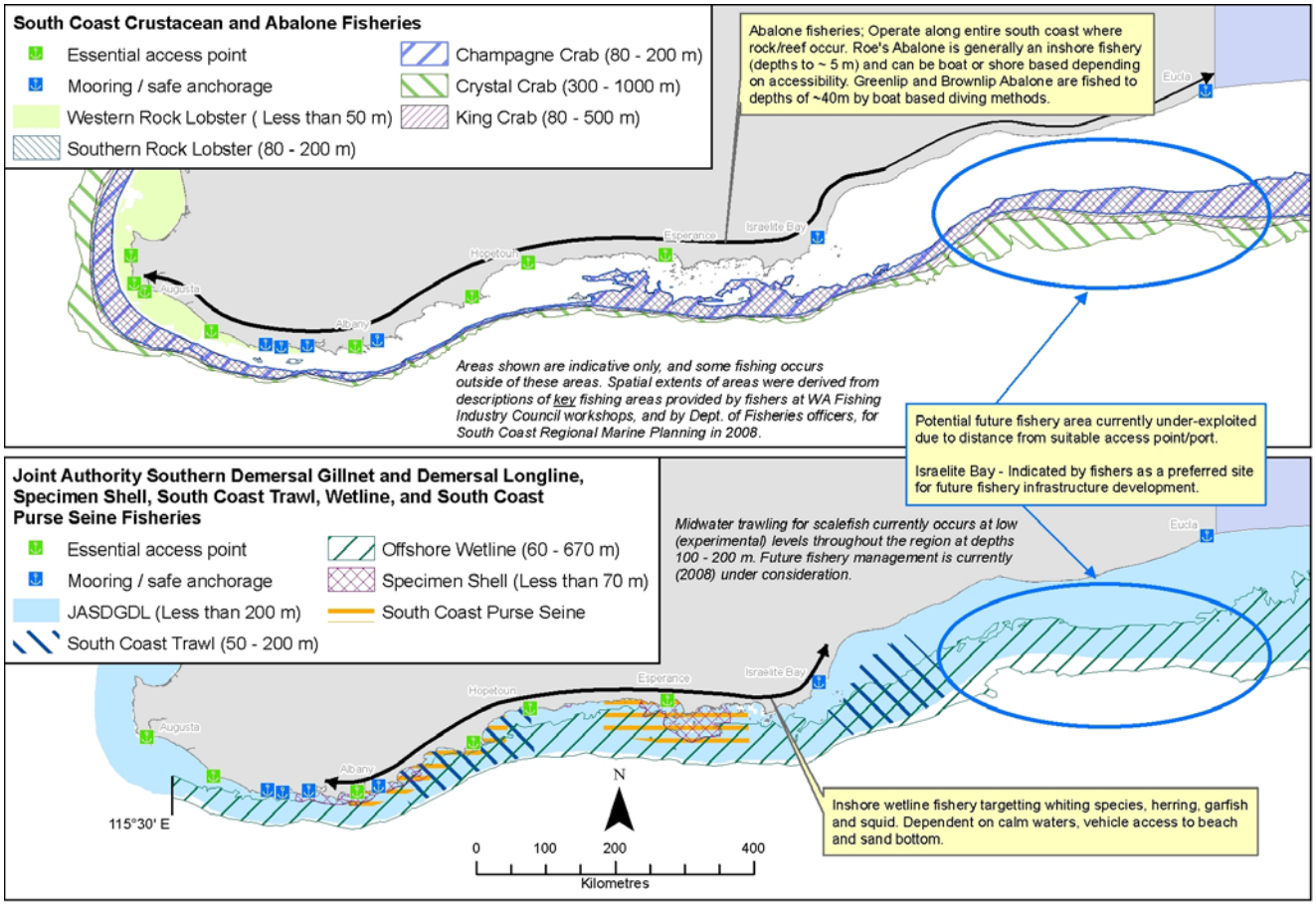

Figure 8: Commercial fishing values noted in WAFIC workshops March 2008.

Objective: Data management for production of the SCRMP Strategic Plan

As the draft South Coast Regional Marine Planning Strategic Plan was being developed, information requirements were also developing. There was a need to respond to data requirements, in map production and processing or analysis of data for content of the draft Strategic Plan.

The objective was to continue refining data requirements for regional marine planning, and to process data to satisfy SCRMP needs. This then adds to the database of existing information by providing new interpretations or analyses or information products from existing data, as required for SCRMP.

Outcome: Maps and other information products for the SCRMP process

Numerous maps, figures and statistics were requested by SCRMP planners throughout the process. Information was drawn from the database, and where appropriate, stored as new datasets, statistics, maps and other products.

General information products are stored in \SouthCoast_GIS\Products\ or in the relevant folders of the directory structure.

Objective: Recommendation of further data creation

With the detailed review and integration of all available information for SCRMP, and the addition of new information created through Phase 2, and in recognition of lessons learnt throughout Phases 1 and 2, comes the opportunity to recommend further data creation.

The objective was to recommend and plan for immediately achievable new data creation project/s and also to recommend more strategic directions for investment in marine information for planning and management.

