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Land and Property
Management Authority

Ex-HMAS Adelaide Artificial Reef

Review of Environmental Factors

301017-00077

2-Dec-09



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LAND AND PROPERTY MANAGEMENT AUTHORITY EX-HMAS ADELAIDE ARTIFICIAL REEF REVIEW OF ENVIRONMENTAL FACTORS

SUMMARY

This Review of Environmental Factors (REF) has been prepared to address the scuttling of the Ex-HMAS ADELAIDE as an artificial reef and its use as a recreational dive site. A number of management and monitoring plans would be implemented to mitigate potential impacts during the scuttling operation; manage access to the dive site; and assess the long term impacts of the vessel on the immediate marine environment.

The scuttling process may have minor, temporary impacts such as discolouration of water due to suspension of sediments and mixing of freshwater, seawater and air; minor fish kills due to cutting charges employed during scuttling or collision with the vessel as it sinks; exclusion of boats within approximately 1km of the vessel during preparation for, scuttling and post scuttling activities; and congestion and altered traffic and parking arrangements during the scuttling event.


Benthic organisms within the 'footprint' of the scuttled vessel may be smothered and a sandy habitat would be replaced with an artificial 'reef' habitat. Considering the extent of sandy habitat in the general area this permanent loss of sandy habitat is not considered significant. Over time the impact of the artificial reef is expected to be positive, providing habitat for a variety of marine species (possibly including threatened species) and increasing the diversity and abundance of marine life at the site.

The Ex-HMAS ADELAIDE is expected to provide a 'world-class' diving experience and would complement other dive opportunities in the Terrigal/ Avoca area. Flow-on benefits to the Central Coast economy are expected.

Disclaimer

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PROJECT 301017-00077 - EX-HMAS ADELAIDE ARTIFICIAL REEF

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal & client review	<u>H Nelson</u>	<u> </u>	<u>N/A</u>	17-Nov-09	<u>N/A</u>	
B	Final	<u>H Nelson</u>	<u>Client</u>	 <u>D Messiter</u>	2-Dec-09	<u>N/A</u>	



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Cover photos taken by Steve Lindfield

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1. INTRODUCTION

The NSW Land and Property Management Authority (LPMA) is the lead agency, on behalf of the NSW State Government, for the Ex-HMAS ADELAIDE Project. The Ex-HMAS ADELAIDE project has a number of components including the following:

- cleaning and preparation of the ship as an artificial reef for recreational diving (at the time of writing, preparation of the ship was still underway)
- determining a suitable scuttling location
- establishing a Crown Reserve to house the scuttled ship
- preparing monitoring and management plans
- this Review of Environmental Factors (REF).

LPMA has undertaken considerable consultation to gain input on the project from other government agencies, diving interests and the general community (see **Section 3** and **Appendix A** for further details).

1.1 Background

Options for managing obsolete and decommissioned military and commercial vessels include reuse of the vessel or parts of the vessel, recycling or scrapping, creating artificial reefs, and disposal on land or at sea (US EPA, 2006). The Australian Government has, in the past, a policy of ceding to the States its decommissioned warships, with the States being invited to lodge expressions of interest for the acquisition of the decommissioned vessels.

Five former warships have already been scuttled to create artificial reefs and recreational dive sites in Australia:

- Ex-HMAS SWAN off Dunsborough, Western Australia (December 1997)
- Ex-HMAS PERTH off Albany, Western Australia (November 2001)
- Ex-HMAS HOBART in Yankalilla Bay, Fleurieu Peninsula, South Australia (November 2002)
- Ex-HMAS BRISBANE off Mooloolaba, Queensland (July 2005)
- Ex-HMAS CANBERRA off Ocean Grove, Victoria (October 2009).



Since around 1990, The Central Coast Artificial Reef Project (CCARP) has worked towards securing a suitable vessel to create an artificial reef off the Central Coast for recreational diving. This has been supported by the NSW Government which put forward expressions of interest for the HMAS BRISBANE, HMAS CANBERRA and HMAS ADELAIDE. The Commonwealth accepted the New South Wales Government's bid for the HMAS ADELAIDE in February 2007.

The HMAS ADELAIDE II was decommissioned in January 2008. It was gifted to the NSW Government in August 2008 and handed over on 30 September 2008, following demilitarisation and initial cleaning at the Royal Australian Navy's Fleet Base East in Sydney (Garden Island Dockyard). The ship is currently being prepared at Glebe Island, Sydney, for scuttling in Bulbararing Bay off Avoca Beach near Terrigal on the NSW Central Coast (see **Figure 1.1** for the general location).

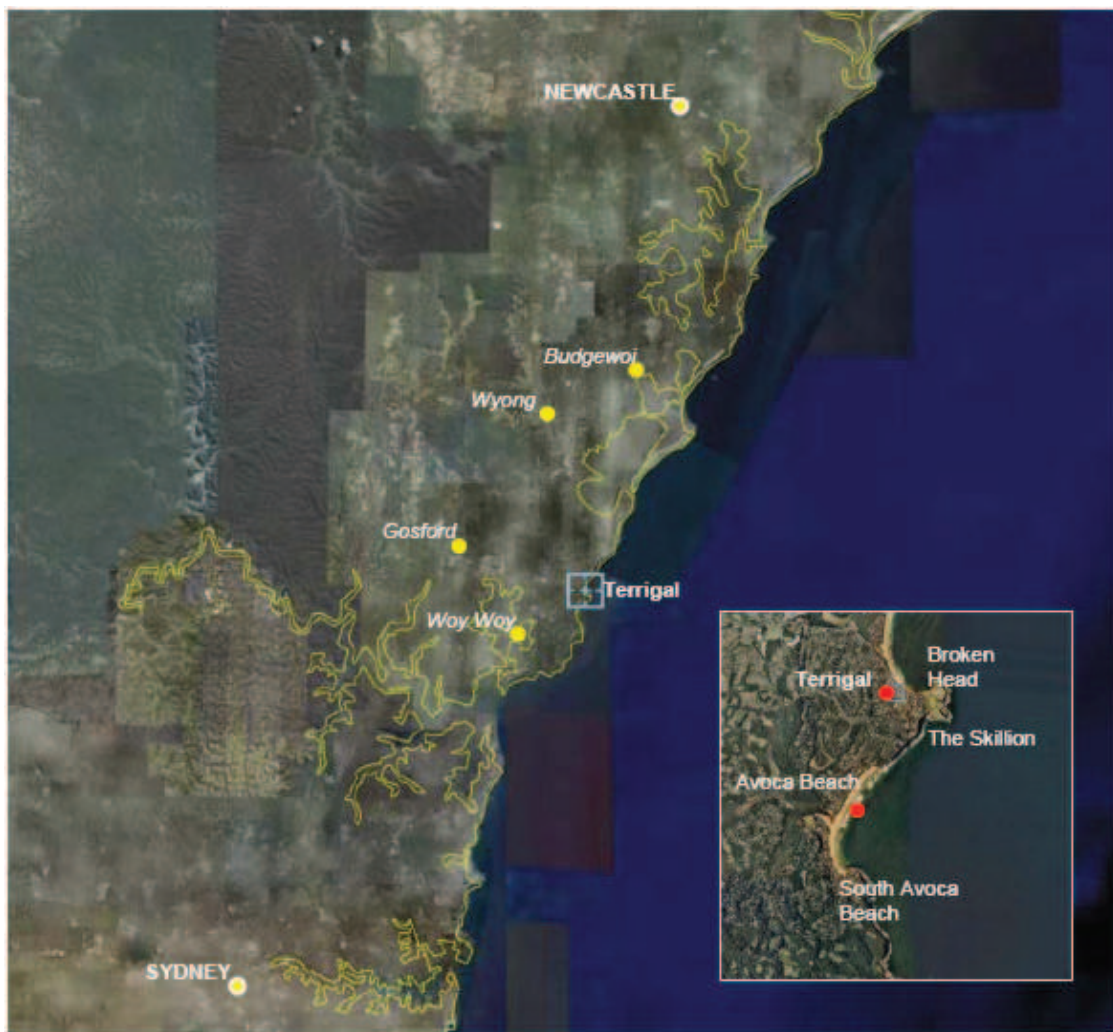


Figure 1.1 Location Plan (Cardno Ecology Lab 2009)



1.2 Preliminary Site Selection

Terrigal/ Avoca was seen as the perfect and natural location for the HMAS ADELAIDE as it is only one hours drive from Sydney, and the Central Coast is the perfect location for Sydneysiders and people from the Hunter to visit the vessel and for attracting interstate and international tourists (7 March 2008 NSW Legislative Assembly Hansard extract).

A site selection study was undertaken to identify a suitable area with the following general characteristics:

- a bare sandy bottom without extreme conditions (e.g. no strong rips or currents)
- the ability to attract marine life to colonise the artificial reef
- appropriate depth to the seabed and underlying rock to ensure the scuttled vessel could penetrate into the sand and remain stable and upright
- meeting navigational safety requirements
- minimal impact on commercial fisheries
- within reasonable proximity to on-shore infrastructure for dive operators.

The *Sinking of Ex-HMAS Adelaide off the Central Coast NSW – Review of Constraints and Site Selection* (TEL 2008) identified a potential scuttling area (roughly rectangular) of approximately 0.42km², 1.14km in length (north to south) and between 0.26km and 0.45km wide. The northern boundary was approximately 1.67km offshore from north Avoca Beach, with the southern boundary approximately 1.73km offshore. Water depths in this area are between 30 and 34m.

TEL report ranked constraints from low to high, see **Table 1.1**. Those identified as moderate to high were examined in more detail as part of the preparation of this REF.

**Table 1.1 Constraints taken into account in preliminary site selection**

Constraint	Level of Constraint	Comments
1) Depth	High	The 30 m - 35 m preferred depth range constrains site selection to an area 0.42km ² , approx. 1.72km offshore from Avoca beach.
2) Exclusion Zones		
Commercial Fishing	High	Potential conflict of interest with commercial fisherman, particularly trawlers. Further stakeholder consultation is required.
Recreational Fishing	Moderate	Recreational fishing from beaches, rock platforms and offshore is popular in the study area. Operation of an exclusion zone around the EX-HMAS ADELAIDE dive site could potentially conflict with offshore reef fishing.
Recreational Diving, Snorkelling and Spearfishing	Low	The additional EX-HMAS ADELAIDE dive site would complement existing nearby sites such as The Skillion Cave, Fifeshire Reef and San Francisco Reef.
Recreational Sailing and Boating	Low	2-3 significant sailing events occur annually offshore of Terrigal. Gosford sailing club do not see the EX-HMAS ADELAIDE dive site as a navigational issue.
Marine Protected Areas (MPA's)	Low	No MPA's exist within the study area. Bouddi National Park marine protection zone is located south of Macmasters beach to Wagstaff Point. This would not be a constraint in site selection for the EX-HMAS ADELAIDE.
Historical Ship Wrecks	Moderate	Wrecks of the Lord Ashley (approx. 9m depth), Yambacoona (26m-28m depth) and the Galava (approx. 50m depth) are located within the study area. These wrecks are not likely to be a constraint in site selection as they are either outside the preferred depth range or located on or near reef.
Offshore Mineral and Petroleum Resources	Moderate	Possibility of future exploitation of sand resources for beach nourishment and/or commercial purposes. Future extraction operations would be at depths > 35m.
FAD's (Fish Aggregation Devices)	Low	One FAD is located in the study area outside the preferred depth range. It is not considered a constraint.



3) Geotechnical Constraints		
Substratum Type	High	Sand covered reefs limit site selection to a rectangular area of fine to medium sand approximately 0.42km ² , 1 km in length (north to south) and 0.45km in width (at its widest point).
Penetration Depth	High	Site selection is limited to areas where sand penetrates ≥2m. Isopach data suggest sand in the target area as <5m depth apart from a channel of sand >10m depth which runs offshore from the centre of Avoca beach.
4) Distribution of Habitats	Moderate	Likely to be typical benthic/ epibenthic habitat associated with fine to medium grained shelf sand. A diverse assemblage of typical reef and demersal fish were observed in the site inspection. Further investigation would be required.
5) Threatened Species	Moderate	Seven protected marine species were shown to occur within the study area according to threatened species databases. In addition one marine reptile (listed as vulnerable/migratory) was recorded during the site inspection.
6) Coastal and Oceanographic	Moderate	Deeper scuttling of the EX-HMAS ADELAIDE within the 30m to 35 m depth limits would generally be favoured to minimise impacts on wave refraction, currents and nearshore sediment transport.
7) Operational feasibility Access	Moderate	One main boat ramp at Terrigal Haven. Access via sheltered moorings is either from Swansea Channel or Broken Bay.
Amenities	Low	Five dive shops in the locality, three large hospitals. Good public amenities at Terrigal Haven boat ramp mean that amenities available to visitors are unlikely to be a constraining factor and level of constraint is low.
Quality	Low	Other high quality dive sites in the study area indicate suitable diving conditions.

1.3 Associated Documents

As noted in the introduction there are a number of components to the Ex-HMAS ADELAIDE project which have, or will, involve the preparation of a number of reports as follows.



1.3.1 Scuttling Management Plan

The Scuttling Management Plan/ Environmental Management Plan (prepared by the Ship Preparation Contractor, McMahon Services Australia) will cover matters including:

- navigation and spectator management associated with towing the vessel from Sydney Harbour to Bulbararing Bay
- security of the ship at the scuttling location, management and safety of spectator vessels, management of the scuttling process to avoid impacts on large marine animals
- design of the scuttling process to ensure the vessel settles to the seabed structurally intact, in an upright position and in the correct location and orientation
- retrieval of debris and a post-sinking inspection to confirm the ship is safe for diving
- installation of marker buoys to indicate the ship's location and exclusion zone.

1.3.2 Long Term Management Plan

The Long Term Monitoring and Management Plan covers field survey methods to monitor:

- the structural integrity, stability and position of the scuttled ship
- colonisation of the artificial reef over time by marine biota
- sediment accretion/ scour around the vessel
- sediment quality
- potential bioaccumulation of contaminants in hull fouling biota.

1.3.3 Asset Management Plan

An Asset Management Plan would be prepared by the Ship Preparation Contractor and would include the following:

- list of recommended life cycle maintenance activities based on a 40 year overall life span (vessel, moorings and navigation aids)
- periodic inspection requirements, listing key activities, inspection details and description of expected repair/ maintenance works.



1.3.4 Ex-HMAS ADELAIDE Reserve Plan of Management

The Ex-HMAS ADELAIDE Reserve (R. 1014968) was gazetted on 20 June 2008 *for access and public requirements, tourism purposes and environmental heritage and conservation*. It includes Crown land below high water mark to the 3nm limit of State waters (approximately 1500ha) in an area between Terrigal Haven and the southern end of Avoca Beach (see **Figure 1.2**). It is intended to reduce the extent of the existing reserve to the area that will be subject to ongoing, active management (i.e. approximately 9 ha). The final boundaries will be established once the Ex-HMAS ADELAIDE is scuttled to ensure the vessel is centrally located within the reserve.

The Crown Lands Reserve Trust (CLRT) was appointed as the Trust Manager of the Ex-HMAS ADELAIDE, with all revenue associated with the reserve to be allocated to the CLRT. A Plan of Management (PoM) for the reserve was prepared by WorleyParsons and LPMA in accordance with the requirements of the *Crown Lands Act 1989*. The draft PoM was publicly exhibited in September/ October 2009.

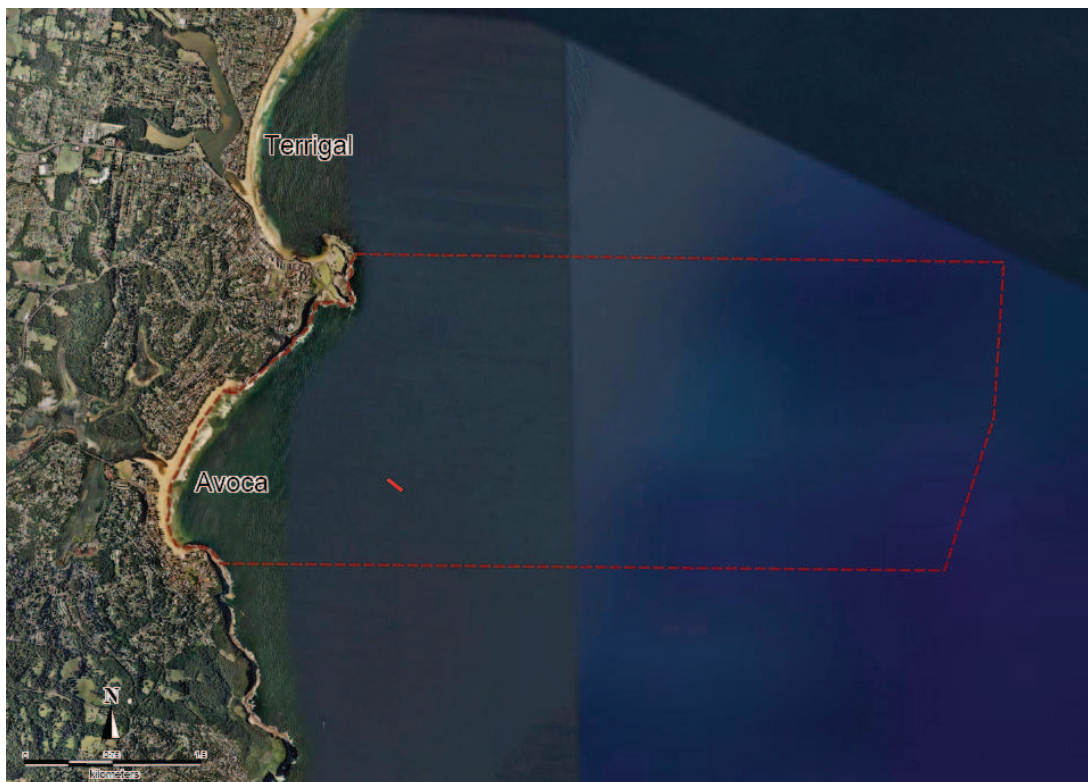


Figure 1.2 Current Ex-HMAS ADELAIDE Reserve Boundaries

1.3.5 Updated Terrigal Haven Plan of Management

Terrigal Haven covers an area of approximately 10.5 ha of Crown land and includes the area known as 'Reserve 48416'. This Reserve was notified by the then State Planning agency for



Public Recreation on 18 December 1912, with Gosford City Council appointed as trustee on 24 April 1959. A Landscape Masterplan for the area was adopted by Council in May 1996 and a PoM for Terrigal Haven was adopted by the then Department of Lands in May 2006. The current version of the PoM was prepared to reflect the changing environmental and recreational requirements of the Terrigal Haven area, and to create a link to the Ex-HMAS ADELAIDE Reserve PoM.

The draft PoM was finalised for public exhibition in November 2008. Subsequently it was amended and re-exhibited concurrently with Ex-HMAS ADELAIDE Reserve PoM. One of the actions included in the PoM was “investigation into and potential provision of infrastructure for access to water based recreation facilities”.

LPMA have recently engaged a consultant to prepare a concept design for a jetty or similar facility at Terrigal Haven. Factors which will be taken into account in the concept design (as per LPMA’s Brief) include:

- the approximate number of divers that will be able to access the wreck simultaneously and the corresponding boating traffic this may generate
- issues associated with access to the facility, given the existing road network and car/ trailer parking areas are already heavily used
- the impact of the facility on existing uses and user groups, given potential conflicts between for example swimming and boating
- provision for a range of boating activities (e.g. recreational fishing and other temporary tourist uses)
- that restrictions on stay times would apply to facilitate turn over of access
- any impact on existing swing moorings in The Haven
- consideration of the feasibility of providing a boat sewage pump out.

1.4 Objectives

The Ex-HMAS ADELAIDE project objectives are to:

- generate economic benefits for the Central Coast region, mostly in the areas of hospitality and tourism;
- enhance marine biodiversity; and
- provide marine research opportunities.



The following goals for the Ex-HMAS ADELAIDE Reserve and dive site were identified in the Crown Reserve Plan of Management:

- *To provide a world-class, challenging, exciting and sustainable (environmentally, socially and economically) dive experience catering for divers with varying interests and levels of experience.*
- *To provide a safe environment for various compatible recreational uses and a safe dive site.*
- *To provide access (for divers and non-divers) to the ex-HMAS ADELAIDE dive site for commercial operators, non-commercial interests, education establishments, researchers and the general public.*
- *To create an artificial reef that provides habitat and protection for a range of species naturally occurring within the area.*
- *To respect the history and heritage of the HMAS ADELAIDE and all who sailed on the vessel.*
- *To enhance commercial opportunities including tourism and hence increase income and employment opportunities (direct and indirect) primarily to benefit the Central Coast economy.*
- *To be internationally recognised as a demonstration and education site for the productive and sustainable use of a ship as a dive site and artificial reef contributing to marine environmental awareness.*



2. ENVIRONMENTAL ASSESSMENT FRAMEWORK

2.1 Environmental Planning and Assessment Act

The Ex-HMAS ADELAIDE would be scuttled in State Waters off Avoca, within the NSW Coastal Zone and offshore from the Gosford City Council Local Government Area (LGA). The ship would rest on unzoned, submerged Crown Land within Reserve R1014968.

As the area is not zoned under an Environmental Planning Instrument, the project is a Part 5 activity under the *Environmental Planning and Assessment (EP&A) Act*. As no significant adverse impacts are likely as a result of the activity (see **Section 9** for summary), this Review of Environmental Factors (REF) was prepared.

The *EP&A Act* requires a determining authority (in this case LPMA) to examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity. Depending on the proposed location of an activity (e.g. NSW Coastal Zone) and the characteristics of the environment where it would occur (e.g. natural and cultural heritage significance), legislation and policies in addition to the *EP&A Act* are applicable.

This includes:

- Policy objectives to be considered in project development. The consistency of the Ex-HMAS ADELAIDE project with relevant objectives is discussed in **Section 9.2**.
- Legislative provisions to be considered in the assessment of the impacts of the project (see **Section 2.2**) below.
- Approvals, licences, permits etc under various Acts and Regulations which are required for project implementation (see **Section 7** for summary)

2.2 Other Relevant Environmental Legislation and Plans

Following is a discussion on the main legislation etc of relevance to this environmental impact assessment. Commonwealth legislation is indicated, with the remainder being NSW legislation.

Commonwealth *Environment Protection (Sea Dumping) Act 1981*

This Act is administered by the Federal Department of Environment, Water, Heritage and the Arts (DEWHA). It applies to all coastal waters, except those deemed to be internal State waters, e.g. coastal embayments and estuaries. It provides for protection of the environment by regulating dumping into the sea, incineration at sea and artificial reef placements etc.



An Artificial Reef Permit under the Act is required to scuttle the Ex-HMAS ADELAIDE. This involves:

- ship cleaning to meet environmental standards and to DEWHA's satisfaction (see **Section 4.2**)
- preparation and implementation of a Long Term Monitoring and Management Plan as referred to in **Section 1.3.2**.

Commonwealth Native Title Act 1993

There is no existing native title claim over the scuttling site. Subdivision N, of Division 3 of Part 2 of the *Native Title Act* authorises acts undertaken in offshore places and in this case, covers the sinking of the Ex-HMAS ADELAIDE and creation and ongoing management of the artificial reef dive site. Notice of the proposed scuttling of the Ex-HMAS ADELAIDE to create an artificial reef and dive site will be given to the NSW Native Title Services Ltd for comment.

Threatened Species Legislation

Relevant threatened species legislation comprises the Commonwealth *Environment Protection and Biodiversity Conservation Act (EPBC) 1999* and NSW *Threatened Species Conservation (TSC) Act 1995* and *Fisheries Management (FM) Act 1994*. An assessment of threatened or migratory species likely to occur along the NSW Central Coast and potential impacts as a result of scuttling the Ex-HMAS ADELAIDE for an artificial reef are discussed in **Section 6.2.5**. This indicated that no significant impact were expected and so a Species Impact Statement is not required under NSW legislation and the proposal does not need to be referred to the Federal Minister for the Environment under the *EPBC Act*.

Historic Shipwrecks Legislation

The relevant legislation is the Commonwealth *Historic Shipwrecks Act (HSA) 1976* and the NSW *Heritage Act (HA) 1977*. The *HSA 1976* protects shipwrecks if they were wrecked over 75 years ago, while the *HA 1977* protects cultural heritage in State waters if the object or objects were created over 50 years ago. As shipwrecks are known and potentially occur off Terrigal and Avoca a submerged cultural impact assessment was undertaken by Cosmos Archaeology Pty Ltd (see **Section 6.2.13** and **Appendix F**).

Coastal Protection Act 1979

The *Coastal Protection Act* applies to coastal regions of NSW. The objectives of this Act are to provide for protection of coastal environments and to supervise activities affecting the coastal zone (which extends from the western boundary of the land in the coastal zone and out to 3nm off the coast).



Any developments or activities occurring in the coastal zone which may affect the sea, beach or other coastal zone habitats, or that are potentially inconsistent with the principles of ecologically sustainable development, require concurrence. The scuttling site for the Ex-HMAS ADELAIDE is within the NSW coastal zone and requires concurrence under the Act as indicated in **Section 7**.

State Environmental Planning Policy No.71 – Coastal Protection

SEPP No.71 sets out matters for consideration in relation to an activity in the coastal zone, with those of relevance listed below (together with the section of the report where they area addressed):

- the suitability of development given its type, location and design and its relationship with the surrounding area (see **Section 9** for a summary, and **Appendices B** (Hydrographic and Geophysical Investigation) and **C** (Marine Survey Report)).
- measures to conserve animals (within the meaning of the *Threatened Species Conservation Act 1995*) and plants (within the meaning of that Act), and their habitats (see **Section 6.2.5** and **Appendix C**),
- measures to conserve fish (within the meaning of Part 7A of the Fisheries Management Act 1994) and marine vegetation (within the meaning of that Part), and their habitats (see **Section 6.2.5** and **Appendix C**),
- the likely impact of coastal processes and coastal hazards on development and any likely impacts of development on coastal processes and coastal hazards (see **Section 6.2.3** and **Appendix D**),
- measures to reduce the potential for conflict between land-based and water-based coastal activities (see **Section 6.2.7** and **6.2.9** which address potential conflicts between water-based activities),
- likely impacts of development on the water quality of coastal waterbodies (see **Section 6.1.5**),
- the conservation and preservation of items of heritage, archaeological or historic significance (see **Section 6.2.13** and **Appendix F**).



3. CONSULTATION

3.1 Interagency Steering Committee

An Interagency Steering Committee (ISC) coordinated by the Department of Premier and Cabinet was established for the Ex-HMAS ADELAIDE Project with representatives from:

- NSW Maritime Authority
- NSW Tourism
- Environment Protection and Regulation Group, Department of the Environment, Climate Change and Water (DECCW)
- Climate Change, Policy and Programs Group, DECCW
- NSW Fisheries
- Land and Property Management Authority (LPMA)
- Department of Planning (DoP)
- Department of Premier and Cabinet (DPC)
- WorkCover Authority.

The Committee met a number of times between late 2007 and mid 2008 to ensure a whole of government approach to the Ex-HMAS ADELAIDE project. This included a Committee workshop on 6 February 2008 to identify issues, risks, uncertainties, tasks, approvals and regulatory requirements. The results of the workshop were documented by The Australian Centre for Value Management (2008).

Consultation was also undertaken with representatives from Gosford City Council, the Department of Defence and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA), Ports and Marine Section.

Agencies also provided written advice on matters for consideration in the preparation of the REF (see **Appendix A**).



3.2 2007/2008 Stakeholder Meetings

Prior to WorleyParsons' engagement consultation for the Ex-HMAS ADELAIDE Project included:

- 14 November 2007, project briefing by the then Department of Lands at Gosford City Council's Terrigal Haven PoM Stakeholder meeting.
- 6 February 2008, site tour with officers from Gosford City Council (including Terrigal Haven) to gain an appreciation of potential site issues and to acquaint Council with the NSW Government's approach to implementing the Ex-HMAS ADELAIDE project.
- 27 February 2008, meeting with dive industry peak bodies in Gosford convened by the Department of Premier and Cabinet (DPC) and attended by Lands. This included representatives from PADI and the Central Coast Artificial Reef Project (CCARP). CCARP is supported by Central Coast dive clubs associated dive operators and Central Coast Tourism.
- 6 May 2008, public meeting and presentation by Lands, NSW Fisheries and Tourism NSW at the Central Coast Leagues Club, Gosford to business operators with an interest in providing recreational diving, tourism or other commercial activities for the Ex-HMAS ADELAIDE.
- 11 June 2008, presentation by Lands and DPI to Friends of the Marine Discovery Centre and interested members of the public (approximately 100 attendees). The Central Coast Marine Discovery Centre is a partnership involving the University of Newcastle; Federal, State and Local Government; local business and tourism operators; and environmental networks.
- July 2008, Lands and DPC newsletter, with an invitation to subscribe to future newsletters.

These meetings/ presentations generally covered the project background, benefits, responsibilities, tasks and milestones, site selection, matters to be covered in the environmental assessment and a potential operation model.

3.3 Consultation for this REF

Activities carried out during the preparation of the REF, included:

- 3 November 2008, presentation to invited stakeholder groups at Gosford RSL covering project background, update, environmental assessment matters and preparation of the Ex-HMAS ADELAIDE Reserve PoM. Nominations for a place on the PoM Reference Group were called at this meeting. Meeting notes were distributed to attendees.



- The Reference Group meet on 4 December 2008 to discuss issues associated with the management of the Ex-HMAS ADELAIDE Reserve, on 20 August 2009 to review the preliminary Draft Plan of Management (which was also sent to the Interagency Steering Committee for review) and on the 26 August 2009 to walk over the Ex-HMAS ADELAIDE and discuss matters related to ship preparation. Subsequently a Dive Design Reference Group was formed to assist the Ship Preparation Contractor. This group included representatives from the PoM Reference Group as well as from peak diving bodies. A Scuttling Management Working Group and Environmental Preparation Reference Group were also formed (see **Appendix A**).
- 16 December 2008, lodgement of an Artificial Reef Permit application to DEWHA including a draft Long Term Monitoring and Management Plan and Draft Sampling Plan. The management and monitoring plans were submitted for comment, prior to finalisation.
- 6 March 2009, consultation with the commercial fishing industry to identify any impacts on trawl grounds.
- As noted in **Section 1.3.4** public exhibition of the Ex-HMAS ADELAIDE Reserve PoM from 21 September to 18 October 2009. This included a 'drop in' evening on the 28 September, at Terrigal Haven, for members of the public to discuss the Ex-HMAS ADELAIDE Project and PoM (and Terrigal Haven PoM) with representatives from LPMA.
- Posting project progress and information on the LPMA website and later the official Ex-HMAS ADELAIDE website www.hmasadelaide.com.



4. DESCRIPTION OF THE ACTIVITY

4.1 Original Ship Details

The HMAS ADELAIDE II was a long-range escort frigate (Adelaide Class). Based on drawings provided by LPMP it is 138.1m long, with a beam of approximately 14.0m and original displacement of 4100 tonnes. The hull is made of steel and the superstructure of aluminium alloy. The ship was built in the United States of America and was the first of six Adelaide class guided-missile frigates to be delivered to the Royal Australian Navy. The ship was launched on 21 January 1978, commissioned on 15 November 1980 and decommissioned on 19 January 2008.

It had a ship's company of 221 and accommodated up to two Seahawk helicopters. It was propelled by two General Electric LM2500 gas turbines driving a single controllable pitch propeller, achieving a speed of 30+ knots.

Weapon systems consisted of:

- 76mm rapid fire gun
- Harpoon anti-ship missiles
- Standard surface to air missiles
- Phalanx Mk 15 close-in weapons system
- Two triple anti-submarine torpedo tubes for Mk 32 torpedoes (www.navy.gov.au).



Heights were about 12m to the main deck, 18m to the bridge, 24m to the top of the foremast (the mast closest to the bow), and 39m to the top of the mainmast.

The ship contained items/ substances, (or items containing these) including:

- polychlorinated Biphenyls (PCBs used for example in transformers and capacitors)
- chlorofluorocarbons (CFCs and other refrigerant chemicals)
- hydrocarbons e.g. oils
- asbestos
- plastics
- high pressure cylinders
- heavy metals: chromate, lead, mercury, copper and zinc.



4.2 Ship Preparation

Initial preparation at the Royal Australian Navy's (RAN) Fleet Base included flushing lines to clear fuel and oils. Items were stripped to be used as operational spares for the remaining Adelaide class ships in the Navy's fleet including the missile launch unit, weaponry, electronic components, rudder, rudder stock, propeller hub, propeller blades, propeller shaft, tail shaft, both fin stabilisers, both auxiliary propulsion units and the sonar dome. Memorabilia and other historical items were also removed for future use by the Navy, RSL clubs, museums and the like.

In summary, final preparation of the ship includes the following activities:

- Removal of all fuels, oils and greases (hydrocarbons); removal of other hazardous materials including heavy metals, batteries, asbestos, PCBs, and paints containing heavy metals and other marine-hazardous material.
- Removal of part of the main mast so that it is at a minimum depth of 6m below lowest astronomical tide and hence does not pose a navigation hazard.
- Making the ship safe as a dive site by removing all machinery, cabling, insulation, non-structural partitions, hatches/ doors, floatable material, access ladders and other items that could create a diver hazard, entanglement or risk, and all objects that could break/ break loose during the scuttling process or over time (e.g. glass, wood) and block access ways or compartments (see **Photographs 4.1** and **4.2** for examples of cabling and pipework that would be removed).
- Undertaking ship modifications to produce a safe and interesting dive site including cutting diver access holes into the sides of the hull; cutting holes in the floors and ceiling to allow extra vertical access between decks; cutting openings to allow light to penetrate; and sealing off areas where diver access should not be permitted for safety reasons.
- Cutting further holes for air to escape during scuttling; ballasting and finally setting charges to blow further holes in the ship below the waterline to flood the hull and sink the vessel.
- Post-scuttling inspection to confirm the safety and stability of the ship on the seabed and to retrieve debris.

4.2.1 Ship Clean-up

The ship is being prepared for use as an artificial reef in accordance with advice and direction from DEWHA and with reference to:

- *Clean-up Standard for Ocean Disposal of Vessels, Revision 1, July 2001*, Environment Canada, Environment Protection Branch, Pacific and Yukon.
- *Clean-up Guideline for Ocean Disposal of Vessels, Revision 1, July 2001*, Environment Canada, Environment Protection Branch, Pacific and Yukon.



The Canadian documents are used in the absence of formal Australian guidelines and standards.

Disposal of material removed from the ship is as follows:

- oily waste from the ship's bilges is pumped into drums and sealed for disposal/ recycling
- hazardous materials (e.g. asbestos, PCBs) are sorted into waste bins for disposal to an appropriately licensed waste management facility
- copper cabling and aluminium etc are sorted into 44 gallon bins for sale
- any components of a 'sensitive' military nature are destroyed beyond recognition (as required by the US, as the designer and builder of the ship).

Records are kept of the tonnage of material removed for sale and tonnage of material destroyed. Where possible, every item or piece of material stripped from the ship is being recycled or reused for the highest possible purpose.

The weight of material removed from the ship would be replaced with concrete to ensure stability of the vessel under tow and on the seabed. It is estimated that the final displacement of the prepared ship would be 3900 to 4000 tonnes.



Photographs 4.1 and 4.2 Internal views of the Ex-HMAS ADELAIDE prior to preparation

4.2.2 Dive Design

Dive design principles include preparing the ship:

- to ensure the long term safety of divers as the vessel corrodes over time and to minimise ongoing maintenance costs
- so that divers with little post-certification experience can enjoy a safe dive, yet the dive still holds interest for more experienced divers



- to ensure as many items as possible remain in place to enhance the appeal of the vessel as a world class wreck dive (taking into account safety issues)
- so that, as far as practical, the entire interior of the vessel is accessible for divers (e.g. engine room, funnels, machinery spaces, magazines, operation and accommodation spaces)
- so that two divers can swim side by side
- so there is a direct line of sight to at least one exit hole from anywhere in the vessel
- to allow extra vertical access points between decks of the ship

This would be achieved by, for example:

- widening passageways
- removing bends, small sections of bulkhead, corners of rooms
- providing two exits to each room (in case one becomes blocked)
- eliminating snag points, bulkheads etc where divers could hit their head
- using shaped charges for scuttling to form additional horizontal diver access to areas which were below the waterline of the ship (McMahon Services Australia, 2009).

The majority of the vessel would be accessible to divers apart from the main fuel tank, other small storage tanks and void spaces (mostly on the lower levels of the ship). Where access to these areas is via a hatch, this would be removed and steel bars welded across the opening (small enough to prevent divers entering with or without tanks) or alternatively the hatch would be welded shut and the opening mechanism purposely damaged to prevent reopening.

As noted in **Section 3.3**, the dive design is being guided by a Reference Group with representatives experienced in wreck diving. The Dive Design Reference Group has inspected some sections of the ship initially prepared for diving and provided advice on further work. Prior to scuttling, an open day would be held for the Reference Group and rescue services personnel so that they could walk through the prepared vessel to become familiar with the final layout. The Water Police and military divers would video each deck/ ship level for reference in the event of a dive emergency and plans of the final dive layout would be made public.

4.3 Ship Placement

4.3.1 Location, Orientation and Depth

The centre of the scuttling location in metres in Map Grid of Australian (MGA) 1994 coordinates and in longitude and latitude is presented in **Table 4.1**. The closest land to the ship would be the



Skillion Rocks, with the distance between low tide at The Skillion and the stern, centre and bow of the ship being approximately 1.41, 1.47 and 1.54km respectively. The distance to the reef to the south of the ship would be around 400m. Directly east, to low tide in Bulbararing Bay the distance between the stern, centre and bow of the ship would be approximately 1.84, 1.90 and 1.97km respectively (see **Figure 4.1** which shows the scuttling location with the ship indicated in red and surrounding rectangular exclusion zone).



Figure 4.1 Scuttling Location



Table 4.1 Scuttling site coordinates

Longitude (east)	Easting (MGA 94)	Latitude (south)	Northing (MGA 94)
151°27.38'	356,560	33°27.91'	6,296,080

The key factor in selecting this site was the depth of sand (around 6m in this location, see **Section 5.2**) available for penetration of the ship's hull to ensure the vessel would be stable on the seabed. The vessel would be orientated ESE so that the bow was facing into the general direction of the largest waves (which are from the SE, ESE and S) and to reduce the lateral load from waves from the NE-E sector (see **Section 6.2.1** for details on the stability analysis).

The seabed at the scuttling site slopes down to the west at approximately 1.4%. Water depth at the site is about 32m (relative to Lowest Astronomical Tide (LAT)). Due to the vessel being orientated along the nearshore slope the bow would sit in a depth of approximately 33m and the stern in 31m (relative to LAT).

Not taking settlement into account (it is understood that the Ex-HMAS BRISBANE has settled into the seabed by approximately 2m and a similar settlement depth is expected for the Ex-HMAS ADELAIDE over time), the depths of water over parts of the vessel superstructure are provided in **Table 4.2**. Note that approximately 13.5m of the main mast has been removed to achieve a 6.5m navigation clearance at LAT, as required by NSW Maritime.

Table 4.2 Clearance over vessel superstructure

Section of Vessel	Clearance (m)
Main Deck (Stern)	22
Mid-vessel (top)	17
Bridge (top)	13
Fore Mast	8
Main Mast	6.5
Main Deck (Bow)	19

4.3.2 Towing and Scuttling Method

To ensure stability of the ship, appropriate sea conditions for towing to the Central Coast would be established by the Ship Preparation Contractor's naval architect. Holes cut in the side of the hull close to the water line would be boarded up to prevent ingress of seawater during towing. The ship would be towed by two tugs and it is estimated that it would take 14 to 16 hours to reach the



scuttling site. The ship would then be moored for two to four days to allow preparations for scuttling. This would include cutting final dive access holes near the waterline and installing detonation devices for the cutting charges.

Bow and stern moorings would be used to position the ship. Fore and aft lines would be attached to the ship and tugs so that they could secure the ship to ensure it settled in an upright position on the seabed. Approximately 16 cutting charges would be set to create 1m x 1m holes below the waterline to allow water to flood through the vessel evenly, with air venting through vertical holes and out the top of the vessel. As noted in **Section 4.2** the cutting charges would also create additional diver access holes, which could not be cut prior to scuttling. The charges would focus superheated gas on a bead to 'cut' a hole in the hull (looking similar to an oxy-acetylene cut). As scuttling the Ex-HMAS ADELAIDE is expected to be a major event for the Central Coast (attracting large crowds), a pyrotechnic display from the deck of the ship would increase the spectacle.

Post-scuttling, a dive inspection would be undertaken to confirm the safety and stability of the ship on the seabed and to retrieve debris. This would include clearing charges (the type of charge to be used would deactivate after a given time to ensure diver safety). Divers would swim through the wreck to remove any items that had come loose and to identify items damaged during the scuttling process and in need of repair. They would also remove any debris from the sea floor and any flotsam or jetsam from the waters around the ship.

Repairs and installation of the moorings and navigation aids would be undertaken over one to two days following scuttling. Before officially opening for dive tours, the divers involved in the post scuttling inspections would conduct a familiarisation dive for the Dive Design Reference Group and relevant rescue services personnel.

4.3.3 Spectator Management

Exclusion zones would be in place around the ship as it is towed out of Sydney Harbour and up to Avoca. An exclusion zone would also apply at the scuttling site, prior to and immediately following scuttling. This would consist of a water exclusion zone, approximately 1km around the ship and an air space exclusion zone, approximately 3km around the ship and 3000ft (just over 900m) above the vessel.

4.4 Completed Reef

4.4.1 Exclusion Zone

Based on arrangements at other ex-Navy vessel dive sites the following restrictions are proposed:

- 350 x 250m restricted zone within which the scuttled vessel is centrally located and which requires an entry permit (i.e. exclusion zone boundary is about 100m from any section of the scuttled vessel)
- 4 knot speed limit within restricted zone



- no anchoring within restricted zone
- no mooring within restricted zone unless a permit has been obtained
- no manoeuvring over the scuttled vessel.

A Fishing Closure is also proposed to address potential conflicts, incompatibilities and safety issues associated with fishing and diving. This is to include prohibition of spear fishing and trolling/trawling across the ship. In consideration of recreational and occasional trawl fishing that may occur in the vicinity of the scuttled vessel, a 350 x 250m fishing closure is proposed. This is considered the minimum closure size, based on a review of restrictions at other ex-Navy dive sites.

Marker buoys indicating the ship location would be installed to NSW Maritime requirements. The Royal Australian Navy (RAN) Hydrographic Service in Wollongong would be advised of the ship's location and buoyed area so that navigation charts and GPS information could be updated.

Above water webcams may be installed to assist in surveillance of the restricted zone and to monitor weather conditions. Below water webcams may also be installed to assist in surveillance of divers and monitoring of marine life.

4.4.2 Access, Moorings, Dive Routes and Down Time

It is anticipated that most divers would visit the dive wreck from boats operating out of Terrigal Haven, with some divers travelling by boat from Brisbane Waters, Pittwater and Sydney. Travel time to the Ex-HMAS ADELAIDE from Terrigal Haven would be about 5 minutes and a bit over an hour for a large boat from Sydney.

There are two boatramps at Terrigal Haven, with moored and trailered dive boats picking up passengers at the larger ramp to access existing dive sites. The size of dive boat operating out of Terrigal Haven is currently limited to about 7.5m, i.e. that which can be held against the swell while equipment is loaded and that can be pushed off the beach (email 30 October 2008, Les Graham to Heather Nelson). It is noted that the boat ramp is very popular and often overcrowded at peak times (Maunsell McIntyre 1999) and that the Ex-HMAS ADELAIDE would attract further visitation to the area and place more pressure on existing facilities. As noted in **Section 1.3.5**, LPMA have engaged consultants to prepare a concept design for a jetty (or similar facility) to cater for a number of user groups, including dive boats to the Ex-HMAS ADELAIDE.

Once at the dive site, the dive boats would tie up to the moorings provided. Currently six moorings are proposed, including two commercially operated moorings, two casual commercial moorings and two recreational/ club use moorings. Divers would use a reference line to execute a controlled descend to depth. The reference line may be the mooring line or an additional shot line provided by the dive operator. It is anticipated that six to eight different dive routes would be possible (all linked together) and that a typical dive would last for 20 to 35 minutes (depending on maximum depth) including a safety stop during ascent (depths to various parts of the ship are shown in



Table 4.3). Divers would be required to maintain a safe ascent rate of no more than 18m/ 60ft per minute, and perform a minimum of a 3 minute safety stop at 5m/ 15ft before surfacing. The location of this safety stop would be provided on the mooring lines or shot line. For safety reasons (e.g. because exits would not be clearly visible at night) night diving would generally be restricted to the exterior of the ship, except for divers with special qualifications and sufficient experience to dive inside the wreck at night.

Table 4.3 Water depths to various parts of the ship

Section of Vessel	Water depth (m) for tidal plane		
	LAT	AHD	HAT
Bow	19.8	20.7	21.8
Deck Head (top) of Bridge (Level 2)	13.7	14.6	15.7
Level 1 (mid-level)	19.7	20.6	21.7
Main Deck (mid-level)	23.8	24.7	25.8
Second Deck (mid-level)	27.5	28.4	29.5
First Platform (mid-level)	30.5	31.4	32.5
Second Platform (mid-level)	33.1	34.0	35.1
Stern (Flight Decks)	22.5	23.4	24.5
Seabed (at bow location)	33.2	34.1	35.2

Notes: Lowest Astronomical Tide (LAT), Australian Height Datum (AHD – which is approximately equal to mean sea level), Highest Astronomical Tide (HAT).

A downtime assessment was undertaken as an indication of expected divability at the proposed Ex-HMAS ADELAIDE artificial reef. The assessment was based on review of regional historical marine conditions and from information provided by local dive operators regarding threshold marine conditions. Offshore wave data was combined with coastal wind data collected at Williamtown Airport (85km NNE of the site) to produce a 16 year wind/ wave timeseries (see **Appendix E** for further information).

The conditions under which dive operations could be conducted have been based on discussion with local dive operators. These are:

- offshore sea/ swell wave heights of less than 2m;



- wind speeds of less than 11m/s (approximately 21 knots); and
- long period swells with peak periods of 13 seconds or greater having wave heights not exceeding 1m.

The first two of these conditions relate to basic marine safety with additional considerations for diving, such as safety on the dive ladder for divers climbing back onto the moored vessels. The last condition is included as an additional safety measure against underwater surges caused by oscillatory wave driven currents moving through the scuttled vessel's hull. These wave driven currents are present at the depths of the scuttled vessel during long period swell events and are likely to create dangerous conditions at the entry/ exit points as flow siphons and jets from these orifices.

Table 4.4 presents the estimated percentages for overall and seasonal downtime/ uptime resulting from the analysis. Overall downtime of 29% (or 71% uptime operations) could be expected with winter having the greatest proportion of downtime with respect to seasonality. Conversely, summer has the least proportion of downtime. As stated above, these estimates include only the downtime from limiting wind and sea/ swell conditions.

Table 4.4 Estimated down time

Period	Downtime (%)	Uptime (%)
Overall	28.7	71.3
Summer (December, January, February)	23.5	76.5
Autumn (March, April, May)	31.6	68.4
Winter (June, July, August)	33.7	66.3
Spring (September, October, November)	25.1	74.9

The assessment did not account for the short or partial day duration events. As such it assumed that if a dive crew had set out in suitable conditions that the crew would return to Terrigal Haven (or other location) as conditions deteriorated. Similarly the assessment assumed that operators would delay only if conditions were unsuitable initially, but improved during the day such that diving was possible (i.e. unsuitable morning conditions did not result in cancellation of the whole day).

The assessment did not include the downtime associated with:

- current events (as currents of a magnitude that may inhibit diving at the site are infrequent events and the data required to quantify the frequency and duration of such currents is not available).



- high turbidity and poor visibility (these conditions may be expected after sustained periods of high rainfall, upwelling or windy conditions and are likely to increase the estimated downtimes provided in **Table 4.4**).

4.4.3 Management

The LPMA has responsibility for the administration and management of all Crown land including commercial leasing and licensing activities. The ocean bed out to the 3nm limit of State waters is Crown land and the foreshores adjoining the Ex-HMAS ADELAIDE Reserve are Crown Reserve (including foreshore land around Terrigal Haven). As such, LPMA is responsible for the preparation and implementation of the Ex-HMAS ADELAIDE Reserve Plan of Management (PoM).

Proposed Management arrangements are as follows:

- The Trust to be administered by the Lands Administration Ministerial Corporation (a statutory body representing the Crown) which would have overall management responsibility for the dive wreck.
- Outsourcing of commercial management arrangements including management of the wreck as a tourist attraction, booking, permitting and franchising.
- Licensing of moorings.

The Commercial Manager's responsibilities would be open to negotiation and could include the following:

- developing a mooring booking system, timeslots etc (for both exclusive and non-exclusive moorings)
- checking insurances, assessing and approving permit applications
- managing special events, activities, one-off group tours etc
- collecting fees ('per head' dive fees for exclusive moorings, mooring and 'per head' fees for non-exclusive moorings, registration, use of brand, fees for special events and other activities)
- maintaining and managing webcams
- undertaking monitoring and reporting (e.g. vessel numbers, movements, dive numbers, wreck hazards and incidents)
- developing a Marketing Plan including franchising and merchandising (souvenirs etc)
- managing the Ex-HMAS Adelaide website.



The permit to dive on the Ex-HMAS ADELAIDE would incorporate a Code of Conduct which would address issues such as:

- vessel speeds, manoeuvring, mooring procedure, lookout
- prohibition of tools which could be used to salvage material from the wreck
- prohibition of collection of marine life
- minimum impact dive practices (e.g. avoid disturbing marine growth, no fish feeding)
- displaying international Code A flag while diving
- record keeping, e.g. manifest of all divers (times, depth, safety stops, surface intervals etc)
- hazard and incident reporting.

It is expected that management of the dive site would involve ongoing liaison with stakeholders such as Central Coast Tourism, Gosford City Council, commercial operators, dive clubs and the University of Newcastle and other research bodies (to facilitate research opportunities).

4.4.4 Monitoring and Risk Management

As noted in **Section 1.3.2** a Long Term Monitoring and Management Plan (**Appendix G**) was prepared as part of the requirements for making an Artificial Reef Permit Application under the *Environment Protection (Sea Dumping) Act 1981*. The plan outlines the methods for monitoring the Ex-HMAS ADELAIDE post-scuttling. A summary of the LTMP is provided below indicating the frequency of monitoring activities over the first five years. The frequency of monitoring and the methodologies used would be reviewed periodically and after five years.

Structural Integrity

Visual inspections would be made by divers twice yearly and following major storm events to identify issues which pose a safety risk to divers and/ or require maintenance works, e.g:

- debris requiring removal from within and surrounding the vessel
- blocked or impeded diver entry and access points
- access to areas designed to have no diver access
- structural damage or failure



In addition, charter operators and others visiting the vessel would be expected to report any structural/ safety issues to the Commercial Manager under the Code of Conduct referred to in **Section 4.4.3**.

Vessel Stability

This would involve annual and post severe storm surveys to determine any change in the position and angle of incline of the vessel and depth of settlement into the seabed.

Environmental Monitoring

This would include:

- surveys to document colonisation of the artificial reef by marine life seasonally for the first two years then biannually
- annual surveys to document sediment movement around the vessel, e.g. presence of scour holes, sediment accumulation against the vessel, sand waves or rippling effects (the presence of benthic organisms would also be noted)
- analysis of sediments at 6 months and 12 months post survey to determine whether sediments around the vessel had become enriched with heavy metals due to flaking of paints and corrosion
- determine whether bioaccumulation of heavy metals (such as chromate) in hull fouling organisms would be likely (annually for the first three years)

Concentrations of heavy metals would be compared with the ANZECC/ ARMCANZ (2000) *Australian Guidelines for Water Quality Monitoring and Reporting* and *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (which includes sediment quality guidelines).

4.4.5 Maintenance

As noted in **Section 1.3.3**, an Asset Management Plan would be prepared to guide maintenance over 40 years. Maintenance activities may be required if significant fouling occurs by barnacles etc which limits diver access, or egress, or presents a hazard to divers. Other maintenance activities may include removal of debris after severe storm events and repairs to make the wreck safe for divers (e.g. refixing any loose items, ensuring barriers to access to tanks/ small spaces are maintained).



5. DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 Water Levels

Astronomical tide varies between about -0.9m AHD LAT and 1.2m AHD HAT along the NSW coast. NSW tides are fairly uniform with only a small phase shift between locations. As such, the tidal planes at the scuttling site can be considered equivalent to the tidal planes calculated for Sydney's Fort Denison (considered to be an open ocean tide site), see **Table 5.1**.

Table 5.1 Tidal planes at Sydney (Fort Denison)

Tidal plane	Elevation (m AHD)
Highest Astronomical Tide (HAT)	1.15
Mean High Water Springs (MHWS)	0.68
Mean High Water Neaps (MHWN)	0.43
Mean Sea Level (MSL)	0.05
Mean Low Water Neaps (MLWN)	-0.33
Mean Low Water Springs (MLWS)	-0.58
Lowest Astronomical Tide (LAT)	-0.88

(Source: Bureau of Meteorology, National Tidal Centre – pers. comms. Paul Davill)

As noted in **Section 4.3.1**, the water depth at the scuttling site is about 32m LAT.

5.2 Physical Characteristics of the Seabed

Side scan sonar mapping and seismic reflection profiling were undertaken as part of this study and this, together with previous multibeam soundings by the Department of Conservation and Climate Change (DECC) was used to interpret water depths and bedrock levels, and hence depth of sediment within the study area.

In summary:

- Seabed levels of 31m to 35.5m below AHD were indicated by DECC multibeam sounding data over the study area, increasing in a regular fashion to the east-southeast.



- A general uniform, sandy seabed was inferred from sidescan sonar data, with one area of low sand banks inferred in the southwest of the study area and small areas of sand waves and low reef outside the study area. Some low (<0.2m) sand waves may occur within the area, unrecognised on the sidescan data.
- A thin veneer (<1m) of sediment or low, patchy reef (unresolved on the seismic records), was interpreted locally in the far northeast of the area. Inferred thicknesses increase to over 6m in the centre of the study area.
- Bedrock levels were interpreted to vary from approximately 33m to approximately 41m below AHD throughout the investigation area, with the deepest bedrock in a broad palaeochannel or basin underlying the centre of the study area (Douglas Partners 2008, see **Appendix B** for further details).

A marine survey (**Appendix C**) undertaken on 21 July 2009 included video transects which confirmed the presence of sand over the proposed scuttling location (see **Figure 5.1** for transect locations and **Figure 5.2** for stills of video footage) and absence of rocky substrate. Formed sand ripples were present at several sites and had an orientation indicating a wave climate roughly from a south-easterly direction. Ripple crests were short, only up to about 2cm, with crests spaced about 10-15cm apart.

5.3 Sediment Characteristics

The percentage of fines and sand from nine sandy sites within the study area (samples collected during the marine survey, see **Figure 5.1**) are presented in **Table 5.2**. Sediment samples were comprised mostly (around 98%) of sediments smaller than 2mm diameter. Most (average 86.4%) of the sand fraction was smaller than 300µm so samples can be classified as 'fine sand'.

Table 5.2 Sediment grain size analysis

Sediment Classification	% Fines and Sand									
	V1	V2	V3	S1	S2	S3	S4	S5	S6	Mean
Fines (<75 µm)	<1	1	1	2	3	2	1	2	2	1.6
Sand (75 µm–2 mm)	100	99	99	98	97	98	99	98	98	98.4

Note: V1 vessel stern location, V2 middle of ship, V3 bow location (for SE orientation).

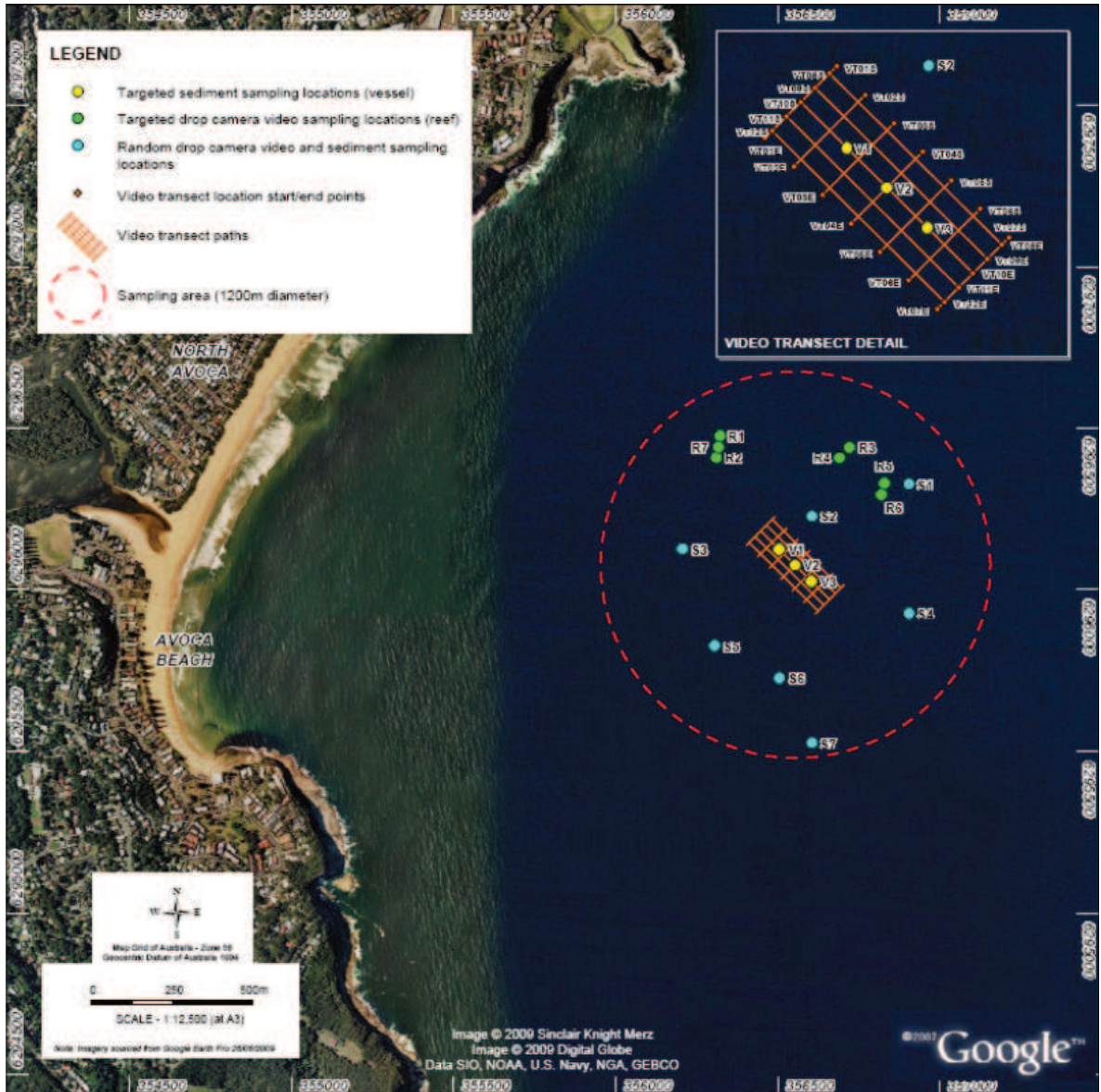
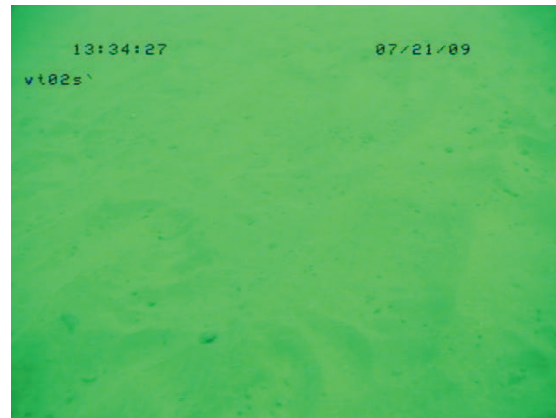


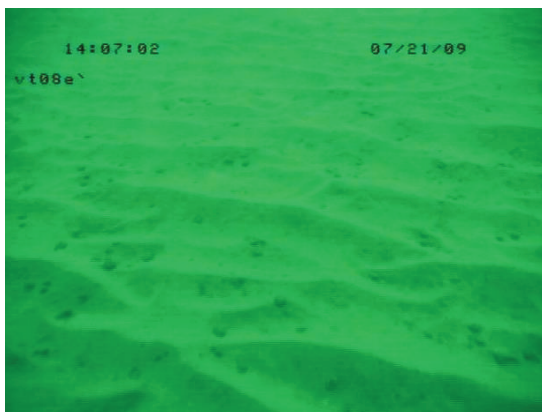
Figure 5.1 Marine Survey Sampling Locations



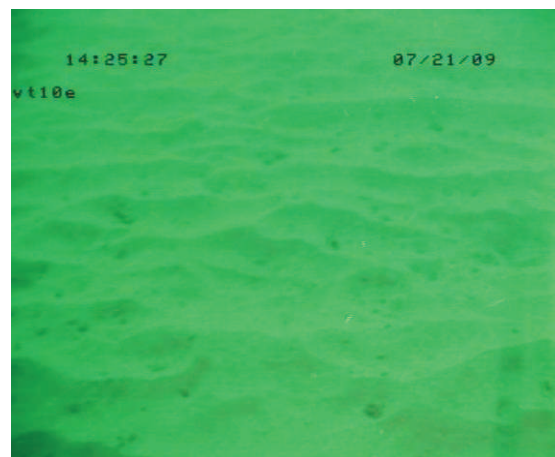
Transect VT01



Transect VT02



Transect VT08



Transect VT10

Figure 5.2 Typical Seabed Characteristics

Metal concentrations (mg/kg dry weight) from sediment samples collected along the proposed centre line of the scuttled vessel (sites V1 – V3) are provided in **Table 5.3**. To assist with interpretation of the results the following have also been provided.

- PQL: which is the Practical Quantitation Limit for each metal species.
- ANZECC ISQG-(Low) and ISQG-(high): ANZECC/ARMCANZ (2000) Interim Sediment Quality Guideline, where the concentration of a contaminant is below the ISQG Low Trigger Value it is unlikely that there would be any adverse impact on organisms inhabiting that sediment.
- Data for MacMasters Beach which is located close by (Matthai *et al.* 2002).

It is clear from **Table 5.3** that the sediments are uncontaminated with respect to metals.



Table 5.3 Metals/ metalloid concentrations (mg/kg dry wt)

Metals & Metalloids	PQL	ANZECC ISQG-Low	ANZECC ISQG-High	V1	V2	V3	Mean Avoca Beach (July 2009)	Mean MacMasters Beach (1995)
Aluminium (Al)	200	-	-	1180	1170	1200	1183	-
Iron (Fe)	100	-	-	10300	8510	10000	9603	10430
Antimony (Sb)	0.5	2	25	<0.50	<0.50	<0.50	N/A	-
Arsenic (As)	1.0	20	70	11.8	10.1	11.5	11.1	-
Cadmium (Cd)	0.1	1.5	10	<0.1	<0.1	<0.1	N/A	-
Chromium (Cr)	1.0	80	370	8	6.8	7.9	7.6	25
Copper (Cu)	1.0	65	270	1.6	1.2	1.4	1.4	6.0
Cobalt (Co)	0.5	-	-	2	1.6	1.8	1.8	3.2
Lead (Pb)	1.0	50	220	3.7	3.1	3.6	3.5	11.2
Manganese (Mg)	10	-	-	86	74	78	79	54
Nickel (Ni)	1.0	21	52	2.8	2.2	2.6	2.5	14.2
Selenium (Se)	0.1	-	-	0.2	0.3	0.2	0.23	-
Silver (Ag)	0.1	1	3.7	<0.1	0.2	<0.1	N/A	0.1
Vanadium (V)	2.0	-	-	17.1	14.5	16.8	16.1	-
Zinc (Zn)	1.0	200	410	12.2	8	10.4	10.2	32
Mercury (Hg)	0.01	0.15	1.0	<0.01	<0.01	<0.01	N/A	-

In the case of metals where interim sediment quality guidelines have been established, the results for antimony, cadmium and mercury were below the relevant PQL and silver was either below or close to the PQL at the scuttling site. Arsenic, chromium, copper, lead, nickel and zinc were all lower than their respective ANZECC/ARMCANZ ISQG-low values.

ANZECC/ARMCANZ sediment quality guidelines have not been set for aluminium, iron, cobalt, manganese, selenium and vanadium. Cobalt and selenium were recorded at slightly higher concentrations than the applicable PQL, manganese and vanadium concentrations were very low. Aluminium was around an order of magnitude higher than the PQL, with iron approximately two orders of magnitude above the PQL.

Data for MacMasters Beach (one of six sampling sites off the Sydney basin in 1995 and reported in Matthai *et al.* 2002) has been provided as a comparison (particularly for metals where no



guidelines have been established). It relates to trace metal concentrations in bulk sediment (0-10cm depth) from eight cores in water depths of around 80m (middle shelf) from a reference site (i.e. representative of natural background conditions) off MacMasters Beach (latitude 33°30' south) to the south of Avoca Beach.

Note that middle shelf sediments (60 to 120m water depths) are typically mud to muddy sands (15-30% mud at the MacMasters Beach sampling site) compared to inner shelf sediments which are typically sandy sediments (less than 2% mud) (Matthai *et al.* 2002) (mean of 1.6% fines for the scuttling site as indicated in **Table 5.2**). Note also that heavy metals are associated with the fine fraction as was apparent in Matthai *et al.* 2002, where concentrations of copper, iron, manganese and nickel were found to increase in proportion to the mud content at all sampling sites. As shown in **Table 5.3**, concentrations for iron, cobalt and manganese (metals for which guidelines have not been established) were the same order of magnitude at the scuttling site and off MacMasters Beach.

5.4 Water Quality and Clarity

Visibility in coastal waters off the NSW coastline is typically good with poor visibility only occurring in areas with nearby river inflows where sediments have high silt contents and are exposed to resuspension through water turbulence. As noted in **Section 5.3** sediments at the scuttling site are fine sands. Water quality parameters measured at three sites during a survey on 21 July 2009 are presented in **Table 5.4**.

Water temperature profiles showed limited variability and generally varied by less than 0.2°C at each site from the sea surface to a depth of 30m. The pH profile showed almost no change from surface waters to depths of 30m, remaining within the range 8.01 – 8.03 at all sites (consistent with the ANZECC/ARMCANZ (2000) water quality guideline range for marine waters of south-eastern Australia, i.e. 8.0 to 8.4). Conductivity readings were consistent with mean seawater conductivity of about 54,000 µS/cm. Turbidity levels at all sites were highest at the surface. However, the difference between surface readings and those at depth was negligible and consistent with ANZECC/ARMCANZ (2000) water quality guidelines for marine waters which specify a range of 0.5 NTU to 10 NTU.

Table 5.4 Average water quality measurements at a range of depths

Depth (m)	Temperature (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
1	16.88	8.02	54194	1.0
5	16.61	8.02	54174	0.6
10	16.85	8.02	54165	0.6
15	16.80	8.02	54051	0.7



Depth (m)	Temperature (°C)	pH	Conductivity ($\mu\text{S/cm}$)	Turbidity (NTU)
20	16.78	8.02	54122	0.6
25	16.76	8.02	54250	0.6
30	16.75	8.02	54198	0.6
Mean	16.77	8.02	54165	0.7

5.5 Ocean and Coastal Currents

Preliminary investigations identified the main processes responsible for coastal circulation in the study region (TEL, 2008). These processes include the East Australia Current (EAC), coastal trapped waves, winds, internal waves, outflows from major estuaries and tides. The processes causing circulation are largely independent of each other, being forced by distinct mechanisms and occurring on different time and space scales. The net current velocity at any location within the study region varies as the differing processes vary in relative or absolute strength (Middleton *et al.*, 1999). Current speeds have been found to be generally less than 1ms^{-1} , but on the rare occasion can exceed 1.5ms^{-1} (Middleton *et al.* 1997).

Table 5.5 summaries the currents that have been observed to occur in the study region. From the available reported observations the typical maximum current speeds that may be expected at the proposed scuttling location are reported. Conservative values have been adopted. However, it should be noted that the following occur only on an occasional basis.

Table 5.5 Summary of regional currents experienced in the study area

Current generating process	Typical maximum observed current (ms^{-1})	Dominant current direction	Comments
EAC	2.0	Poleward (south-westward)	The EAC does not generally impinge of the study region, as a result currents associated with the EAC are rare. However, strong current events are possible. Typically currents would decrease with depth.
Coastal trapped waves	0.6	Longshore	Oscillating longshore currents generated by strong wind events in the Bass Strait. Predictable.
Wind-driven currents	0.4	Longshore	Caused by prolonged periods of alongshore wind or during storm events.



Current generating process	Typical maximum observed current (ms ⁻¹)	Dominant current direction	Comments
Internal waves	0.1	-	
Estuaries	negligible	n/a	
Tides	negligible	Oscillating onshore - offshore	Background clockwise rotating vector field with approximate 12 hour period.

5.6 Coastal Storms and Wave Climate

The NSW coastline is subject to intense tropical and non-tropical storms at irregular intervals. The Public Works Department (PWD 1985, 1986) has categorised coastal storms in NSW on the basis of estimated offshore significant wave heights (H_s) which is generally defined as the average height of the highest one third of waves recorded in an given monitoring period.

Category X storms were defined as those with an estimated $H_s \geq 6m$, and Category A storms were defined as those with $5 m \leq H_s < 6m$. When combined with available waverider buoy data, it is evident that over the 1880 to 2003 period there was one Category X event every 2.3 years (on average). However, the time period between storms has not been uniform. For example, there were no Category X storms from 1880-1891, 1900-1907, 1946-1951, 1960-1965, 1969-1973 and 1979-1985. Also, there were three Category X storms in both 1978 and 1990.

For the NSW Central Coast, PWD (1985, 1986) found that, on average:

- the Central Coast (incorporating the study area) and South Coast had more storms than areas further north in NSW;
- southern secondary lows and east coast lows were the dominant storm types in the study area; and
- most storms in the study area occurred in autumn and winter, in particular due to the prevalence of southern secondary lows and east coast lows during these seasons. This seasonal variation can be confirmed by analysis of the Sydney directional waverider buoy data collected from 1992 to 2003, derived from MHL (2004). The relative wave energy for storms with an H_s exceeding 3m for each month is shown in **Figure 5.3**.
- Based on a recent analysis of long-term offshore wave records the months of March and June-July experience the largest average monthly wave heights (Harley *et al.* 2009). Although moderate waves dominate the climate, large waves ($H_s > 4 m$) and/ or low swell may occur in any month (Short and Trenaman, 1991). Extreme events ($H_s > 6m$) occur predominately in autumn and winter. Waves in the region are generated by five typical meteorological systems: east-coast lows, tropical cyclones, mid-latitude cyclones, zonal anticyclonic highs and local summer sea breezes (Short and Trenaman, 1991).

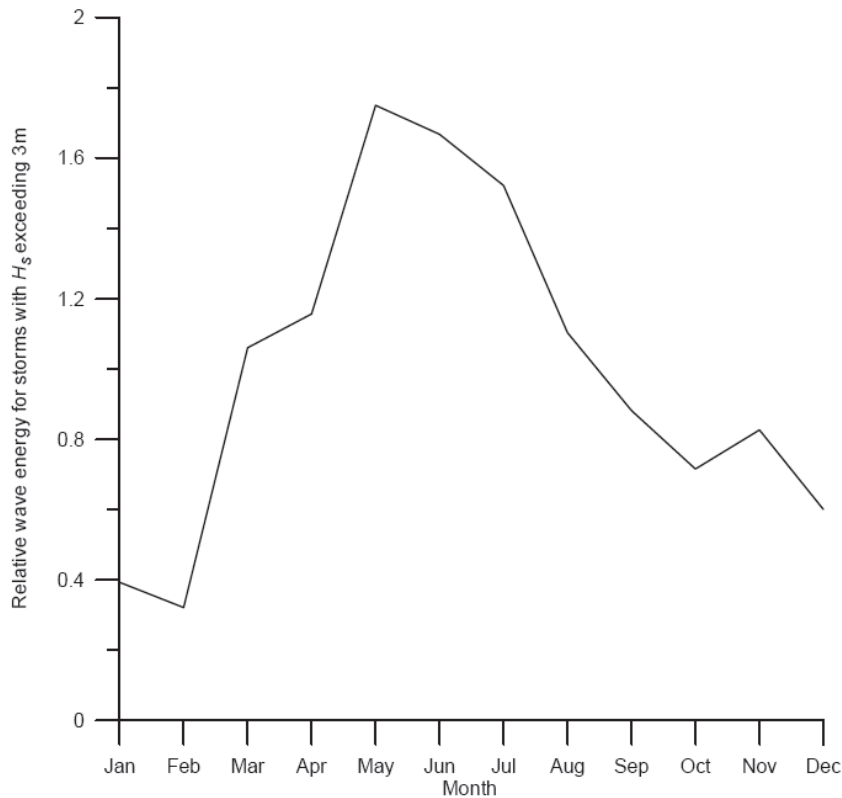


Figure 5.3 Relative Wave Energy for Storms with a H_s exceeding 3m

In order to assess the nearshore wave climate at the proposed vessel scuttling site, wave transformation modelling was undertaken using MIKE 21 SW (see **Appendix E** for more information). MIKE 21 SW is a state-of-the-art third generation spectral wind-wave model that simulates the growth, decay and transformation of wind-generated waves and swells in offshore and coastal areas. The model accounts for all the main physical processes for wave propagation from an offshore deep water location to the nearshore.

For the scuttling site, **Figure 5.4** shows the wave height (top) and wave period (bottom) roses (i.e. percentage of time waves come from these directions) with scatter plots of wave height and peak period versus wave direction presented in **Figure 5.5**.

A directional extreme wave analysis was also conducted on the nearshore wave record, as hindcast by the wave transformation modelling. **Table 5.6** presents the directional wave extremes for the 5, 50 and 100 year Average Recurrence Interval (ARI) return periods at the proposed scuttling location.

The expected 100 year ARI design wave height (H_s) at the scuttling site was calculated as 8.4m and occurring from the SE. This is compared to the equivalent offshore design wave height of 9.3m from the SSE.

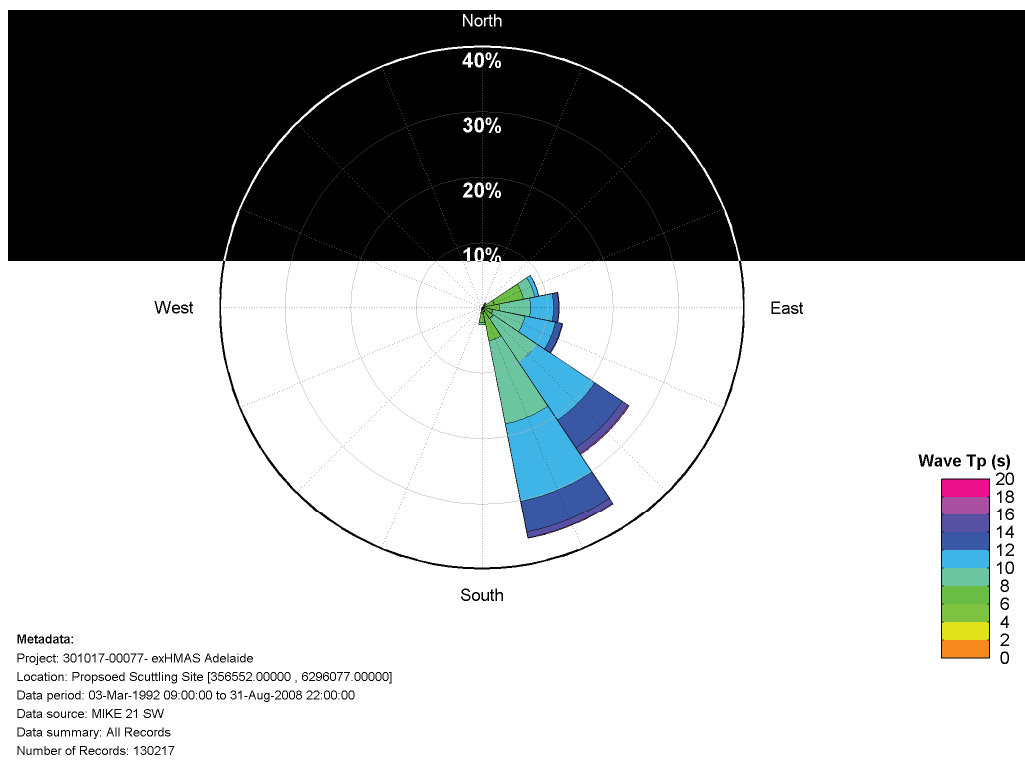
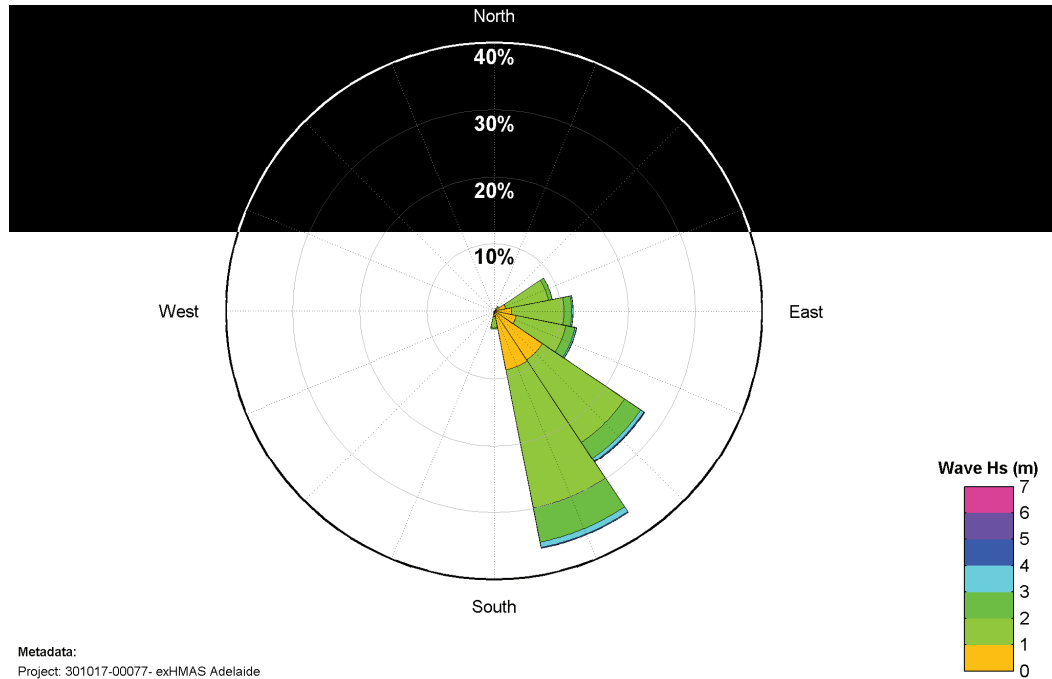
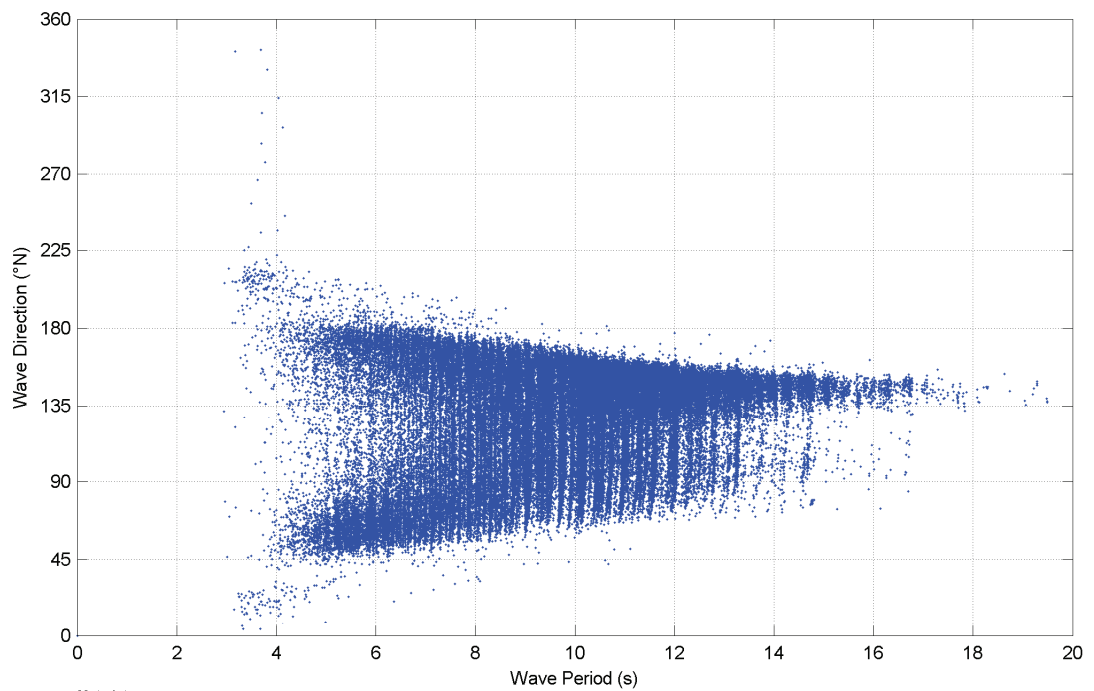
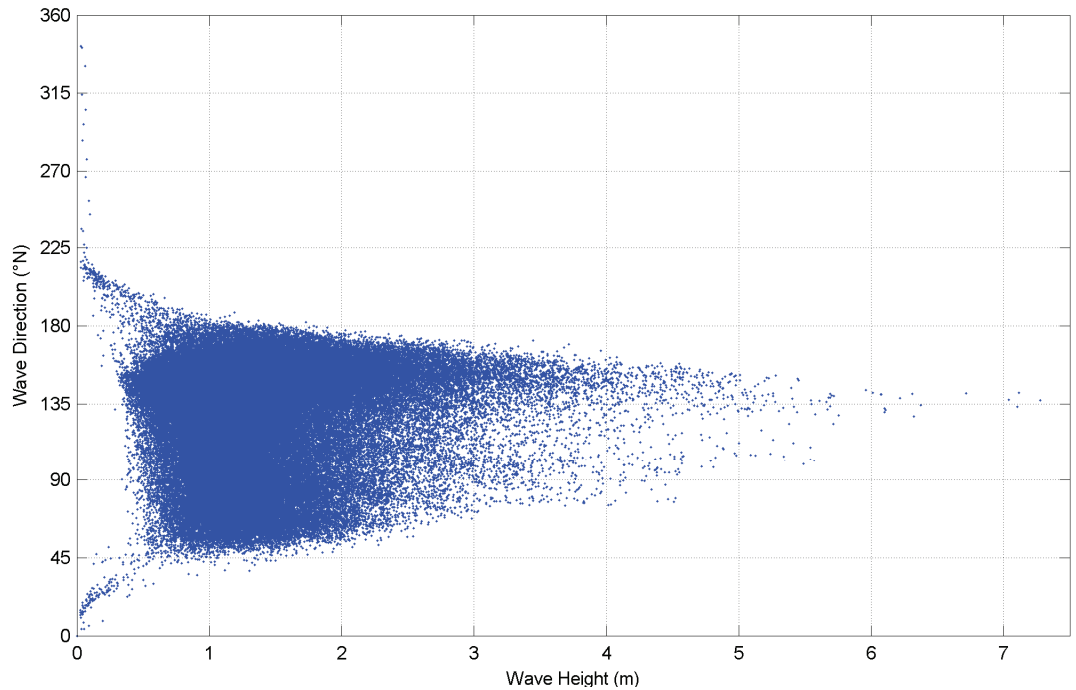


Figure 5.4 Scuttling Site Wave Height and Wave Period



Metadata:
Project: 301017-00077- exHMAS Adelaide
Location: Proposed Scuttling Site [358552.00000 , 6296077.00000]
Data period: 03-Mar-1992 09:00:00 to 31-Aug-2008 22:00:00
Data source: MIKE 21 SW
Data summary: All Records
Number of Records: 130217

Figure 5.5 Scuttling Site Scatter Plots – Height vs Direction and Period vs Direction



Table 5.6 Directional wave extremes for scuttling site

Return Period	Direction (°N)						
	NE	ENE	E	ESE	SE	SSE	S
5-year							
Significant Wave Height (Hs) (m)	2.1	3.5	4.6	5.0	5.8	5.0	3.2
Peak energy period (Tp) (s)	7.5	8.9	9.5	9.8	11.0	10.5	7.8
50-year							
Significant Wave Height (Hs) (m)	2.5	4.9	5.7	6.6	7.8	5.9	3.8
Peak energy period (Tp) (s)	8.5	10.2	11.2	11.4	13.0	12.7	8.7
100-year							
Significant Wave Height (Hs) (m)	2.6	5.3	6.1	7.0	8.4	6.1	4.0
Peak energy period (Tp) (s)	9.0	10.4	11.6	12.0	13.3	13.0	9.2

NOTE:

Location: [358,555, 6,296,077]

Water Depth: 32m

The above are the extremes likely to be reached, or exceeded, once on average every 1-year, every 50-years and every 100-years, respectively for the directional sector indicated at the above location

5.7 Marine Ecology

5.7.1 Benthic Habitats

The marine survey of the scuttling site and immediate vicinity undertaken on 21 July 2009 (see **Appendix C**) using video transects and a drop camera survey found that the area was largely compact, contoured sand with very little epifauna or macroalgae. The area covered by the transects was 300m long by 100m wide. The 300m long transects were at 50m spacings and the 100m long transects were at 25m spacings, see **Figure 5.1**.