Outcome: Development of Phase 3 – broadscale marine benthic habitat data collection and standardisation

Through Phase 1 and 2, numerous broadscale habitat mapping datasets were collected covering parts of the south coast primarily between Albany and Israelite Bay. These were:

- Fisheries Research and Development Corporation (FRDC) Fish Habitats of the Recherche Archipelago – a combination of field-based methods.
- CSIRO/Dr Hugh Kirkman seagrass habitat mapping between Albany and Israelite Bay – primarily desktop digitisation of aerial photos and satellite imagery with some groundtruthing
- DEC Marine Habitat Mapping – Cape Leeuwin to Cape Naturaliste, and some overlap with FRDC project. Combination of broadscale depth and geomorphology modelling with some groundtruthing
- Securing WA's Marine Futures data were available as draft only at the time of this project, and so were not included in the Phase 3 project. Marine Futures data are delivered to NRM groups via their own data management system - for final Marine Futures datasets and reports, contact the Centre for Marine Futures. GoogleEarth KMZ files of south coast Marine Futures results have since been stored in \SouthCoast_GIS\Data\GIS\Ecosystem\Habitat\MarineFutures

These various datasets were of varying spatial and attribute accuracy, with habitats classified differently between them. This makes standardised mapping and analyses difficult, as the different data were not directly comparable.

Phase 3 was developed to focus effort on the production of a standardised habitat mapping layer, incorporating some new mapping over areas where none was available, through manual digitising of Landsat image enhancements and integrating available broadscale mapping datasets into one layer for region-wide mapping and analyses. This project was developed to be undertaken over 6 months from July 2008. It was recognised that manual digitising of satellite imagery is a subjective technique, however it does achieve rapid, low cost indicative data where none previously existed, and with detailed documentation regarding the methods and image sources used, can be used in future comparisons with other data sources.

Outcome – Development of the South Coast Marine Remote Sensing project (CSIRO)

With joint funding from South West Catchments Council, whose focus area encompassed one of the planned study sites, the South Coast Marine Remote Sensing project was developed to investigate the feasibility of remote sensing of marine habitats in some inaccessible and un-mapped areas of the south coast. Upon advice from the CSIRO Environmental Earth Observation team, 2 QuickBird (2.5 m resolution, multispectral, 16 x 16 km extent) images were selected, covering an area offshore of Broke Inlet and the Roe Plains near Eucla. An additional Landsat scene area between Albany and Windy Harbour was also chosen for the project.

A contract Terms of Reference document was produced, further outlining the project set-up and aims: **Terms-of-Reference-RemSens_SthCst_2_10thDec.doc** stored in G:\SouthCoast_GIS\Documents\SthCst_RemoteSensingProject

Outcome: Recommendations for future data capture

Recommended directions for future data capture (post-Phase 3) include:

- more study areas of studies similar to the Securing WA's Marine Futures project;
- widespread high-resolution/continuous bathymetric mapping;
- investment in remote sensing techniques and tasking of satellites for marine remote sensing data capture to complement other techniques;
- continuation of the Recreational Marine Usage Survey;
- community-based habitat mapping, based on Phase 3 dataset;
- engagement of commercial fishers in environmental values mapping;
- research into relationship between localised, high-resolution mapping and broader less detailed mapping. i.e. how far can surrogacy go?
- Research into the usage of geomorphic and other physical surrogates for biodiversity mapping;
- Engagement of the south coast indigenous community in producing descriptive information layers of Aboriginal cultural values of the marine and coastal environment.

Phase 3 Objectives and Outcomes

Objective: Integrate and standardise existing broadscale habitat mapping

Gap analyses during the South Coast Regional Marine Planning (2008) process identified the need for a region wide, consistently attributed marine benthic habitat layer for the coastal marine environment between Cape Leeuwin and the WA-SA border.

Polygonised marine benthic habitat information that existed at the time consisted of three main layers, with the Department of Environment and Conservation (DEC), the Fisheries Research and Development Corporation (FRDC) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) each contributing. Each layer contained localised habitat descriptions for various sections of the study area. Attribution was unique to each layer, making region wide analysis difficult, and gaps existed along the coast where no information was available.

The objective was to integrate these and other broadscale benthic habitat mapping layers into a single layer with standardised attributes that can be analysed and queried.

Outcome: South Coast Marine Benthic Habitat GIS dataset

Chris Nutt appointed as Project Officer (DEC Marine Policy and Planning Branch) to complete SCMBH mapping project.

The purpose of this data set was to provide a continuous, consistently attributed, regional marine benthic habitat layer for the optically shallow waters between Cape Leeuwin and the WA-SA border. The data set was created through the collation of existing marine benthic information into one consistently attributed layer, followed by desktop mapping, using best available information and imagery, to provide a comprehensive coverage of the study area. Although not without its limitations, this dataset has successfully linked previous scientific research and habitat surveys with modelled information created through desktop mapping to provide a characterisation of marine benthic habitats that is comparable across the entire south coast of Western Australia.

Region wide coverage and consistent attribution are central elements for analysis and comparison of habitat characteristics over an area such as the south coast. Previously, benthic habitat data that existed for the south coast was localised to a few areas and each study group had a unique classification system. By breaking down the unique classification terminology into the individual physical and biological components this dataset provides a region wide solution to these issues, whilst still maintaining the integrity of the original data. Importantly this also allows users of the dataset to search, select, query and analyse the data based on the individual physical and biological components that make up the benthic habitat description.

Recognizing the need to provide a relative measure of confidence on a feature by feature level also gave as a result a first pass assessment of south coast marine benthic habitat data. This process is not exhaustive however, and as further advances are made in image technology, and this technology becomes more affordable, a secondary review would be a valuable exercise.

This dataset supplies coastal and marine planners with a useful broad scale marine benthic habitat layer for the south coast, and identifies areas with low finer scale representation and/or confidence providing a framework for further marine benthic habitat surveys in the region.