As noted in **Section 5.3**, sediment samples from the scuttling site were mainly fine sands and there were no signs of algal discolouration in any of the sediments collected. Although bioturbation was evident at a few sites no live benthic fauna, with the exception of a single small echinoderm, were large enough to be observed by eye from the collected sediments.



Cardno Ecology Lab (2009) noted that rocky reef benthic habitats are found near the study area, with rocky reefs extending out from the rocky headland to the north and south of Avoca Beach. Rocky reef environments support very different environments to sandy bottom habitats and generally show 'stratification' or 'zonation' of organisms with depth (Underwood *et al.* 1991). WBM Oceanics Australia (1997) found subtidal rocky reef benthic communities in the vicinity of The Entrance (to the north of the scuttling site) to be diverse, patchy and both spatially and temporally variable. They are considered to be typical of shallow rocky subtidal communities occurring on the east coast of Australia (Dakin 1987, Underwood and Kennelly 1990, WBM 1997). Horizontal rock surfaces are dominated by alga including *Eklonia radiata* (kelp), *Phyllospora comosa* and *Sargassum* spp., lithothamnion pavement, turfing and coralline algae. Lithothamnion pavement, an association of hard coralline algae, other encrusting algae and macrofauna inhabit areas beneath the canopy of *E. radiata* and *P. comosa*. Boulders and rocky areas are covered extensively by lithothamnion. A wide variety of sponges, anemones, hydroids, ascidians, echinoderms and corals are also present beneath the algal canopy.

Drop camera surveys on 21 July 2009 (see **Appendix C**) of rocky reef sites north of the scuttling location (see **Figure 5.1** for locations) found kelp *E. radiata* present but uncommon and the presence of short turfing species of algae (possibly coralline species) as well as sponges and ascidians. Fish were generally uncommon.

5.7.2 Pelagic Environment

The pelagic environment constituting the water mass between the surface and the seabed is inhabited by a wide variety of organisms including plankton, planktivorous and predatory fishes and marine mammals and reptiles. Plankton is made up of two general groups: the meroplankton (spend part of their life in the plankton) and the holoplankton (spend their entire life in the plankton) (Kingsford 1995).

5.7.3 Fish

Information relating to fish assemblages on the sandy bottom and nearby reefs was collected using Baited Remote Underwater Video Stations (BRUVS). Four replicate video samples were collected at each location (see **Figure 5.6**) in December 2008. The bait used was whole pilchards. Visibility varied among samples and ranged from 3 to 10m. The BRUVS sampled a broad suite of species including carnivorous, herbivorous and omnivorous fishes and some cephalopods. They also recorded actively swimming pelagic species and cryptic sedentary and less mobile species.

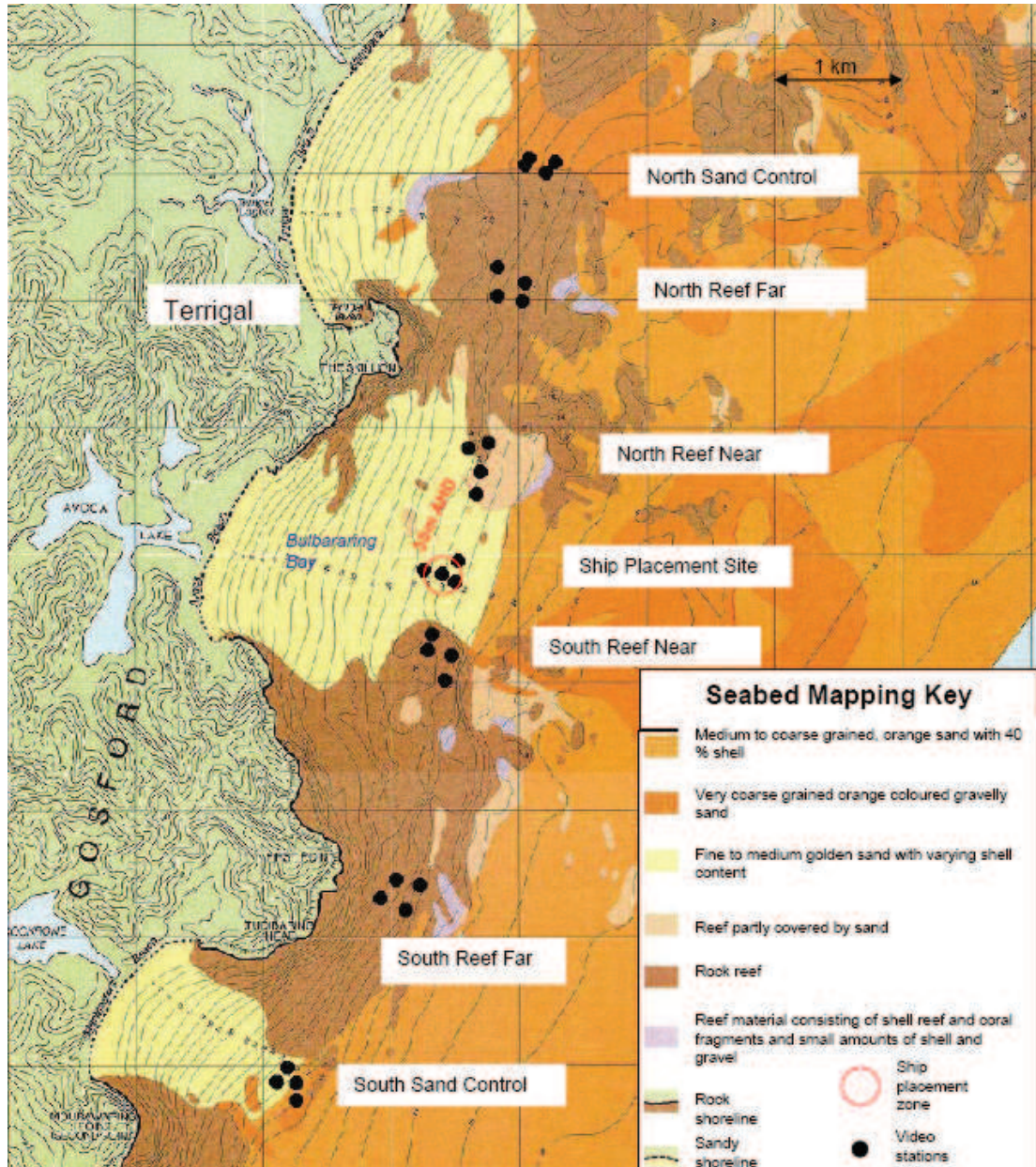


Figure 5.6 Video Sample Locations for Fish Survey

Sandy Bottom Sites

The fish fauna of sandy bottom areas in NSW are dominated by elasmobranch fishes, which are often represented by stingarees (Urolophidae) and small planktivorous fishes. Common commercially important groups include flatheads (Platycephalidae), which are voracious predators and whiting (Sillaginidae), which are benthic feeders (Connell and Lincoln Smith 1999).



Cardno Ecology Lab (2009) recorded 22 species of fish, representing 16 families (including sharks and rays) in sand habitat (see **Table 5.7** which shows the average maximum number of fish recorded at any one time for each species over four sampling periods). No squid, octopus or cuttlefish were recorded on sand. Many of the species recorded were typically benthic and are known to occur on sand (e.g. flatheads and school whiting). Some typically pelagic species (e.g. yellowtail and longfin pike) and some demersal species normally associated with reef (e.g. red rock cod, sergeant baker) were also recorded. Yellowtail, school whiting and long-spine flathead (*Platycephalus longispinis*) were the most common species observed in the study area and South Sand Control locations. Yellowtail were also abundant at the North Sand Control, but at this location, long-spine flathead were much less abundant and school whiting were not recorded. Some species were only recorded in the North Sand Control. Those of most notable abundance were snapper (*Pagrus auratus*) and silver trevally (*Pseudocaranx dentex*). Some other species not normally associated with sand habitat were also recorded in the North Sand Control including the red rock cod, sergeant baker, old wife (*Enoplosus armatus*), maori wrasse (*Ophthalmolepis lineolata*) and the leatherjackets *Meuschenia flavolineata* and *Meuschenia scaber* (Cardno Ecology Lab 2009).

Table 5.7 Fish species recorded at sandy bottom sites using BRUVS

Scientific Name	Common Name	Placement Area of Ship Ave. Max No. n=4	North Sand Site Ave. Max No. n=4.	South Sand Site Ave. Max No. n=4.
CHONDRICHTHYES (CARTILAGINOUS FISHES)				
<i>Heterodontus galeatus</i>	Crested Horn Shark	-	0.3	-
<i>Orectolobus maculatus</i>	Spotted Wobbegong	-	0.3	-
<i>Aptychotrema sp.</i>	Shovelnose Ray	1.8	-	1.8
<i>Trygonorrhina fasciata</i>	Southern Fiddler Ray	2	0.5	1
<i>Trygonorrhina sp.</i>	Stingarees	0.3	-	0.5
<i>Myliobatis australis</i>	Southern Eagle Ray	0.5	0.3	0.3
OSTEICHTHYES (BONY FISHES)				
<i>Aulopus purpurissatus</i>	Sergeant Baker	-	1	-
<i>Scorpaena cardinalis</i>	Red Rockcod	-	0.5	-
<i>Platycephalus caeruleopunctatus</i>	Eastern Blue Spotted Flathead	1.3	-	0.8
<i>Platycephalus sp.</i>	Flathead sp.	6.3	0.3	3.5
<i>Dinolestes lewini</i>	Long Finned Pike	0.3	-	0.3



Scientific Name	Common Name	Placement	North	South
		Area of Ship Ave. Max No. n=4	Sand Site Ave. Max No. n=4.	Sand Site Ave. Max No. n=4.
<i>Sillago flindersi</i>	Eastern School Whiting	18.8	-	21.3
<i>Pseudocaranx dentex</i>	Silver Trevally	-	0.8	0.3
<i>Trachurus novaezelandiae</i>	Yellowtail Scad	19	16	4.8
<i>Pagrus auratus</i>	Snapper	-	4.8	-
<i>Enoplosus armatus</i>	Old Wife	-	0.5	-
<i>Ophthalmolepis lineolata</i>	Maori Wrass	-	0.3	-
<i>Pseudorhombus sp.</i>	Flounder	0.3	-	-
<i>Meuschenia flavolineata</i>	Yellow Striped Leatherjacket	-	0.3	-
<i>Meuschenia freycineti</i>	Six Spine Leatherjacket	0.5	0.5	0.3
<i>Meuschenia scaber</i>	Velvet Leatherjacket	-	0.3	-
<i>Nelusetta ayraudi</i>	Ocean Jacket	0.8	0.5	0.3
Number of Species observed at site (all samples)		12	16	12
Total number of species (all locations)		22		

Max No. = the number of individuals of each species in view at any one time for each of four, 45 min videos.

Reef Sites

Fish depend on subtidal rocky reef environments for food, shelter and/ or spawning sites. Reef topography and the presence of kelp can affect the occurrence and abundance of different fish species. Fish are generally more abundant in areas of greater reef complexity, presumably due to the provision of shelter (Lincoln Smith and Jones in Underwood and Chapman 1995). Spatial and temporal variation in fish assemblages on rocky reefs is often observed.

Cardno Ecology Lab (2009) recorded 47 species of fish, representing 28 families, in reef habitat (Table 5.8 which shows the average number of fish observed for each species over for four sampling periods). This included eight species of sharks or rays and two species of cephalopods. The species included a mixture of benthic, demersal and pelagic reef species common to the region. Chondrichthys were observed mostly in the southern reef locations. Only one species of chondrichthys (the eagle ray *Myliobatis australis*) was recorded at the North Reef Near location and none were recorded at the North Reef Far location. Cephalopods were rare, with one



southern calamari (*Sepioteuthis australis*) observed at the North Reef Near location and one giant cuttlefish (*Sepia apama*) at the South Reef Near location. Yellowtail was the most abundant species observed at all of the reef locations. Maori wrasse was the second most abundant at locations apart from the North Reef Near location where it was the fourth most abundant. Other species of notable abundance at one or more locations were moray eels (*Gymnothorax prasinus*), longfin pike, hula fish (*Trachinops taeniatus*), silver trevally, snapper, sweep (*Scorpius lineolata*), one-spot puller (*Chromis hypsilepis*) and blue morwong (*Nemadactylus douglasi*). The mean maximum number of all other species observed at locations was less than 1.5. The number of species observed at the North Reef Far location (15 species) was much less than the others (ranging between 28 – 34) (Cardno Ecology Lab 2009).

Table 5.8 Fish species found in reef locations

		North Reef Near	North Reef Far	South Reef Near	South Reef Far
Scientific Name	Common Name	Ave No.	Ave No.	Ave No.	Ave No.
CEPHALOPODA (SQUIDS AND CUTTLEFISHES)					
<i>Sepia apama</i>	Australian Giant Cuttlefish	-	-	0.3	-
<i>Sepioteuthis australis</i>	Southern Calamari	0.3	-	-	-
CHONDRICHTHYES (CARTILAGINOUS FISHES)					
<i>Heterodontus galeatus</i>	Crested Horn Shark	-	-	0.3	-
<i>Heterodontus portusjacksoni</i>	Port Jackson Shark	-	-	-	0.3
<i>Brachaelurus waddi</i>	Blind Shark	-	-	0.5	-
<i>Aptychotrema sp.</i>	Shovelnose Ray	-	-	-	0.3
<i>Trygonorrhina fasciata</i>	Southern Fiddler Ray	-	-	0.3	0.3
<i>Trygonorrhina sp.</i>	Stingarees	-	-	-	0.3
<i>Myliobatis australis</i>	Southern Eagle Ray	0.3	-	0.5	0.3
OSTEICHTHYES (BONY FISHES)					
<i>Gymnothorax prasinus</i>	Green Moray	0.8	0.5	1.5	0.5
<i>Aulopus purpurissatus</i>	Sergeant Baker	0.3	0.8	1.3	0.3
<i>Lotella rhacina</i>	Rock Cod/ Beardie	0.3	-	0.5	-
<i>Centroberyx affinis</i>	Redfish	0.3	0.3	-	0.5



		North Reef Near	North Reef Far	South Reef Near	South Reef Far
Scientific Name	Common Name	Ave No.	Ave No.	Ave No.	Ave No.
<i>Hypoplectrodes annulatus</i>	Blackbanded Seaperch	-	-	1.3	0.5
<i>Hypoplectrodes maccullochi</i>	Half-banded Seaperch	0.8	0.5	1.3	1.3
<i>Trachinops taeniatus</i>	Eastern Hulafish	1.25	-	1.5	-
<i>Dinolestes lewini</i>	Long Finned Pike	4	-	2.5	-
<i>Pseudocaranx dentex</i>	Silver Trevally	0.5	0.3	0.3	3
<i>Trachurus novaezelandiae</i>	Yellowtail Scad	9.3	6	4	5
<i>Pagrus auratus</i>	Snapper	2	0.3	0.3	0.8
<i>Upeneichthys lineatus</i>	Blue-lined Goatfish	0.5	-	0.3	0.3
<i>Pempheris sp.</i>	Bullseye/ Sweeper	1	-	-	-
<i>Atypichthys strigatus</i>	Australian Mado	-	-	1	-
<i>Kyphosus sydneyanus</i>	Southern Silver Drummer	0.3	-	-	-
<i>Scorpius lineolata</i>	Silver Sweep	1.5	-	0.5	0.5
<i>Enoplosus armatus</i>	Old Wife	0.8	0.5	0.3	0.3
<i>Chromis hypsilepis</i>	One Spot Puller/ Brown Puller	-	-	2	-
<i>Mecaenichthys immaculatus</i>	Immaculate Damsel	0.3	-	0.3	0.5
<i>Parma microlepis</i>	White Ear	0.5	0.5	1.3	1
<i>Cheilodactylus fuscus</i>	Red Morwong	-	-	0.3	-
<i>Nemadactylus douglasi</i>	Blue Morwong	0.5	1	0.5	1.5
<i>Achoerodus viridis</i>	Eastern Blue Groper	-	-	-	0.3
<i>Bodianus unimaculatus</i>	Red Pigfish	-	-	-	0.3
<i>Notolabrus gymnogenis</i>	Crimson Banded Wrasse	0.5	-	0.8	0.3



		North Reef Near	North Reef Far	South Reef Near	South Reef Far
Scientific Name	Common Name	Ave No.	Ave No.	Ave No.	Ave No.
<i>Ophthalmolepis lineolata</i>	Maori Wrasse	1.8	1.8	6.3	4.3
<i>Pictilabrus laticlavus</i>	Senator Wrasse	-	-	0.3	-
<i>Odax cyanomelas</i>	Herring Cale	-	-	0.3	-
<i>Parapercis ramsayi</i>	Spotted Grubfish	0.3	0.3	-	-
<i>Eubalichthys bucephalus</i>	Black Reef Leatherjacket	-	-	-	0.3
<i>Eubalichthys mosaicus</i>	Mosaic Leatherjacket	0.3	-	-	0.3
<i>Meuschenia flavolineata</i>	Yellow Striped Leatherjacket	0.5	-	1.3	0.5
<i>Meuschenia freycineti</i>	Six Spined Leatherjacket	-	0.3	0.8	0.8
<i>Meuschenia scaber</i>	Velvet Leatherjacket	-	-	-	1
<i>Meuschenia trachylepis</i>	Yellow Finned Leatherjacket	0.5	0.3	0.3	-
<i>Nelusetta ayraudi</i>	Ocean Jacket	0.5	-	-	-
Number of species observed at location (all samples)		28	15	34	29
Total number of species (all locations) 47					

Max No. = the number of individuals of each species in view at any one time for each of four, 30 minute videos.

The sand and reef locations surveyed by Cardno Ecology Lab (2009) supported fish assemblages typical of these habitats in this region. In addition, observations by staff of Cardno Ecology Lab who frequently dive in the region indicate that several species were recorded on BRUVS footage that are not usually observed while SCUBA diving. These include large, active species such as snapper, squid and eagle rays and small cryptic species such as bullseye (*Pempheris* sp.) and black-banded seaperch (*Hypoplectrodes annulatus*). No threatened or protected fish species were recorded. Those potentially occurring in the study area are discussed in **Section 6.1.6**.



5.8 Recreation and Tourism

5.8.1 Visitation and Dive Tourism

The Central Coast is approximately 1 hour and 30 minutes drive from Sydney and 1 hour and 15 minutes drive from Newcastle on the F3. It is serviced by rail and Sydney (domestic and international flights) and Newcastle (domestic flights) airports.

Terrigal is one of the most well known areas in the Central Coast and is very popular with visitors. It features Terrigal Lagoon and Beach, shopping centre, a range of restaurants and cafes and a variety of accommodation. The Haven, at the southern end of Terrigal, provides sheltered waters for snorkelling, a large rock platform to explore marine life and scenic views from the headland, known as the Skillion. The Haven is also a base for fishing and diving charters.

Avoca Beach is one of the most consistent surfing beaches on the Central Coast and also has an extensive rock platform at the base of the southern headland. It features many cafes and the historic Avoca Beach Picture Theatre.

Visitation to Central Coast

In 2007, the most popular regional destinations for domestic overnight trips for leisure included the Central Coast at 10th place (1,174,000 overnight trips) (www.tra.australia.com – *Top ten regions: domestic overnight trips for leisure*). Based on data from January 2005 to December 2006, on average around 32,000 international visitors per annum visited the NSW Central Coast (www.tra.australia.com – *Activities in regions: International travellers*).

The Gosford Local Government Area (LGA) attracted (on average, over three to four years to June 2007) around 25,000 international visitors, 848,000 domestic overnight visitors and 2,078,000 domestic day visitors. For overnight domestic visitors, 51% stayed at a friend or relative's property and 65% were from Sydney. For day visitors, 46% travelled for leisure, while 44% were visiting friends or relatives (Tourism Australia 2008).

Participation in Nature Tourism

Tourism Australia defines seven activities for nature-based tourism as listed in **Table 5.9**. In 2008, 65% (3.36 million) of international visitors to Australia participated in one or more of these activities. For domestic overnight and day visitors, the figures were 18% (12.92 million) and 9% (12.37 million) respectively.



Table 5.9 Percentage of international visitors who undertook different ‘nature’ activities

Type of nature activities	International %	Domestic overnight %	Domestic day %
visiting national or state parks	37	51	39
visiting wildlife parks, zoos or aquariums	66	47	42
visiting botanical or other public gardens	56	19	25
bushwalking or rainforest walks	58	16	13
whale or dolphin watching (in the ocean)	13	4	2
snorkelling	18	4	1
scuba diving	8	1	0

Source: Tourism Research Australia 2009.

Since 2003, visiting national and state parks and going whale or dolphin watching have shown the largest growth for overnight domestic visitors, while scuba diving has seen the most significant decline. For international visitors, going whale or dolphin watching has seen the largest growth.

More than one third of international visitor nights were spent in rented accommodation, with 24% of domestic visitor nights spent in hotel or motel accommodation. International ‘nature’ visitors spent more on their trips than other visitors due to a longer trip length. Domestic nature visitors spent around the same as other domestic visitors www.tra.australia.com – *Nature Tourism in Australia 2008 snapshot*.

Dive Tourism

In 2003, Tourism Queensland conducted a review of research to gain a better understanding of the dive tourism market. Findings included that:

- there are an estimated 5 to 7 million active divers worldwide
- there are over 34,600 scuba divers in Australia, with 57% having an annual household income greater than \$52,000
- the Australian recreational diving market has been estimated to be worth \$1 billion from international visitors and \$547 million from Australian divers
- around 5% of international visitors dive during their stay in Australia, and about 0.5% of Australian domestic travellers dive while on holiday



- Queensland is a stopover for 93% of international divers visiting Australia and around 40% of domestic diving holidays in Australia
- apart from diving, the most common holiday activities for domestic dive visitors to Queensland are going to the beach (75%), eating out or going to restaurants (68%), general sight seeing (49%), bushwalking or rainforest walks (36%), going to pubs, clubs or discos (35%) and going shopping (33%).

Tourism Queensland (2003) found that an attractive dive destination is one that provides:

- a healthy marine environment
- information trails or information provided on the trip
- a variety of different diving sites (e.g. wreck sites, wall sites, coral reefs etc)
- good visibility
- an abundance of wildlife.

International dive visitors to Australia most commonly stay in:

- hotels, resorts, motels or motor inns (63%)
- backpacker hostels (45%)
- home of a friend or relative (33%).

Domestic dive visitors in Australia most commonly stay in:

- hotels, resorts, motels or motor inns (26%)
- home of family or friends (22%).

Of the international dive visitors to Australia:

- 42% identify as adventure travellers, 32% identify as budget travellers, and 29% identify as backpackers

Tourism businesses and opportunities

As at June 2007, the total number of tourism businesses in the Gosford LGA was 3,753, with 77% being sole traders or micro businesses (up to four employees) and 16% small businesses (www.tra.australia.com – *City of Gosford Detailed Profile of Domestic Overnight Travel to Local Government Area*).

Research shows that domestic diving visitors also enjoy going to the beach, eating out at restaurants, sightseeing (walking/ driving) and bushwalking. It may benefit operators to consider these activities when preparing packages for the diving market (Queensland Tourism 2003). More than half the Central Coast Region is comprised of national parks, state forests, regional and local



open space, conservation areas and aquatic systems including lakes, estuaries, lagoons, beaches, rivers, creeks and wetlands (DoP 2006).

5.8.2 Water-based Facilities and Uses

Terrigal Haven is protected from weather emanating from the southwest, south, southeast and east and is also partially sheltered from weather from the northeast and north, making it an overnight destination for sailors moving up and down the NSW coast. It contains a number of permanent swing moorings for commercial vessels and some private boats (approximately 17 moorings in total). There are two boat ramps, with the smaller facility used by divers and for launching small watercraft. The Draft Plan of Management for Terrigal Haven lists investigation into, and potential provision of infrastructure for access to water-based recreation activities (GCC and LPMA, 2009). This would assist in supporting both existing, and future dive opportunities created by the scuttling of the Ex-HMAS ADELAIDE.

Activities undertaken at or near Terrigal Haven include surf boat and nipper activities, surfing, swimming/ wading, snorkelling, diving, marine education and research, recreational fishing (including spearfishing), jetskiing, power boating, canoeing and sailing. The area has also hosted events such as the 2008 World Laser Championships and NSW Outrigger Canoe Championships.

Dive sites close to, but outside, the proposed final boundaries of the Ex-HMAS ADELAIDE Reserve include Fifeshire Reef, The Skillion Cave and the *Yambacoona* and *Lord Ashley* wrecks. The recreational fishing sites, Avoca Reef and Avoca Drop Off, are also located close by and outside the proposed final boundaries of the Ex-HMAS ADELAIDE Reserve.

Commercial fish trapping and line-fishing (for snapper, rubber-lipped morwong and leatherjackets) occurs on top of, or on the edge of reefs. Purse seining for garfish, yellowtail scad and blue mackerel also occurs off The Haven. Trawlers may work in the deeper waters (further offshore than the proposed location of the Ex-HMAS ADELAIDE) targeting species such as bream, flathead, school whiting, silver trevally, boarfish and red mullet. On rare occasions a trawl run may be made between the subtidal reefs offshore from the northern and southern ends of Avoca Beach (The Ecology Lab 2009).

5.8.3 Adjoining Shore-based Facilities and Uses

The Terrigal Haven Reserve contains both active and passive recreational facilities, as well as commercial operations. Two restaurants/ cafes, a dive centre, sports clubhouse and the volunteer coastguard are located within the reserve. There are two main car parking areas with approximately 150 car spaces and a smaller car park adjacent to The Skillion which contains approximately 20 car spaces. Further parking is available in the Terrigal CBD, including a parking station 10 minutes walk away (GCC and LPMA, 2009). The Terrigal Haven Coastal Walk is also to be constructed in the near future.



Reserve activities include sightseeing, walking, dog walking, jogging, cycling, sports training and games (including school sports), picnicking, individual and group fitness training, wedding ceremonies, marine studies and exploring the rock platform. Events held in the general area have included the Terrigal Food and Wine Fair and the Cluster Film fest (GCC and LPMA, 2009).

5.9 Maritime Archaeology

A maritime archaeology study was undertaken by Cosmos Archaeology Pty Ltd (see **Appendix F**) with reference to the following information sources:

- *NSW Historic Shipwrecks Database*, NSW Heritage Office - Maritime Heritage Online 2007
- *Shipwreck Atlas of NSW*, Heritage Office NSW 1995
- *Australian Hydrographic Office*, wreck positions plotted on navigation chart AUS 808 which is incorporated in the *Shipwreck Atlas*
- *Australian Hydrographic Services*, online information on Sea Dumping in Australia 2007
- *Unpublished report on shipwrecks in NSW (John Riley 1998)*.
- Review of sidescan sonar data by Hydrographic Services Pty Ltd for a survey undertaken as part of this study on 25 September and 17 October 2008 (see **Appendix B**).

Following is a summary of information provided in the report.

From the time Sydney was established in 1788, vessels traversed the coast of NSW. Initially the volume of traffic was small and limited, maintaining communication with the Hawkesbury and Illawarra region as well as British colonial possessions in South and East Asia. As the colony of NSW developed throughout the 19th century, vessel traffic increased substantially.

The first loads of coal were exported to Sydney via ship from Newcastle in 1798, as road transport was slow and greater quantities could be sent by sea. Colliers were sent to Port Jackson full, where the coal was then redistributed, and the vessel was sent back empty or with other supplies for the mining communities. The amount of coal exported from the area increased during the mid 19th century, which led to an increase in the amount of shipping out of the Newcastle area heading south to Sydney.

From the early 1800s, timber cutters worked their way into the area around the Central Coast, logging cedar for the Sydney market. Many of these operations established makeshift jetties and wharves in the Terrigal, Gosford, and Norah Head area, to allow vessels to come into shore and load the timber logs. As such, shipping increased in the local area. Much of this timber cutting was not sanctioned by the colony, and as such many of these early operations were not recorded. Other significant shipping movements through the study area during the 19th and 20th Centuries



were coastal traders transporting cargo and passengers along the north coast of NSW and beyond.

There are three known shipwreck sites within 2.5nm of the study area. These are the *Lord Ashley* (1nm north-northwest), the *Yambacoon* (approximately 0.8nm to the north), and the wreck of the *Galva* (approximately 2.2nm to the northeast). However the location of many vessels lost off the coast is unknown, with 18 shipwrecks reported as “*Lost xnm of Terrigal*” or “*off Terrigal*”. Of these, nine were driven ashore and one sank in Terrigal Harbour. Of the remaining eight ships, Cosmos Archaeology identified two shipwrecks possibly located within the study area, the *Maud Weston* and the *Union*. It was reported that the *Maud Weston* sprang a leak and floundered near Terrigal Head and that the *Union* was wrecked at Avoca Bay during a gale.



6. ASSESSMENT OF THE LIKELY ENVIRONMENTAL IMPACTS

6.1 Ship Scuttling Operation

6.1.1 Optimal Scuttling Season

Knowledge of seasonal variations may assist in planning the ship scuttling operations. For example, it would be most likely that wave conditions would be calmer from October to February. The scuttling of the Ex-HMAS ADELAIDE is currently programmed for April. As coastal storms can occur at any time, it would be necessary to refer to Bureau of Meteorology coastal waters forecasts and the like to ensure that conditions on the proposed scuttling day would be acceptable.

Structural analysis of the scuttling process would be essential to ensure that structural integrity would not be compromised during sinking.

6.1.2 Navigation

The ship would be towed under Water Police escort from the preparation site (Glebe Island), through Sydney Harbour to the scuttling location. Precautions to ensure vessel stability under tow would be included in the Scuttling Management Plan, prepared by McMahon Services Australia and approved by DEHWA as part of the Artificial Reef Permit under the Commonwealth *Protection of the Environment (Sea Dumping) Act*.

As the towing and scuttling of the Ex-HMAS ADELAIDE would be a major event, the main navigation impact is expected to be associated with the control of spectator craft (some of which are expected to follow the vessel from Sydney Harbour to the scuttling location). As noted in **Section 4.3.3** an exclusion zones would be maintained around the ship as it is towed out of Sydney Harbour (500m) and up to Avoca Beach (1km). A 1km exclusion zone would also apply at the scuttling site, prior to and immediately following scuttling. This would be advertised in the press. Local commercial fishers would also be advised of activities and timing of scuttling so that damage to any nearby fishing gear is avoided.

6.1.3 Noise and Vibration

Noise from the scuttling charges would be audible above water at the shoreline (approximately 1.8km away) with some attenuation of sound under water. Noise impacts and the creation of additional holes under the waterline using cutting charges could potentially harm or kill marine mammals or fish.

To minimise impacts a spotter plane would patrol the area to ensure no marine mammals, large fish or large schools of fish were present during the scuttling exercise. Fish kills within the immediate scuttling site would be unavoidable, however, significant numbers are not expected



given the relatively lower number and diversity of species observed in the general scuttling area, compared to rocky reef sites, see **Section 5.7.3**.

6.1.4 Air Quality

Apart from diesel fumes associated with tugs and works boats engaged in preparing the ship for scuttling, impacts on air quality would be restricted to smoke and haze as a result of the pyrotechnic display on the ship upon sinking.

6.1.5 Water Quality

Discolouration of the water (similar to a 'slick') may occur around the scuttled vessel due to a sediment plume forming as the vessel hits the seabed and/ or as a result of freshwater within the ship (some potable freshwater from the Sydney water system may be taken on as ballast), air and seawater mixing. There may also be some flotsam and jetsam from items dislodged from the ship during sinking. As noted in **Section 5.3** only about 1% of the sediments at the site are fines and so any discolouration of the water would be minor and temporary, as suspended fines would resettle on the seabed. Post scuttling, divers would remove any material floating on the water surface, as well as any debris on the seabed.

6.1.6 Aquatic Ecology

Many species of dolphins, seals and small whales could potentially encroach upon the scuttling area at any time. Humpback whales may come close to shore in their northward migration in early May–July and with calves from late September–early December. Southern right whales have potential to rest and calve in Bulbararing Bay in winter (Cardno Ecology Lab 2009).

Species within the vicinity of the scuttling area have the potential to be injured from cutting charges set in the hull. Within the 'footprint' of the vessel, soft sediment habitat and associated benthic invertebrates would be smothered. Demersal fishes inhabiting sediments within the 'footprint' of the vessel may be lost by smothering when the vessel is scuttled. However, the ship would take a few minutes to sink and so some fish may be able to avoid collision with the hull.

Sandy sediments occur elsewhere in the region and surveys of fish indicated that assemblages at the scuttling site were typical of others nearby. The direct loss of sandy habitat, benthic infauna and fish from placement of the ship is small and equates to a negligible loss overall in the region.

Threatened and Protected Species

Cardno Ecology Lab (2009) identified threatened or protected marine species scheduled under the *Fisheries Management (FM) Act*, *Threatened Species Conservation (TSC) Act*, *National Parks and Wildlife (NP&W) Act* and the *Environment Protection and Biodiversity Conservation (EPBC) Act* which have the potential to occur in the study area are listed in **Table 6.1**. The likelihood of the project impacting on these species is indicated in column 5 of **Table 6.1**.



Table 6.1 Threatened/ protected species/ populations potentially occurring near the scuttling site

Scheduled Species	Common Name	Status under TSC / FM / NP&W Acts	Status under EPBC Act	Relevance to proposal
Marine Reptiles				
<i>Caretta caretta</i>	Loggerhead turtle	E	E, M, L	Mod
<i>Chelonia mydas</i>	Green turtle	V	V, M, L	Mod
<i>Dermochelys coriacea</i>	Leathery turtle	V	V, M, L	Mod
<i>Eretmochelys imbricata</i>	Hawksbill turtle *	V	V, M, L	Mod
<i>Pelamis platurus</i>	Yellow-bellied sea snake		L	Low
Marine Mammals				
<i>Eubalaena australis</i>	Southern right whale	V	E, M	Low
<i>Megaptera novaeangliae</i>	Humpback whale	V	V, M	Low
<i>Arctocephalus pusillus doriferus</i>	Australian fur-seal	V	L	Low
<i>Arctocephalus forsteri</i>	New Zealand fur-seal	V	L	Low
<i>Hydrurga leptonyz</i>	Leopard seal	P	L	Low
<i>Balaenoptera acutorostrata</i>	Dwarf minke whale	P	M	Low
<i>Dugong dugon</i>	Dugong	E	M	Neg
<i>Balaenoptera edeni</i>	Bryde's whale	P	M	Low
<i>Caperea marginata</i>	Pygmy right whale	P	M	Low
<i>Orcinus orca</i>	Killer whale	P	M	Low
<i>Lagenarhynchus obscurus</i>	Dusky dolphin	P	M	Low
<i>Delphinus delphis</i>	Common dolphin	P	Cet	Low
<i>Grampus griseus</i>	Risso's dolphin, Grampus	P	Cet	Low
<i>Stenella attenuata</i>	Spotted dolphin, Pantropical spotted	P	Cet	Low
<i>Tursiops aduncus</i>	Indian Ocean Bottlenose dolphin	P	Cet	Low
<i>Tursiops truncatus s. str.</i>	Bottlenose dolphin	P	Cet	Low



Scheduled Species	Common Name	Status under TSC / FM / NP&W Acts	Status under EPBC Act	Relevance to proposal
Fish				
East coast population of <i>Carcharias Taurus</i>	Grey nurse Shark	E	CE	Mod
<i>Carcaradon carcharias</i>	Great white shark	V	V, M	Low
<i>Pristis zijsron</i>	Green sawfish	E	V	Neg
<i>Rhincodon typus</i>	Whale shark		V, M	Neg
<i>Epinephelus daemeli</i>	Black cod	V		Mod
<i>Epinephelus coioides</i>	Estuary cod	P		Mod
<i>Epinephelus lanceolatus</i>	Queensland groper	P		Mod
<i>Anampses elegans</i>	Elegant wrasse	P		Mod
<i>Paraplesiops bleekeri</i>	Eastern blue devil	P		Mod
<i>Chaetodontoplus ballinae</i>	Ballina angelfish	P		Mod
<i>Epinephelus lanceolatus</i>	Seadragons and pipefish	P (21 spp.)	L (21 spp.)	Mod
Birds				
	Marine Birds	V (10 spp.), P (31 spp.), E (2 spp.)	V (9), E (1), M (19), L (27)	Neg

* CE = critically endangered, E = endangered, V = vulnerable. M = migratory, L = listed, Cet = cetacean and P = protected. Relevance to the scuttling of the Ex-HMAS ADELAIDE is indicated by High, Mod (Moderate), Low or Neg (negligible). (*) Species observed during the site inspection (5th April 08).

The potential impact of the scuttling the Ex-HMAS ADELAIDE on each of the threatened species or populations, with the exception of species with a negligible relevance to the project was assessed using the "Assessment of Significance", under Part 5A of the EP&A Act (see Appendix to Cardno Ecology Lab, 2009 included as **Appendix D**).

Assessments of individuals and groups concluded that the proposal is unlikely to affect the listed threatened species of fish, marine mammals or marine reptiles that potentially occur in, or around, the study area. Hence, there is no need to prepare a Species Impact Statement (SIS) under NSW legislation or refer the proposal to the Federal Minister for the Environment for further consideration and approval under the EPBC Act 1999.

As noted above, threatened species encroaching upon the area when the vessel is scuttled have the potential to be injured when cutting charges are used to blow additional holes in the hull. Pre-scuttling aerial surveillance of local waters for cetaceans and other large marine animals would assist in reducing potential for impacts to any locally occurring threatened and protected species



during the scuttling process. It should be noted that the proposed timing for scuttling the vessel (April 2010) would lessen the chance of any migratory whales being in the area.

6.1.7 Associated Land-based Impacts

To maximise public attendance, the scuttling of the Ex-HMAS ADELAIDE would be held on a weekend. It is envisaged that the scuttling operation would be a major attraction for Terrigal/ Avoca and the Central Coast, with an influx of visitors from within and outside the local area (including the major population centres of Sydney and Newcastle). Unlike other vessels that were scuttled further out to sea, the scuttling of the Ex-HMAS ADELAIDE would be easily viewed from land. Accordingly, tens of thousands of people are expected to vie for the best viewing positions at The Skillion, North Avoca, Avoca Beach and other vantage points.

The event would benefit the local hospitality industry but poses traffic, parking and crowd management issues as the Terrigal/ Avoca area has restricted vehicle entry and exits, and can normally be congested over weekends.

To address this, an Event Management Plan would be prepared by the Community Engagement and Events Division (DPC) assisted by LPMA, Gosford City Council and the Police to manage traffic and transport, parking and spectator viewing areas. This is likely to include road closures and park and ride options for spectators. It may also include managing launching of powered and handheld craft from the Terrigal Haven boatramps and beach areas.

6.2 Artificial Reef Impacts

6.2.1 Vessel Stability

The basic dimensions of the Ex-HMAS ADELAIDE were determined from drawings provided by LPMA and a weight of 3900 tonnes was adopted for this assessment based advice from LPMA. Based on inferred sediment property characteristics, an initial settlement of 0.5m was estimated for the submerged vessel. Over the long-term scour and sediment burial processes are likely to result in a settlement of 1 to 2m. This range has been adopted for other similar vessels (*ex-HMAS Canberra*). As a result this stability assessment has includes sensitivity analysis using settlements of 0.5m and 2.0m.

Based on an assessment of the optimal orientation, two possible vessel orientations were assessed:

- Option 1: Vessel is pointed SE (on 135°N bearing). This option is selected such that the bow is pointed into the dominant direction for the largest waves. The largest design waves from beam on directions are from the NE, ENE and the E.
- Option 2: Vessel is pointed ESE (on 112°N bearing). This option is selected to reduce the exposure to lateral loads from the ENE experienced in Option 1. The shape of the wave



height/ peak period directional distribution is such that orientating the vessel more to the east reduces its exposure to lateral loads from the NE-E sector. The largest waves from beam on directions are from the SE, ESE and the S.

A range of wave conditions was determined from a review of the extreme waves at the site with three wave directions assessed for each vessel orientation option (see **Table 6.2**). A range of ARI design events were assessed with the corresponding wave heights based on the directional extreme analysis. The maximum wave height (H_{max}) used in the stability analysis was based on 1.8 times the significant wave height (H_s) (US Army Corp of Engineers, 2002). Sensitivity to wave period was included with wave periods selected based on the assigned peak periods for the directional extreme analysis and the peak period/ direction relationship presented in Appendix C to **Appendix E**. It should be noted that the estimated design wave heights for the 500 year ARI event are provided for sensitivity analysis purposes, as the procedure adopted is not accurate for such rare events.