The project report **SCMBH_Report_20090622.doc** is stored in
\SouthCoast_GIS\Documents\SthCst_MarBenthHabMap\

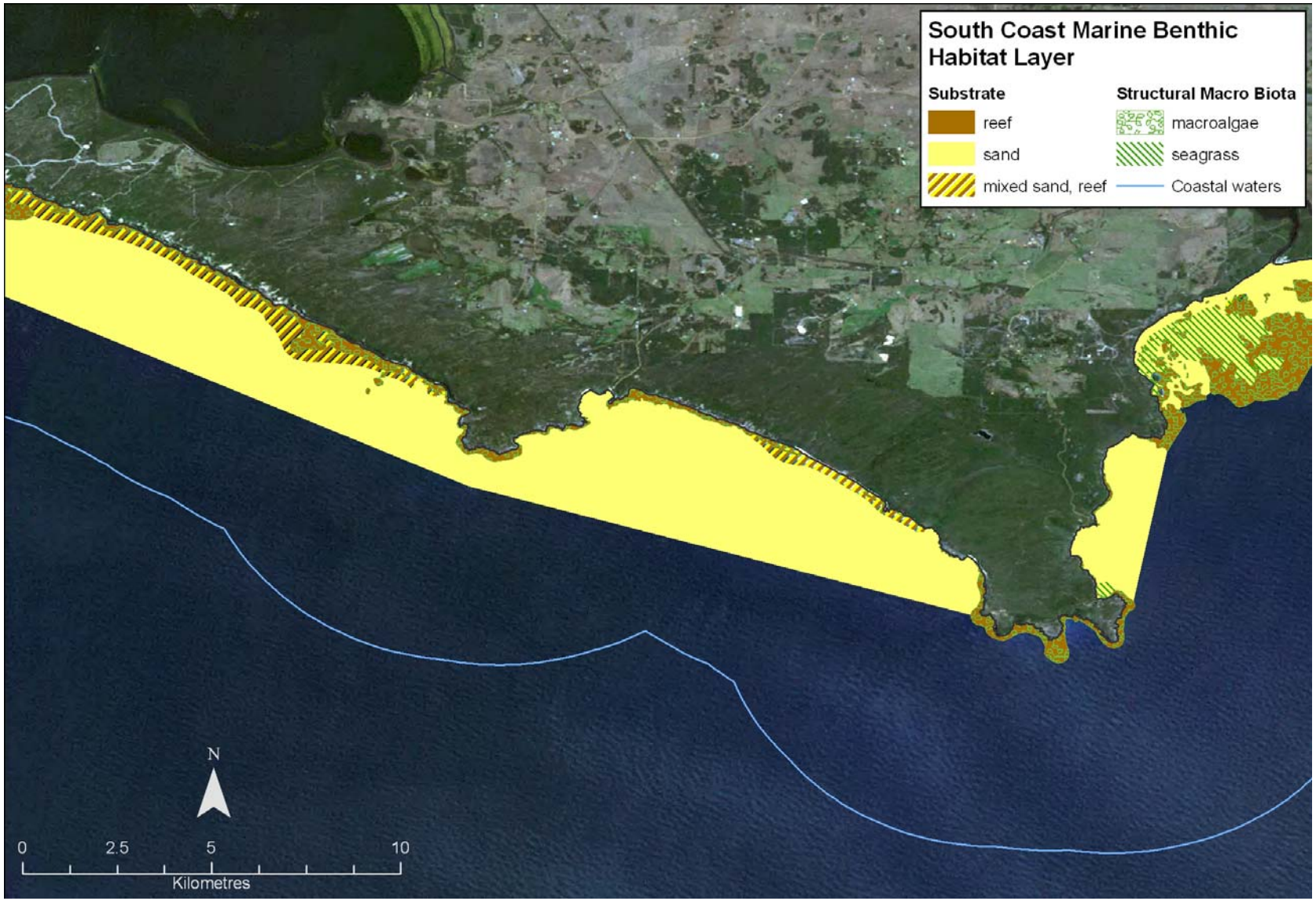

Figure 9: Example of the South Coast Benthic Habitat Mapping dataset.

Objective: Contract CSIRO to demonstrate feasibility of remote sensing habitat mapping

Commission the CSIRO Environmental Earth Observation Group to investigate the applicability of satellite remote sensing methods to deliver broadscale habitat mapping over selected areas of the south coast with no available habitat mapping, within time and available budget constraints.

Outcome: CSIRO satellite remote sensing of marine benthic habitats

CSIRO Earth Environmental Earth Observation (Dr Arnold Dekker, Dr Elizabeth Botha) were commissioned to undertake coastal marine benthic habitat mapping of selected areas along the south coast. Satellite imagery was processed using the Semi-Analytical Model for Bathymetry, Un-mixing and Concentration Assessment (SAMBUCA). SAMBUCA estimates water column constituent concentrations, water column depth and benthic substrate composition from remote sensing data, and is thus able to deliver a bathymetric model and benthic substrate mapping from suitable satellite images.

Following a review of available imagery and funds for the project, and in consultation with CSIRO, two QuickBird images were selected and purchased for use in this project (see Figure 10. Two additional Landsat images, both covering the same scene (Path/Row ID: 111/084), were also sourced for use in this project. One QuickBird image covered an area west of Red Rocks Pt, along Middini Beach in the remote Roe Plains coast. This site falls within a broader coastal compartment stretching from Eucla to Scorpion Bight for which there was no habitat mapping available. It was expected that information from remote sensing substrate mapping would add significantly to the understanding of the coastal marine environment in this region.