Table 6.2 Design wave conditions for each vessel orientation option

(a) *Option 1* Vessel is pointed SE

ARI (years)	Wave Direction A		Wave Direction B		Wave Direction C	
	Beam on (NE)		22.5° Beam on to port (ENE)		45° Beam on to port (E)	
	H_{max} (m)	T_p (s)	H_{max} (m)	T_p (s)	H_{max} (m)	T_p (s)
5	3.8	8-12	6.4	9-13	8.3	10-14
50	4.2	8-12	7.8	9-13	9.5	10-14
100	4.6	8-12	9.6	9-13	10.9	10-14
500	5.0	8-12	11.4	9-13	12.2	10-14

(b) *Option 2* Vessel is pointed ESE

ARI (years)	Wave Direction D		Wave Direction E		Wave Direction F	
	22.5° Beam on (S)		45° Beam on to starboard (SSE)		67.5° Beam on to starboard (SE)	
	H_{max} (m)	T_p (s)	H_{max} (m)	T_p (s)	H_{max} (m)	T_p (s)
5	5.7	8-12	9.1	11-15	10.4	11-15
50	6.4	8-12	10.0	11-15	12.5	11-15
100	7.2	8-12	10.9	11-15	15.1	11-15
500	8.0	8-12	11.9	11-15	17.8	11-15

For each wave case and vessel orientation option the absolute maximums (over the wave cycle) of forces and moments were determined. It should be noted that these forces are not static forces and change with wave phase, (i.e. they do not occur simultaneously). For example, the maximum horizontal force (F_x) does not occur simultaneously with the maximum vertical force (F_y).



The factor of safety against overturning (FOS_{OT}) was calculated based on the total horizontal overturning moment and the total restoring moment (based on the total vertical force, the sum of the submerged weight of vessel and vertical wave force). The factor of safety against sliding (FOS_S) was calculated based on the total horizontal wave force, the total vertical force and the frictional capacity of the underlying sand and the sand resistance due to the vessel embedment depth. The minimum (critical) FOS_{OT} and FOS_S over a full wave cycle are reported in **Tables 6.3- Table 6.6** for each case and vessel orientation.

Taking into account multiple conservative assumptions inherent in the force calculation, an acceptable factor of safety for sliding and overturning is considered to be 1.0. Where this acceptable factor of safety is not satisfied for a particular condition, it is indicated in bold in the result tables below.

Sensitivity to the depth of settlement is indicated through consideration of two different vessel settlement depths of 0.5m and 2.0m.

Table 6.3 Critical factor of safety against overturning (FOS_{OT}) and sliding (FOS_S) for vessel orientated towards SE (Option 1) Settlement Depth 0.5m

Wave Direction NE (beam on to port)

ARI (years)	$H_{max}(m)$	T=8s		T=9s		T=10s		T=11s		T=12s	
		FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S
5	3.8	1.80	1.46	1.70	1.38	1.69	1.37	1.72	1.39	1.75	1.42
20	4.2	1.61	1.31	1.53	1.24	1.52	1.23	1.55	1.25	1.58	1.28
100	4.6	1.46	1.19	1.39	1.13	1.38	1.12	1.40	1.14	1.43	1.16
500	5.0	1.34	1.09	1.27	1.03	1.26	1.02	1.28	1.04	1.31	1.06

Wave Direction ENE (22.5° beam on to port)

ARI (years)	$H_{max}(m)$	T=9s		T=10s		T=11s		T=12s		T=13s	
		FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S
5	6.4	1.30	1.07	1.23	1.01	1.24	1.01	1.26	1.03	1.27	1.04
20	7.8	1.04	0.86	0.99	0.82	1.00	0.82	1.02	0.83	1.04	0.85
100	9.6	0.82	0.68	0.78	0.64	0.79	0.65	0.81	0.66	0.83	0.68
500	11.4	0.66	0.55	0.64	0.53	0.65	0.53	0.67	0.55	0.68	0.56

Wave Direction E (45° beam on to port)

ARI (years)	$H_{max}(m)$	T=10s		T=11s		T=12s		T=13s		T=14s	
		FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S	FOS_{OT}	FOS_S
5	8.3	1.80	1.53	1.68	1.41	1.64	1.37	1.63	1.35	1.63	1.36
20	9.5	1.55	1.32	1.45	1.21	1.42	1.19	1.41	1.17	1.42	1.18
100	10.9	1.33	1.13	1.24	1.04	1.23	1.02	1.22	1.02	1.22	1.02
500	12.2	1.17	1.00	1.10	0.92	1.09	0.90	1.08	0.90	1.08	0.90



Table 6.4 Critical factor of safety against overturning (FOS_{OT}) and sliding (FOS_S) for vessel orientated towards ESE (Option 2) Settlement Depth 0.5m

Wave Direction S (22.5° beam on to starboard)

ARI (years)	H _{max} (m)	T=8s		T=9s		T=10s		T=11s		T=12s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	5.7	1.72	1.44	1.47	1.22	1.40	1.15	1.40	1.15	1.42	1.16
20	6.4	1.51	1.27	1.30	1.07	1.23	1.01	1.24	1.01	1.26	1.03
100	7.2	1.33	1.11	1.14	0.94	1.09	0.89	1.09	0.89	1.11	0.91
500	8.0	1.18	0.99	1.01	0.84	0.96	0.79	0.97	0.79	0.99	0.81

Wave Direction SSE (45° beam on to starboard)

ARI (years)	H _{max} (m)	T=11s		T=12s		T=13s		T=14s		T=15s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	9.1	1.52	1.27	1.49	1.24	1.48	1.23	1.48	1.23	1.49	1.24
20	10.0	1.37	1.15	1.34	1.12	1.34	1.11	1.34	1.11	1.35	1.12
100	10.9	1.24	1.04	1.23	1.02	1.22	1.02	1.22	1.02	1.23	1.02
500	11.9	1.13	0.95	1.12	0.93	1.11	0.92	1.11	0.92	1.12	0.93

Wave Direction SE (67.5° beam on to starboard)

ARI (years)	H _{max} (m)	T=11s		T=12s		T=13s		T=14s		T=15s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	10.4	3.24	2.83	3.00	2.57	2.91	2.47	2.88	2.43	2.88	2.43
20	12.5	2.67	2.33	2.47	2.12	2.39	2.03	2.37	2.00	2.37	2.00
100	15.1	2.16	1.89	2.02	1.73	1.96	1.66	1.94	1.64	1.94	1.63
500	17.8	1.79	1.56	1.68	1.44	1.63	1.39	1.62	1.37	1.62	1.37

Table 6.5 Critical factor of safety against overturning (FOS_{OT}) and sliding (FOS_S) for vessel orientated towards SE (Option 1) Settlement Depth 2.0m

Wave Direction NE (beam on to port)

ARI (years)	H _{max} (m)	T=8s		T=9s		T=10s		T=11s		T=12s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	3.8	1.99	2.40	1.87	2.25	1.85	2.22	1.87	2.25	1.91	2.29
20	4.2	1.79	2.16	1.68	2.03	1.66	2.00	1.69	2.03	1.72	2.07
100	4.6	1.63	1.97	1.53	1.85	1.51	1.83	1.54	1.85	1.56	1.88
500	5.0	1.49	1.81	1.40	1.69	1.39	1.68	1.41	1.70	1.43	1.73



Wave Direction ENE (22.5° beam on to port)

ARI (years)	H _{max} (m)	T=9s		T=10s		T=11s		T=12s		T=13s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	6.4	1.44	1.78	1.36	1.67	1.36	1.66	1.37	1.67	1.39	1.68
20	7.8	1.16	1.45	1.10	1.36	1.10	1.35	1.12	1.36	1.13	1.38
100	9.6	0.93	1.16	0.88	1.09	0.88	1.09	0.90	1.10	0.91	1.11
500	11.4	0.76	0.97	0.72	0.91	0.73	0.91	0.74	0.91	0.75	0.92

Wave Direction E (45° beam on to port)

ARI (years)	H _{max} (m)	T=10s		T=11s		T=12s		T=13s		T=14s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	8.3	1.98	2.52	1.83	2.28	1.77	2.19	1.76	2.17	1.76	2.17
20	9.5	1.71	2.19	1.59	1.99	1.54	1.91	1.53	1.89	1.53	1.89
100	10.9	1.48	1.90	1.37	1.73	1.33	1.66	1.32	1.64	1.33	1.64
500	12.2	1.30	1.69	1.21	1.54	1.19	1.48	1.18	1.46	1.18	1.46

Table 6.6 Critical factor of safety against overturning (FOS_{OT}) and sliding (FOS_S) for vessel orientated towards ESE (Option 2) Settlement Depth 2.0m

Wave Direction S (22.5° beam on to starboard)

ARI (years)	H _{max} (m)	T=8s		T=9s		T=10s		T=11s		T=12s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	5.7	1.91	2.39	1.63	2.01	1.54	1.88	1.53	1.87	1.55	1.88
20	6.4	1.69	2.12	1.44	1.78	1.36	1.67	1.36	1.66	1.37	1.67
100	7.2	1.49	1.87	1.27	1.58	1.20	1.48	1.20	1.47	1.21	1.48
500	8.0	1.33	1.68	1.13	1.41	1.07	1.32	1.07	1.32	1.09	1.32

Wave Direction SSE (45° beam on to starboard)

ARI (years)	H _{max} (m)	T=11s		T=12s		T=13s		T=14s		T=15s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	9.1	1.66	2.08	1.61	2.00	1.60	1.97	1.60	1.97	1.62	1.99
20	10.0	1.51	1.89	1.46	1.81	1.45	1.79	1.45	1.79	1.46	1.80
100	10.9	1.37	1.73	1.33	1.66	1.32	1.64	1.33	1.64	1.34	1.64
500	11.9	1.25	1.58	1.22	1.52	1.21	1.50	1.21	1.49	1.22	1.50



Wave Direction SE (67.5° beam on to starboard)

ARI (years)	H _{max} (m)	T=11s		T=12s		T=13s		T=14s		T=15s	
		FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S	FOS _{OT}	FOS _S
5	10.4	3.53	4.56	3.25	4.12	3.14	3.95	3.11	3.89	3.11	3.88
20	12.5	2.91	3.77	2.68	3.42	2.59	3.27	2.57	3.22	2.56	3.21
100	15.1	2.39	3.10	2.20	2.81	2.13	2.69	2.10	2.65	2.10	2.63
500	17.8	2.00	2.62	1.85	2.37	1.78	2.26	1.76	2.23	1.76	2.22

From the above results the following statements can be made:

- The vessel is likely to be stable under a broader range of conditions, including a greater ARI return period, if the vessel is orientated such that the bow points ESE (Option 2).
- The two vessel orientations have been chosen to reduce the magnitude of direct beam on waves through consideration of the directional wave climate at the scuttling site. The critical case for each vessel orientation option is the 22.5 angle from beam on. The orientation of the vessel compared to the wave direction reduces the lateral load significantly for greater angles.
- If oriented such that the bow points ESE (Option 2), the vessel is likely to remain stable for wave conditions up to the 100 year ARI wave condition.
- The analysis shows that for the cases where vessel settlement is 0.5m, sliding is critical. For the 100 year ARI wave condition, even when the vessel is oriented such that the bow points ESE (Option 2), the minimum FOS_S over the wave cycle is marginal for the worst wave direction. However given the dynamic and oscillatory nature of the wave loading, such that this minimum FOS_S condition would occur for a very short time with forces reversing in direction over the wave cycle, significant net sliding movements are not expected. Rather, it could be expected that small movements from side to side may occur during the passing of the maximum wave under extreme storm conditions.
- The analysis indicates that for a 2.0m vessel settlement, sliding is not the critical stability issue.
- The initial vessel settlement will be no greater than 0.5m under its own self weight. Consequently, the vessel will be most vulnerable to stability issues immediately after scuttling. However, it is considered that the side to side movements under storm wave conditions as a result of vulnerability to sliding will encourage settlement into the seabed sediments. This is likely to occur as agitation of the seabed sediment by vessel movements in such conditions will reduce the bearing capacity of the sediment.
- It could be expected that some movement, settlement and tilting may occur during large storm events with waves arriving from directions that have a beam on component. Consequently post storm inspections would be required.



- Over time the vessel will settle further into the seabed, reducing the impact of wave forces.
- Providing holes in the vessels hull for diver access will reduce the potential wave load forces. At the time of analysis the dive design was not at a detailed stage so as to provide an indicative porosity. The results presented do not take into account porosity of the vessel and are therefore conservative in this regard.

It should be noted that the stability assessment method is conservative (see **Appendix E** for more details). However, given the indicated stability of the scuttled vessel generally up to 100 ARI (under the anticipated initial 0.5m settlement) if oriented with the bow towards the ESE, in net terms sliding is expected to be marginal, and therefore no further detailed analysis is considered necessary.

This assessment addresses the overall stability of the vessel under lateral wave induced forces. It has not included analysis of local failures (such as the collapse of the mast and other structures). The assessment of longitudinal wave forces (i.e. from bow on waves) has not been included as these are not likely to be critical.

From the stability analysis it has been calculated that orbital (wave-induced) currents at the depths of the scuttled vessel frequently exceed 2m/s. Background ocean currents have not been considered because at this location they are not significant in terms of the scuttled vessel stability, with maximum currents occurring infrequently and generally being much weaker than design wave induced currents (see **Table 5.5**).

6.2.2 Scour

Sand waves evident in the region (including the study area), between water depths of 25m and 75m, are consistent with a general current structure flowing to the south. Wave-generated ripples are found on the seabed to depths of about 60m. This results in reworking of the seabed surface to depths of about 0.2m on a daily basis at depths of 25m, and for about 25% of the time at depths of 60m (Nielsen, 1994). However, Nielsen (1994) found that there was negligible net sediment transport beyond the 35m depth contour.

At a scuttling depth of 32m, there is unlikely to be:

- sediment movement such that significant regional seabed lowering or raising would occur at the submerged vessel; or
- capture of sediment that would otherwise be worked on to beaches.

However, during large wave conditions there is potential for sediments to become mobile and local scour to occur at the bow and stern. Occasionally, currents may also induce scour.



The flow regime around the submerged vessel during periods of extreme wave conditions is complex. It is not possible to be definitive with regard to the extent and location of scour features without undertaking a comprehensive investigation of such effects. This may include case studies from other scuttled vessels in similar coastal environments and potentially some type of modelling technique (for example, Computational Fluid Dynamics (CFD) or physical modelling). Such an undertaking is beyond the scope of this investigation.

An assessment of scour potential is possible which will highlight whether local scour effects are likely to present a stability problem to the scuttled vessel. In carrying out this assessment, reference is made to a number of case studies presented by Whitehouse (1998). Reference is made, where possible, to information on scour gathered from other scuttled vessels that have a similar hull shape to the Ex-HMAS ADELAIDE and that are situated in comparable coastal environments.

For the situation where the direction of waves and currents is perpendicular to the alignment of the submerged vessel, the induced scour is dependent upon a number of factors. However, the dominant factor is the shape and size of the 'end effects' of the vessel. For a rectangular end effect, similar to the shape of the stern of the vessel, it has been estimated that a local scour feature will develop to a depth of approximately 5% to 10% of the width of the obstruction (i.e. the width of the hull in contact with the seabed). For the Ex-HMAS ADELAIDE, a scour hole of approximately 0.7m to 1.4m depth would be expected to develop in the region of the stern (given the vessel width is approximately 14m at the stern).

This extent of this scour feature is likely to be comparable to the width of the end obstruction, that is some 7m to 14m in diameter. The shape of the vessel's hull at the stern is not, however, simply rectangular. The 'cut-up' (i.e. the region from the keel to the transom) may induce additional flow separation and vortices as currents flow through the gap between the seabed and the hull. This additional turbulence might result in a slightly larger scour feature developing than is predicted for a simple rectangular end effect. The extent of any such influence is difficult to estimate because of the complexity of the flow regime.

For the narrow, more angular 'end effect' (i.e. the bow of the vessel), flow separation and vortices that are generated are likely to induce a scour feature. It is estimated that a scour hole of some 8 to 10m in diameter and some 1.5m deep will develop immediately.

For the situation of wave and current directions parallel to the long axis of the submerged vessel, the likely scour is expected to be confined to local depressions at each end of the vessel. No significant scour elsewhere on the seabed around the vessel would be expected. Such scour features are not expected to compromise the overall stability of the vessel and may assist the stability through encouraging long term settlement into the seabed.

For situations where the incident waves and currents are aligned along the main axis of the submerged vessel (as would be the case of the dominate wave directions for the proposed vessel orientation) it is postulated that the appearance of the sandy seabed would be similar to the form



of the water surface flowing around the hull of a vessel underway on the ocean surface. That is, there would be a 'bow wave' formed in the seabed, albeit of different dimensions and extent to a bow wave on the water surface. The characteristic height and extent of such local sand wave features is difficult to quantify. However, they are not likely to be large scale and would not necessarily constitute a threat to the stability of the vessel.

However, without the benefit of a scaled mobile-bed physical model, it is not possible to conclusively determine whether local scour effects will represent a stability threat. At this stage, seabed scour around the hull does not appear to represent a threat to vessel stability.

6.2.3 Impact on Nearshore Wave Climate

Avoca Beach provides for recreational amenity and tourism, as well as serving as a natural barrier system to protect against storm wave attack and erosion damage. Any change in the nearshore wave climate, as a result of introducing the scuttled vessel to Bulbararing Bay, has the potential to cause shoreline impacts.

One of the main factors influencing the medium to long-term morphologic trends at Avoca Beach is littoral transport. Littoral transport, also commonly referred to as longshore transport or littoral drift, is typically the dominant factor in determining the sediment budget of a beach. If the net littoral transport of a beach is in deficit the shoreline will recede, if in surplus it will accrete.

Littoral transport occurs when the waves approach the shoreline obliquely, creating wave driven longshore currents. Typically, sediment is brought into suspension by the bottom shear created by passing waves, suspended sediment is then carried along by the wave driven longshore currents. Larger particles move over the bed by rolling, sliding, and hopping (or saltating). The sum of suspended sediment transport and bed load is the littoral drift.

The most relevant forcing mechanisms for littoral transport are currents (tidal, wave-driven or any other) and wave action. There are other elements that may also play a significant role in littoral transport processes; these can briefly be described as:

- water level;
- shape and depth of seabed;
- sediment characteristics; and
- sources and sinks of sediment, such as rivers, eroding coast etc.

Of the forcing mechanisms and other elements that may affect littoral transport the only processes that may be significantly impacted by the submerged vessel are waves. Short period wave ($T_p < 6s$) will pass over the vessel. However, longer period swell waves ($T_p > 10s$) will feel the effect of the submerged vessel.



Wave diffraction is expected to be the dominant process affecting swell waves passing over the scuttled vessel. For the purpose of this investigation, wave diffraction is best described as the apparent bending of waves around small (relatively speaking) obstacles. When ocean waves propagate over submerged objects, as would be the case for the scuttled vessel, some of the wave energy will be blocked by the submerged object. This creates a partial wave 'shadow' in the lee of the object. Wave diffraction around the ends of the vessel acts to redistribute the wave energy from the nearby wave crest into this wave shadow. Due to the water depth at the proposed scuttling location the blocking effect of the submerged vessel will only occur for longer period swell waves.

The MIKE 21 SW spectral wave model was used to determine the impact of the scuttled vessel on the nearshore wave climate (see **Appendix E** for details on methodology). Using the 2002 offshore wave parameters, the model was used to simulate both the existing and design conditions. The sensitivity of the nearshore wave climate to vessel orientation was assessed by including simulations of four vessel orientations: bow pointing SE (135°N); E (90°N); NE (45°N); and N (0°N).

The modelled wave condition (H_s , T_p and wave direction) timeseries were output at a number of locations along the coastline of Avoca Beach and the adjacent rock shelves. Model output locations are in approximately 10m of water as shown **Figure 6.1**.

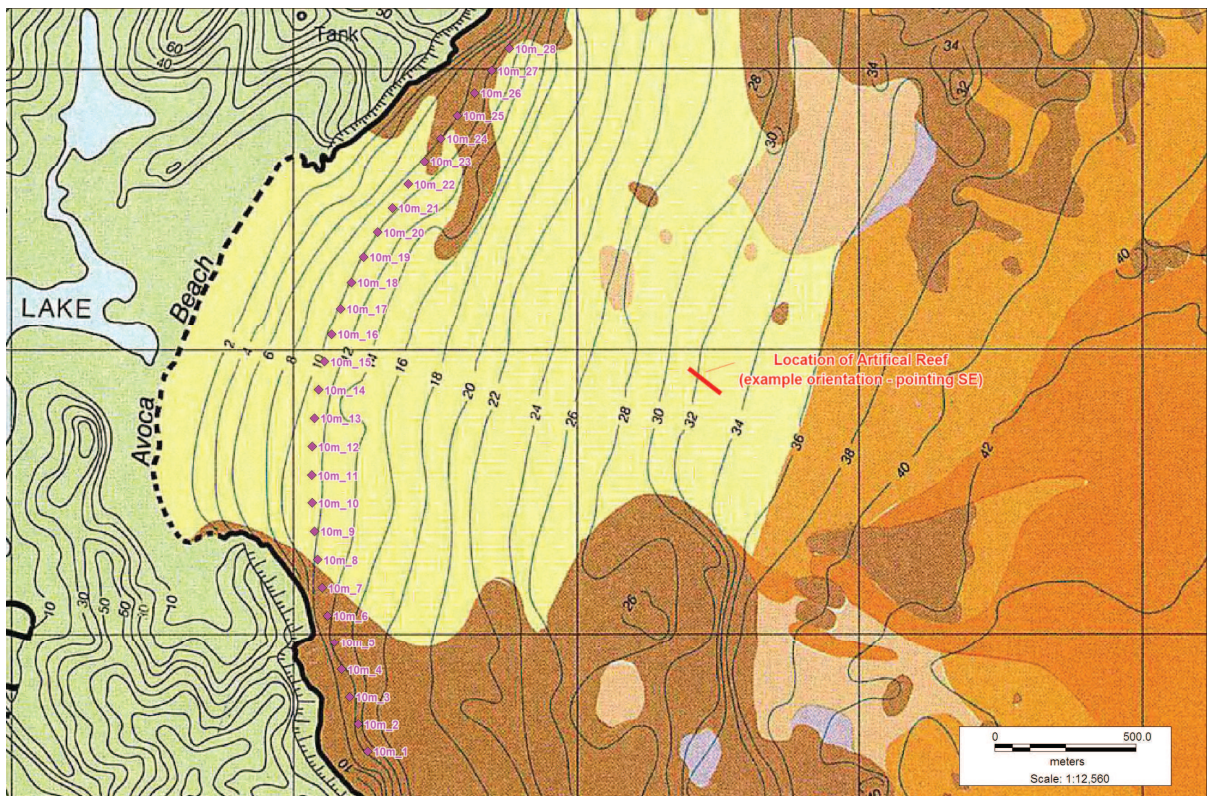


Figure 6.1 Location Outputs for Nearshore Wave Climate Modelling



In order to describe the long-term average condition, the resulting timeseries at each output location were further analysed to determine the quantity of littoral drift likely to be impacted; whether any significant change in wave climate would occur that may effect rocky habitats and the safety of rock fishermen; and the probability of exceedence of the nearshore wave height for the timeseries used in the model.

A summary of the impact modelling for nearshore wave climate is provided in the appendices to **Appendix E** including a summary of the overall deviations (presented as the root mean square deviations (RMSD)) and the deviations for each shoreline compartment. The shoreline compartments are the First Point rock shelf, Avoca Beach and the northern rock shelf. From this, the following points can be noted:

- Across the overall shoreline there is less than 1% RMSD for both long-term wave height and direction.
- Along Avoca Beach the RMSD's in long-term wave height and directions are negligible for all vessel orientation scenarios, being generally less than 0.5%.
- The largest long-term wave height and directions deviations occur along the northern rock shelf shoreline. This is expected as this area is in the shadow of the artificial reef for the dominate wave direction at the site. However the RMSD's are still not significant, being less than 2.5cm and 1° in absolute terms, which is less than 2% RMSD.

Based on the results presented in *Appendix E* to **Appendix E**, and discussed, above the change in the long-term nearshore wave climate is negligible (less than 1% RMSD). As a result, along Avoca Beach the quantity of littoral drift or other related beach processes such as surf quality, beach safety or beach state, is not expected to be significantly altered. Based on these findings no significant shoreline response at Avoca Beach is anticipated as a result of the introduction of the artificial reef. There is not expected to be a significant change to the wave climate off the rocky headlands.

While there is sensitivity to the vessel orientation, none of the vessel orientation scenarios evaluated caused significant changes to the long-term nearshore wave climate.

6.2.4 Water and Sediment Quality

Monitoring of heavy metals in sediments for the Ex-HMAS SWAN (aluminium, iron, cadmium, chromium, copper, lead, zinc) at five and 12 months and the Ex-HMAS PERTH (as per the Ex-HMAS SWAN plus nickel, tin and mercury) at six and 12 months was reported by MacLeod *et al* (2004). For the Ex-HMAS SWAN, after 12 months, there was a marked enrichment of aluminium, chromium, copper, iron, lead and zinc adjacent to the vessel. For the Ex-HMAS PERTH, analysis showed that metal enrichment in sediment decreased with increasing distance from the vessel. Although heavy metal enrichment of sediments was associated with both vessels, all concentrations were below the ISQG-low guidelines with the exception of copper at one site. This was thought to be due to a dislodged paint flake being present in the sample.



Similarly, metal enrichment of sediments surrounding the Ex-HMAS ADELAIDE could occur through metal corrosion and the degradation of protective paint layers. For the Ex-HMAS SWAN (commissioned in 1970) and Ex-HMAS PERTH (commissioned in 1965), MacLeod *et al* identified possible sources of heavy metal contamination as follows. Note that some sources would not be relevant to the Ex-HMAS ADELAIDE due to the recent use of more 'environmentally friendly' paints and antifoulants.

- Aluminium and iron mainly from corrosion of the superstructure and hull respectively; and possibly from aluminium flake contained in primers used below the water line and iron in top coats.
- Chromium from any remaining zinc chromate primer that may have originally been used on aluminium alloys (note that more recent coating formulations would not have contained chromium salts).
- Chromium and nickel as alloying metals in stainless steel, but only in areas below the seabed as corrosion of stainless steel occurs predominantly under anaerobic conditions.
- Copper, zinc and tin from corrosion of copper and copper alloy components (however, much of this would have been stripped from the vessels during preparation).
- Zinc salts, such as zinc phosphates and zinc powder added to primers as corrosion inhibitors.
- Copper from the copper linear flex shaped charges used to scuttle the Ex-PERTH and lead from the lead linear flex shaped charges used to scuttle the Ex-SWAN (note that the latter are no longer used).
- Copper and tin from tributyltin (TBT) self-polishing copolymer (SPC) coatings used as antifoulants (note that tin-free antifoulants, based on a copper acrylate polymer containing cuprous oxide and zinc pyrithione (ZPT) were phased in across the RAN fleet from April 2002, Lewis 2008).
- Lead from lead oxides used in original coatings (note that lead oxides were not present in more recent paints and that lead ballast was removed from the Ex-HMAS ADELAIDE during vessel preparation).

According to the Canadian Standards, anti-fouling paints must be at least five years old before a permit can be issued. This is taken as a guide of acceptability given that the Canadian Standards and Guidelines currently represent best practice in the absence of Australian guidelines.

The Ex-HMAS ADELAIDE was decommissioned in 2008 and according to navy records, the hull was last applied with antifouling paint in November 2003. The antifouling paint used on the vessel was International Intersmooth Ecoloflex SPC (which does not contain tributyltin (TBT))



manufactured by International Coatings Ltd. This paint is a patented self-polishing copolymer technology developed to provide controlled biocide release. The release is obtained by an hydrolysis mechanism based on a copper acrylate copolymer system with inherent self smoothing for extended in-service periods. Given that the antifouling coating is more than five years old, no further management of antifouling systems is required.

As noted in **Section 4.2**, as far as practicable, substances and items containing heavy metals would be removed from the ship and the paints and antifoulants used on the Ex-HMAS ADELAIDE in more recent years would not have contained tin and chromium. Accordingly, no significant impacts on sediment or water quality are anticipated. However, as some heavy metal enrichment of sediments is possible, monitoring of a suite of heavy metals is included in the Long Term Monitoring and Management Plan (see **Appendix G**). In addition, active bioaccumulation monitoring would be undertaken to identify any potential effects on fouling biota that would colonise the vessel over time (see **Section 6.2.5**).

6.2.5 Biological Environment

Cardno Ecology Lab (2009) carried out an assessment of the impacts of the completed reef on the marine environment which is discussed below. See **Appendix D** for further information.

Artificial Reef Colonisation

The sunken vessel would provide habitat and substratum for many local invertebrates and fish, therefore increasing the diversity and biomass of biota in the placement location and creating an attractive dive site. Based on studies of Ex-HMAS BRISBANE, colonisation by algae and sessile invertebrates would be relatively fast, with filamentous and foliose algae, limpets, barnacles and hydroids most likely appearing within the first three months of deployment (however the rate of colonisation of the Ex-HMAS ADELAIDE may vary depending on a number of factors such as water temperature, proximity to adjacent reefs). Colonisation by sponges, ascidians, polychaete worms and soft corals would soon follow. Mobile invertebrates (e.g. cuttlefish and octopus) would also colonise the reef. As was observed for the Ex-HMAS SWAN, assemblages may change with the seasons with some taxa (e.g. algae) being more common in summer months and on upper surfaces. Surveys of Ex-HMAS SWAN also found sessile groups such as sponges, ascidians, anemones and soft corals proliferated on the shaded portions of the vessel.

As for other scuttled vessels, the Ex-HMAS ADELAIDE would most likely attract some of the large species observed in the video surveys of nearby reefs, but the community composition is likely to be distinctly different from nearby reefs. Monitoring of the fish community on the Ex-HMAS SWAN over a two year period post scuttling showed an average increase in richness from two to 32 species, with a shift from omnivorous weed/ sand fishes to a community dominated by planktivorous and carnivorous reef fishes (Morrison 2001).

Fish and mobile invertebrates would, to some extent, be attracted to the vessel from nearby natural reefs. Reef habitats are wide spread within the region and the fish survey indicated that



assemblages of fish on reefs near the scuttling site are typical of those in the region. It is predicted that potential attraction of fish from other areas would be compensated for by processes of recruitment. Further, with no fishing permitted over the vessel, it is possible that natural recruitment and movement of fish would replenish natural populations over time in any depleted reefs.

There is potential for assemblages of fauna in soft sediment habitat near the vessel to change because reefs are known to alter assemblages in adjacent soft sediment. Halo effects of reefs can be confined to areas very close to a reef (within a few metres) or extend over a larger area and may depend on the size of the reef and/ or the trophic structure of fish on the reef. Changes in localised hydrodynamic processes and predation by fishes venturing out from the vessel could result in changes to assemblages of demersal fishes and infauna in surrounding sedimentary habitats. These effects could occur over spatial scales of 10s of metres and the impact will depend on the species colonising the vessel. However, given that any such effects would be localised and that sedimentary habitats are very common in the area, this is not considered an issue.

Threatened or Protected Species and Areas of Conservation Significance

No sensitive aquatic habitats such as seagrasses occur within the study area or would be affected by the project. Some threatened species occur or have been recorded on reefs close to the proposed location of the vessel (e.g. grey nurse shark). The vessel would have no adverse impact on threatened species and it may indeed be beneficial to some species by providing new foraging and sheltering habitat.

Toxic Effects on Marine Biota

As noted in **Section 6.2.4**, there is potential for metal enrichment of adjacent soft sediments from heavy metals leaching from the superstructure of the ship and remnant paint, although most of these would have little affect on species or food chains. There is also potential for some epibiota and egg cases of invertebrates and fish to experience metal toxicity if attached to the ship. Lethal effects to damselfish larvae attached to metal surfaces have been observed overseas (Kerr 1996) but there have been no reports of such effects to assemblages associated with sunken vessels in Australia (Cardno Ecology Lab, 2009).

Zinc chromate was routinely used in the past as an anticorrosive undercoat on the topside of naval vessels (as noted in **Section 6.2.4**). Once the vessel is scuttled, any remaining paints containing zinc chromate would be subject to corrosion and microbial attack and are likely to deteriorate over time. The exact process of decomposition is unknown, but it is assumed that zinc and chromium would be liberated into the marine environment through multiple processes involving dissolution and flaking. Therefore an experimental study would form part of the Long Term Monitoring and Management Plan (see **Appendix G**) to identify if bioaccumulation of heavy metals (such as chromium) is likely in the tissue of marine fouling organisms which later colonise the vessel.



The Blue Mussel *Mytilus edulis*, often used for bioaccumulation studies, is therefore proposed to be used as the test organism. Bags filled with mussels from a consistent source would be deployed around the vessel and at control sites. Mussel samples would be periodically removed over three years and tissue analysis carried out for heavy metals. Analysis of variance (ANOVA) would be used to determine any significant differences between the concentration of heavy metals at the impact, control sites and original source. Samples may also be analysed for compliance with food standards. Should heavy metal contamination be evident, additional monitoring could be undertaken.

Introduced Marine Species

It is assumed that during the final voyage of the Ex-HMAS ADELAIDE before decommissioning, any ballast water was exchanged at sea in accordance with AQIS requirements. It is also understood that none has been taken on when inside Sydney Harbour where it was decommissioned at Garden Island or at Glebe Island where it is being cleaned and prepared as a dive wreck.

With no more exchanges of ballast water it is unlikely that non-cyst forming introduced marine species (IMS) would survive in the tank without repletion of light and nutrients (Burkholder *et al.* 2007). Even if a small number of species survived a long holding time in the ballast tank, it is unlikely that they would pose a risk because successful invasions depend on the size and frequency of introductions (e.g. Hayes *et al.* 2002). Accordingly, the likelihood of an IMS introduction from ballast water is considered negligible.

The Ex-HMAS ADELAIDE was dry docked on 29 August 2008 and re-entered the water again at Garden Island on 29 September 2008. Prior to re-entry an inspection of the vessel hull was undertaken to document hull fouling organisms and the presence of any marine pests. No introduced marine pest species were found and all organisms observed, primarily barnacle and bryozoan fauna, were found to be dead and desiccated due to the one-month period in dry dock, see **Photograph 6.1**.

However, since the vessel re-entered the water, biofouling organisms from Sydney Harbour would have colonised the ship. The majority of the IMS found in the sheltered waters of Sydney Harbour are unlikely to successfully establish off Avoca Beach, due to the open, energetic environment, and differences in water quality, temperature and depth. Of the thirty plus IMS recorded, most are not considered as pest species (AMBS, 2002).

Cardno Ecology Lab (2009) identified a number of introduced or pest species which could possibly utilise the vessel from the National Introduced Marine Pests Information System (NIMPIS) database. While the known impact of many of these species on the Australian marine environment is negligible, many compete for resources such as food and space, exclude native species and can potentially interfere with nutrient cycles.



Photo 6.1 Ex-HMAS ADELAIDE in Dry Dock

Given the artificial reef would not be very close to international ports or visited by international vessels regularly, it is considered that the risk of introducing pest species via shipping mechanisms (ballast or hull fouling) is negligible. It is more likely that introduced species reaching the reef would be those which have the ability to actively swim to, or passively (e.g. floating in ocean currents) encounter, the sunken vessel.

In summary, as the vessel would not contain ballast water from Sydney Harbour and the presence of introduced marine pest species on the hull is unlikely, there would be little potential for it to act as a vector for introduced pest species by these methods. Notwithstanding this, the scuttled ship would be a potential area for colonisation by a number of IMS or declared marine pests. The risk of colonisation, however, would be no more than for any natural rocky reef that had been scoured of old growth by a storm or from sand (Cardno Ecology Lab, 2009).

6.2.6 Hazardous Materials

Electrical cabinets and transformers are present throughout the vessel. These could contain PCBs or radioactive compounds. The RAN identified most of these items and installed warning labels to assist the Ship Preparation Contractor in either removing hazardous material from the equipment, or removing the piece of equipment.

Equipment that is suspected of having any sort of valves (such as radio equipment) has been removed from the vessel or opened and any tubes removed. Equipment containing cathode ray tubes would be removed from the vessel, particularly as they contain glass that is unlikely to withstand the scuttling event and may pose a risk to divers.

When bulkheads are removed, the associated fibreglass insulation is also removed. Where additional access holes are cut into the bulkheads/ deckheads, the fibreglass around the cut would



be trimmed back as far as practicable from the metal to prevent it separating during the sinking event. Fibreglass behind undisturbed bulkheads/ deckheads would be left in situ, which is in line with the Canadian guidelines.

As noted in **Section 4.2.1** the ship is being prepared to appropriate standards and to DEWHA requirements which require the removal of hazardous materials and disposal to an appropriately licensed water management facility.

6.2.7 Increased Boating

As noted in **Section 5.8.2** there are approximately 17 swing moorings located in Terrigal Haven. Vessels using these moorings include:

- Five commercial fishing vessels which operate out of The Haven at various times of the year trapping for snapper plus other marketable fish, lobsters in season, plus netting for white bait and mullet in season.
- Four commercial charter fishing vessels which operate for approximately 150-200 days per year, depending on sea conditions and cater for eight or 10 passengers each.
- The Terrigal Sea Rescue boat which assists in any breakdown at sea within a 15nm radius.
- Two dive club boats, both 6.4m long, which operate on weekends and cater for eight passengers each.
- Two dive charter boats, both 7.5m in length catering for eight passengers each plus crew.
- Two private boats from time to time.

In addition to vessels moored at Terrigal Haven and recreational vessels launched at the boatramp, there are:

- About five trailered commercial fishing boats, up to about 7m long, that work traps out of Terrigal Haven.
- Two trailered dive boats (around 7m long) from dive shops outside the Terrigal area which carry eight passengers per boat.

Currently, all dive boats pick up passengers near the larger boatramp (due to the amount of heavy gear that needs to be loaded) with access to other vessels on moorings via dinghies. The size of trailerable vessels is limited by what is easily towed on the highway, what can be launched and retrieved at the Terrigal boatramp (depending on tides), and the ability of passengers and crew to push the vessel off the beach. The size of moored dive boats is also restricted to that which



can be readily pushed off the beach (Les Graham, Terrigal Dive Centre email to Heather Nelson 30 October 2008).

According to Les Graham, an ideal boat to service the Ex-HMAS ADELAIDE dive site would be capable of carrying between 16 or 20 divers at a time plus a skipper and four or five dive guides. The Scuba World dive boat which services the Ex-HMAS BRISBANE dive wreck is 12m in length. This size boat cannot be successfully handled off the beach and would need a jetty to operate (as noted in **Section 1.3.5** the preparation of a concept design for a jetty or similar facility is currently underway). It is anticipated that perhaps another three other dive operators would operate boats of this size to service the Ex-HMAS ADELAIDE dive wreck. Some of the fishing charter boats have also indicated they may change to operating dive charters.

Although it is expected that most divers would access the Ex-HMAS ADELAIDE from Terrigal Haven, as noted in **Section 4.4.2** other boats may travel from Sydney, Pittwater and Brisbane Water. These would have no impact on boating traffic and other facilities within Terrigal Haven.

A comparison of operations for the Ex-HMAS BRISBANE, HOBART, PERTH and SWAN provided by LPMA in 2008, indicated three, two, four and two dive tour operators respectively for these vessels. It is now understood that there are only two operators running dive trips to the Ex-HMAS BRISBANE.

It is difficult to predict the impact on boating traffic within Terrigal Haven as this would be somewhat regulated by the facilities available (e.g. size of proposed jetty), number of moorings for commercial vessels, number of moorings at the Ex-HMAS ADELAIDE dive wreck and the booking system whereby timeslots will be staggered so that divers are not entering or leaving the water at the same time. The number of boat movements may not necessarily increase if larger vessels, carrying more passengers, are able to pick up and drop off passengers at The Haven. However, some increase in boating traffic would be expected, particularly in the first few years of operation, when visitation is expected to peak. A jetty facility may also attract new uses, such as tourist passenger boats from Sydney undertaking day trips to Terrigal.

As the number of moorings within Terrigal Haven is not expected to change, and access to the Ex-HMAS ADELAIDE dive site would be controlled by a permitting system, no significant change in boat movements to and from The Haven is anticipated. The provision of a jetty would decrease congestion around the main boatramp (and improve its efficiency) and provide safer access to dive boats. As the amount of car/ trailer parking constrains boatramp use, no significant increase in boatramp usage and associated boating traffic is anticipated, unless more trailer parking is provided. The study carried out as part of the concept design for a jetty and actions arising from The Terrigal Haven PoM would consider associated land-based facilities in determining the size, location etc of the proposed jetty.



6.2.8 Recreational Diving

The Central Coast provides a variety of dive sites (caves, reefs, wrecks etc) including shore and boat dives suited to all levels. Although other former warships have been scuttled in Australia to create artificial reefs, the Ex-HMAS ADELAIDE will be the only former warship dive site in NSW. In addition, the ship will be prepared specifically for divers. Accordingly, the Ex-HMAS ADELAIDE artificial reef will add to the variety of dive sites and complement existing dive opportunities. This is consistent with the findings of Tourism Queensland (2003) that an attractive dive destination includes a variety of dive sites (see **Section 5.8.1**).

6.2.9 Recreational and Commercial Fishing

Recreational fishing in the area is popular and a number of chartered recreational fishing vessels operate out of Terrigal Haven equipped for estuary, nearshore, deep sea bottom fishing and gamefishing. Recreational fishers use hook and line to target demersal reef species such as yellowfin bream (*Acanthopagrus australis*), Silver trevally (*Pseudocaranax dentex*), mulloway (*Argyrosomus hololepidotus*), snapper (*Pagrus auratus*) and kingfish (*Seriola lalandii*) on offshore reefs, and species such as leatherjackets (Monacanthidae) and flathead (Platycephalidae) on sandy areas.