The other QuickBird image covered an area west of Broke Inlet on the coast between Walpole and Windy Harbour. This site abuts the Broke Inlet study site of the Securing WA's Marine Futures project (http://marinefutures.com.au/index) thus can provide a comparison between boat-based and remote sensing methodologies. Boat-based methods in this region are limited to a minimum safe working depth of 10-15m, depending on proximity to the coast and weather conditions, thus remote sensing can provide complementary information to such habitat mapping projects, as it is most effective in shallow waters.

The Landsat scene chosen for this project (Path/Row ID: 111/084) extends from Bald Island to west of Broke Inlet, overlapping the Broke Inlet QuickBird image, and two Marine Futures study sites – Broke Inlet and Mt Gardiner. This area covered many different sub-regions and substrate types within the large spatial extent that the Landsat image provides. Two separate images covering the same scene were provided to be used as required, as both are sun-glinted in different areas of the image. The 'best' parts of each were intended to be used in the analysis.

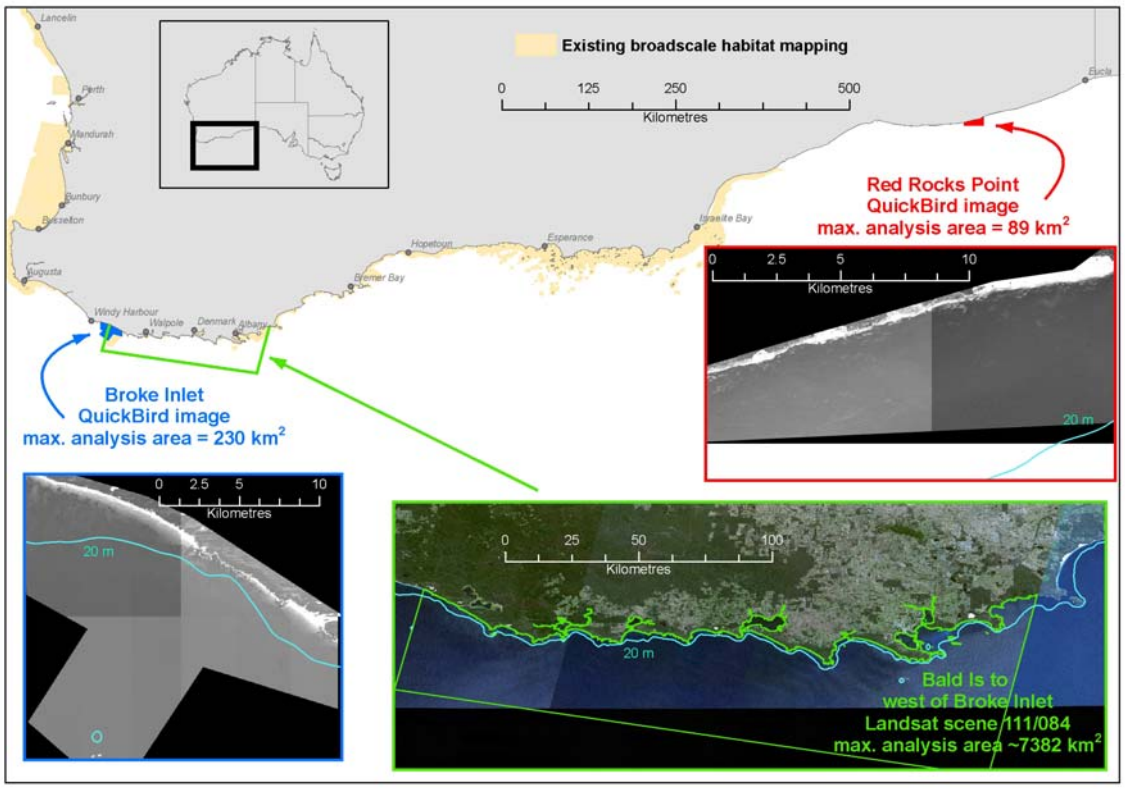

Figure 10: Study areas for the CSIRO marine benthic habitat remote sensing project.

Study sites were selected to address the lack of habitat mapping in their respective areas. Both areas are relatively remote and/or difficult to survey using boat-based methods due to their distance from safe anchorages, and the often-inclement weather experienced in the south coast region of WA.

Whilst it was not possible to conduct field trip validation in the Red Rocks Point area, due to the time and funds that would be required to visit this remote region, a two-day site visit was undertaken at Broke Inlet and Two Peoples Bay sites in November 2008. Substrate samples were analysed *in situ* for measurements of substrate reflectance, using field spectrometers on loan from Geoscience Australia. This work both enhanced the results possible for this project and also added to the marine substrate spectral library being developed nationally. The field work was successful in providing the CSIRO team valuable contextual and spectral information to use in the remote sensing analysis. A potentially new species of *Riphilia* macroalgae was collected at the Two Peoples Bay study site, and is currently being analysed and described by experts in Belgium.

The final CSIRO report of the marine habitats remote sensing project **WA_South_coast _habitat_mapping_Report_final_28May09.pdf** is stored in \SouthCoast_GIS\Documents\SthCst_RemoteSensingProject

The data produced through this project are stored in: **\SouthCoast_GIS\Data\GIS\Contextual\remote_sensing\SatelliteImagery\CSIRO_SthCstRemSensProj_Results**. At the time of writing, not all of the information products of this project had been received. These will be forwarded to SCNRM and SWCC as soon as they have been delivered to DEC.

Outcome: Marine remote sensing workshop

As part of the CSIRO site visit, a one-day workshop was hosted by DEC in Perth to discuss the role of remote sensing in marine planning and management in Western Australia and nationally. Case studies were presented by CSIRO to demonstrate the applicability of marine remote sensing techniques to various marine and coastal

environments, the kinds of products that can be produced, and the research program to operationalise the methods for local/state authorities to utilise.

Presentations were also given by local experts Halina Kobryn (Murdoch University), Peter Fearns (Curtin University), Kathy Murray (DEC), Russell Teede (WA Landgate). Following the demonstration and general discussion of the application of marine remote sensing to planning and management, a technical workshop was held for scientists, remote sensing and GIS specialists to gain a more detailed understanding of the SAMBUCA methodology and its benefits and limitations. The workshop was well attended, with 36 participants from a wide range of backgrounds, from government, universities, NRM groups and industry.

The proceedings of the remote sensing workshop **MarRemSensWshop_20081113_proceedings.doc** are stored in \SouthCoast_GIS\Documents\SthCst_RemoteSensingProject

Objective: capture new information about the region east of Recherche Archipelago

Throughout the South Coast GIS project, it was apparent that the amount and quality of available information to describe the environmental and socio-economic values of the region declined east of the Recherche Archipelago, to the WA/SA border (Eucla).

The objective was to find a rapid, cost effective method to gather basic information to cover over 700 km of remote coastline.

Outcome: Esperance to Eucla oblique aerial photograph project

Extract from Nutt (2009):

"Oblique aerial photography has proven very useful in previous projects for DEC, in rapidly gathering contextual information about an area with little available information. On smaller spatial scales high resolution digital photographic imagery allows greater visual interpretive power when compared to lower resolution satellite imagery such as Landsat, and has been used extensively in the habitat mapping component for Phase 3 of the 04SC1-01k project. Currently no aerial/ortho- photographic information is available for this area.

On 13 January 2009, a Cessna 210L light aircraft and pilot were chartered from Esperance Air Services. The combination of plane type and pilot qualifications allowed for open window photography, with a capacity of four people. Each of the 4 passengers had a digital camera to be used throughout the duration of the return flight from Esperance to Border Village.

Camera times were synchronized before commencing the flight, and a GPS was used to track the flight path. A photo of the GPS displaying the time was taken with each camera before commencing the flight so that correct time information could loaded into software after the flight to synchronise the time stamps of each photograph to the GPS track route time stamps. An altitude of 1200ft and speed of 120 mph were maintained over the duration of the flight.

A polarizing filter was used on the Nikon D80 to maximize water penetration. Shutter speed, dictated by available light levels, was maximized to compensate for aircraft movement. For areas with visibly changing geomorphology and/or other visibly changing biophysical characteristics, a continuous photographic coverage was aimed for. For areas of relative geomorphologic and/or biophysical homogeneity photographs were taken at larger spatial and temporal intervals.

A selection of photographs were processed along with the GPS track log using the geo-processing software GPS-Photo Link (available online from www.geospatilaexperts.com). Using a spectrometer and "how to" booklet supplied by Geoscience Australia, spectral signatures of available substrata in the Border Village coastal area were recorded.

All photographs taken during the expedition are stored in the coastal and marine information database produced for the South Coast NRM Inc. as part of the Marine GIS Information and Resource Compilation Project 04SC1-01k. Processed photographs and outputs can be found in the "nikon_D80" folder (\SouthCoast_GIS\Data\GIS\Contextual\Photos \GPS_PhotoLibrary\ Esp-Eucla_oblique-aerial_20090113\ Photos_and_Outputs_20090113). Spatially linked photographs from this expedition form part of a spatially linked photographic library. It is intended for this library to continually grow in coverage and detail of areas covered

The "picture.kml" file will open directly to Google Earth™ (installation is free via the web - http://earth.google.com/download-earth.html). A time line will appear at the top right of screen in Google Earth™ with two sliding brackets. Slide each bracket to their respective ends of the time line to view the locations of where the photographs taken. The photograph positions will appear as camera icons (labeled with the photograph file name) and the GPS track log will appear as a series of red dots revealing the flight path of the expedition. Clicking on individual camera icons will give a thumbnail view of the photograph taken from that position. To view larger versions of the photographs, note the

photograph file name, then open the “index.htm” file in the “nikon_D80“ folder mentioned above and scroll down to the desired photograph.

Results of the project have provided a comprehensive and continuous, high resolution, spatially referenced, oblique aerial photographic library covering over 700 km of coastline between Esperance and the WA/SA border. This area is isolated, posing many logistical difficulties for survey work and has very little biophysical information available on it. This photographic dataset has provided a good contextual base layer which, through interpretation, can provide insights into biophysical characteristics of the area. It could also be a useful information layer for future research projects in the area.

This style of information gathering proved to be a time and cost effective method of gathering large amounts of information for a large, isolated area that was previously information limited.

Creating a spatially linked photographic library was a relatively simple process and has proven to be a useful resource for many projects. This style of information gathering requires minimal capital and can be undertaken with little or no training by all members of the community. If managed well, a large spatially linked photographic library could prove to be a very useful resource. In particular, re-visiting and photographically documenting sites over time could provide a useful and cost effective method for monitoring environmental change.”

Over 700 km of coastline was surveyed for a cost of approximately $5,000, demonstrating the cost-effectiveness of this method of rapid assessment.

The project report **Esperance-Border Village oblique aerial photo project report_20090622.doc** is stored in \SouthCoast_GIS\Documents\Esp-Eucla_FlightProject\, and with the data in \SouthCoast_GIS\Data\GIS\Contextual\Photos\GPS_PhotoLibrary\Esp-Eucla_oblique-aerial_20090113\

Conclusion

The South Coast GIS Information and Resource Compilation project successfully completed its main aims, and went further in providing new data for regional marine planning and other marine planning and management applications.