The project would have little effect on recreational fishing in the area as very few of these activities occur within the scuttling site. Furthermore, there are many similar areas nearby where these activities could and do occur. However, recreational fishing for flathead would no longer be possible within the restricted zone.

Although some fish would be attracted to the vessel from nearby reefs, any localised loss would be negligible at a regional scale. Further it is likely, that over time, natural recruitment and movement of fish would replenish natural populations in any depleted reefs. Moreover, there is potential that the vessel may increase overall production of reef fishes in the region. It is feasible that the new habitat created by the ship would increase the carrying capacity of the region and species would recruit to the vessel. Although fishers would have no direct access to the vessel itself, some fish would become available to fishers when they move away from the ship.

Although spear fishing and lobster gathering is popular on headlands and reefs between Maitland Bay in the south (near Broken Bay), up to The Entrance, given the depth of the vessel and that there is no reef in the proposed placement location this type of fishing is unlikely to occur there.

The project would have little effect, if any, on commercial fishers as very few commercial fishing activities occur in the area and those that do occur there, are undertaken rarely, and can be undertaken elsewhere. Notwithstanding this, as trawlers occasionally operate in Bulbararing Bay, the size of the proposed fishing closure has been kept to a minimum to allow for the occasional run out from Avoca Beach between the exclusion zone and southern reef.



6.2.10 Tourism

Tourism opportunities associated with the Ex-HMAS ADELAIDE include charters, accommodation, dive schools, add-on tours, holiday/ diving packages and merchandising. There has already been international interest from groups seeking to dive on the Ex-HMAS ADELAIDE.

Based on the experience of the Ex-HMAS BRISBANE dive site, the Ex-HMAS ADELAIDE would encourage increased dive tourism. The Ex-HMAS BRISBANE has directly benefited the local dive industry and increased tourist numbers have contributed to the local hospitality industry and broader local economy (www.epa.qld.gov.au). As noted in **Section 5.8.1 Tourism Queensland (2003)** found that dive visitors participate in a number of other activities and experiences that can also be found or undertaken on the NSW Central Coast.

In 2007 the Department of State and Regional Development estimated that dive visitation associated with the Ex-HMAS ADELAIDE would lead to an increase of 3,200 visitor nights to the Central Coast per annum. It was also estimated that day and overnight dive trips would generate an additional \$1M in revenue annually for the Central Coast Region over the early years of operation, plus around \$1.18M annually in dive fees. The increase in employment is expected to be five full-time equivalent positions.

6.2.11 Research and Education

Creation of the Ex-HMAS ADELAIDE Reserve would protect not only the vessel, but the area's increasing ecological values over time due to the habitat provided by the artificial reef. Management of the area as a Crown Reserve will also facilitate use for research and educational purposes. The proximity of the artificial reef to university campuses (e.g. Newcastle University, Gosford campus and Sydney Universities) and the recently established Central Coast Marine Discovery Centre (CCMDC) enhances the artificial reef's value as a research site and educational resource.

6.2.12 Visual Impact

The vessel would be entirely below the water line. As noted in **Section 4.3.1**, approximately 13.5m of the mainmast was removed to provide 6.5m of navigation depth. The only visual impact associated with the artificial reef would be the vessel and restricted area marker buoys and the moorings (and dive boats) for accessing the dive site. Given these would be located nearly 2km offshore and boating activities are common in the general Terrigal area, this visual impact is not considered significant.

6.2.13 Maritime Archaeology

A search of the Australian Heritage Database did not return any listed heritage features when searched under the NSW locations *Avoca*, *North Avoca*, *Avoca Beach*, and *Terrigal*.



As noted in **Section 5.9** it is possible that the *Union* and *Maud Weston* are located within the study area. The *Union* was lost off “Avoca Bay” near Terrigal during a storm in 1848. The cargo listed for the voyage was “general” and as such may not have included material that would be recognisable on sidescan or other remote sensing imaging data. Identifiable features of this wreck are likely to be limited to the hull and other structural remains, such as the mast. A visible feature relating to the *Maud Western* would be a mound of coal the collier was carrying at the time it floundered near Terrigal Head.

A review of sidescan data identified one anomaly of cultural heritage potential within the study area. It consists of a cluster of three individual anomalies within 20m of each other, two of which (6.4 and 9m in length) could be tall objects collecting passing sediment. The anomaly is located adjacent to a low sandbank in the north-western corner of the study area.

Scuttling vessels can have both direct and indirect impacts on cultural heritage sites, with the latter difficult to determine. As such known shipwrecks and anomalies within 100m of a scuttling site are investigated prior to scuttling to positively identify any cultural heritage sites, determine the nature and extent of each site, and to understand and record current condition of each site. Following scuttling, sites can then be monitored and any adverse impacts mitigated by, for example, sandbagging to protect remains.

However, direct and indirect impacts on cultural heritage sites for the scuttling of the Ex-HMAS ADELAIDE are considered remote because:

- there are no known shipwrecks, or other submerged cultural heritage items within close proximity (< 0.25nm) of the study area; and
- the one anomaly identified from sidescan sonar imagery is located approximately 250m north-east of the proposed scuttling site.

6.2.14 Access to Resources

Exploration

The Ecology Lab (2008) undertook a review of other potential uses of the area as part of the site selection constraints analysis. A search of the NSW Department of Primary Industry ‘TAS Map’ database (a GIS enabled database providing details of current and expired tenement titles), showed no current mining exploration titles within the 30m–35m suitable depth range of the study area. Just within and beyond the 3nm limit of State waters (well beyond the proposed depth of 32m for the Ex-HMAS ADELAIDE), Sydney Marine Sand Pty Ltd hold a Marine Exploration License (issued August 2006) for an area of 58 units (approximately 130km² in total) for depths greater than 50m. The area runs from The Entrance, south to Broken Bay and begins approximately 4.4km offshore from Terrigal Headland and approximately 5.9km offshore from the centre of Avoca Beach. Although an exploration license has been issued there are no current plans to exploit the resource.



Petroleum Exploration Licence (PEP) 11 is the only offshore petroleum exploration area in NSW. The extent of the area is from Port Stephens to Wollongong (200km) covering 2,000,000 acres, starting from 3nm offshore. Bounty Oil and Gas NL currently have plans to drill the first exploratory oil rig in the licence area, Biggus-1. Location of the exploratory oil rig is expected to be 25km south of Newcastle and approximately 22km offshore at a depth of 125m. A 2nm exclusion zone will apply around the rig for the time that it is in place. Due to the depth and planned location of the exploratory rig, the proposed location of the Ex-HMAS ADELAIDE artificial dive reef will not impact on this exploration work.

Access to Beach Nourishment Sand

Coastal erosion and receding shorelines are a major issue on the Gosford Beaches, particularly at Wamberal where storms have resulted in severe erosion threatening properties located close to the foreshore. A number of methods have since been adopted to help prevent further erosion, although these may not be adequate to cope with ongoing loss of sand, shoreline retreat and potential sea level rise related to climate change. The Gosford City Open Coast Beaches Coastal Management Plan (1995) recommended that a review of the practical, economic and environmental feasibility of sand nourishment be undertaken for the Gosford beaches as a long term mitigation measure for coastal erosion.

The feasibility study was completed in 2002 and prepared by Manly Hydraulics Laboratory. Gosford City open beaches (Macmasters, Avoca, Terrigal, Wamberal and Forresters) were identified for potential beach nourishment. Potential sand resources included the Stockton Bight dune system, Lake Macquarie entrance channel (at Swansea) and sand reserves offshore from the Gosford City beaches in deep water (as mentioned above). Based on an overall assessment of economic/ environmental impacts and resource availability, the Gosford offshore resource was considered the most favourable, due to the properties of the sand resource, potential for extensive demand (for beach nourishment and commercial uses), natural distribution and the proximity of the resource to the beaches.

Access to the resource however, has not been secured since the time of the feasibility study in 2002, and at present there are no immediate plans to extract sand resources offshore from the Gosford Local Government Area. This has been due to legislative restrictions and the approvals process which is still underway. Exploitation of sand resources would not be a constraining issue for the scuttling site at this stage. Should plans proceed in the future (either for beach nourishment or commercial for purposes) it is likely that sand extraction operations could be managed outside the area of the artificial reef, as the resource is located in depths greater than 35m. The volumes of sand required for nourishment of the Gosford beaches would be easily met by these resources.



7. LIST OF APPROVALS, CONCURRENCES, LICENCES, PERMITS

Table 7.1 lists approvals, concurrences, licences and permits required for the Ex-HMAS ADELAIDE Artificial Reef Project.

Table 7.1 List of Approvals, Concurrences, Licences and Permits

Agency	Environmental/ planning approval requirements	Scuttling/ operational requirements
US Government	Permission to use the ship for the purpose of a dive wreck.	
DEHWA	<i>Artificial Reef Permit</i> under the <i>Environment Protection (Sea Dumping) Act 1981</i> .	
Sydney Ports Corporation	nil	Harbour Masters approvals for vessel movements within Sydney Harbour. Declaration of 500m exclusion zone around vessel in Sydney Harbour via <i>Towing Permit</i> .
NSW Maritime	nil	<i>Towing Permit</i> (including 1km exclusion zone around vessel in open waters). <i>Towing Stability Condition Report</i> to be submitted to NSW Maritime. <i>Aquatic Licence</i> required for exclusive use of waters prior to and immediately following scuttling. <i>Commercial Mooring Licence</i> .
Gosford City Council	nil	Declaration of 'Special Event'.
Civil Aviation Safety Authority (CASA)		<i>Temporary Restricted Area Licence. Management Plan</i> including permitted aircraft/ surveillance details.
Dept of Environment and Climate Change	Minister's concurrence under the <i>Coastal Protection Act 1979</i> .	nil



Agency	Environmental/ planning approval requirements	Scuttling/ operational requirements
Department of Primary Industries	Minister's concurrence under s199 of the <i>Fisheries Management Act 1994</i> .	Note that a Fishing Closure would be gazetted under the <i>Fisheries Management Act</i> .
Department of Planning	nil (Part 5 assessment under the <i>Environmental Planning and Assessment Act 1979</i>).	nil
WorkCover	nil	<i>Demolitions Permit</i> for cutting charges.
Tourism NSW	nil	nil

An *Aquatic Licence* is issued by NSW Maritime for the exclusive use of the waters. It prohibits the use of the designated waters by recreational vessels and provides for an appropriate security zone around the ship. Note that it is a requirement (as part of the *Aquatic Licence*) for a Marine Notice advertisement advising mariners of the above to be placed in local papers. Similarly, notification of aircraft restrictions is required by CASA.

In addition, any activity to ready the vessel for sinking must be carried out in a manner that does not pollute waters as defined under s120 of the *Protection of the Environment Operations Act 1997*.

'Waste' removed during vessel preparation must be disposed of to a premises that is lawfully able to accept the waste as defined under the *Protection of the Environment Operations Act 1997*.



8. PROPOSED ENVIRONMENTAL SAFEGUARDS

As outlined below, a number of Management and Monitoring Plans have/ are being prepared as part of the Ex-HMAS ADELAIDE Project which will assist in:

- mitigating potential short-term environmental impacts
- identifying long-term impacts (and management/ control measures for any negative impacts)
- maintaining a sustainable dive experience.

8.1 Scuttling Management Plan

The Scuttling Management Plan would be prepared by McMahon Services Australia and would address all aspects of the scuttling process, including:

- Arrangements for the scuttling event including issues such as security, management of the sinking area, establishment and policing of suitable danger area zone(s), interception zone(s), warning signals/ protocol.
- Managing the potential for spills from vessels assisting with scuttling the vessel and search and recovery of any dislodged material.
- A procedure for minimising the potential disturbance to marine animals during scuttling (including air surveillance), particularly stopping or scaling down noisy activities if marine mammals are approaching the area of operation. Activities to ready the vessel for sinking would be carried out in such a manner that does not pollute waters as defined under s120 of the Protection of the Environment Operations Act 1997.
- Placement of a Marine Notice advertisement advising mariners of the Aquatic Licence which would allow for exclusive use of the waters around the Ex-HMAS Adelaide reef.
- Placement of a Notice to airmen of the Temporary Restricted Area Licence.
- Contacting commercial fishermen currently operating, or with potential to operate, in or nearby the placement location to notify as to when scuttling would be occurring so that fishing gear (particularly fish traps) is not damaged by, or gets entangled with large vessels.
- Contingency Plan for potential mishaps during the scuttling event.
- Post scuttling activities and the like.



The latter would include:

- ensuring charges have detonated and that there is no internal damage to the ship
- retrieval of any debris after scuttling
- a post-sinking safety inspection to confirm the safety and security of the vessel on the seabed
- rectification of any defects, unexpected damage and any necessary repairs to scuttling holes or temporary works associated with towing and scuttling
- installation of a navigation buoy to mark the location of the vessel
- installation of four commercial mooring buoys and two recreational mooring buoys
- installation of directional signage in accordance with the dive design (but not installed prior to scuttling)
- provision of photographic and video records.

8.2 Towing Stability Condition Report

This would consider the modifications made to the vessel for preparation as a dive wreck and assess the stability and strength of the vessel under tow, as well as the stability of the vessel when moored at the scuttling site, prior to sinking.

A riding crew would be aboard the vessel whilst it is under tow to assist in the safety and security of the towing operation.

8.3 Crown Reserve Plan of Management

The Ex-HMAS ADELAIDE Reserve Plan of Management provides for:

- Establishment of a fishing closure which will protect marine species colonising and inhabiting the wreck.
- Installation of webcams to assist in surveillance of the fishing exclusion zone and dive wreck (and to monitor marine species colonising/ utilising the wreck).
- Development of a diver Code of Conduct addressing issues such as minimum impact dive practices (avoid disturbing marine growth, no fish feeding) and prohibition of collection of marine life or items from the wreck.



- Development of a Communications Plan.
- Installation of marker buoys within Terrigal Haven to separate boating traffic (to and from the dive wreck) and near-shore diving and other activities.
- Development of a Rescue Response Plan.
- Development of an Asset Management Plan (see **Section 8.4**).
- Development of an Environmental Management and Habitat Management Plan.

The Communications Plan would include dissemination of information pre-visit and locally on site conditions (e.g. visibility, sea conditions, local weather, water temperature), navigation hazards, channels and mooring locations, vessel orientation/ dive routes, booking and permit arrangements, safety, the Code of Conduct and dive orientation plan (including depths to decks, no-go zones, minimum equipment requirements etc).

The Environmental Management Plan would include:

- observing and describing sediment movement around the vessel, biota present and sediment accumulation rates
- assessing sediment quality against ANZECC/ARMCANZ guidelines
- bioaccumulation studies.

The Habitat Management Plan would include surveys documenting and describing:

- the artificial reef community assemblages including (where applicable) corals, hydroids and sponges, invertebrate and fish communities
- any bioaccumulating species such as oysters, barnacles and mussels where present including new growth and the rate of growth of fouling biota
- where present, any introduced marine pest species (species listed in the CSIRO's National Introduced Marine Pest Information System (NIMPIS) and management/ control measures)
- any use of the area by protected or threatened species (as listed in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, NSW *Threatened Species Conservation Act 1995*, NSW *Fisheries Management (General) Regulation 2002*) and any special management measures.



Note that research by others, including assessment of changes to existing habitats following sinking of the vessel, is proposed and may be available to supplement the above. The last two plans would be based on the Long Term Management and Monitoring Plan (see **Appendix G**).

8.4 Asset Management Plan

This would be prepared by the ship preparation and scuttling contractor and cover the following:

- list of recommended life cycle maintenance activities based on a 40 year overall life span (vessel and moorings, navigation aids)
- periodic inspection requirements, listing key activities, inspection details and description of expected repair/ maintenance works.
- event based inspections (e.g. post major storm) and urgent risk management procedures (e.g. diver hazard).

Maintenance activities could include removal of debris (or fouling organisms) from within and surrounding the vessel, restoring access to blocked or impeded diver entry points, reinstating barriers to areas designed to have no diver access, removing structures that have come loose and pose an entanglement risk or sharp objects hazard.



9. SUMMARY

9.1 Discussion on Key Issues

The findings of the REF are summarised in **Table 9.1** in relation to key issues (constraints identified as moderate or high) identified in the initial site selection report (TEL 2008), see **Table 1.1**.

Table 9.1 Key issues and impact assessment

Constraint	Comments
1) Depth	At the proposed scuttling location the water depth is about 32m (relative to Lowest Astronomical Tide (LAT)). Due to the vessel being orientated along the nearshore slope the bow would sit in a water depth of approximately 33m and the stern in 31m (relative to LAT). Part of the main mast has been removed to provide for 6.5m navigation clearance.
2) Exclusion Zones	The proposed exclusion zone (rectangle of 350m x 250m around the vessel) took into account: commercial fishing activities (see below); minimising the area where other waterway uses were excluded; and ease of policing, i.e. relatively small area, easily defined using GPS coordinates and marker buoys.
Commercial Fishing	Trawler groups advised that they needed at least 300m between the southern reef and the scuttling site for an occasional trawl run out from Avoca Beach. Distances between the southern reef and the proposed scuttling site are approximately 400m. The size of the fishing exclusion zone would reduce this distance to approximately 300m, which would still be sufficient for occasional trawling operations.
Recreational Fishing	Baited Remote Underwater Video Stations (BRUVS) deployed by Cardno Ecology Lab between 17 and 19 December 2008 identified 12 fish species in sandy habitat sites within Bulbararing Bay (compared to 15 to 34 species at reef sites, refer to Section 5.7.3). A marine survey undertaken on 21 July 2009 found that the diversity and abundance of fish at the scuttling site was very low. Stingarees were mainly observed. In addition, no recreational fishing boats were recorded in morning photographs (taken at 8.30 am) of the site over a period of three months in 2009 (pers. comm. Les Graham). It is unlikely that the proposed scuttling site would currently be utilised for recreational fishing because it provides little habitat for marine species (i.e. it is essentially a sandy, unvegetated seabed). Furthermore (as noted in Section 6.2.9) there are many similar areas nearby which recreational fishing can be undertaken.



Historical Ship Wrecks	Further investigations (Cosmos Archaeology 2009) found that the <i>Maud Weston</i> and <i>Union</i> were possibly lost in the vicinity of the study area; however no known shipwrecks, or other submerged cultural heritage items are located within close proximity <0.25nm of the proposed scuttling site; and the only anomaly of cultural heritage potential is located well over 100m (approximately 250m) from the scuttling site.
Offshore Mineral and Petroleum Resources	The situation with regard to offshore resources remains unchanged from that reported in the Constraints Study (TEL 2008). With regard to sand resources, should plans proceed in the future (either for beach nourishment or commercial purposes) sand extraction operations would be outside the artificial reef exclusion zone, as the resource is located in water depths greater than 35m.
3) Geotechnical Constraints Substratum Type	Bedrock levels were interpreted to vary from approximately 33 m to approximately 41 m below AHD throughout the investigation area, with the deepest bedrock in a broad palaeochannel or basin underlying the centre of the study area (Douglas Partners 2008, see Section 5.2).
Penetration Depth	Seismic and sidescan sonar investigations (Douglas Partners 2008) identified the deepest area of sand (around 6m) over bedrock around the middle of the area indentified in the preliminary site selection (see Section 5.2). Accordingly, there is sufficient depth of sand for the vessel to settle into the seabed which will increase stability under storm events. It is understood the <i>ex-HMAS Brisbane</i> has settled approximately 2m into the seabed.
4) Distribution of Habitats	A marine survey of the scuttling site and immediate vicinity found that the area was largely compact, contoured sand with very little epifauna or macroalgae and that bioturbation was evident at only a few sites.
5) Threatened Species	Cardno Ecology Lab (2009) identified four species of listed marine turtles and eight species of fish as having a moderate chance of occurring in the study area (see Section 6.1.6). However impacts on these species during the scuttling process were considered negligible, with positive impacts possible due to the habitat provided by the artificial reef.
6) Coastal and Oceanographic	Modelling demonstrated that the effect of the artificial reef on the nearshore wave climate was not significant (see Section 6.2.3). As a result, minimal shoreline response is expected.
7) Operational feasibility	
Access	Gosford City Council and the LPMA are currently investigating suitable additional infrastructure for boat access at Terrigal Haven as discussed in Section 1.3.5 .



9.2 Consistency with Relevant Principles, Policies and Strategies

Principles of Crown Land Management

Under the *Crown Lands Act 1989*, the principles of Crown land management are as follows:

- environmental protection principles be observed in relation to the management and administration of Crown land
- the natural resources of Crown land (including water, soil, flora, fauna and scenic quality) be conserved wherever possible
- public use and enjoyment of appropriate Crown land be encouraged
- where appropriate, multiple use of Crown land be encouraged
- where appropriate, Crown land should be used and managed in such a way that both the land and its resources are sustained in perpetuity
- Crown land be occupied, used, sold, leased, licensed or otherwise dealt with in the best interests of the State consistent with the above principles.

As noted in **Section 1.3.4** a Plan of Management (PoM) for the Ex-HMAS ADELAIDE Reserve was prepared in accordance with the provisions of the *Crown Lands Act*. The draft PoM was publicly exhibited in September/ October 2009. The PoM goals (as listed in **Section 1.4**) are consistent with the principles of Crown Land management.

NSW Coastal Policy

Goals include accommodating natural coastal processes; protecting/enhancing aesthetic and cultural heritage qualities; and providing for ecologically sustainable development and appropriate public access and use. Key actions of relevance to coastal waters and the project are summarised below:

- Water quality in coastal waters will be maintained where it is currently adequate and that this be assessed and managed through measures such as monitoring programs.
- Aquatic environments with conservation values will be assessed and appropriate tenures, reservations, zonings and/or regulations will be put in place to protect them and conserve biodiversity.
- Cultural heritage will be protected and conserved through a variety of planning and management programs.
- Potential opportunities for the sustainable use and development of coastal resources, across all industry sectors, will be identified, and facilitated where appropriate.



The vessel would be cleaned to DEWHA requirements and a sediment monitoring program would be implemented (**see Appendix G** for details). A consideration in final site selection was that the vessel's location on the seabed not affect any known historic shipwrecks or potential maritime archaeological sites, or have a significant impact on commercial fisheries (this was confirmed by the environmental impact assessment, see **Sections 6.2.9** and **6.2.13**). A Crown Reserve (R.1014968) was gazetted in June 2008 for the purpose of access and public requirements, tourism purposes and environmental heritage conservation. As noted above, a PoM was prepared under the *Crown Lands Act* which guides the management and operation of the reserve to protect ecological, heritage and recreational values, as well as providing for commercial dive operations. A 350m x 250m fishing exclusion zone is proposed around the wreck for diver safety and conservation of marine life colonising the wreck.

Central Coast Regional Strategy 2006-31

The Strategy identifies a number of key challenges including supporting and strengthening tourism opportunities. Part of the vision for the area is an economy that effectively competes in a range of value added activities in business services, cultural, sporting and recreational industries, health services, advanced manufacturing and logistics, tourism and hospitality.

Strategy outcomes for the Region's national parks, waterways, coastline and foreshore areas envisage that they will be conserved and managed to ensure both their preservation for environmental purposes, as well as their continuing contribution to recreation and scenic amenity.

The artificial reef is expected to enhance the current dive tourism industry and provide flow on benefits to the Central Coast accommodation and hospitality sectors. The Ex-HMAS ADELAIDE Crown Reserve would be managed to enhance and conserve marine habitat values associated with the scuttled vessel, as well as providing a safe and interesting recreational dive site.



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**EX-HMAS ADELAIDE
ARTIFICIAL REEF**
REVIEW OF ENVIRONMENTAL FACTORS



Appendix A – Consultation



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Appendix B – Hydrographic & Geophysical Investigation



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Appendix C – Marine Survey Report



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Appendix D – Flora & Fauna Studies



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Appendix E – Coastal & Oceanographic Processes



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Appendix F – Submerged Cultural Heritage Impact



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Appendix G – Long Term Monitoring & Management Plan

Stakeholders

Organisations etc represented on stakeholder groups are listed below. Consultation processes completed/ proposed are outlined in the table below.

Interagency Steering Committee: NSW Maritime, NSW Tourism, Department of Environment & Climate Change, Department of Primary Industry, Department of Planning, Department of Premier & Cabinet, Workcover, NSW Treasury and Land & Property Management Authority.

Plan of Management Reference Group: Terrigal Haven Professional Fishermen's Association, Central Coast Fishing Charter Operators, Recreational Fishing Alliance, Central Coast Community Environmental Network (CCCEN), Gosford City Council, Surfrider Foundation, Royal Volunteer Coast Guard, Terrigal Sea Rescue, Central Coast Artificial Reef Project (CCARP), commercial dive operators, dive clubs and School of Environmental & Life Sciences University of Newcastle.

Dive Design Reference Group: RAN Clearance Divers, NSW Police Divers, Army Divers, Workcover, PADI, CCARP, Terrigal Underwater Group (TUG), Dive Terrigal, ProDive, Scuba Clubs of NSW, Brisbane Water Aqualung Club and Scuba Schools International.

Scuttling Management Working Group: NSW Maritime, NSW Water Police, NSW Police Divers, Workcover, Royal Australian Navy (RAN), RAN Clearance Divers, Gosford City Council, Central Coast Surf Life Saving, Westpac Rescue Helicopter Service, Civil Aviation Safety Authority, NSW Police Local Area Command, Royal Volunteer Coast Guard, Terrigal Sea Rescue and Department of Primary Industries (Fisheries).

Environmental Preparation Reference Group: CCCEN), Gosford City Council, Scuba Clubs, School of Environmental & Life Sciences University of Newcastle, Surfrider Foundation, Department of Environment & Climate Change and Department of Primary Industries (Fisheries), DEWHA.

Ship Preparation Stakeholder Group: NSW Police Divers, RAN Clearance Divers, CCCEN, Gosford City Council, Scuba Clubs, Surfrider Foundation, Royal Volunteer Coast Guard, Terrigal Sea Rescue, CCARP, TUG, Dive Terrigal, PADI, ProDive, Brisbane Water Aqualung Club, School of Environmental & Life Sciences University of Newcastle and SBS Filming.

Community Events Committee: Gosford City Council and Business Chamber.

Consultation Completed/ Proposed

Group	Process	Timing
<i>Agencies, Stakeholders and Peak Bodies</i>		
1. Interagency Steering Committee	<ul style="list-style-type: none"> • Initial Meeting • Site Visit • Risk Assessment Workshop • Progress Meetings • Comment on HMAS Adelaide Reserve Plan of Management • Advice on an Agency basis as required 	January 2008 February 2008 February 2008 March 2008 April 2008 May 2008 March 2009 Ongoing
2. Plan of Management Reference Group	<ul style="list-style-type: none"> • Public stakeholder meeting to provide advice on the project and the PoM • Reference Group Meeting – Discussion Papers 1 & 2s • Reference Group Meeting – Review of preliminary PoM • Public Meeting for PoM & PoM exhibition • Gazettal of PoM 	November 2008 December 2008 August 2009 September 2009 January 2010
3. Ship Preparation Stakeholder Group	<ul style="list-style-type: none"> • Targeted Stakeholder meeting and tour of Ex-HMAS Adelaide to advise re the project and identify correct stakeholders for further consultation. 	August 2009
4. Dive Design Reference Group	<ul style="list-style-type: none"> • Initial Dive Design Reference Group Meeting – Terms of Reference and Presentation of Preliminary Design • Initial Dive Design Tour – Marked up areas of Ship • Tour of Prepared Ship (limited areas) • Tour of Prepared Ship (all areas) • Tour of final design and documentation for dissemination to user groups • First Dive on EX-HMAS ADELAIDE 	September 2009 October 2009 December 2009 February 2009 March 2009 April 2009
5. Environmental Preparation Reference Group	<ul style="list-style-type: none"> • Initial Tour of Ship with Environmental consultants • Email updates on ship preparation progress and issues • Review of draft Environmental Assessment • Final Meeting with environmental Consultants/DEWHA 	October 2009 Ongoing January 2010 March 2010
6. Scuttling Management Working Group	<ul style="list-style-type: none"> • Initial Scuttling Management Workshop – Issues, Resources and Responsibilities Identification • Consultation with Individual Agencies for Agency requirements • Circulation of Draft Scuttling Management Plan for Comment • Circulation of Draft Operations Instructions for comment 	September 2009 October 2009 November 2009 November 2009

<i>Group</i>	<i>Process</i>	<i>Timing</i>
	<ul style="list-style-type: none"> • Second Scuttling management Working group Meeting to finalise Plan • Final Pre-Scuttling Meeting to confirm last minute details, communications and responsibilities • Post Scuttling review meeting (If required) 	<p>December 2009</p> <p>March 2010</p> <p>April 2010</p>
7. Community Events Committee	TBA-DPC, Gosford City Council, Business Chamber,	
General Community		
8. Community Consultation	<p>Community to be kept continually updated via:</p> <ul style="list-style-type: none"> • Weekly updates on project website • Release of project documentation via website • Media releases as outlined in Section 2.6 • Media campaign immediate prior to scuttling regarding scuttling arrangements 	Ongoing

Sinking of the Ex-HMAS Adelaide
Steering Committee Members
(as per email list)

Dear Steering Committee member

Re: Environmental Assessment for Sinking of ex-HMAS Adelaide as a Dive Site

The Commonwealth Government is gifting the ex-HMAS Adelaide (138-metre long-range escort frigate) to the NSW Government to be scuttled to create an artificial reef and recreational dive site in waters off the NSW Central Coast near Terrigal. The Department of Lands is project managing a range of activities to implement this project.

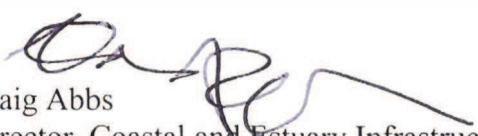
It is anticipated that the proposal will be determined by the Department of Lands under Part 5 of the *Environmental Planning and Assessment Act 1979*. The Department of Lands has initiated a site selection and constraints study, and is about to prepare a brief for an environmental assessment of all relevant activities in sinking the vessel at the selected location to form an artificial reef and recreational dive site.

As you are aware, the Department of Premier and Cabinet is co-ordinating a multi-agency approach to this project, through a Steering Committee on which you are a representative. The purpose of this letter is to seek your department's requirements for consideration in the environmental assessment. Your early advice of the following would be appreciated in order to support the multi-agency approach to this project:

- the specific regulatory role of your agency under the *Environmental Planning and Assessment Act 1979* and/or other legislation
- issues to be addressed in the environmental assessment
- the timeframe for issue of approvals or permits from your agency (where relevant)
- any other relevant information

Your response will be utilised in preparing the brief for the environmental assessment. If there is more than one representative from your agency on the Steering Committee due to various areas of responsibility and expertise, a consolidated response would be appreciated. If you require further information, please contact the Department's representatives, Natalie Heise (phone 4920 5058) or Cathy Cole (phone 49205092). Your written response by 26 March 2008 would be appreciated.

Yours faithfully



Craig Abbs
Director, Coastal and Estuary Infrastructure
Crown Lands Division
14 March 2008



27 March 2008

Department of Lands
Att Craig Abbs
PO Box 2385
DANGAR NSW 2309

Dear Mr Abbs

I refer to your letter regarding the sinking of ex-HMAS Adelaide as a dive site off Terrigal. I wish to advise NSW Maritime has an operational role in this matter and the following requirements are to be noted in this regard:

Towing of the vessel.

Once a contractor has been selected to conduct the tow from Sydney Harbour, they will be required to obtain a Towing Stability Condition Report. This report is then referred to NSW Maritime and a Towing Permit is then issued. The Towing Permit can be issued up to two weeks before the actual towing occurs.

The one permit would be applicable in the event the vessel is relocated to Newcastle for further removal of military equipment provided there are no fundamental changes to the hull.

Aquatic Licence.

Once the vessel has been towed to Terrigal and final preparations are made prior to its immediate scuttling, it is unclear of the length of time the vessel will remain on the surface. An Aquatic Licence issued for exclusive use of the waters by NSW Maritime prohibits the use of the designated waters by recreational vessels and will provide for a security zone around the ship.

It is a requirement for a Marine Notice advertisement advising mariners of the above be placed in local papers. A minimum period of six weeks should be allowed for the issue of the Aquatic Licence.

Please contact me if you wish to discuss this matter.

Yours sincerely

Stephen Black
Regional Manager
Hawkesbury/Broken Bay

CA 21/3

N. HEBB

NSW MARITIME

4 Bridge Road,
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PO Box 797,
Hornsby NSW 1630

TELEPHONE: (02) 9477 6600
FACSIMILE: (02) 9477 3418

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ABN.21 220 712 305

Cathy Cole

From: Cathy Cole
Sent: Tuesday, 8 April 2008 2:07 PM
To: 'Black, Stephen'
Subject: ex HMAS Adelaide project

Hi Steve

Just tried to phone but you weren't available, so thought I'd send a quick email in case I miss you later today.

Thanks for your quick response about approvals etc required for the HMAS Adelaide project. I just had 2 further questions:

1. **Is a licence required for the permanent moorings at the site?** Some would be leased to commercial dive operators for exclusive use, and some would be for public use. Other naval wreck dive sites around Australia have 4-5 commercial moorings and 2-4 recreational moorings.
2. **Should there be a vessel exclusion zone around the site? If so, should it be put in place by NSW Maritime, or through entry requirements to the reserve under the Crown Lands Act?** For comparison, the ex-HMAS Hobart (in SA) has an Exclusion Zone under the *Harbours and Navigation Act 1993*, whereby vessel activities are restricted within a radius of 0.5 nautical mile of the vessel. The ex-HMAS Brisbane Conservation Park has a Restricted Access Area declaration that also prohibits entry to the park without a permit from QPWS. In WA, access to the sites of the ex-Perth and ex-Swan are managed through permits and a Code of Practice. So each state has a different approach, based on their legislation. What would you recommend for NSW? (Note: Each state uses some form of permit and Code of Practice, and we propose to have these too.)

I have attached a summary of our current thinking on the dive management model, together with a PPT file that shows the models from other states (slide 5 shows the ex-Hobart exclusion zone).

Happy to discuss by phone – I'm only available until 3pm today, but available all day tomorrow.

Cathy Cole
Project Manager
Coastal and Estuary Infrastructure
Department of Lands
Tel (02) 4920 5092

23 April 2008



Department of Lands
Att Cathy Cole
PO Box 2185
DANGAR NSW 2309

Dear Ms Cole

I refer to your email of 8 April 2008 regarding the management of the dive-site once *HMAS Adelaide* has been scuttled.

I wish to advise the following:

1. Pursuant to the Management of Waters and Waterside Lands Regulations – NSW, a floating object, an apparatus or a vessel to occupy navigable waters must be subject to an occupation license. Following consideration of this matter it will be necessary to issue a Commercial Mooring License to the agency which will act as the trustee of the reserve. This license may be associated with a number of mooring sites as is necessary.

This license will allow the trustee to charge a fee for those vessels wishing to utilise the moorings. There will be a requirement to incise on the buoys the license number and any other requirements the trustee or NSW Maritime considers essential.

In normal circumstances an establishment fee of \$97 plus the annual commercial licence fee of \$343 per mooring site is applicable. Under the circumstances consideration is to be given in issuing this licence at a reduced rate.

2. As with similar sites, an exclusion zone should be established thereby restricting access to the site to approved operators only. As we have discussed it is considered such an exclusion zone be established by the powers contained within the Crown Lands Act.

Please do not hesitate to contact me should you require further information.

Yours sincerely

A handwritten signature in black ink that reads "Black".

Stephen Black
Regional Manager
Hawkesbury/Broken Bay

NSW MARITIME

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07/8556
00008/10759

Department of **Environment & Climate Change** NSW



Contact: Douglas Lord
Phone: (02) 4960 5049
Mobile: 0417 438 571
Fax: (02) 4960 5055
Email: doug.lord@dnr.nsw.gov.au

File: 2008-04-03 HMAS Adelaide Lands Response.doc

Mr Craig Abbs
Director, Coastal and Estuary Infrastructure
NSW Department of Lands
PO Box 2185
DANGAR NSW 2309

3rd April 2008

Dear Craig,

RE: Environmental Assessment for Sinking of ex-HMAS Adelaide as a Dive Site

Further to your letter dated 14th March and addressed to the Steering Committee members, DECC requesting the DECC requirements for consideration in the environmental assessment, the DECC response is as follows.

From the Environment Protection and Regulation Group's (EPRG's) perspective, and assuming the scope of the Part 5 assessment does not include 'shore based' activities, Lands Dept. are advised that:

- The sinking of the Adelaide is not a scheduled activity under the Protection of the Environment Operations Act, 1997 and therefore the activity is not required to be licensed under this act by DECC.
- Assuming the Part 5 assessment does not include 'shore based' activities the proponent/determining authority (Lands Dept) is not required to consult with or obtain the concurrence of DECC provided the development is unlikely to significantly affect a threatened species, population, or ecological community or its habitat, as defined under the Threatened Species Conservation Act 1995.
- Assuming the Part 5 assessment does not include 'shore based activities" DECC will not be a 'determining authority' under Part 5 of the Environmental Planning and Assessment Act 1979 for the activity.

The following issues should be taken into consideration in the constraints study.

- Any activity to ready the vessel for sinking must be carried out in a manner that does not pollute waters as defined under s120 of the Protection of the Environment Operations Act, 1997, unless the activity is carried out in accordance with a licence issued by DECC.

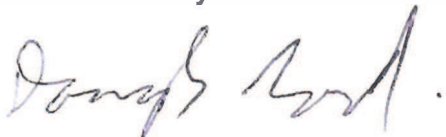
Natalie Kesi

- Any 'waste' removed from the vessel must be disposed of to a premises that is lawfully able to accept the waste as defined under the Protection of the Environment Operations Act, 1997.

The role of the coastal unit of DECC is restricted to the provision of expert technical advice on any aspects of the proposal which may affect or be affected by coastal processes. No formal approval or license from the DECC is required in this regard. Following the selection of the site for the sinking of the vessel and the subsequent environmental assessment and approval to proceed with the project, a concurrence from the Minister for DECC may be required under Regulation 1 to the Coastal Protection Act 1978 (for that part of the project below High Water Mark). The need for this concurrence will depend on the final work proposed, the location selected and the final approval process. If required the concurrence would be a formality subject to the satisfactory completion of the environmental assessment currently proposed.

Should you wish to discuss the matter further or require additional information or clarification of any of the issues raised herein, please contact me on (02) 4960 5049.

Yours Faithfully

A handwritten signature in black ink, appearing to read 'Douglas Lord', followed by a period.

Douglas Lord
Manager Coastal
Urban and Coastal Water Policy Directorate
Department of Environment and Climate Change



NSW GOVERNMENT
Department of Planning

29 April 2008

Contact: Chris Ritchie
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Email: chris.ritchie@planning.nsw.gov.au

Craig Abbs
Director, Coastal and Estuary Infrastructure
Crown Lands Division
PO Box 2185
DANGAR NSW 2309

Dear Mr Abbs

Environmental Assessment for the Sinking of the ex-HMAS Adelaide, Terrigal.

I refer to your correspondence seeking the Department's requirements for consideration in the environmental assessment for the proposed sinking of the ex-HMAS Adelaide.

I have attached a copy of the issues the Department considers should be included in the environmental assessment (see Attachment 1). To assist with the assessment of these issues, the Department has also provided a list of the State Government Technical and Policy Guidelines which outline the procedures and requirements in assessing these issues (see Attachment 2). The environmental assessment issues outlined in Attachment 1 will need to be applied to all aspects of the proposal, including any land based components.

Please note that should a determination be made that an Environmental Impact Statement (EIS) is required to support the proposal, then the proponent will be required to contact the Department and obtain the Director-General's Requirements for the EIS.

If the proposal is likely to have a significant impact on matters of National Environmental Significance, it will require an additional approval under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). An approval may also be required under the Commonwealth *Environment Protection (Sea Dumping) Act 1981*. These approvals are in addition to any approvals required under NSW legislation. I suggest contact be made with the Department of Environment, Water, Heritage and the Arts in Canberra (6274 1111 or <http://www.environment.gov.au>) to determine if any approvals are required from the Commonwealth.

If you have any queries or would like to discuss this matter further, please contact me on 9228 6413.

Yours sincerely

A handwritten signature in blue ink, appearing to read 'C. Ritchie'.

Chris Ritchie
Manager – Manufacturing and Rural Industries
Major Development Assessment

Attachment 1

General Issues:

The assessment should generally include:

- an executive summary;
- a detailed written description and graphical representation of the project, including:
 - all aspects of the proposal, including land and water based components;
 - the need for the project;
 - the alternatives considered;
 - engineering and/or architectural plans; and
 - various components and stages of the project;
- consideration of any relevant statutory provisions, including whether the project is consistent with the objects of the *Environmental Planning and Assessment Act 1979*;
- a general overview of all the environmental impacts of the project, identifying the key issues for further assessment, and taking into consideration the issues raised during consultation;
- a detailed assessment of the key issues specified below, and any other significant issues identified in the general overview of environmental impacts of the project (see above), which includes:
 - a description of the existing environment;
 - an assessment of the potential impacts of the project, including any cumulative impacts;
 - a description of the measures that would be implemented to avoid, minimise, mitigate, offset, manage, and/or monitor the impacts of the project; and
- a conclusion justifying the project, taking into consideration the environmental impacts of the project, the suitability of the site, and the benefits of the project.

Assessment Issues:

- **Strategic Planning** – including:
 - an assessment of the proposal in the context of the strategic direction of the locality and region with consideration of the *Draft Central Coast Regional Strategy*;
 - *State Environmental Planning Policy No. 71 – Coastal Protection* particularly Part 2 Clause 8 and Part 4 of the Policy, *the NSW Coastal Policy 1997* including its goals and objectives, and any the relevant Local Environment Plans and Development Control Plans; and,
 - and justification of any inconsistencies between the proposal and these strategies/plans.
 - **Coastal Processes** – including:
 - coastal hazards, coastal inundation, wave run up/ reflection, and adequacy of the structures stability and height in light of the projected sea level rises;
 - sediment circulation, sedimentation budgets, erosion and sand bypassing;
 - changes in wave behaviour, including wave dispersion and creation via amendments to orbital/oscillatory motions; and,
 - measures for the ongoing management of these issues.
 - **Water and sediment** – including:
 - sediment disturbance, such as during the sinking process;
 - leaching of materials, such as oils, anti-foulants and heavy metals; and
 - measures for the ongoing management of these issues.
 - **Flora and Fauna** – including
 - critical habitats, threatened species, and populations, ecological communities or their habitats;
-

- impacts from draw down effects from natural reef areas and aggregation of any threatened species / communities;
- any potential vessel strike on marine fauna as a result of an increase in boating activities;
- potential entanglement of turtles, whales or dolphins in any site related infrastructure such as surface lines or anchoring points; and,
- measures for the ongoing management of these issues.