- A data management system was developed to store and document the information acquired and created through this project.
- A project documentation directory was created to house documents relating to this project.
- NRM reporting obligations have been met.
- A number of new datasets were developed to, within time and budget constraints, address key gaps in knowledge for regional marine planning
    - Collection of community recreational marine usage data;
    - Coastal landform mapping;
    - Sub-regionalisation of the south coast;
    - Satellite remote sensing of marine benthic habitats;
    - Commercial fishing values mapping, and;
    - Standardised broadscale habitat mapping dataset.
- Map, analyses and other information products were developed for the South Coat Regional Marine Planning process.
- Recommendations were made for ongoing gap-filling work.

The regional perspective and cross-sectoral involvement of the regional marine planning process enabled an integrated, holistic approach to marine planning information requirements. This was accomplished very effectively through a partnership between NRM Groups and a Government agency. Both partners have benefited from the conduct of the project and its outcomes.

Two volunteers for the project (Michael Higgins and Chris Nutt) successfully gained marine GIS skills which led to their eventual employment in the DEC Marine Policy and Planning Branch Marine Information Section. There is a general paucity of skills in this field, with few GIS operators skilled in the unique needs of marine information management, so this is considered a significant supplementary outcome of this project.

Data Use

The data are available to South Coast NRM and South West Catchments Council for marine planning purposes. Datasets should not be provided to third parties without prior approval from source custodians, as noted in the Acquisition Log and/or metadata statements and license agreements. Additionally, custodians should be contacted prior to usage of information contained in this system, to assess fitness-for-use, and to check for updates to the data.

A general Data Licensing Agreement has been formulated to cover all of the datasets collected or produced through this project. This agreement is found in \SouthCoast_GIS\Data\ and \SouthCoast_GIS\Documents\DataManagement\DataLicensing\

Key Recommendations

It is highly recommended that:

1. Similar future projects, whether they be regional marine planning projects in other areas, or the implementation of a regional marine plan on the south coast, be better integrated with strategic marine research projects such as the WA Marine Science Institute research themes. Thus information on gaps in knowledge needed for planning and management could feed directly into strategic research

directions, and conversely, high level scientific expertise and recent research outcomes could more easily be leveraged in the production of new data for the planning process.

2. The lessons learnt and the datasets identified and acquired through a project such as this could advise and even provide the content for strategic state-wide marine data management and online access portals, such as are being investigated and developed through the WA Land Information System. It is recommended that the key information themes identified as being required for Regional Marine Planning be prioritised for acquisition, update or other management (if not already) via a state-wide data management system involving all government agencies and other organisations concerned with marine planning.

3. A project such as this should include the provision of more resources for the data management component if possible through the provision of core positions in key Government organisations. The workload for a single information officer has at times been very excessive (i.e. more than the assigned 1 FTE for the project officer role) in order to meet the demands of administering an externally-funded project and the financial and reporting obligations associated with this arrangement, GIS processing and data management, project management of new data capture sub-projects, and scientific interpretation of data and methods, etc.

4. The final duration of this project (2 years) was appropriate for the aims and outcomes required. It is highly recommended that any similar future projects be designed to run over this timeframe, rather than be divided into the Phases described in this report. The requirement for end-of-phase reporting, financial accounting and the effort required to apply for new funding for subsequent phases, whilst necessary for this arrangement, took substantial amounts of time and effort away from the core data management and capture work.

Particular ongoing developments to note

- The ongoing development of coastal compartments mapping and research into coastal and marine planning and management
    - Current (May 2009) project between DPI Strategic Planning, DPI Marine (Charlie Bicknell) and DEC Marine Policy and Planning Branch (Ian Eliot and Chris Nutt).

- Ongoing development of national strategies for marine remote sensing of aquatic habitats for Estuarine, Marine and Coastal habitat extent and condition (formerly part of the Commonwealth National Land and Water Resource Audit www.nlwra.gov.au , now run the through Caring for Our Country program http://www.nrm.gov.au/). Information also available through OzCoasts http://www.ozcoasts.org.au/ and the image acquisition project management website http://www.auricht.com/Coasts/index.html. further information about remote sensing and available resources is available through Geoscience Australia http://www.ga.gov.au/remote-sensing/index.jsp.

- Ongoing development and operationalisation of local expertise in marine remote sensing, particularly through the Centre for Marine Futures (UWA), Murdoch University School of Environmental Science Marine Management Group and Curtin University Centre for Marine Science and Technology.
    - A/Prof Merv Lynch (Curtin University Imaging and Applied Physics) has advised that his and Dr Peter Fearns' research group have been awarded funding to build a marine purpose-built hyperspectral scanner, to be housed on a National Aircraft Facility out of Flinders University, and which will be available for use once completed (1-2 years). The instrumentation will also include LIDAR and synthetic aperture RADAR. Their group is part of a consortium of universities working on the project, receiving a $450,000 ARC LIEF grant to complete the work. The sensor will be the only hyperspectral scanner that is dedicated to marine applications in Australia – the spectral range will target the wavelengths of most use in marine applications – and will be amongst the most advanced of its kind in the world. http://www.arc.gov.au/pdf/LIEF09/FlindersU_LIEF09.pdf

- Programs to undertake strategic capture of marine information such as high-resolution continuous bathymetric mapping, and more Marine Futures projects. The WALIS Marine Group provides an avenue to stay abreast of and input into strategic marine data programs http://www.walis.wa.gov.au/projects/WALIS_Marine_Group.

- Ongoing development of a marine data management portal for WA (WALIS).

- Ongoing investigations into marine habitat mapping techniques and integration of different techniques into multi-scale mapping and analysis for marine planning and management. OzCoasts provides links and information regarding key projects occurring nationally (www.ozcoasts.org.au). Also, the University of Western Australia, DEC, CSIRO and other project partners.

Acknowledgements

The initial recognition of the need for this project, and subsequent core funding support by South Coast NRM for the position and operational costs, is gratefully acknowledged. Significant achievements in the status of available marine information for the south coast have been made thanks to South Coast NRM's involvement and support of the project. South Coast NRM Marine and Coastal Facilitator Dylan Gleave, with support from Rob Edkins CEO, has at all times been exceptionally helpful in the administration and direction of the project.

The contribution of the South West Catchments Council is also gratefully acknowledged. Contributions to core funding for the South Coast GIS project primarily enabled wider distribution of the SCRMP Community Recreational Marine Usage Survey and the remote sensing components of the project. Rhiannon Addams, Emily Hugues-Dit-Ciles and Bill Bennell, with the support of Damien Hills CEO, provided significant liaison and assistance with applying for funding and administration aspects of the project with SWCC.

The in-kind support (administration, office facilities and management) of DEC Marine Policy and Planning Branch is acknowledged, particularly project management, guidance and mentoring by Ian Herford (former Principal Marine Policy Officer for Regional Marine Planning), and branch management by Peter Dans, John Lloyd and Fran Stanley. The assistance of Dale Harvey (Branch Business Manager) is particularly noted in the financial administration of the project. The highly valuable advice, assistance, knowledge and mentoring of Marine Information Section Leader Ray Lawrie and Mark Sheridan were of fundamental importance in completing this project successfully. The assistance of Chris Nutt and Michael Higgins in data production is gratefully acknowledged.

Volunteers Michael Higgins and Dr Ian Eliot spent many unpaid weeks on the production of the Smartline and Coastal Compartments datasets. Chris Nutt was initially employed as a casual contractor in the production of the Community Recreational Marine Usage Survey data, which then led to his contractual full-time employment on the project. As the Project Officer for Phase 3, Chris took over administration and reporting for the project and contributed significant unpaid hours in the production of the various map products, datasets and reports, as well as organising the final project presentations to SCNRM and SWCC.

Many other people provided valuable advice to this multi-disciplinary project; particular acknowledgements and thanks are extended, but not limited to the following people – apologies for any who are not noted here!

Data management contacts in government agencies and NGO groups contacted for data acquisition
Members of the SCRMP Planning Advisory Group
Members of the SCRMP Planning Working Group
Members of the public, contributing to the recreational marine usage survey and SCRMP workshop series
Participants in the WA Marine Remote Sensing Workshop, particularly presenters Dr Halina Kobryn (Murdoch), Dr Peter Fearns (Curtin), Russell Teede (Landgate), Kathy Murray (DEC), Dr Arnold Dekker and Dr Hannelie Botha (CSIRO)
Dr Chris Simpson and Kev Bancroft (DEC Marine Science Program)
Dr Gary Kendrick and Prof. Jessica Meeuwig (UWA/Centre for Marine Futures)
Dr Ian Eliot (DEC/DPI)
Dr Arnold Dekker and Dr Elizabeth Botha (CSIRO Earth Observation Group)
Dr Richard Mount (former National Land and Water Audit)
Dr Chris Sharples (University of Tasmania)
Graeme Behn and Kathy Murray (DEC Remote Sensing)
Chris Johns (community member, diver)
John Jackway and Syd Sepkis (DEC Donnelly District)
David Palmer (Dept of Agriculture and Food, Eucla)

References

Buckley E.D. (2009). Results of the South Coast Regional Marine Planning Community Recreational Marine Usage Survey (October 2007 – March 2008). Marine Policy and Planning Branch. WA Department of Environment and Conservation. Fremantle.

Eliot I., Buckley E.D., Nutt C.D., Higgins M. (2009). (Draft, in prep.) Coastal compartments & sediment cells of the South Coast, Western Australia. Marine Policy and Planning Branch. WA Department of Environment and Conservation. Fremantle.

Nutt C.D. (2009). A report on the Esperance to WA/SA border coastal oblique aerial photographic expedition. Marine Policy and Planning Branch Department of Environment and Conservation. Fremantle.

Nutt C.D. (2009). A report on the South Coast Marine Benthic Habitat Mapping Project. Marine Policy and Planning Branch Department of Environment and Conservation. Fremantle.

Appendices

Appendix A: an example of an Acquisition Log text file

```
20/08/2007 - Ewan Buckley Department of Environment and Conservation
           Marine Policy and Planning Branch

Dataset Title: Polygonised GIS 'Coastal Environments of WA'

Original Filename: Coastal_Environs_Map.pdf, wa_coastalEnvirA0_npj_transfer.dgn,
wa_coastalEnvirA0_z50_transfer.dgn, legend.dgn

Acquisition source: Matt Devlin and Susan Hames, DPI, also
http://www.wapc.wa.gov.au/Publications/312.aspx

Acquisition date: 21/6/2007

Licensing details: Licensed to DEC and SCNRM (Coastal_Environs_Map_license.pdf)

DEC MPPB Processing:
1) DGN converted to GDA shapefile in ArcGIS.
2) Lines attributed with Descriptors as per legend.dgn and legend on maps, etc by
selecting by level/color/layer attributes of original DGN
3) Line shapefile imported into ArcGIS personal geodatabase of, and converted to
polygons (loss of coordinate precision in this step, due
to ArcGIS limitations)
4) Centroids calculated from line shapefile, using X-Tools in ArcGIS
5) Centroids used to select respective polygons in line-to-poly conversion,
polygons attributed as per centroids attributes, derived from original lines
6) basic error checking of unattributed polygons, no more error checking done...
7) Renamed to Department of Environment and Conservation Marine Policy and
Planning Branch
   Marine Information System naming convention 'what_where_when'
```

Appendix B: Sub-regions and primary compartments of the south coast.