Navigation and safety – including an assessment of the impacts on water based traffic.

Visual – including any surface buoys, infrastructure or land based works from private properties and publicly accessible locations.

Fisheries – including any impacts or conflicts with commercial and recreational fishery activities.

Attachment 2

State Government Technical and Policy Guidelines - For Reference

Aspect	Policy /Methodology
Soil and Waters	
<i>Acid Sulfate Soils</i>	Acid Sulfate Soil Manual (ASSMAC)
<i>Coastal</i>	NSW Coastal Policy (NSW Government)
	Coastline Management Manual (NSW Government)
	Coastal Design Guidelines for NSW (Coastal Council)
<i>Water Quality</i>	National Water Quality Management Strategy: Water quality management - an outline of the policies (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Policies and principles - a reference document (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Implementation guidelines (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ)
	Bunding and Spill Management (EPA)
	Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC)
	Using the ANZECC Guideline and Water Quality Objectives in NSW (DEC)
Flora and Fauna	
	Policy & Guidelines - Aquatic Habitat Management and Fish Conservation (NSW Fisheries)
	Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft (DEC)
	Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 - Guide to implementation in NSW (DoP)
	Environment Protection and Biodiversity Conservation Regulations 2000 (Schedule 4)
Visual	
	Control of Obtrusive Effects of Outdoor Lighting (Standards Australia, AS 4282)



Mr Craig Abbs
Director, Coastal and Estuary Infrastructure
Crown Lands Division
Department of Lands

30 April 2008

Dear Mr Abbs

I am writing in response to your letter of 14 March 2008 regarding the environmental assessment for the sinking of the ex-HMAS Adelaide as a dive site.

Regarding the regulatory role of DPI this involves the following:

- Control over impacts on threatened fish and marine vegetation, and protected marine vegetation under the requirements of the Fisheries Management Act (Parts 7 and 7A).
- Under the "reclamation" provisions of the Fisheries Management Act (s199) DoL must provide written notice of the proposed work, and consider any matters concerning the proposed work that are raised.
- Under the Environmental Planning and Assessment Act (s112C) concurrence of the Director General of the Department of Primary Industries is required if the proposed activity is likely to significantly affect a threatened species, population or ecological community or its habitat listed under the Fisheries Management Act.

Issues to be considered in the environmental assessment include an assessment of the flora and fauna and habitat types present in the vicinity of the study area, including the significance of any likely impacts on protected and threatened fish and marine vegetation. Considerations should include both the short term impacts on marine species of the process used to sink the ship including the effect of explosives and the longer term expected colonisation of the artificial reef, in particular by threatened species or pest species.

The assessment should also consider any impact on commercial and recreational fishing activities including the alienation of fishing grounds and potential increase in competition for land based facilities such as boat launching and associated parking areas.

Regards

Bill Talbot
Director, Fisheries Conservation and Aquaculture

Cathy Cole

From: Aaron Spadaro [Aaron.Spadaro@tourism.nsw.gov.au]
Sent: Tuesday, 29 April 2008 10:20 AM
To: Cathy Cole
Subject: Re: FW: Ex-HMAS Adelaide Project

Hi Cathy,

Apologies for the delayed response.

I've reviewed Craig's letter. Given that he's asking for inputs primarily from regulatory bodies with a role in the environmental assessment and approvals, Tourism NSW would not have any issues to contribute to this brief. Our involvement is more around promotion of the eventual sinking event and of the dive site post sinking.

Thanks,
Aaron

Aaron Spadaro | Strategy & Planning Coordinator | Strategy & Insights
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Integrated Practical Solutions

**REPORT
ON
SEISMIC AND SIDESCAN SONAR INVESTIGATION**

**SCUTTLING OF EX-HMAS ADELAIDE
AVOCA, NSW.**

**Prepared for
WORLEYPARSONS SERVICES PTY LTD**

**DP Project 45820
NOVEMBER 2008**



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Drawings 1 to 3

JL:pc
Project 45820
14 November 2008

**REPORT ON
SEISMIC AND SIDESCAN SONAR INVESTIGATION
SCUTTLING OF EX-HMAS ADELAIDE
AVOCA, NSW.**

1. INTRODUCTION

At the request of WorleyParsons Services Pty Ltd (WorleyParsons), Douglas Partners Pty Ltd (DP) undertook a seismic reflection and sidescan sonar investigation offshore from Avoca, NSW, within an area (Figure 1 below) proposed for the scuttling of the ex-HMAS Adelaide and the creation of a dive site. The area measures approximately 750 m x 400 m, and lies in water depths of 29 - 34 m. A sandy seabed, with depths to rock of 5 – 10 m in the south of the area, were inferred by others.

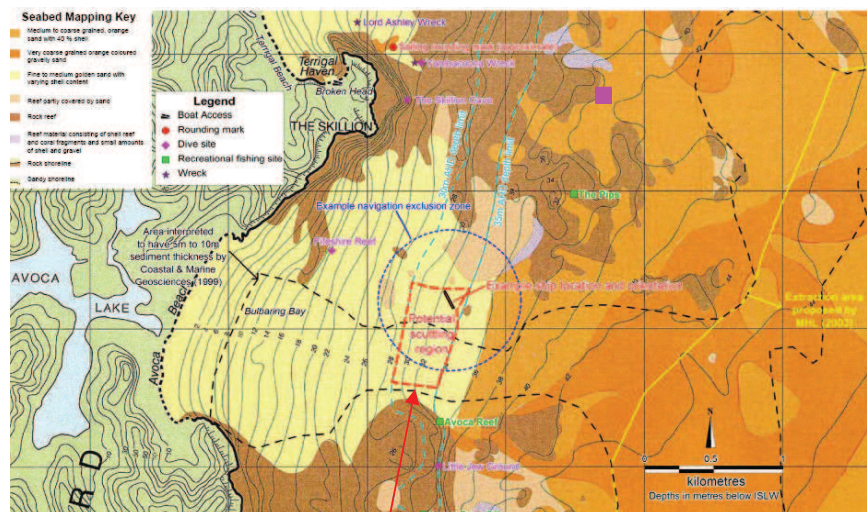


Figure 1 – Survey Location

The investigation aimed to provide detailed information on seabed materials and bedforms (e.g. sand waves which are indicative of sand movement) and on rock levels beneath the proposed scuttling area. This information was required to enable assessment by WorleyParsons of the optimum scuttling location within the area.

For these purposes, sidescan sonar mapping and seismic reflection profiling were carried out on 25 September and 17 October 2008 respectively, supervised by DP's Principal Geophysicist John Lean and Senior Hydrographic Surveyor Greg Halls of Hydrographic Surveys Pty Ltd (HS). Work was carried out from the 6.6 m HS Class 2C survey vessel "Alpha", launched in Pittwater.

Bathymetric data for the area were provided by the Department of Environment and Climate Change (DECC), in the form of an ascii grid file generated from a multibeam soundings survey.

This report presents the results of the investigation, together with figures, drawings and explanatory notes.

2. LOCAL GEOLOGY

Reference to the Gosford 1:100,000 Geological Series Map indicates cliffs of the Terrigal Formation onshore to the northwest and southwest of the the investigation area, flanking Avoca Beach. The Terrigal Formation belongs to the Narrabeen Group of Triassic age and comprises interbedded laminite, shale and sandstone. Alluvium of Quaternary age infills a palaeochannel which trends eastward beneath the Quaternary sands of Avoca Beach.

3. PREVIOUS INVESTIGATIONS

The brief for this investigation included Figure 1 (above), which refers to previous work understood to have comprised seismic profiling by Coastal & Marine Geoscience (1999) and seabed mapping by The Ecology Lab Pty Ltd. The other known previous investigation comprised multibeam soundings by DECC.

4. INVESTIGATION METHODS

4.1 Field Work

4.1.1 Navigation

A Hemisphere Crescent VS110 Differential Global Positioning System (DGPS) provided 1 second updates of the vessel position during all profiling, which was carried out at a speed of approximately 3 - 4 knots. Positions with respect to the World Geodetic Spheroid 1984 (WGS84), subsequently transformed to the Geodetic Datum of Australia 1994 and Map Grid of Australia 1994 (GDA94/MGA94 Zone 56), were logged to the navigation computer via Trimble HYDRO navigation software, which also provided a real time helmsman's display of actual vessel positions against proposed run lines. Sidescan sonar and primary seismic traverses were carried out parallel to the long dimension of the survey area and seismic tie-lines were carried out in the perpendicular direction, as indicated on the Drawings 1 and 2 (Appendix A).

4.1.2 Sidescan Sonar Mapping

In order to map the distribution of seabed materials, a dual channel C-Max CM2 325 kHz Sidescan Sonar towfish was towed with constant layback and depth. Digital data were displayed on a laptop and were recorded to laptop using 75 m slant ranges both port and starboard, with overlapping swathes and complete seabed coverage of the area. Geographical co-ordinates were provided by the navigation system and were logged with the sidescan sonar data.

4.1.3 Seismic Reflection Profiling

Continuous seismic data were obtained using a towed high resolution "boomer" seismic system and other equipment as detailed in Table 1 (following page). Time-tagged positional data were logged to the navigation computer and to a seismic acquisition laptop, for direct positioning of interpreted seismic features.

Table 1 – Seismic Equipment and Settings

240VAC power source	Portable generating set
Energy source	EG&G 232A Power Supply and EG&G 231 Triggered Capacitor Bank
Energy level	200 Joules/pulse
Firing rate	3 pulses/second
Sound source	MonoPulse boomer
Receiver	Benthos 15/10S single channel hydrophone array
Source/receiver layback	18 m
Source-receiver offset	4 m
Digital recording	Laptop running Activesoft “DrGeo” seismic acquisition software

4.2 Processing and Interpretation

4.2.1 Navigation and Bathymetric Data

Logged co-ordinates were offset to the positions of the sidescan sonar and seismic systems for subsequent data processing. To enable reduction of the seismic data to Australian Height Datum (AHD), a 3D surface was fitted to the DECC sounding data and the soundings at each seismic data point were extracted from this surface using Discover 9 software within MapInfo. Drawing 1 (Appendix A) shows the soundings re-contoured at 1 m intervals relative to AHD.

4.2.2 Sidescan Sonar Data

Using C-Max software, recorded data were adjusted for towfish layback and corrected for height above seabed. Adjacent swathes were then merged and presented as a mosaic over the survey area (Drawing 1, Appendix A). Data from individual lines were also replayed in detail and examined for sonar shadows and patterns created by the seabed topography and bedforms. The few anomalies identified, within and surrounding the survey area, were extracted as bitmaps for addition to Drawing 1.

4.2.3 Seismic Reflection Data

4.2.3.1 Seismic Velocities

In order to convert measured reflection times to depths, seismic velocities must be assigned to the materials between the seismic reflectors of interest, i.e. the seabed and the inferred bedrock

reflector. An average velocity of 1700 m/sec was assumed for the sediments, based on their sandy nature (inferred from previous investigations and confirmed at seabed by the current sidescan sonar data) and on published data for marine sand.

4.2.3.2 Consistency and Reflector Digitizing

The digital seismic records were replayed using the DrGeo seismic software and reflectors having the form and character of an erosional interface were traced, digitized and re-scaled from seismic reflection times to depths using the assumed seismic velocity in the sediments.

Tracing of the reflectors took into account depths interpreted on intersecting seismic lines, which were found to be internally consistent. Figure 2 (below) is an example of interpreted seismic data.

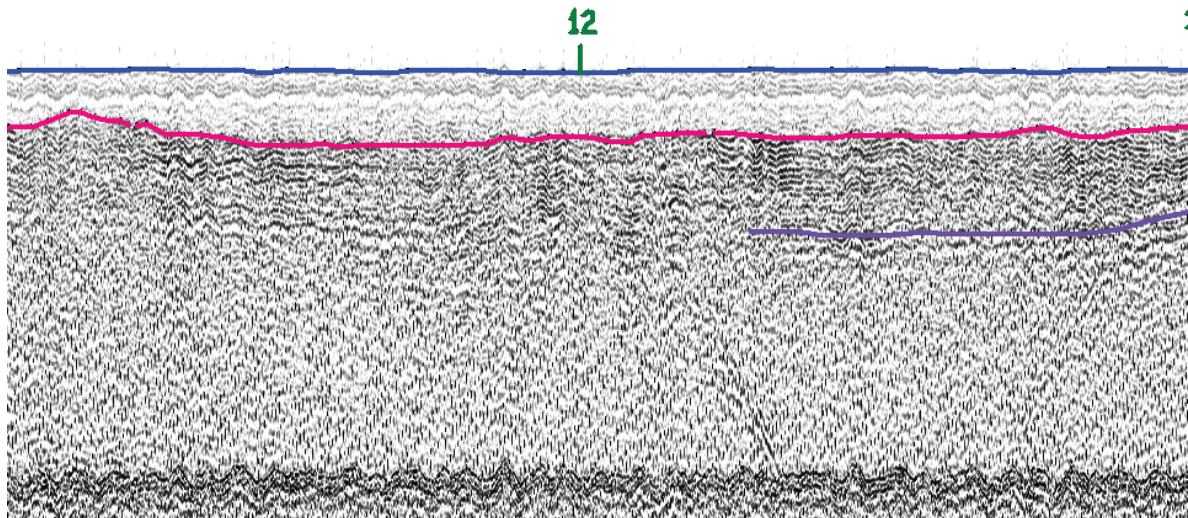


Figure 2 – Interpreted Seismic Line 3 (NS) at intersection with Line 12 (EW)

Upper (blue) line traces the seabed reflector (approx 32m bsl)
Magenta line traces the interpreted bedrock reflector (approx 5m below seabed at Line 12 intersection)
Purple line traces an interpreted sub-bedrock reflector
The first multiple seabed reflector appears at the base of the record.

4.2.3.3 Gridding and Contouring

Seabed and bedrock reflectors were interpreted and traced on all lines. Digitized bedrock reflector depths and seabed depths were subtracted in the DrGeo software for line-by-line

export of co-ordinates and total sediment thicknesses in ascii format, for gridding and contouring (Drawing 2, Appendix A) using Discover software embedded in MapInfo. DECC seabed levels were extracted at all seismic data points, for combination with sediment thicknesses, leading to a grid of reduced levels of the interpreted bedrock surface relative to AHD. This grid was contoured for presentation in Drawing 3 (Appendix A).

5. RESULTS

5.1 Bathymetry and Sidescan Sonar Mapping

Drawing 1 shows DECC soundings varying from approximately 31 m below AHD along the western area boundary, to approximately 35.5 m below AHD along the eastern area boundary. Contours are approximately parallel and regular, consistent with the generally uniform, featureless, sandy nature of the seabed (i.e. “blanket” sands) shown by the sidescan sonar mosaic.

The only bedforms observed within the investigation area are inferred to represent low sand banks in the southwest of the area, as shown by the lower sonargram extract on Drawing 1. Other bedforms observed include:

- sand waves outside the area to the northwest, oriented perpendicular to the prevailing southeasterly swell direction, with wavelengths of the order of 1 m and heights of the order of 0.2 m or less;
- low reef and low reef or gravel outside the area to the northwest and northeast respectively; and
- scour marks or a rough seabed surface outside the area to the northeast.

The reef and scour marks/rough seabed are close to some of the previously inferred reef, outside the investigation area, although the previously inferred reef inside the northern area boundary was not identified on the DP data.

It is likely that sand waves and ripple marks of low amplitude (< 0.2 m) occur in some places within the investigation area but were not identifiable, due to slight degradation of the sonar data in the choppy seas prevailing during the DP investigation.

5.2 Seismic Reflectors

Bedrock reflectors were interpreted from their slightly erosional form, over most of all lines. Some weak, dipping reflector segments were interpreted as sub-bedrock strata on some lines (e.g. Figure 2, above), consistent with the interbedded nature of the Terrigal Formation visible on nearby cliff faces.

5.3 Interpreted Sediment Thicknesses and Interpreted Bedrock Levels

Sediment thicknesses (Drawing 2, Appendix A) of the order of 1 m or less are inferred locally in the far northeast of the area, where previous investigations indicated a reef. This sediment thickness is at the limit of resolution of the seismic system and some low/patchy reef may occur in the area, unrecognized in both the sidescan sonar and seismic data. Inferred thicknesses increase to over 6 m in the centre of the investigation area, where the previous investigation indicated 5 – 10 m of sediment.

The interpreted bedrock surface (Drawing 3, Appendix A) varies in level from approximately RL-33 to approximately RL-41 with respect to AHD, deepening to the east-southeast in a broad palaeochannel or basin, with its axis approximately through the centre of the investigation area.

6. SUMMARY

- Sidescan sonar mapping and seismic reflection profiling were completed within the area of proposed scuttling of the ex-HMAS Adelaide, offshore from Avoca.
- Seabed levels of 31 m to 35.5 m below AHD were indicated by DECC multibeam sounding data over the investigation area, increasing in a regular fashion to the east-southeast.
- A generally uniform, sandy seabed was inferred from sidescan sonar data, with one area of low sand banks inferred in the southwest of the area and small areas of sand waves

and low reef outside the area. Some low (<0.2 m) sand waves may occur within the area, unrecognised on the sidescan sonar data.

- A thin veneer (<1 m) of sediment or low, patchy reef (unresolved on the seismic records), was interpreted locally in the far northeast of the area. Inferred thicknesses increase to over 6 m in the centre of the investigation area, where a previous investigation indicated 5 – 10 m of sediment.
- Bedrock levels were interpreted to vary from approximately 33 m to approximately 41 m below AHD throughout the investigation area, with deepest bedrock in a broad palaeochannel or basin underlying the centre of the area.

DOUGLAS PARTNERS PTY LTD

Reviewed by

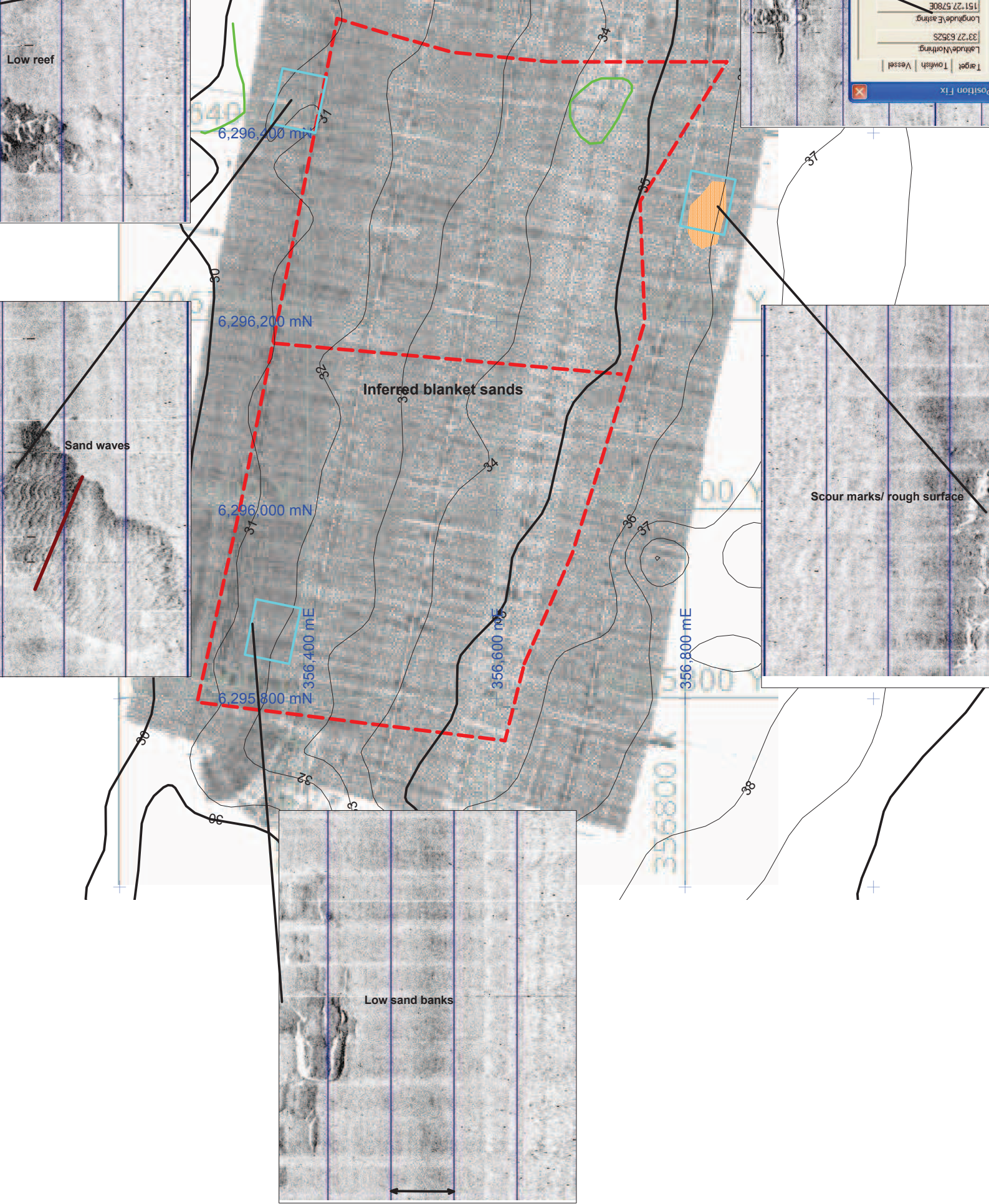
John Lean

Principal Geophysicist

G R Wilson

Principal

APPENDIX A
Notes Relating to this Report
Drawings 1 to 3



Sonagram scales: 10m per division.

Specified investigation area

one marked as "Reef 2008" in the brief for this investigation



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Sydney,
 Melbour
 Wyong,
 Townsvi

TITLE:



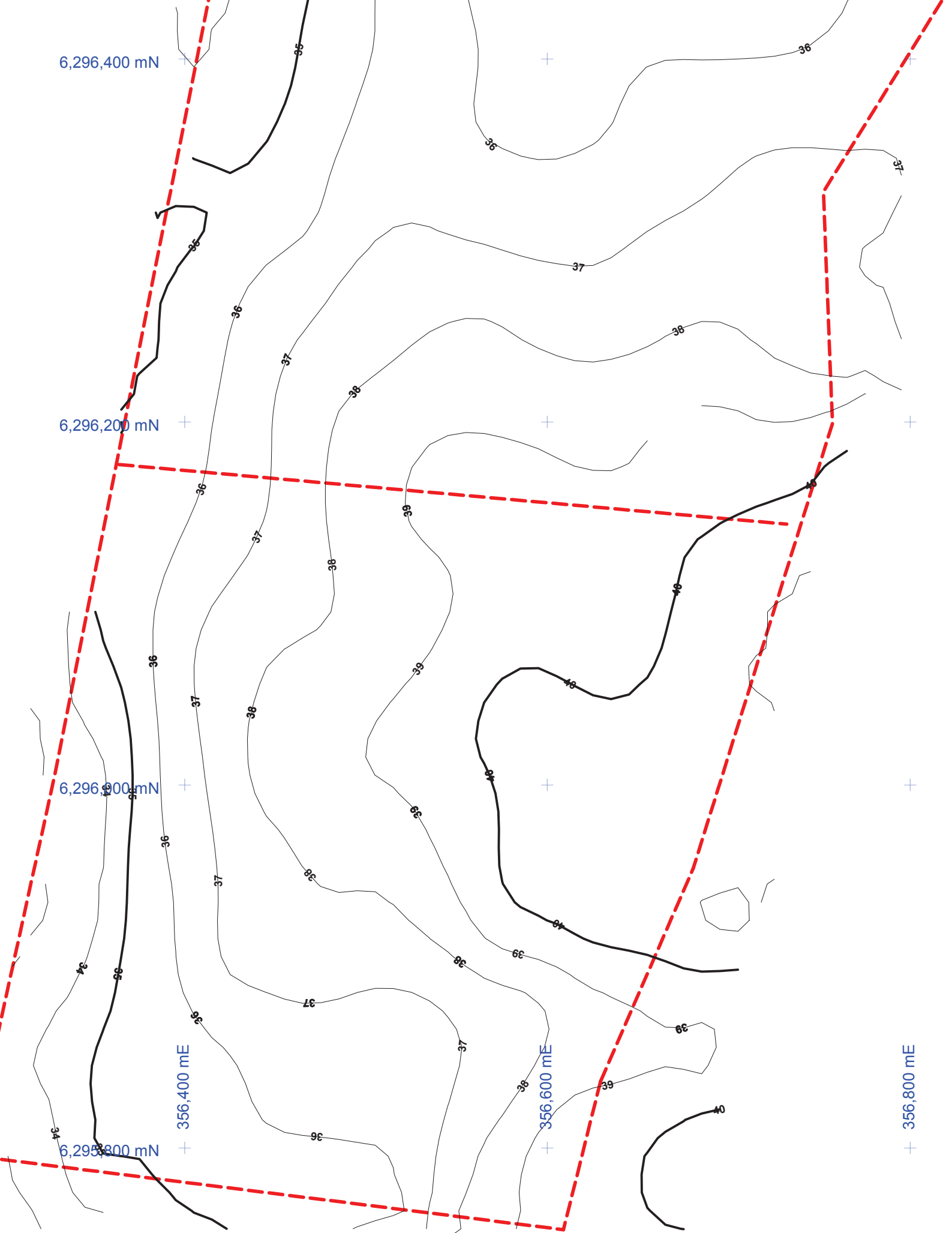
Projection: GDA94 / MGA94 (Zone 56)

Specified investigation area

Interpreted sediment thickness (5m contour intervals)

Interpreted sediment thickness (1m contour intervals)

	Douglas Partners <i>Geotechnics . Environment . Groundwater</i>	Sydney, N Melbourne Wyong, C Townsville
	TITLE:	



6,296,400 mN

6,296,200 mN

6,296,000 mN

6,295,800 mN

356,400 mE

356,600 mE

356,800 mE

LEGEND

+ Grid: GDA94 / MGA94 (Zone 56)



Douglas Partners
Geotechnics . Environment . Groundwater

Sydney, N
 Melbourn
 Wyong, C
 Townsvill

TITLE:



WorleyParsons

resources & energy



Land and Property
Management Authority

LAND AND PROPERTY MANAGEMENT AUTHORITY

Ex-HMAS Adelaide Artificial Reef Project

Marine Survey Report



301017-00077

27-Oct-09

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**LAND AND PROPERTY MANAGEMENT AUTHORITY
EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT
MARINE SURVEY REPORT**

Disclaimer

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PROJECT 301017-00077 - EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	<u> </u> K Newton	<u> </u> A Cohen	<u> </u> N/A	4 August 2009	<u> </u> N/A	
B	Issued for internal review	<u> </u> A Cohen	<u> </u> J Kennedy	<u> </u>	15 September 2009	<u> </u>	
C	Final	<u> </u> J Kennedy	<u> </u> H Nelson	 <u> </u> D Messiter	27 October 2009	<u> </u>	



**LAND AND PROPERTY MANAGEMENT AUTHORITY
EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT
MARINE SURVEY REPORT**

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**LAND AND PROPERTY MANAGEMENT AUTHORITY
EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT
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**LAND AND PROPERTY MANAGEMENT AUTHORITY
EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT
MARINE SURVEY REPORT**

1. INTRODUCTION

1.1 Background

The HMAS ADELAIDE was built in the United States and launched in 1978. It was the first of six Adelaide class guided-missile frigates to be delivered to the Royal Australian Navy and was commissioned in November 1980. The vessel is 138.1 m long, with a beam of 14.3 m and displacement of 4100 tonnes. The ship fulfilled a number of key roles including area air defence, anti-submarine warfare, surveillance, reconnaissance and interdiction. It participated in the 1990/91 Gulf War, in peace-keeping operations in East Timor in 1999 and 2006, and was deployed to the Arabian Gulf in 2001 and 2004. It was also involved in the high profile search and rescue of solo yachtsmen Thierry Dubois and Tony Bullimore from the Southern Ocean in 1997. The HMAS ADELAIDE was decommissioned in January 2008.

The Australian Government has a policy of ceding decommissioned warships to the States through an expression of interest process. Through this process five former Australian warships have already been scuttled to create artificial reefs as recreational dive sites in Australia, these being:

- the ex-HMAS SWAN and ex-HMAS PERTH in Western Australia (in December 1997 and November 2001 respectively);
- the ex-HMAS HOBART in South Australia (November 2002);
- the ex-HMAS BRISBANE in Queensland (July 2005); and
- the ex-HMAS CANBERRA in Victoria (October 2009).

After decommissioning, the Ex-HMAS ADELAIDE was demilitarised. Initial preparation of the vessel at the Royal Australian Navy's Fleet Base East in Sydney (Garden Island Dockyard) included flushing lines to clear fuel and oils. The vessel was gifted to the New South Wales (NSW) Government in August 2008 and handed over on 30 September 2008. Final preparation of the vessel prior to scuttling included removal of machinery, cables and other items that could entangle divers, removal of any hazardous materials and provision of diver access holes in the sides of the hulls and in the floors and ceilings.

The Ex-HMAS ADELAIDE will be the only military wreck dive site in NSW and is expected to generate significant economic benefits to the Central Coast Region through tourism and hospitality. It is also expected that the creation of this artificial reef will enhance marine biodiversity in the area and provide marine research opportunities, particularly for NSW Universities.

The process of selecting the most suitable site for scuttling the Ex-HMAS ADELAIDE has been phased, comprising a review of physical, environmental and operational constraints in waters



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adjacent to Avoca Beach near Terrigal (TEL, 2008); and sidescan sonar and seismic reflection profiling surveys (Douglas Partners, 2008) that enabled mapping of seabed characteristics and underlying bedrock to ascertain the depths of overlying sand available for vessel penetration. A preferred scuttling site was subsequently identified in Bulbararing Bay, 1.87 km offshore from Avoca Beach in approximately 32 m of water (at lowest astronomical tide (LAT)). This site has a reasonably flat sandy substrate with up to 6 m of sand overlying bedrock (**Figure 1-1**).

1.2 Objectives

WorleyParsons was commissioned by the NSW Land and Property Management Authority (LPMA) to prepare the following documentation for the Ex-HMAS ADELAIDE artificial reef project:

- Long Term Management Plan (LTMP) as part of an Artificial Reef Permit under the *Commonwealth Environment Protection (Sea Dumping) Act 1981*;
- Review of Environmental Factors (REF); and
- Crown Reserve Plan of Management.

This study was undertaken in order to inform a permit application under the *Commonwealth Environment Protection (Sea Dumping) Act 1981* and also to provide information relevant to the LTMP and REF.

The objectives of the marine baseline survey were to provide:

- Provide site characterisation information relevant to the Artificial Reef Permit application;
- Provide reference data regarding site characteristics (physical, chemical and biological), to enable the monitoring of the vessel post scuttling; and
- Confirm the suitability of the site for scuttling of the Ex-HMAS ADELAIDE.

1.3 Scope of Work

The scope of work for the baseline site survey included an:

- Environmental survey of the area, and documentation of:
 - bathymetry, sediment characteristics, physico-chemical conditions and biological characteristics.
 - inspection of potential rocky reef areas identified by side scan sonar and seismic reflection studies (Douglas Partners, 2008);
- Assessment of the physical and ecological effects of the dumping activity, including impact on existing and adjacent habitats and biota; and
- Conclusions regarding the environmental suitability of the site, based on the survey work.



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Figure 1-1 Proposed location of the Ex-HMAS ADELAIDE dive reef.



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2. METHODS

A structured, boat-based sampling survey offshore from Avoca Beach in Bulbararing Bay (at and near the proposed Ex-HMAS ADELAIDE scuttling site) was undertaken on the 21st July 2009. The survey methods were consistent with those developed in consultation with the Department of Environment, Water, Heritage and the Arts (DEWHA) and consisted of:

- a towed-video camera survey at the proposed wreck site to confirm the existence of flat, sandy seabed and to check for any areas of biological importance, such as subtidal reef communities, within the immediate vicinity of the proposed wreck site;
- a drop-camera video deployed at specified sites adjacent to the proposed scuttling site to confirm the location of reef habitats and the general spatial habitat characteristics of the area;
- water quality measurements and sediment chemistry; and
- collection of sediment samples for analysis.

Field survey positions were obtained from the boat's geographic positioning system (GPS) device located in the wheelhouse.

2.1 Video Transects

A light-equipped, remotely-operated video camera was mounted to a sled arrangement at a height of approximately 1 m above the sled base, facing downwards at about 30° from the horizontal in the tow direction (**Figure 2-1**). The sled was tethered and lowered to the seabed at the proposed scuttling site and towed at a suitable speed for optimum image definition and interpretation.

Video transects were established in a 5 x 7 grid pattern (see **Figure 2-2**) to characterise benthic habitats. Five 300 m long video transects, each spaced 25 m apart, were surveyed along the same vertical axis as the proposed position of the vessel, in a northwest (stern) southeast (bow) orientation (note that the preferred orientation was later determined to be ESE, based on stability analysis). In addition, seven 100 m long transects, each spaced 50 m apart (centred at the ship midpoint) and lying horizontal to where the ship will lie, were also surveyed. The location of the start and end point for each video transect is provided in

Table 2-1 and shown in **Figure 2-2**. Towed-video transects commenced at point VT01E and continued in the following order: VT01S - VT02S - VT02E - VT03E – VT03S - VTO4S - VT04E - VT05E - VT05S – VT06S - VT06E - VT07E - VT07S etc. Co-ordinates are expressed in the MGA94 (zone 56) Mercator projection.



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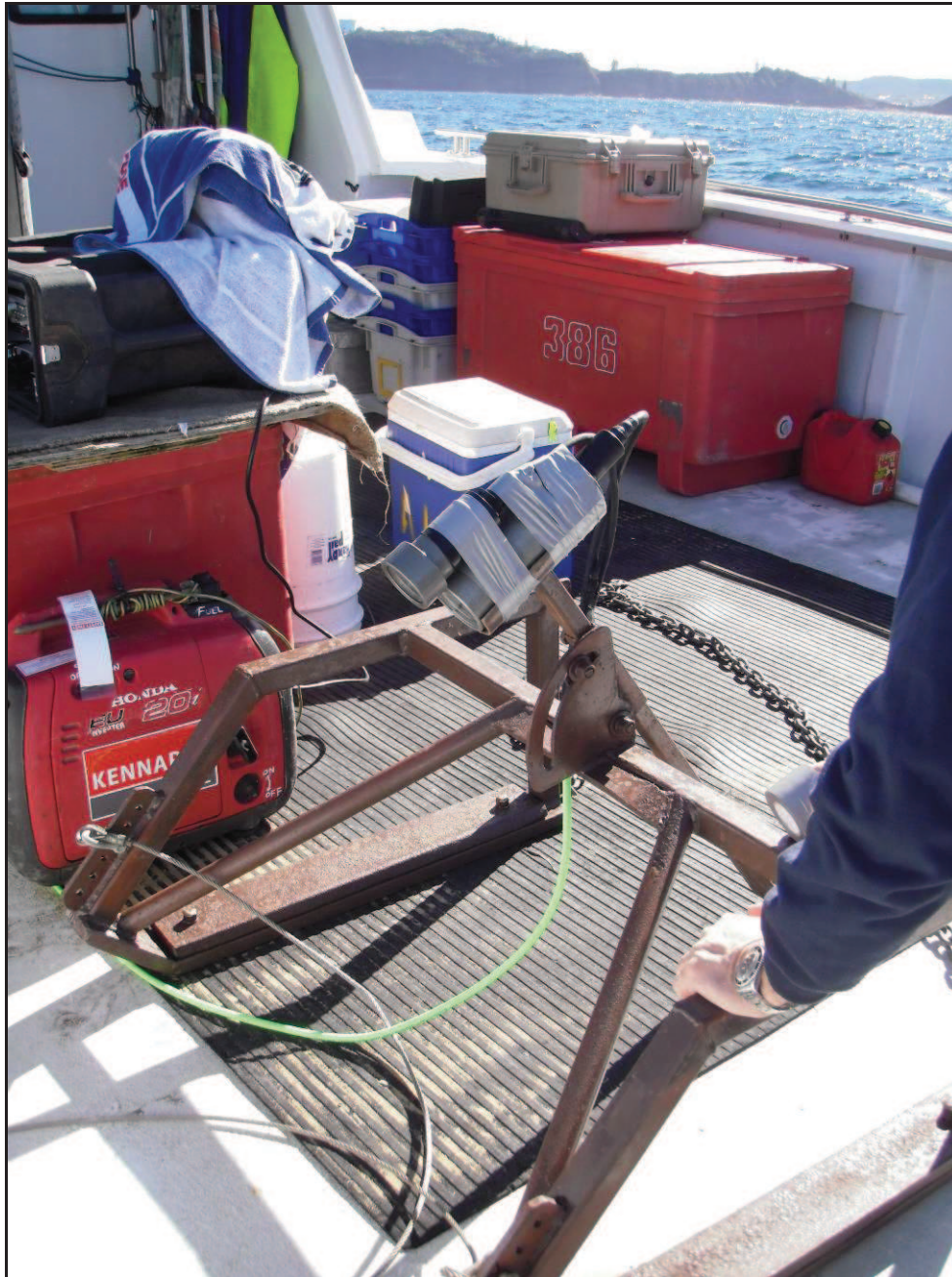


Figure 2-1 Light-equipped remotely operated underwater video camera mounted to a sled.



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2.2 Drop-video Camera Survey

A drop-video camera survey, using a light-equipped, remotely operated video camera was used to target areas of potentially exposed reef or underlying hard substrate, previously identified during the hydrographic and seismic reflection profiling survey (Douglas Partners, 2008).

Fourteen drop-camera locations were surveyed within a 600 m radius circle of the proposed wreck site. Locations of potential rocky reef, as well as soft bottom habitat, were targeted using a combination of targeted sampling (seven locations; R1 – R7) and random grid-selected sampling (seven locations; S1 – S7).

Following deployment of the drop-video camera at each of the nominated locations, the boat and camera were allowed to drift with the current for between one to two minutes. This method was used to provide greater coverage than the 360 degree pans traditionally recovered from a single point. The co-ordinates of each targeted and randomly selected sampling site are given in **Table 2-2** and the sites are illustrated in **Figure 2-2**. The video footage recorded during this survey will be provided as supporting evidence for the Artificial Reef Permit application.



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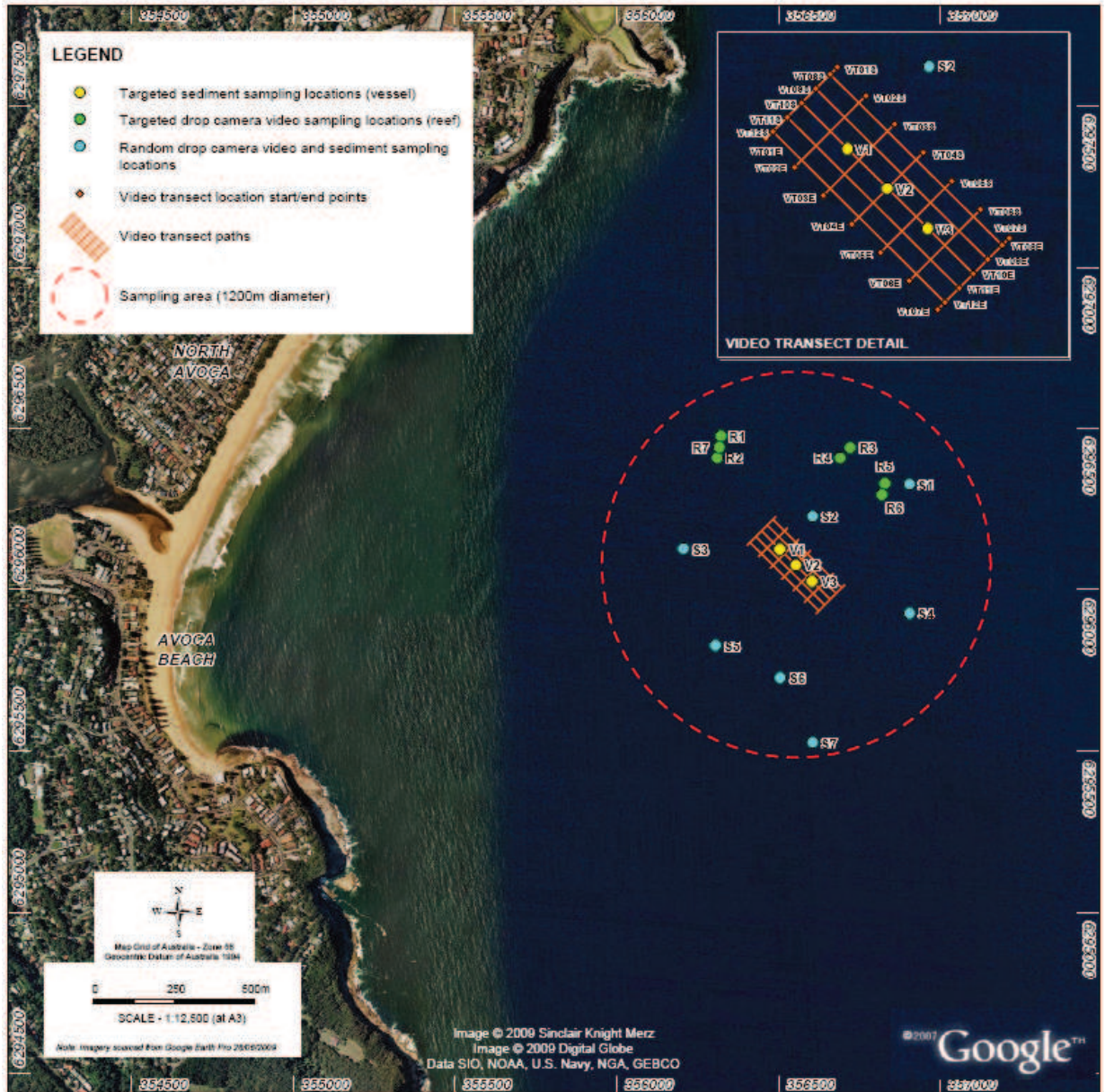


Figure 2-2 Location of video transects and drop-camera survey points.