SUB-REGION	PRIMARY COMPARTMENT	WESTERN BOUNDARY OF COMPARTMENTS	COMPARTMENT GEOLOGY	KEY LANDFORMS	ASPECT
FLINDERS	DONNELLY	Cape Leeuwin	Perth Basin, Leeuwin Complex	Granite islands, rocky headlands, beach, Blackwood Estuary, Scott River foredune plain	SSW
		Black Point	Perth Basin	Rocky headlands, limestone cliffs, beach and dunes	SW
	BROKE	Point D'Entrecasteaux	Albany-Fraser Orogen	Granite islands, limestone headlands and cliffs, beach and dunes, Broke Inlet	SSW
		Broke Inlet SE	Albany-Fraser Orogen	Rocky islands, rocky head lands and cliffs, beach and dunes	SSW
	NULLAKI	Point Nuyts	Albany-Fraser Orogen	Granite islands, rocky headlands, arcuate embayments, beach and dunes, Nornalup Inlet	S
		Point Irwin	Albany-Fraser Orogen	Granite islands, rocky headlands, arcuate embayments, beach and dunes, Irwin Inlet	S
		Stanley Island - Point Hillier	Albany-Fraser Orogen	Granite islands, rocky headlands, zeta formed bays, beach and dunes	S
		Wilson Head	Albany-Fraser Orogen	Rocky headlands, limestone cliffs, beach and dunes, Wilson Inlet	SSW
		Torbay Head	Albany-Fraser Orogen	Granite islands, rocky headlands, limestone cliffs, zeta formed bay, beach and dunes, Torbay Inlet	SSW
BAUDIN	ALBANY	Bald Head	Albany-Fraser Orogen	Granite islands, Albany sounds, Vancouver tombolos, spits, rocky headlands and cliffs, sheltered beaches and dunes	E
	CHEYNE	Herald Point	Albany-Fraser Orogen; Bremer Basin	Granite islands and headlands, arcuate beach, dunes	S
		Cape Vancouver	Albany-Fraser Orogen	Granite islands and headlands, embayed granite coast	S

		Bald Island	Bremer Basin	Arcuate beaches and dunes, rocky headlands and coast	SE
		Groper Bluff	Bremer Basin, Albany-Fraser Orogen	Rocky headlands, arcuate beaches and dunes	SSW
		Cape Knob	Bremer Basin, Albany-Fraser Orogen	Granite headlands, broad embayments, beaches and dunes	SE
		Point Hood	Bremer Basin, Albany-Fraser Orogen	South: zeta bays. North: granite headlands and coast, beaches and dunes	ESE
THIJSSEN	MUNGLINUP	Red Island	Albany-Fraser Orogen, Bremer Basin	Rocky headlands and coast, Culham Inlet	SSE
		Mary Ann Point	Albany-Fraser Orogen	Limestone platform, cliffs, beaches and dunes, Jerdacuttup lakes	S
		Mason Bay	Albany-Fraser Orogen, Bremer Basin	Granite islands, rocky platforms and headlands, beach and dunes	S
	RECHERCHE	Shoal Cape	Albany-Fraser Orogen, Bremer Basin	Granite islands, rocky headlands and coast, zeta formed bays, archipelago	S
		Observatory Point	Bremer Basin, Albany-Fraser Orogen	Archipelago, granite headlands, rock platforms, zeta formed bays, limestone cliffs, beaches and dunes	SW
		Cape Le Grand	Albany-Fraser Orogen	Archipelago, granite headlands and coast, pocket beaches and dunes	S
		Mississippi Point	Albany-Fraser Orogen	Archipelago, granite headlands and coast, beaches and dunes	SSE
		Hammer Head	Albany-Fraser Orogen	Archipelago, granite headlands and coast, beaches and dunes	S
		Tagon Point	Albany-Fraser Orogen	Archipelago, granite headlands and coast, arcuate beach and parabolic dunes	SW
		Cape Arid	Albany-Fraser Orogen	Archipelago, granite headlands and coast, arcuate beach and parabolic dunes	S
GILES	MALCOLM	Cape Pasley	Albany-Fraser Orogen,	Archipelago, granite headlands,	SE

			Eucla Basin	beaches and dunes	
		Point Malcolm	Albany-Fraser Orogen	Archipelago, granite headlands, spits, coastal lagoons beaches and dunes	SE
		North Israelite Bay	Albany-Fraser Orogen	Platform reef, sand sheets, seagrass banks, beach, dune ridge, coastal lagoons	ESE
		Wattle Camp	Albany-Fraser Orogen	Platform reef, seagrass banks, beach, dunes, coastal lagoons, limestone cliffs	SE
	BAXTER	Point Culver	Eucla Basin	Limestone platform and cliffs	SE
		Point Dover	Eucla Basin	Limestone platform and cliffs	SE
	KANIDAL	Twilight Cove	Eucla Basin	Platform reef and seagrass banks, beach and dunes	SSW
		Scorpion Bight	Eucla Basin	Platform reef and seagrass banks, beach and dunes	SSE
		Red Rocks Point	Eucla Basin	Platform reef and seagrass banks, beach and dunes	SE