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Table 2-1 Co-ordinates of the start (S) and end (E) points for towed-video transects (MGA 94).

Transect Point	Longitude (east)	Easting (MGA) m	Latitude (south)	Northing (MGA) m
VT01E	151°27.285'	356,403.6	33°27.876'	6,296,137.6
VT01S	151°27.343'	356,492.2	33°27.829'	6,296,225.8
VT02E	151°27.308'	356,439.7	33°27.895'	6,296,103.0
VT02S	151°27.366'	356,528.3	33°27.848'	6,296,191.3
VT03E	151°27.330'	356,474.4	33°27.915'	6,296,066.6
VT03S	151°27.388'	356,562.9	33°27.867'	6,296,156.6
VT04E	151°27.353'	356,510.5	33°27.934'	6,296,032.0
VT04S	151°27.411'	356,599.1	33°27.887'	6,296,120.2
VT05E	151°27.375'	356,545.1	33°27.953'	6,295,997.4
VT05S	151°27.433'	356,633.7	33°27.906'	6,296,085.6
VT06E	151°27.398'	356,581.3	33°27.973'	6,295,960.9
VT06S	151°27.456'	356,669.8	33°27.926'	6,296,049.2
VT07E	151°27.420'	356,615.9	33°27.992'	6,295,926.4
VT07S	151°27.478'	356,704.5	33°27.945'	6,296,014.6
VT08E	151°27.472'	356,695.3	33°27.950'	6,296,005.2
VT08S	151°27.337'	356,483.0	33°27.833'	6,296,218.3
VT09E	151°27.461'	356,678.5	33°27.959'	6,295,988.3
VT09S	151°27.326'	356,466.2	33°27.843'	6,296,199.6
VT10E	151°27.449'	356,660.2	33°27.969'	6,295,969.5
VT10S	151°27.314'	356,447.8	33°27.852'	6,296,182.6
VT11E	151°27.438'	356,643.4	33°27.978'	6,295,952.6
VT11S	151°27.303'	356,431.1	33°27.862'	6,296,163.9
VT12E	151°27.426'	356,625.1	33°27.987'	6,295,935.7
VT12S	151°27.291'	356,412.8	33°27.871'	6,296,147.0



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Table 2-2 Co-ordinates of drop-video camera and sediment sampling locations.

Sample point	Longitude (east)	Easting (MGA) m	Latitude (south)	Northing (MGA) m
R1	151°27.236'	356,322.6	33°27.692'	6,296,476.6
R2	151°27.228'	356,311.3	33°27.729'	6,296,408.0
R3	151°27.493'	356,721.4	33°27.714'	6,296,441.8
R4	151°27.473'	356,690.8	33°27.732'	6,296,408.1
R5	151°27.562'	356,830.0	33°27.776'	6,296,328.8
R6	151°27.555'	356,819.6	33°27.795'	6,296,293.5
R7	151°27.232'	356,317.0	33°27.711'	6,296,441.3
S1	151°27.611'	356,905.8	33°27.777'	6,296,328.1
S2	151°27.416'	356,605.2	33°27.829'	6,296,227.5
S3	151°27.157'	356,205.5	33°27.880'	6,296,127.2
S4	151°27.607'	356,905.6	33°27.994'	6,295,926.9
S5	151°27.219'	356,306.0	33°28.043'	6,295,827.5
S6	151°27.347'	356,505.7	33°28.099'	6,295,726.9
S7	151°27.410'	356,606.3	33°28.208'	6,295,527.0
V1*	151°27.350'	356,504.5	33°27.883'	6,296,126.1
V2*	151°27.382'	356,554.8	33°27.910'	6,296,077.0
V3*	151°27.413'	356,603.5	33°27.938'	6,296,026.0

Notes: * denotes sediment sampling only

2.3 Physical and Chemical Site Characterisation

Towed-video and drop-video camera footage were used to describe the following physical characteristics along each transect and at each sample site:

- confirmation of site bathymetry and sediment/seabed (sand or reef) characteristics previously identified using sonar and seismic reflection survey methods;
- visibility;
- direction, height and crest-to-crest distance of sand ripples; and
- exposed rock or outcrop, including the presence and extent of any attached flora and fauna.



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2.3.1 Sediments

Single sediment grab samples were collected at three locations along the proposed centre line of the vessel (i.e. stern, middle and bow; sites V1 – V3) and from the seven random grid-selected locations near the proposed wreck site (sites S1 – S7) (see **Figure 2-2**). Sediments were collected from the surface to a depth of approximately 100 - 150 mm, using a stainless steel van Veen grab sampler (**Figure 2-3**). The grab sampler was slowly lowered from the survey vessel to the seabed and retrieved following sediment capture. The collected sediment was emptied into a clean plastic core tray and packaged separately in glass jars for contaminant (metals/metalloids) testing, and in plastic bags for particle size analyses. All samples were kept in the dark and on ice until delivery to the analytical laboratory the following day.



Figure 2-3 van Veen grab sampler.



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MOISTURE CONTENT AND PARTICLE SIZE ANALYSIS

The moisture content of each of the sediment samples was determined using a gravimetric procedure based on weight loss over a 12 hour drying period at 103 - 105°C. The ALS Laboratory Group (Newcastle) procedure that was used (EA055 -103) is compliant with NEPC (1999) Schedule B(3) (Method 102).

Particle size analysis (PSA) was conducted on each of the sediment samples collected (sites S1 - S7; sites V1 - V3 plus QA sample from V3). PSA was performed by ALS Laboratory Group, Newcastle, by wet sieving according to AS1289.3.6.1-1995 guidelines.

METALS/METALLOIDS

The concentrations of 16 metals in sediments, collected from sites V1 – V3, were determined by ALS Laboratory Group (Sydney). ALS (Sydney) is NATA accredited for the metal analyses performed for this study. The analyses covered Aluminium (Al), Antimony (Sb), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Cobalt (Co), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), Selenium (Se), Silver (Ag), Vanadium (V) and Zinc (Zn), according to the following procedures:

- Total Fe and Al in sediments were analysed using the ICPAES (Inductively Coupled Plasma Atomic Emission Spectrometer) technique, which ionises samples in plasma, emitting a characteristic spectrum based on the metals present. This method is compliant with NEPC (1999) Schedule B(3).
- Total Hg was analysed using Field Ionisation Mass Spectrometer (FIMS), which is an automated flameless atomic absorption technique. The level of Hg in solids was determined following acid digestion and reduction of ionic Hg to atomic Hg vapour by SnCl₂ which was then purged into a heated quartz cell. Quantification was achieved by comparing absorbance against a calibration curve. This method is in accordance with AS 3550 and is compliant with NEPC (1999) Schedule b(3).
- The remaining metals were analysed using ICPMS (Inductively Coupled Plasma Mass Spectrometry), which uses argon plasma to ionise selected elements. These ions were passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios. This method is compliant with APHA (2005), 3120.

2.3.2 Water Quality

Vertical profiling of temperature (°C), pH, dissolved oxygen (DO) (mg/L), conductivity (micro Siemens per cm)(μ S/cm) and turbidity (Nephelometric Turbidity Units, NTU) was performed at the mid-point of the proposed wreck site (V2) and at two randomly selected drop-video sites (R5 and S6), using an *in-situ* multi-parameter water quality meter (Troll 9500). Given the exposed, open-coastal nature of the



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site, it was anticipated that there would be limited spatial variability in water quality parameters between locations and so, three locations were considered a suitable representation for characterising water quality. Water quality measurements were taken at 1 m below the sea surface, at 5 m below the surface and every 5 m thereafter to a depth of 30 m. Vertical profiles of each of the physio-chemical water quality parameters measured are presented in **Section 3.3.2**, except for DO values, where a malfunction in the probe sensor led to erroneous results.

2.4 Quality Assurance/Quality Control

A field duplicate sample was collected at site V3, in addition to the primary sample and was marked as "QA". This sample was collected to test homogeneity of the sampled material. The Relative Percent Difference (RPD) was calculated between the primary (V3) and field duplicate (QA). An acceptable level of difference between samples was set at $\pm 50\%$, in accordance with ANZECC/ARMCANZ (2000b).



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3. RESULTS

3.1 Field Conditions

Weather conditions at the site on 21st July 2009 were generally fine and sunny with a maximum air temperature of 22°C, calm seas with a 0.5 m swell and a light NW breeze of up to 5 knots increasing to 10 knots in the mid-afternoon. Surveys were carried out between approximately 8 am and 4.30 pm Australian Eastern Standard Time (AEST). High tide (1.33 m) occurred at 7.23 am AEST and low tide (0.38 m) at 12.56 pm AEST. Sunrise was at 6.55 am AEST and sunset at 5.08 pm AEST (Department of Commerce 2008).

Australian Government Bureau of Meteorology (BOM) climate statistics for Gosford (Narara Research Station) for July 2009 were as follows:

- Mean maximum air temperature of 17.5°C.
- Mean minimum temperature of 4.6°C.
- Mean 3 pm air temperature of 16.2°C.
- Mean 3 pm wind speed of 7.7 km/h (4.2 knots).
- Mean rainfall of 78.7 mm.

3.2 Video Transects and Drop-Camera Survey

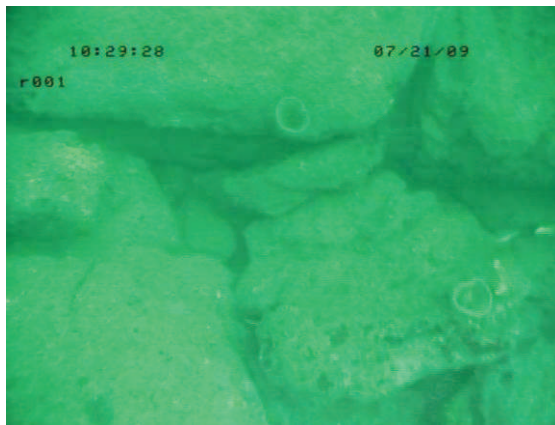
A summary of the results from video footage analyses are presented in **Table 3-1**.

3.2.1 Rocky Reef Sites

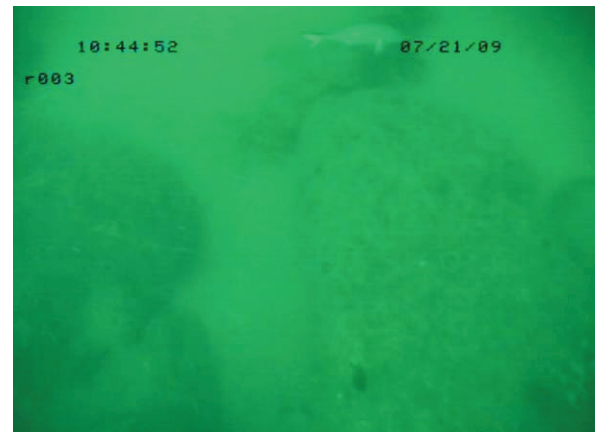
Seven rocky reef sites (R1 - R7) were inspected using the drop-camera. Of the seven sites, five were confirmed as rocky reef while Sites R5 and R6 comprised sandy seabed. Site R1 (**Figure 3-1**) was rocky reef consisting of large boulders with large horizontal surfaces and crevices between the boulders. The kelp, *Ecklonia radiata*, was present but uncommon as most of the rocks were clear of algal growth. Closer inspection showed the presence of short turfing species of algae (possibly coralline species) as well as sponges and ascidians on the rock surface. Fish were generally uncommon.



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Site R1



Site R3

Figure 3-1 Rocky reef habitat (Sites R1 and R3).

Site R2 was predominantly coarse sand and shell with rock outcrops visible in the latter part of the footage. Site R3 was similar to Site R1 with large rock boulders that appear bare but are covered in small species of turfing algae. Abundance and diversity of fish was also highest at this site.

Site R4 begins with sand which then grades into low profile rocky reef. The reef at the site is essentially a small rocky outcrop which is limited in size. Most of the footage from this site consists of bare, rippled sand. As previously mentioned, Sites R5 and R6 were sand. The seabed at Site R5 looked bioturbated in comparison to Site R6 which was the typical bare, rippled sand habitat. Very little biota was seen on the seabed.

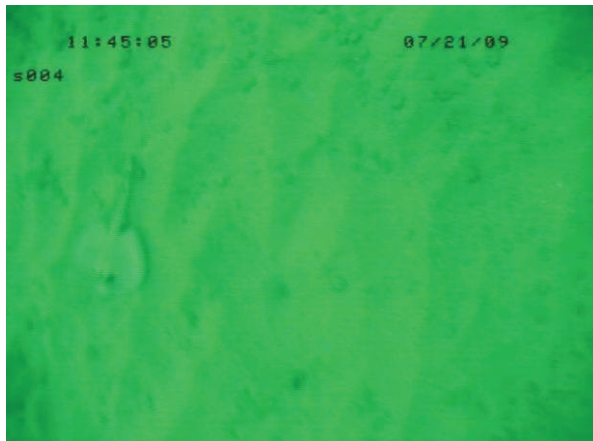
3.2.2 Soft Sediment Sites

Seven soft seabed sites (S1-S7) were inspected using the drop-camera. Of the seven sites, six sites were confirmed as sand while Site S7 was rocky reef. Sites S1 through to S6 were largely compact, contoured sand with very little epifauna or macroalgae present (**Figure 3-2**). Some evidence of bioturbation was noted at some of the sites. Fish were generally uncommon over the sandy seabed sites with the exception of rays which were encountered at most of the sites.

Site S7 was rocky reef consisting of large boulders with crevices between the boulders similar to Site R1. Water clarity at Site S7 was generally poor.



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Site S4



Site S5

Figure 3-2 Sandy seabed habitat (Sites S4 and S5).

3.2.3 Proposed Scuttling Location

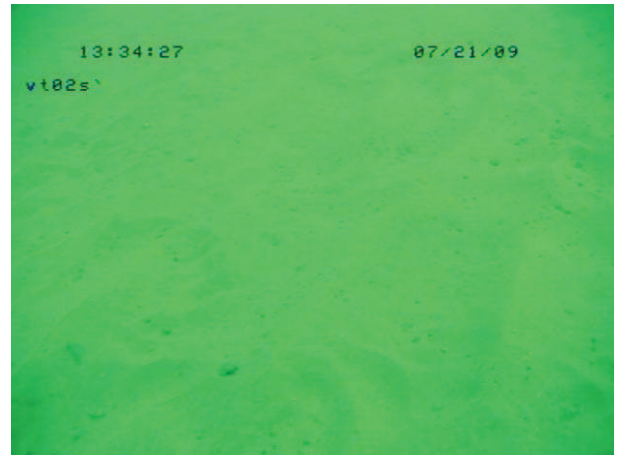
A total of 12 video transects over the proposed scuttling location were viewed using towed sled apparatus (refer **Figure 2-1**). Footage over all twelve transects confirmed the presence of sand over the proposed scuttling location (**Figure 3-3**) and absence of rocky substrate. Formed sand ripples were present at several sites and had an orientation indicating a wave climate roughly from a south-easterly direction. Ripple crests were short, only up to about 2 cm, with crests spaced about 10-15 cm apart.



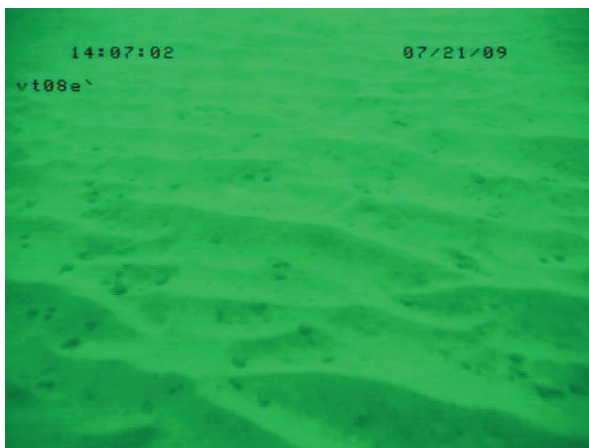
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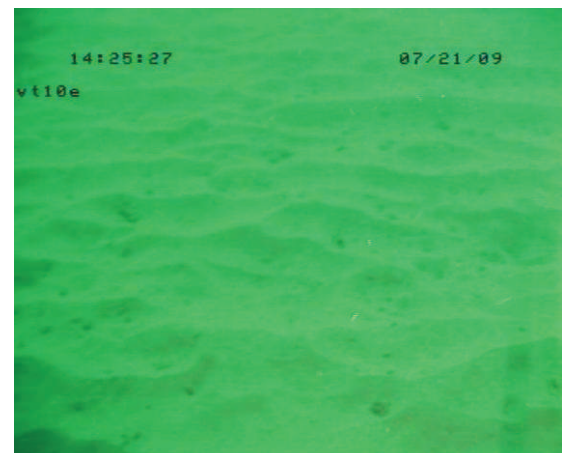
Transect VT01



Transect VT02



Transect VT08



Transect VT10

Figure 3-3 Selected screen capture from video transects (VT01, VT02, VT08 and VT10).



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Table 3-1 Summary of the major seabed characteristics for each sampling site.

Site	Longitude (east)	Latitude (south)	Water Depth (m) *	Seabed type	Biological features
V1	151° 27.350	33° 27.883	33.3 m	Sand	
V2	151° 27.382	33° 27.910	33.3 m	Sand	
V3	151° 27.413	33° 27.938	33.6	Sand	
R1	151° 27.229	33° 27.690	28.7 m	Low – medium profile boulder reef	Sponges and macroalgae
R2	151° 27.231	33° 27.724	28.9 m	Coarse sand with ripples and patchy reef	Macroalgae
R3	151° 27.496	33° 27.708	32.6 m	Boulder reef with some sandy patches	Macroalgae and fish
R4	151° 27.474	33° 27.728	32.4 m	Low profile patchy reef with sandy patches	
R5	151° 27.564	33° 27. 774	34.2 m	Coarse rippled sand	Stingray
R6	151° 27.557	33° 27.794	34.4 m	Rippled sand	
R7	151° 27.240	33° 27.707	27.6 m	Low profile patchy reef with some ledges and boulders	Sponges
S1	151° 27.613	33° 27.772	34.9 m	Sand	
S2	151° 27.419	33° 27.825	32.0 m	Rippled Sand	
S3	151° 27.158	33° 27.87	27.0 m	Rippled Sand	
S4	151° 27.609	33° 27.993	35.3 m	Sand	Macroalgae and stingray
S5	151° 27.220	33° 28.042	29.1 m	Sand	
S6	151° 27.347	33° 28.095	32.7 m	Sand	
S7	151° 27.410	33° 28.208	31.1 m	Medium profile boulder reef	

* Water depths are as recorded on the survey day between 8 am and 4.30 pm. They are not corrected to MSL.



3.3 Physical and Chemical Characteristics

3.3.1 Sediments

MOISTURE CONTENT

The moisture content of sediment samples collected from the three locations at the proposed scuttling site varied between 20.7% and 23% with a mean moisture content of 22.2%. The moisture content of each sample is presented in **Table 3-2**.

Table 3-2 Sediment moisture content.

	Sampling Site			Mean
	V1	V2	V3	
Moisture Content (%)	20.7	23	22.9	22.2

PARTICLE SIZE ANALYSIS

Particle size analyses were performed on the three sediment samples collected from the proposed scuttling site (V1 – V3, with an additional QA sample from site V3) and on the seven random grid-selected locations within 600 m of the proposed scuttling site (S1 – S7) (**Table 3-3**). Sediment classifications based on particle size categories are also presented in **Table 3-3**.

All sediment samples collected (with the exception of Site S7, which, as noted in **Section 3.2.2**, was classified as rocky reef) were comprised mostly (around 98%) of sediments smaller than 2 mm diameter. Most (average 86.4%) of the sand fraction was smaller than 300 µm so samples can be classified as 'fine sand'.

Sediments collected from Site S7, were comprised of a broader spread of particle sizes, with around 20% of particles classed as gravel (i.e. greater than 2 mm diameter), but with most (approximately 75%) within the 'sand' fraction.

There were no signs of algal discolouration in any of the sediments collected. No live benthic fauna, with the exception of a single small echinoderm, were large enough to be observed by eye from the collected sediments.



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Table 3-3 Particle size analysis.

Particle Size	Particle Size %									Mean
	V1	V2	V3	S1	S2	S3	S4	S5	S6	
+75 µm	100	99	99	98	97	98	99	98	98	98.4
+150 µm	86	88	90	89	81	81	96	89	95	88.3
+300µm	10	12	13	12	9	10	20	8	28	13.6
+425 µm	3	4	5	5	3	4	5	2	4	3.9
+600 µm	1	1	1	2	1	2	2	1	2	1.4
+1180 µm	<1	1	<1	1	<1	1	1	<1	<1	N/A

Sediment Classification	% Fines, Sand and Gravel									Mean
	V1	V2	V3	S1	S2	S3	S4	S5	S6	
Fines (<75 µm)	<1	1	1	2	3	2	1	2	2	1.6
Sand (75 µm – 2 mm)	100	99	99	98	97	98	99	98	98	98.4
Gravel (>2 mm)	<1	<1	<1	<1	<1	<1	<1	<1	<1	N/A

Note that S7 was omitted from **Table 3-3** as this site was not characteristic of the scuttling site.



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METALS

Metal concentrations (mg/kg dry weight) from sediment samples collected along the proposed centre line of the scuttled vessel (sites V1 – V3) are provided in **Table 3-4**. To assist with interpretation of the results the following have also been provided in **Table 3-4**.

- PQL: which is the Practical Quantitation Limit for each metal species;
- ANZECC ISQG-(Low): which is the ANZECC/ARMCANZ (2000a) Interim Sediment Quality Guideline (low risk value); and
- ANZECC ISQG-(High): which is the ANZECC/ARMCANZ (2000a) Interim Sediment Quality Guideline (high risk value).
- Data for MacMasters Beach which is located close by (Matthai *et al.* 2002).

It is noted that the ANZECC/ARMCANZ (2000a) Interim Sediment Quality Guidelines (ISQG) have been used in marine sediment assessments in numerous State and National documents. The levels still remain in the current dredging guidelines, the *National Assessment Guidelines for Dredging* (NAGD, Commonwealth of Australia, 2009). The ANZECC (2000) sediment quality guidelines provide low and high interim sediment quality guideline (ISQG) trigger values. Where the concentration of a contaminant is below the ISQG Low Trigger Value, it is unlikely that there would be any adverse impact on organisms inhabiting that sediment. The ISQG-Low has been adopted as the screening level for contaminants in the NAGD.

NAGD primarily applies to environmental impact assessment and permitting of the ocean disposal of dredged material. However, it also provides guidance on sampling and analysis to assist in characterising ambient baseline conditions at disposal sites. Accordingly, a range of common metals and metalloids were analysed at the proposed scuttling site to provide information on existing conditions and as a reference for future monitoring of potential contamination from those metals associated with corrosion of the ship over time.



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Table 3-4 Metals/metalloid concentrations (mg/kg dry wt).

Metal	PQL	ANZECC ISQG- Low	ANZECC ISQG- High	V1	V2	V3	Mean Avoca Beach (July 2009)	Mean MacMasters Beach (1995)
Aluminium	200	-	-	1180	1170	1200	1183	-
Iron	100	-	-	10300	8510	10000	9603	10430
Antimony	0.5	2	25	<0.50	<0.50	<0.50	N/A	-
Arsenic	1.0	20	70	11.8	10.1	11.5	11.1	-
Cadmium	0.1	1.5	10	<0.1	<0.1	<0.1	N/A	-
Chromium	1.0	80	370	8	6.8	7.9	7.6	25
Copper	1.0	65	270	1.6	1.2	1.4	1.4	6.0
Cobalt	0.5	-	-	2	1.6	1.8	1.8	3.2
Lead	1.0	50	220	3.7	3.1	3.6	3.5	11.2
Manganese	10	-	-	86	74	78	79	54
Nickel	1.0	21	52	2.8	2.2	2.6	2.5	14.2
Selenium	0.1	-	-	0.2	0.3	0.2	0.23	-
Silver	0.1	1	3.7	<0.1	0.2	<0.1	N/A	0.1
Vanadium	2.0	-	-	17.1	14.5	16.8	16.1	-
Zinc	1.0	200	410	12.2	8	10.4	10.2	32
Mercury	0.01	0.15	1.0	<0.01	<0.01	<0.01	N/A	-

In the case of metals where interim sediment quality guidelines have been established, the results for Antimony, Cadmium and Mercury were below the relevant PQL and Silver was either below or close to the PQL at the scuttling site. Arsenic, Chromium, Copper, Lead, Nickel and Zinc were all lower than their respective ANZECC/ARMCANZ ISQG-low values.



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ANZECC/ARMCANZ sediment quality guidelines have not been set for Aluminium, Iron, Cobalt, Manganese, Selenium and Vanadium. Cobalt and Selenium were recorded at slightly higher concentrations than the applicable PQL, Manganese and Vanadium concentrations were very low, Aluminium was around an order of magnitude higher than the PQL, with Iron approximately two orders of magnitude above the PQL.

Data for MacMasters Beach (one of six sampling sites off the Sydney basin, Matthai *et al.* 2002) has been provided as a comparison (particularly for metals where no guidelines have been established). It relates to trace metal concentrations in bulk sediment (0 - 10 cm depth) from eight cores in water depths of around 80 m (middle shelf) from a reference site (i.e. representative of natural background conditions) off MacMasters Beach (latitude 33°30' south) to the south of Avoca Beach.

Note that middle shelf sediments (60 to 120 m water depths) are typically mud to muddy sands (15-30% mud at the MacMasters Beach sampling site) compared to inner shelf sediments which are typically sandy sediments (less than 2% mud) (Matthai *et al.* 2002) (mean of 1.6% fines for the scuttling site, as indicated in **Table 3-3**). Note also that heavy metals are associated with the fine fraction as was apparent in Matthai *et al.* 2002, where concentrations of copper, iron, manganese and nickel were found to increase in proportion to the mud content at all sampling sites. As shown in **Table 3-4**, concentrations for iron, cobalt and manganese (metals for which guidelines have not been established) were the same order of magnitude at the scuttling site and off MacMasters Beach.



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Table 3-5 Field Quality Assurance for metal/metalloid concentrations.

Analytical Parameter	Units	Detection level	V3	QA	RPD (%)
Moisture Content (dried at 103°C)	%	1.0	22.9	21.9	4
Metals					
Aluminium	mg/kg	50	1200	1200	0
Iron	mg/kg	50	10000	10000	0
Antimony	mg/kg	0.5	<0.50	<0.50	0
Arsenic	mg/kg	1.0	11.5	11.4	0.9
Cadmium	mg/kg	0.1	<0.1	<0.1	0
Chromium	mg/kg	1.0	7.9	8	1.3
Copper	mg/kg	1.0	1.4	1.5	6.9
Cobalt	mg/kg	0.5	1.8	1.8	0
Lead	mg/kg	1.0	3.6	3.6	0
Manganese	mg/kg	10	78	83	6.2
Nickel	mg/kg	1.0	2.6	2.6	0
Selenium	mg/kg	0.1	0.2	0.1	66.7
Silver	mg/kg	0.1	<0.1	<0.1	0
Vanadium	mg/kg	2.0	16.8	16.7	0.6
Zinc	mg/kg	1.0	10.4	10.5	1.0
Mercury	mg/kg	0	<0.01	<0.01	0

Quantitative indicators of Quality Assurance (QA) for comparison of duplicate field samples commonly involve calculation of Relative Percent Difference (RPD). The designated RPD of ±50% was exceeded only for selenium (**Table 3-5**), which was at the PQL for two samples and just above the PQL limit for the other sample. Accordingly, this statistical exceedance is a consequence of the very low selenium values from which the RPD was derived, and hence can be discounted.

3.3.2 Water Quality

Vertical profiles of temperature (°C), pH, conductivity (µS/cm) and turbidity (NTU) were recorded at three sites and are summarised in **Table 3-7**. **Table 3-7** provides the average water quality measures for each depth. Profiles were relatively consistent as shown by the values in and **Figure 3.4 to 3-7**. The results of monitoring demonstrate typical oceanic water quality.



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Table 3-6 Water quality data.

Site	Depth (m)	Water Temperature (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
V2	1	16.91	8.02	54218	1.8
	5	16.88	8.02	54242	0.7
	10	16.83	8.02	54266	0.6
	15	16.80	8.02	53930	0.7
	20	16.76	8.01	54039	0.7
	25	16.75	8.01	54305	0.6
	30	16.74	8.01	54126	0.6
range		0.17	0.01	266	1.20
S6	1	16.87	8.03	54091	0.9
	5	16.08 **	8.03	54014	0.6
	10	16.86	8.02	54099	0.6
	15	16.80	8.02	54104	0.7
	20	16.79	8.02	54112	0.6
	25	16.78	8.02	54336	0.6
	30	16.77	8.02	54336	0.6
range		0.79	0.01	322	0.30
R5	1	16.87	8.02	54274	1.2
	5	16.87	8.02	54266	0.6
	10	16.86	8.02	54131	0.6
	15	16.80	8.02	54119	0.6
	20	16.78	8.03	54216	0.6
	25	16.76	8.02	54109	0.7
	30	16.74	8.02	54131	0.6
range		0.13	0.01	165	0.6

** This outlying value may have been a result of an error in reading off, or recording the water temperature in this location and so has been excluded from the plot of water temperature shown in **Figure 3-4**.



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Table 3-7 Average water quality measurements at a range of depths.

Depth (m)	Temperature (°C)	pH	Conductivity (μ S/cm)	Turbidity (NTU)
1	16.88	8.02	54194	1.0
5	16.61	8.02	54174	0.6
10	16.85	8.02	54165	0.6
15	16.80	8.02	54051	0.7
20	16.78	8.02	54122	0.6
25	16.76	8.02	54250	0.6
30	16.75	8.02	54198	0.6
Mean	16.77	8.02	54165	0.7



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WATER TEMPERATURE

Water temperature profiles (**Figure 3-4**) showed limited variability and generally varied by less than 0.2 °C at each site from the sea surface to a depth of 30 m. Although slight, there was a general trend for a decrease in water temperature with increased depth. There was also minimal difference between the results recorded at each location.

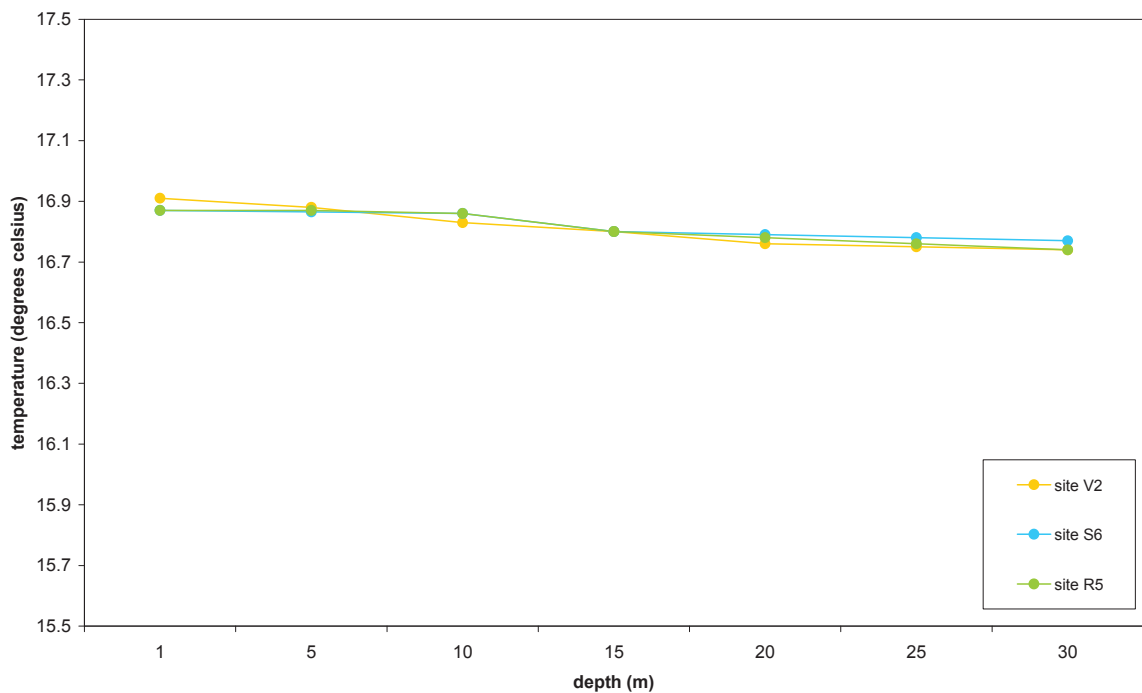


Figure 3-4 Vertical profiles of water temperature (°C) at each of the three sampling sites



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PH

The pH profile (**Figure 3-5**) showed almost no change from surface waters to depths of 30 m, remaining within the range 8.01 – 8.03 at all sites. The pH levels recorded were within the ANZECC/ARMCANZ (2000a) water quality guideline range for marine waters of south-eastern Australia, i.e. 8.0 to 8.4.

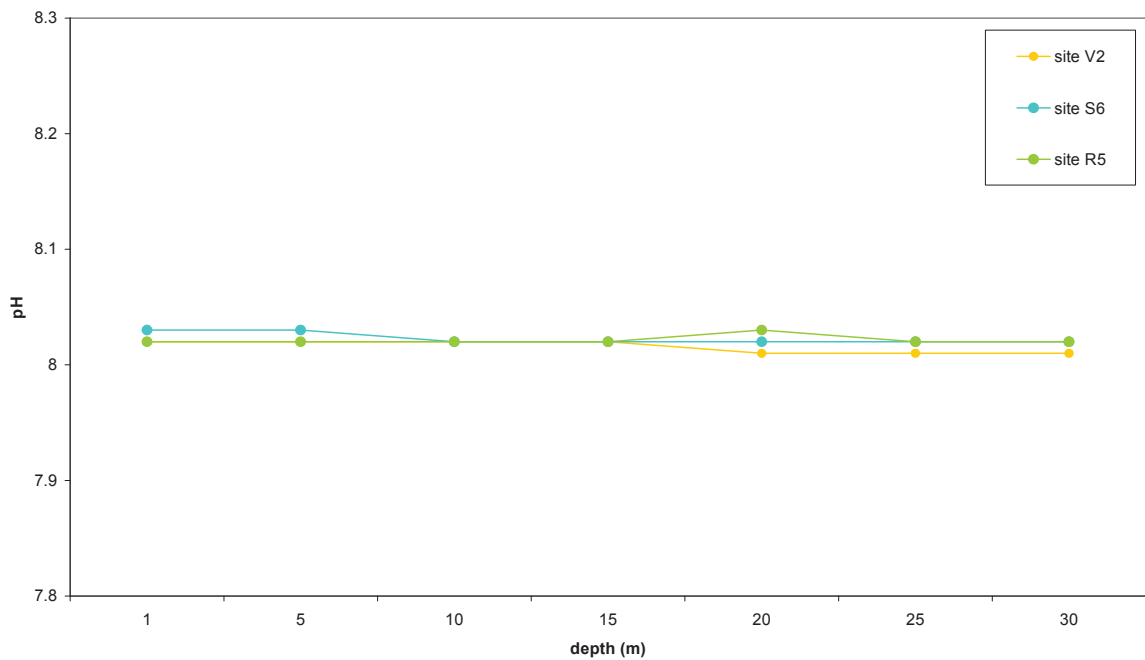


Figure 3-5 Vertical profiles of pH at the three sites sampled.



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CONDUCTIVITY

Vertical profiles for conductivity are shown in **Figure 3-6**. Readings are consistent with mean seawater conductivity of about 54,000 $\mu\text{S}/\text{cm}$, with any variation being less than 1% and within probe error tolerances. No consistent trend in conductivity change with depth was evident from the data. Variability at a site was greatest at S6 (322 $\mu\text{S}/\text{cm}$) and least at R5 (165 $\mu\text{S}/\text{cm}$).

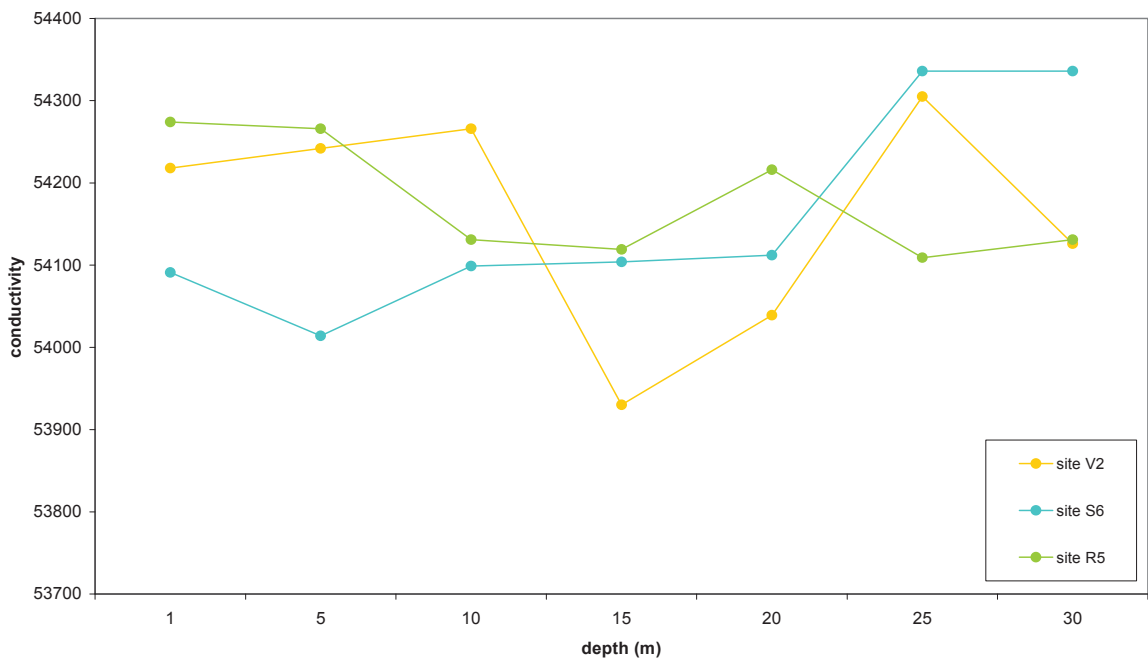


Figure 3-6 Vertical profiles of conductivity at each sampling site.



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TURBIDITY

Vertical profiles for turbidity are shown in **Figure 3-7** Profiles were similar at the three sampling sites and reflected relatively clear oceanic water. Turbidity levels at all sites were highest at the surface and reasonably consistent within and between sites at depths from 5 to 30 m. However, the difference between surface readings and those at depth (1 NTU or less) was negligible. Site V2 had the highest surface turbidity level of 1.8 NTU which was twice the surface level recorded at site R5. Turbidity levels were consistent with ANZECC/ARMCANZ (2000a) water quality guidelines for marine waters which specify a range of 0.5 NTU to 10 NTU.

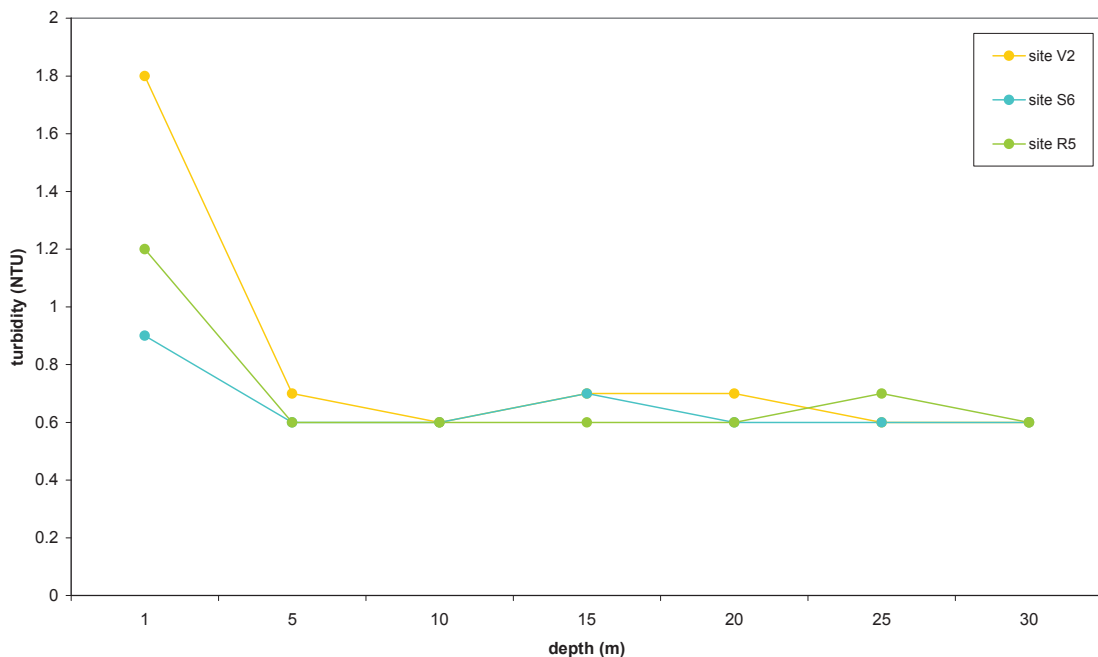


Figure 3-7 Vertical profiles of turbidity at the three sampling sites.



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4. SUMMARY OF SITE CHARACTERISTICS

4.1 Marine Ecology

MARINE BENTHOS

Bioturbation was evident at a few sites. However, with the exception of some fish (i.e. flathead) and rays (both of which are able to relocate) benthic macrofauna at the proposed scuttling site are limited in diversity, typical of open-sandy benthic communities. The area of seabed likely to be directly impacted by the proposed scuttling (i.e. around 1970 m² based on the length of the ship multiplied by the width of the beam) is negligible compared with the extent of surrounding seabed with similar characteristics, see **Section 4.2.2**. Any impact on benthos at the site during scuttling would be highly localised.

The closest rocky reef habitats to the proposed scuttling site occur approximately 340 m to the north and north-west (measured from the nearest point of the vessel, not the central point). Sponges, macroalgae and fish were the most common and visually evident components of the local reef-associated assemblage.

The submerged vessel structure will provide hard substrates, hydrodynamic complexities and light variations for development of epibenthic communities. Over time the biomass and diversity of these epibenthic assemblages are expected to increase leading to an increased abundance of pelagic organisms that will utilise the diversity of habitats provided by the fouled superstructure. The rates and character of such community establishment and development have been documented for those decommissioned naval vessels previously scuttled in Australian nearshore coastal waters (Cardno 2009). The question as to whether such 'artificial reefs' result in an increased abundance of local fish resources or merely serve to concentrate those that would normally occupy the broader area is a moot point. However, the fact remains that with time the submerged structure will develop a series of diverse biotic assemblages over an area of seabed and within the overlying water column in which there had previously been a comparatively depauperate biological community. These newly established communities could also be expected to make a positive contribution to the composition and biomass of nearby 'natural' reef communities.

THREATENED AND PROTECTED SPECIES

Threatened or protected marine species scheduled under the *Fisheries Management (FM) Act*, *Threatened Species Conservation (TSC) Act*, *National Parks and Wildlife (NP&W) Act* and the *Environment Protection and Biodiversity Conservation (EPBC) Act* which have the potential to occur in the study area are listed in **Table 4-1**. The likelihood of the project impacting on these species is indicated in column 5.



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Table 4-1 threatened/protected species & populations potentially occurring in the study area.

Scheduled Species	Common Name	Status under TSC / FM / NP&W Acts	Status under EPBC Act	Relevance to proposal
Marine Reptiles				
<i>Caretta caretta</i>	Loggerhead turtle	E	E, M, L	Mod
<i>Chelonia mydas</i>	Green turtle	V	V, M, L	Mod
<i>Dermochelys coriacea</i>	Leathery turtle	V	V, M, L	Mod
<i>Eretmochelys imbricata</i>	Hawksbill turtle *	V	V, M, L	Mod
<i>Pelamis platurus</i>	Yellow-bellied sea snake		L	Low
Marine Mammals				
<i>Eubalaena australis</i>	Southern right whale	V	E, M	Low
<i>Megaptera novaeangliae</i>	Humpback whale	V	V, M	Low
<i>Arctocephalus pusillus doriferus</i>	Australian fur-seal	V	L	Low
<i>Arctocephalus forsteri</i>	New Zealand fur-seal	V	L	Low
<i>Hydrurga leptonyz</i>	Leopard seal	P	L	Low
<i>Balaenoptera acutorostrata</i>	Dwarf minke whale	P	M	Low
<i>Dugong dugon</i>	Dugong	E	M	Neg
<i>Balaenoptera edeni</i>	Bryde's whale	P	M	Low
<i>Caperea marginata</i>	Pygmy right whale	P	M	Low
<i>Orcinus orca</i>	Killer whale	P	M	Low
<i>Lagenarhynchus obscurus</i>	Dusky dolphin	P	M	Low
<i>Delphinus delphis</i>	Common dolphin	P	Cet	Low
<i>Grampus griseus</i>	Risso's dolphin, Grampus	P	Cet	Low
<i>Stenella attenuata</i>	Spotted dolphin, Pantropical spotted	P	Cet	Low



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<i>Tursiops aduncus</i>	Indian Ocean Bottlenose dolphin	P	Cet	Low
<i>Tursiops truncatus s. str.</i>	Bottlenose dolphin	P	Cet	Low

Fish

East coast population of <i>Carcharias Taurus</i>	Grey nurse Shark	E	CE	Mod
<i>Carcaradon carcharias</i>	Great white shark	V	V, M	Low
<i>Pristis zijsron</i>	Green sawfish	E	V	Neg
<i>Rhincodon typus</i>	Whale shark		V, M	Neg
<i>Epinephelus daemeli</i>	Black cod	V		Mod
<i>Epinephelus coioides</i>	Estuary cod	P		Mod
<i>Epinephelus lanceolatus</i>	Queensland groper	P		Mod
<i>Anampses elegans</i>	Elegant wrasse	P		Mod
<i>Paraplesiops bleekeri</i>	Eastern blue devil	P		Mod
<i>Chaetodontoplus ballinae</i>	Ballina angelfish	P		Mod
<i>Epinephelus lanceolatus</i>	Seadragons and pipefish	P (21 spp.)	L (21 spp.)	Mod

Birds

	Marine Birds	V (10 spp.), P (31 spp.), E (2 spp.)	V (9), E (1), M (19), L (27)	Neg
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* CE = critically endangered, E = endangered, V = vulnerable. M = migratory, L = listed, Cet = cetacean and P = protected. Relevance to the scuttling of the Ex-HMAS ADELAIDE is indicated by High, Mod (Moderate), Low or Neg (negligible). (*) Species observed during the site inspection (5th April 08).

The potential impact of the scuttling of the Ex-HMAS ADELAIDE on each of the threatened species or populations, with the exception of species with a negligible relevance to the proposal was assessed using the "Assessment of Significance", under Part 5A of the EP&A Act.



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Specific Assessments of Significance for the following threatened species listed under the *FM* Act and *TSC* Act (see Appendix 2 of Cardno Ecology Lab, Flora and Fauna Studies 2009) were undertaken:

- East Coast population of Grey Nurse Sharks
- Black Cod
- Southern Right Whale
- Humpback Whale
- Australian Fur Seal
- New Zealand Fur Seal
- Great White Shark

Generic “Assessments of Significance” were undertaken for the following threatened species listed under the *FM* Act and *TSC* Act (see Appendix 2 of Cardno Ecology Lab, Flora and Fauna Studies 2009):

- Listed Marine Turtles

Assessments under *EPBC* Act “Significant Impact Guidelines” were undertaken for the following (see Appendix 2 of Cardno Ecology Lab, Flora and Fauna Studies 2009):

- Loggerhead Turtle
- Green, Leathery and Hawksbill Turtles
- East Coast population of Grey Nurse Shark
- Humpback Whale
- Southern Right Whale
- Great White Shark
- Dusky Dolphin
- Dwarf Minke Whale
- Brydes Whale
- Pygmy Right Whale
- Killer Whale

Assessments of individual and generic (group) concluded that the proposal is unlikely to affect the listed threatened species of fish, marine mammals or marine reptiles that potentially occur in, or



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around, the study area. Hence, there is no need to prepare a Species Impact Statement (SIS) under state legislation or refer the proposal to the Federal Minister for the Environment for further consideration and approval. In addition, the proposal would provide new foraging and sheltering habitat for threatened species of fish, marine reptiles and seals.

However, threatened species encroaching upon the area when the Vessel is scuttled have the potential to be injured when cutting charges are used to blow additional holes in the hull. Pre-scuttling aerial surveillance of local waters for cetaceans and large marine animals would assist in reducing the potential for impacts, significant or otherwise, to any locally occurring threatened and protected species during the scuttling process.

4.2 Physical and Chemical Characteristics

The surface sediments at the sites adjacent to the proposed scuttling site consisted almost entirely of fine sands.

4.2.1 Sediment Contaminants

The concentrations of all metals/metalloids indicate that the sediments at the proposed scuttling location are “uncontaminated”. Where they have been established, they were lower at each site than their respective ANZECC/ARMCANZ ISQG-low values,

Although sacrificial anodes would be employed, over time it is expected that the scuttled vessel’s surfaces will start to degrade. Corrosion will occur and, in concert with development and senescence of epibenthic communities, will result in the deposition of organic material and corroded metal fragments around the margins of the wreck. Deposition of organic material around the vessel’s margins is expected to cause a slight increase in the diversity and abundance of the local sedimentary infauna, whilst the expected slow rate of vessel degradation is unlikely to cause appreciable changes to sediment chemistry, particularly with respect to metal contaminants.

4.2.2 Physical Characteristics

Physical characterisation of the proposed scuttling site and surrounding areas determined they were largely consistent with those of previous investigations reported by Douglas Partners (2008) and TEL (2008). On the basis of towed-video results, sediment characterisations and previous side-scan sonar and seismic reflection surveys, the proposed scuttling site is comprised exclusively of fine sands overlying deeper bedrock. There are no readily discernible reef outcrops or other structures that might affect the seating and settlement of the vessel. Seismic reflection study results were confirmed by depth readings during the towed-video survey, and those recorded during the sediment grab sampling from sites V1, V2 and V3, confirming limited bathymetric variability across the area of seabed on which it is proposed the vessel will rest.



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Based on the Douglas Partners (2008) seismic reflection results, the closest point where 3 m sediment depth over bedrock occurs (minimum desirable is 2 – 3 m for settling) is at least 160 m from the proposed scuttling location. This provides a substantial margin for error during positioning of the vessel for scuttling (e.g. more than the length of the vessel which is 138.1 m). It is noted that the ex-*HMAS Brisbane* was at the most 30 m out from its proposed scuttling position. It is understood that the ex-*HMAS Canberra* was in the correct position when detonated, however, surveys have not yet been undertaken to determine the final resting place of the vessel in relation to the proposed scuttling position (Brett Davis, Birdon Group, personal communication, 13th October 2009).

4.2.3 Water Quality

Water quality in the Bulbararing Bay study area, offshore from Avoca Beach, on the day of sampling was characteristic of good quality coastal waters. The water temperature of almost 17°C varied little with depth indicating well-mixed conditions. Additionally, there was limited thermal variation between sites. Measured water quality values and the limited intra- and inter-site variation in pH and, to a lesser extent, conductivity and turbidity, in concert provide evidence of good quality and well-mixed coastal waters at the proposed scuttling site.

While dissolved oxygen could not be measured due to probe malfunction, it is anticipated to also reflect good quality, well mixed oceanic/coastal water.



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5. CONCLUSIONS

The proposed location for scuttling of the Ex-HMAS ADELAIDE is in Bulbararing Bay, about 1.87 km offshore from Avoca Beach, on the Central Coast of New South Wales. It is intended that the vessel be scuttled with the bow pointing to the south-east, centred on the longitude 151°27.382'E (356,554.8 m MGA 94) and latitude 33°27.910'S (6,296,077.0 m MGA 94). Water depths at the proposed scuttling site, from the seabed to water surface at the lowest astronomical tide, are conservatively 32 m.

The seabed at the proposed scuttling site is reasonably flat and consists of slightly rippled, fine sand overlying bedrock. The sediments are uncontaminated with respect to metal toxicants. When compared to the metal/metalloid concentrations in sediments from a site in waters of 80 m off nearby MacMasters Beach (Matthai *et al.* 2002), concentrations were generally of the same order of magnitude to those at the scuttling site, indicating that the site is representative of natural background conditions.

Available evidence indicates a depauperate epibenthic community typical of an open coastal marine environment. Good quality and well-mixed oceanic/coastal waters are evident.

Vessel preparation prior to scuttling includes removal of all hazardous materials, potentially dangerous structures and debris and the creation of easy diver access. The process associated with scuttling should minimise potential impacts on threatened or migratory marine mammals previously recorded in the broader area. The area of soft sediment seabed that would be covered by the scuttled vessel is small. It is expected that the loss of existing limited benthic productivity over the area on which the vessel will rest will be more than compensated by the development, over time, of diverse epibenthic communities over the vessel structure. It is also expected that the vessel and attached epibenthos will serve to attract fish and other pelagic organisms to the area and will also contribute to the development of nearby reef communities.

Over time it is expected that there will be some deterioration of the vessel's surfaces, but this process will be gradual and is expected to result in no measurable alteration to water quality in the vicinity of the vessel. Tidal and other hydrodynamic processes will act to maintain ambient water quality characteristics within, adjacent to and in local waters more remote from the vessel structure. The expected slow rate of vessel degradation is also unlikely to cause appreciable changes to sediment chemistry, particularly with respect to metal contaminants.

This document provides a baseline assessment of the ecological, sediment and water quality conditions in the vicinity of the proposed scuttling site. Future studies associated with the Long Term Management Plan will be used to examine changes in marine communities over time, as well as any changes in water and sediment quality.



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EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT
MARINE SURVEY REPORT**

6. REFERENCES

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**LAND AND PROPERTY MANAGEMENT AUTHORITY
EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT
MARINE SURVEY REPORT**

TEL (The Ecology Lab), (2008). *Sinking of the of Ex-HMAS Adelaide off the Central Coast, NSW: Review of Constraints and Site Selection*. Report No. 58/0708 A prepared for NSW Department of Lands.



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LAND AND PROPERTY MANAGEMENT AUTHORITY
EX-HMAS ADELAIDE ARTIFICIAL REEF PROJECT
MARINE SURVEY REPORT

Appendix 1 – Laboratory Sediment Analysis Results



Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: ES0910698	Page	: 1 of 7
Client	: WORLEY PARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Sydney
Contact	: MR HARRY HOURIDIS	Contact	: Charlie Pierce
Address	: LEVEL 12, 333 COLLINS STREET MELBOURNE VIC, AUSTRALIA 3000	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: harry.houridis@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: +61 03 0412 969 630	Telephone	: +61-2-8784 8555
Facsimile	: +61 03 86763770	Facsimile	: +61-2-8784 8500
Project	: 301017-00077	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 22-JUL-2009
C-O-C number	: ----	Issue Date	: 30-JUL-2009
Sampler	: K NEWTON	No. of samples received	: 11
Site	: ----	No. of samples analysed	: 11
Quote number	: EN/034/09		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Celine Conceicao	Spectroscopist	Inorganics
Dianne Blane		Newcastle
Hoa Nguyen	Inorganic Chemist	Inorganics



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

Compound	CAS Number	LOR	Unit	V1	V2	V3	S1	S2
				21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00
				ES0910698-001	ES0910698-002	ES0910698-003	ES0910698-004	ES0910698-005
EA150: Particle Sizing								
+75µm	----	1	%	100	99	99	98	97
+150µm	----	1	%	86	88	90	89	81
+300µm	----	1	%	10	12	13	12	9
+425µm	----	1	%	3	4	5	5	3
+600µm	----	1	%	1	1	1	2	1
+1180µm	----	1	%	<1	1	<1	1	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	20.7	23.0	22.9	----	----
EA150: Soil Classification based on Particle Size								
Fines (<75 µm)	----	1	%	<1	1	1	2	3
Sand (>75 µm)	----	1	%	100	99	99	98	97
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1180	1170	1200	----	----
Iron	7439-89-6	50	mg/kg	10300	8510	10000	----	----
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	----	----
Arsenic	7440-38-2	1.00	mg/kg	11.8	10.1	11.5	----	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	----	----
Chromium	7440-47-3	1.0	mg/kg	8.0	6.8	7.9	----	----
Copper	7440-50-8	1.0	mg/kg	1.6	1.2	1.4	----	----
Cobalt	7440-48-4	0.5	mg/kg	2.0	1.6	1.8	----	----
Lead	7439-92-1	1.0	mg/kg	3.7	3.1	3.6	----	----
Manganese	7439-96-5	10	mg/kg	86	74	78	----	----
Nickel	7440-02-0	1.0	mg/kg	2.8	2.2	2.6	----	----
Selenium	7782-49-2	0.1	mg/kg	0.2	0.3	0.2	----	----
Silver	7440-22-4	0.1	mg/kg	<0.1	0.2	<0.1	----	----
Vanadium	7440-62-2	2.0	mg/kg	17.1	14.5	16.8	----	----
Zinc	7440-66-6	1.0	mg/kg	12.2	8.0	10.4	----	----
EG035T: Total Recoverable Mercury by FIMS								



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

				V1	V2	V3	S1	S2
				21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00
Compound	CAS Number	LOR	Unit	ES0910698-001	ES0910698-002	ES0910698-003	ES0910698-004	ES0910698-005
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	----	----



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

Compound	CAS Number	LOR	Unit	S3	S4	S5	S6	S7
				21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00	21-JUL-2009 15:00
				ES0910698-006	ES0910698-007	ES0910698-008	ES0910698-009	ES0910698-010
EA150: Particle Sizing								
+75µm	----	1	%	98	99	98	98	96
+150µm	----	1	%	81	96	89	95	95
+300µm	----	1	%	10	20	8	28	84
+425µm	----	1	%	4	5	2	4	58
+600µm	----	1	%	2	2	1	2	48
+1180µm	----	1	%	1	1	<1	<1	30
+2.36mm	----	1	%	<1	<1	<1	<1	16
+4.75mm	----	1	%	<1	<1	<1	<1	11
+9.5mm	----	1	%	<1	<1	<1	<1	6
+19.0mm	----	1	%	<1	<1	<1	<1	2
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Fines (<75 µm)	----	1	%	2	1	2	2	4
Sand (>75 µm)	----	1	%	98	99	98	98	80
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	16
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

				QA				
				21-JUL-2009 15:00				
Compound	CAS Number	LOR	Unit	ES0910698-011				
EA150: Particle Sizing								
+75µm		1	%	98				
+150µm		1	%	89				
+300µm		1	%	13				
+425µm		1	%	5				
+600µm		1	%	2				
+1180µm		1	%	<1				
+2.36mm		1	%	<1				
+4.75mm		1	%	<1				
+9.5mm		1	%	<1				
+19.0mm		1	%	<1				
+37.5mm		1	%	<1				
+75.0mm		1	%	<1				
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)		1.0	%	21.9				
EA150: Soil Classification based on Particle Size								
Fines (<75 µm)		1	%	2				
Sand (>75 µm)		1	%	98				
Gravel (>2mm)		1	%	<1				
Cobbles (>6cm)		1	%	<1				
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1200				
Iron	7439-89-6	50	mg/kg	10000				
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50				
Arsenic	7440-38-2	1.00	mg/kg	11.4				
Cadmium	7440-43-9	0.1	mg/kg	<0.1				
Chromium	7440-47-3	1.0	mg/kg	8.0				
Copper	7440-50-8	1.0	mg/kg	1.5				
Cobalt	7440-48-4	0.5	mg/kg	1.8				
Lead	7439-92-1	1.0	mg/kg	3.6				
Manganese	7439-96-5	10	mg/kg	83				
Nickel	7440-02-0	1.0	mg/kg	2.6				
Selenium	7782-49-2	0.1	mg/kg	0.1				
Silver	7440-22-4	0.1	mg/kg	<0.1				
Vanadium	7440-62-2	2.0	mg/kg	16.7				
Zinc	7440-66-6	1.0	mg/kg	10.5				
EG035T: Total Recoverable Mercury by FIMS								



Analytical Results

Sub-Matrix: **SOIL**

Client sample ID

Client sampling date / time

				QA	----	----	----	----
				21-JUL-2009 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	ES0910698-011	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.01	mg/kg	<0.01	----	----	----	----



Environmental Division

QUALITY CONTROL REPORT

Work Order	: ES0910698	Page	: 1 of 5
Client	: WORLEY PARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Sydney
Contact	: MR HARRY HOURIDIS	Contact	: Charlie Pierce
Address	: LEVEL 12, 333 COLLINS STREET MELBOURNE VIC, AUSTRALIA 3000	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: harry.houridis@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: +61 03 0412 969 630	Telephone	: +61-2-8784 8555
Facsimile	: +61 03 86763770	Facsimile	: +61-2-8784 8500
Project	: 301017-00077	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----	Date Samples Received	: 22-JUL-2009
C-O-C number	: ----	Issue Date	: 30-JUL-2009
Sampler	: K NEWTON	No. of samples received	: 11
Order number	: ----	No. of samples analysed	: 11
Quote number	: EN/034/09		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits



NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Celine Conceicao	Spectroscopist	Inorganics
Dianne Blane		Newcastle
Hoa Nguyen	Inorganic Chemist	Inorganics

Environmental Division Sydney

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General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key :

- Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
- CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
- LOR = Limit of reporting
- RPD = Relative Percentage Difference
- # = Indicates failed QC



Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA055: Moisture Content (QC Lot: 1053696)									
ES0910698-001	V1	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	20.7	19.2	7.3	0% - 50%
ES0911043-006	Anonymous	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	41.6	43.8	5.1	0% - 20%
EG005-SD: Total Metals in Sediments by ICP-AES (QC Lot: 1050508)									
ES0910698-001	V1	EG005-SD: Aluminium	7429-90-5	50	mg/kg	1180	1180	0.0	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	10300	9820	4.7	0% - 20%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 1050507)									
ES0910698-001	V1	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Selenium	7782-49-2	0.1	mg/kg	0.2	0.2	0.0	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Cobalt	7440-48-4	0.5	mg/kg	2.0	1.8	10.5	No Limit
		EG020-SD: Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	0.0	No Limit
		EG020-SD: Chromium	7440-47-3	1.0	mg/kg	8.0	7.2	10.4	No Limit
		EG020-SD: Copper	7440-50-8	1.0	mg/kg	1.6	1.3	20.9	No Limit
		EG020-SD: Lead	7439-92-1	1.0	mg/kg	3.7	3.1	15.8	No Limit
		EG020-SD: Nickel	7440-02-0	1.0	mg/kg	2.8	2.3	17.1	No Limit
		EG020-SD: Zinc	7440-66-6	1.0	mg/kg	12.2	9.7	22.9	No Limit
		EG020-SD: Arsenic	7440-38-2	1.00	mg/kg	11.8	11.1	6.0	0% - 50%
		EG020-SD: Manganese	7439-96-5	10	mg/kg	86	74	15.9	No Limit
		EG020-SD: Vanadium	7440-62-2	2.0	mg/kg	17.1	15.4	10.5	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 1050506)									
ES0910698-001	V1	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.0	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
EG005-SD: Total Metals in Sediments by ICP-AES (QCLot: 1050508)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 1050507)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1.0	mg/kg	<1.00	13.1 mg/kg	119	70	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	2.76 mg/kg	106	70	130
EG020-SD: Chromium	7440-47-3	1.0	mg/kg	<1.0	60.9 mg/kg	124	70	130
EG020-SD: Copper	7440-50-8	1.0	mg/kg	<1.0	54.7 mg/kg	114	70	130
EG020-SD: Cobalt	7440-48-4	10	mg/kg	<10.0	24.5 mg/kg	121	70	130
EG020-SD: Lead	7439-92-1	1.0	mg/kg	<1.0	54.8 mg/kg	110	70	130
EG020-SD: Manganese	7439-96-5	10	mg/kg	<10	136 mg/kg	123	70	130
EG020-SD: Nickel	7440-02-0	1.0	mg/kg	<1.0	55.2 mg/kg	120	70	130
EG020-SD: Selenium	7782-49-2	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	5.6 mg/kg	130	70	130
EG020-SD: Vanadium	7440-62-2	2	mg/kg	<2.0	34 mg/kg	121	70	130
EG020-SD: Zinc	7440-66-6	1.0	mg/kg	<1.0	104 mg/kg	108	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1050506)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	0.090 mg/kg	79.8	74.2	126



Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				<i>Matrix Spike (MS) Report</i>				
<i>Laboratory sample ID</i>	<i>Client sample ID</i>	<i>Method: Compound</i>	<i>CAS Number</i>	<i>Spike</i>	<i>Spike Recovery (%)</i>		<i>Recovery Limits (%)</i>	
				<i>Concentration</i>	<i>MS</i>	<i>Low</i>	<i>High</i>	
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 1050507)								
ES0910698-002	V2	EG020-SD: Arsenic	7440-38-2	50 mg/kg	98.3	70	130	
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	92.9	70	130	
		EG020-SD: Chromium	7440-47-3	50 mg/kg	116	70	130	
		EG020-SD: Copper	7440-50-8	250 mg/kg	98.1	70	130	
		EG020-SD: Lead	7439-92-1	250 mg/kg	95.3	70	130	
		EG020-SD: Nickel	7440-02-0	50 mg/kg	105	70	130	
		EG020-SD: Zinc	7440-66-6	250 mg/kg	89.8	70	130	
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1050506)								
ES0910698-001	V1	EG035T-LL: Mercury	7439-97-6	0.50 mg/kg	79.9	70	130	



Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: ES0910698	Page	: 1 of 6
Client	: WORLEY PARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Sydney
Contact	: MR HARRY HOURIDIS	Contact	: Charlie Pierce
Address	: LEVEL 12, 333 COLLINS STREET MELBOURNE VIC, AUSTRALIA 3000	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: harry.houridis@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: +61 03 0412 969 630	Telephone	: +61-2-8784 8555
Facsimile	: +61 03 86763770	Facsimile	: +61-2-8784 8500
Project	: 301017-00077	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----	Date Samples Received	: 22-JUL-2009
C-O-C number	: ----	Issue Date	: 30-JUL-2009
Sampler	: K NEWTON	No. of samples received	: 11
Order number	: ----	No. of samples analysed	: 11
Quote number	: EN/034/09		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers



Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: SOIL

Evaluation: * = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EA055: Moisture Content								
Soil Glass Jar - Unpreserved V1, V3,	V2, QA	21-JUL-2009	----	----	----	29-JUL-2009	28-JUL-2009	*
EA150: Particle Sizing								
Snap Lock Bag V1, V3, S2, S4, S6, QA	V2, S1, S3, S5, S7,	21-JUL-2009	---	---	----	22-JUL-2009	17-JAN-2010	✓
EA150: Soil Classification based on Particle Size								
Snap Lock Bag V1, V3, S2, S4, S6, QA	V2, S1, S3, S5, S7,	21-JUL-2009	---	---	----	22-JUL-2009	17-JAN-2010	✓
EG005-SD: Total Metals in Sediments by ICP-AES								
Soil Glass Jar - Unpreserved V1, V3,	V2, QA	21-JUL-2009	27-JUL-2009	18-AUG-2009	✓	27-JUL-2009	17-JAN-2010	✓
EG020-SD: Total Metals in Sediments by ICPMS								
Soil Glass Jar - Unpreserved V1, V3,	V2, QA	21-JUL-2009	27-JUL-2009	18-AUG-2009	✓	27-JUL-2009	17-JAN-2010	✓

Page : 3 of 6
 Work Order : ES0910698
 Client : WORLEY PARSONS - INFRASTRUCTURE MWE
 Project : 301017-00077



Matrix: **SOIL**

Evaluation: * = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EG035T: Total Recoverable Mercury by FIMS								
Soil Glass Jar - Unpreserved								
V1, V3,	V2, QA	21-JUL-2009	27-JUL-2009	18-AUG-2009	✓	28-JUL-2009	18-AUG-2009	✓



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: * = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Reaular	Actual	Expected	Evaluation	
Analytical Methods							
Laboratory Duplicates (DUP)							
Moisture Content	EA055-103	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Fe and Al in Sediments by ICPAES	EG005-SD	1	5	20.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS (Low Level)	EG035T-LL	1	7	14.3	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	1	7	14.3	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Total Mercury by FIMS (Low Level)	EG035T-LL	1	7	14.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	1	7	14.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Total Fe and Al in Sediments by ICPAES	EG005-SD	1	5	20.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS (Low Level)	EG035T-LL	1	7	14.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	1	7	14.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Total Mercury by FIMS (Low Level)	EG035T-LL	1	7	14.3	5.0	✓	ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	1	7	14.3	5.0	✓	ALS QCS3 requirement



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Moisture Content	EA055-103	SOIL	A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (1999) Schedule B(3) (Method 102)
Particle Size Analysis (Sieving)	EA150	SOIL	Particle Size Analysis by Sieving according to AS1289.3.6.1 - 1995
Total Fe and Al in Sediments by ICPAES	EG005-SD	SOIL	(APHA 21st ed., 3120; USEPA SW 846 - 6010) (ICPAES) Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (1999) Schedule B(3). LORs per NODG
Total Metals in Sediments by ICPMS	EG020-SD	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector. Analyte list and LORs per NODG.
Total Mercury by FIMS (Low Level)	EG035T-LL	SOIL	AS 3550, APHA 21st ed., 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	USEPA 200.2 Mod. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (1999) Schedule B(3) (Method 202)



Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- For all matrices, no Method Blank value outliers occur.
- For all matrices, no Duplicate outliers occur.
- For all matrices, no Laboratory Control outliers occur.
- For all matrices, no Matrix Spike outliers occur.

Regular Sample Surrogates

- For all regular sample matrices, no surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: SOIL

Method	Extraction / Preparation			Analysis			
	Container / Client Sample ID(s)	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA055: Moisture Content							
Soil Glass Jar - Unpreserved							
V1, V2, V3, QA					29-JUL-2009	28-JUL-2009	1

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- No Quality Control Sample Frequency Outliers exist.



SCUTTLING OF EX-HMAS ADELAIDE FLORA AND FAUNA STUDIES

FINAL

December 2009

Prepared for
WorleyParsons



SCUTTLING OF EX HMAS ADELAIDE FLORA AND FAUNA STUDIES

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Document Control						
Job Number/Seq	Status	Date	Author		Reviewer	
			Name	Initials	Name	Initials
EL0809007 A	Final	3 December 2009	Craig Blount	CB	Marcus Lincoln Smith	MLS

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SUMMARY

HMAS ADELAIDE ('the Vessel') was decommissioned by the Australian Navy in January 2008 and has been handed over to the NSW Government for the purpose of creating a recreational dive site and artificial reef in a water depth of 33 – 34 m off the Central Coast. The expectation is that the Vessel would boost the local economy (particularly from increased dive tourism and hospitality) and enhance marine biodiversity in the vicinity of the scuttled ship.

The Vessel was a long-range escort frigate (Frigate Fast Guided Missile 7 Class), 138.1 m in length, with a beam of approximately 14 m, a displacement of 4100 tonnes and draft of approximately 5 m. Not considering any burial into the seabed, the sunken Vessel's deck, superstructure, foremast and mainmast would extend approximately 12 m, 18 m, 24 m and 39 m respectively above the seabed. However, part of the main mast was removed to provide a minimum of 6 m navigation clearance.

Cardno Ecology Lab Pty Ltd has been commissioned by WorleyParsons to provide specialist advice into flora and fauna issues associated with scuttling of the Vessel. Potential effects on benthic infauna are being assessed by other specialists. The information in this report will contribute to a Review of Environmental Factors (REF) in order for the activity to be approved under the *Environmental Planning and Assessment Act 1979*.

Probable impacts to aquatic habitats, biota and fishing were identified and assessed as follow:

1. The sunken Vessel would provide habitat and substratum for many local invertebrates and fish, therefore increasing the diversity and biomass of biota in the placement location and creating an attractive dive site.
2. Fish and mobile invertebrates would, to some extent, be attracted to the Vessel from nearby natural reefs. Importantly, commercial and recreational fishing at the Vessel would not occur. It is predicted that potential attraction of fish from other areas would be compensated for by processes of recruitment.
3. Benthic infauna and some demersal fishes inhabiting sediments within the 'footprint' of the Vessel would be lost by smothering. Changes in localised hydrodynamic processes and predation by fishes venturing out from the Vessel could result in changes to assemblages of demersal fishes and infauna in surrounding sedimentary habitats. These effects could occur over spatial scales of 10s of metres and the impact will depend on the species colonising the Vessel. However, given that any such effects would be localised and that sedimentary habitats are very common in the area, this is not considered an issue.
4. There is potential for heavy metal contamination of sediments surrounding the Vessel due to corrosion of the hull and superstructure. Accordingly, monitoring of appropriate metals and metalloids should be done as part of the Long-Term Management Plan.
5. The Vessel would have no adverse impact on threatened species and it may indeed be beneficial to some species by providing new foraging and sheltering habitat.
6. The scuttling of the Vessel would require setting some cutting charges which, if not managed properly, could potentially harm or kill marine mammals or fish. The management plan developed for scuttling should include measures to minimise the risk of damage to biota.
7. As the Vessel would not contain ballast water from other regions and colonisation by introduced marine pest species from Sydney Harbour during preparation would be unlikely there would be little potential for it to act as a vector for introduced species. Notwithstanding this, the superstructure would be a potential area for colonisation of introduced species. The risk of colonisation, however, would be no more than for any natural rocky reef that had been scoured of old growth by a storm or from sand.
8. The project would have little effect, if any, on commercial and recreational fishermen in the local area as very few of these activities occur in the area and those that do occur there, are done rarely, and can be done elsewhere. Notwithstanding this, as trawlers occasionally

operate in Bulbararing Bay, their needs should be considered when planning the size and allowable activities in the Ex-HMAS ADELAIDE Reserve. Care should be taken during the scuttling process to contact local commercial fishers to advise of activities and timing of scuttling so that damage to nearby fishing gear is avoided.

Environmental management of potential marine ecological impacts of the project during scuttling and in the longer-term, that include appropriate responses to problematic situations if they arise would be addressed in 'the Scuttling Plan' and 'Long-Term Management Plan'.

1 INTRODUCTION

1.1 Background

HMAS ADELAIDE ('the Vessel') was decommissioned by the Australian Navy in January 2008 and has been handed over to the NSW Government to create a recreational dive site and artificial reef in waters off the Central Coast. In choosing the precise placement location, depth and proximity to onshore infrastructure for divers along with geotechnical, oceanographic and ecological aspects of the area were considered in a 'Review of Constraints and Site Selection Report' (The Ecology Lab 2008). A placement location was selected approximately 1.87 km offshore of north Avoca Beach (1.51 km south-west of the Skillion) in a water depth of 33 – 34 m (Figure 1).

The placement site within this location would include a zone of exclusion to fishing (size yet to be determined) within the existing 'Ex-HMAS ADELAIDE Reserve'.

The artificial reef is expected to boost the local economy (particularly from increased dive tourism and hospitality), enhance marine biodiversity in the vicinity of the scuttled ship and could provide ongoing research opportunities.

The Vessel is 138.1 m in length, with a beam of approximately 14 m, a displacement of 4100 tonnes and draft of approximately 5 m. Not considering any burial into the seabed and assuming no removal of masts or superstructure, the sunken Vessel's deck, superstructure, foremast and mainmast would extend approximately 12 m, 18 m, 24 m and 39 m respectively above the seabed. Preliminary advice from NSW Maritime recommends a depth clearance of 6 m at lowest astronomical tide to allow for the navigational safety of vessels operating in the area. To achieve this clearance, part of the main mast has been removed. It is noted that the Ex-HMAS BRISBANE has settled approximately 2 m into the seabed since it was sunk in 2005. It is understood that setting charges to blow additional holes in the hull would occur to assist with sinking the Vessel.

Cardno Ecology Lab Pty Ltd has been commissioned by WorleyParsons to provide specialist advice on flora and fauna issues associated with the scuttling of the Vessel. The information will contribute to a Review of Environmental Factors (REF) in order for the activity to be approved under the *Environmental Planning and Assessment Act 1979*.

This report contains the environmental impact assessment of the proposal in relation to flora and fauna, and includes the results of a survey of fish at the placement location and surrounding habitats. It is understood that WorleyParsons is undertaking a survey of benthic habitats. Long-term management of the dive site with respect to the flora and fauna components will be addressed in a Long-Term Management Plan.

1.2 Report Deliverables

The deliverables included in this report are:

- Background information and review of relevant literature, including information on threatened aquatic species;
- Methodology used, including field and statistical procedures;
- Descriptions of sites sampled;
- Report of any condition or occurrence that may have influenced results of the study;
- Results of review of existing information and field studies, presented in tables and figures;
- Identification of predicted types of impacts on habitats / biota;
- Recommendations for mitigation of impacts during scuttling and operational phases of the artificial reef; and

- Advice on the expected colonisation of the artificial reef over time, in particular by threatened or pest species.

A preliminary assessment of flora and fauna issues associated with the proposal was undertaken as part of the 'Review of Constraints and Site Selection' Report (The Ecology Lab 2008). Relevant information from that preliminary assessment has been used to complete this assessment.

1.3 Study Area

The study area for this assessment is Bulbararing Bay (the Avoca Beach embayment) and subtidal and sandy areas to the north and south between Wamberal and McMasters Beaches (Figure 1).

1.4 Statutory Requirements

The following statutory requirements are relevant to the proposal.

1.4.1 NSW State Legislation

Fisheries Management Act 1994

The *FM Act*, and its Regulations, is administered by the NSW Department of Industry and Investment (DII) and applies to habitat and aquatic flora and fauna in State waters that have the potential to be affected by a proposal. The Act has been amended by the inclusion of provisions (listed in the *Fisheries Management Amendment Act 1997*) to declare and list threatened species of fish and marine vegetation, endangered populations and ecological communities and key threatening processes.

Threatened Species Conservation Act 1995

The *TSC Act* applies to terrestrial and aquatic flora and fauna and is administered by the NSW Department of Environment and Climate Change (DECC) Parks Services Division. In the aquatic environment, the *TSC Act* includes seabirds, wader birds, aquatic reptiles, aquatic mammals and some insects, as well as endangered aquatic ecological communities and key threatening processes. The Act is relevant to this proposal as there is potential for marine vertebrate and non-vertebrate species and vegetation to be affected.

Coastal Protection Act 1979

The *CP Act* applies to the coastal region of NSW and is administered by the NSW Department of Planning. The objects of this Act are to provide for protection of the coastal environment of the State and to generally supervise activities affecting the coastal zone (i.e. the area between the western boundary of the land in the coastal zone, as defined under the Act, and the outward limit of the coastal waters of NSW (i.e. 3 nm). The placement location occurs in the coastal zone. Developments and activities occurring in the coastal zone that may adversely affect the sea, beach and other habitats in the coastal zone, or that are potentially inconsistent with the principles of ecologically sustainable development, require concurrence from the Minister for Planning.

Environmental Planning and Assessment Act 1979

The *EP&A Act*, also administered by the Department of Planning, requires the proper management, development and conservation of natural and artificial resources for the purpose of promoting the social and economic welfare of the community and a better environment. The Act lists a number of development control processes that relate to different types of activities and in considering an activity states that a determining authority must examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity. The proposal would be assessed under Part 5 of the Act.

Part 5 of the Act also integrates other environmental legislation into the approval process. Threatened Species legislation administered by DECC under the *TSC Act* and by DPI under amendments of the *FM Act*, are essentially identical in application. DPI deals with 'fish' and 'marine vegetation' and the DECC deals with all other flora and fauna. One of the major features of the

legislation is the integration of threatened aquatic species into the development control processes under the *EP&A Act*. The *EP&A Act* sets out the factors to be considered in preliminary assessments of whether there is likely to be a significant effect on threatened species arising from a development. Seven factors are considered and the assessment process is referred to as the 'Assessment of Significance'. The test is a series of questions, the answers to which assist in determining whether a planned action would significantly affect threatened species, populations, ecological communities or their habitats. If the test indicates that the activity is likely to significantly affect threatened species, then the Determining Authority for the project must seek the concurrence of the Director of DII or DECC where appropriate. In essence, the primary role of the DPI and the DECC in such a situation is to provide the Director's Requirements for a detailed assessment of impacts on the threatened species. The assessment is referred to as a Species Impact Statement (SIS).

National Parks and Wildlife Act 1974

Under the *National Parks and Wildlife Act*, the Director-General of the National Parks and Wildlife Service (NPWS) is responsible for the care, control and management of all national parks, historic sites, nature reserves, reserves, Aboriginal areas and State game reserves. State conservation areas, karst conservation reserves and regional parks are also administered under the Act. The Director-General is also responsible under this legislation for the protection and care of native fauna and flora and Aboriginal places and objects throughout NSW. On 1 September 2002 the *National Parks and Wildlife Regulation* came into effect. The regulation governs various activities under the *National Parks and Wildlife Act 1974*, including protection of fauna.

1.4.2 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*, which is administered by the Department of Water, Environment, Heritage and the Arts (DEWHA), actions that are likely to have a significant impact on a matter of national environmental significance (NES) are subject to a rigorous referral, assessment, and approval process. In the aquatic environment the Act lists threatened species, ecological communities and key threatening processes; migratory species; cetaceans; marine species and Ramsar areas of national significance.

For the purposes of this report, species listed under the *EPBC Act* that would potentially be affected by the proposal are assessed according to the *EPBC Act* 'Administrative Guidelines on Significance'. The assessments are used to assist in determining whether the proposal should be referred to the Federal Minister of the Environment for a decision on whether approval would be required. The scope-of-works for Cardno Ecology Lab in this project includes marine vertebrate and non-vertebrate species and vegetation.

Sea Dumping Act 1981

The placement and construction of artificial reefs are regulated under the Commonwealth *Environment Protection (Sea Dumping) Act 1981 (the Sea Dumping Act)* which is administered by the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA). The *Sea Dumping Act* applies to Australian waters, from the low water mark to the limits of the Exclusive Economic Zone (EEZ), other than internal waters within the limits of a State or Territory (such as Sydney Harbour or Port Phillip Bay). A permit is required to place materials for the creation of an artificial reef in order to ensure that a suitable site is selected, that the materials are suitable and properly prepared, that no significant adverse impacts occur on the marine environment and that the reef does not pose a danger to navigation, fishermen or divers. Once a permit is issued then it becomes charted on maritime maps.

2 REVIEW OF EXISTING INFORMATION

The study involved a review of existing information of biological and ecological characteristics of the study area, fishing activities and the impacts of artificial reefs. Some of the information presented in this report was taken from the 'Review of Constraints and Site Selection' Report (The Ecology Lab 2008). Additional information was obtained from the library database of Cardno Ecology Lab, published studies and the World Wide Web.

2.1 Review of Existing Information

2.1.1 Artificial Reefs

2.1.1.1 Introduction

Artificial reefs are generally designed with the aim of creating a structure on the seafloor for the purpose of increasing or concentrating populations of fishes or other animals or plants. From humble beginnings in the eighteenth century in Japan where villagers sunk ships to attract yellow spotted grunt (*Plectrorhynchus cinctus*) (Pollard 1975), they are now used in some countries on a massive scale (Kim *et al.* 1994).

2.1.1.2 Construction and Materials

Various materials have been used in the construction of artificial reefs including: building rubble, concrete pipes, solid and hollow concrete blocks, motor car bodies, motor car tyres, decommissioned ships (Pollard and Matthews 1985), and, more recently, mineral accretion technology (Van Treek and Schumacher 1998, 1999). Some of these materials have proven to be inadequate, either sinking into the sediment (e.g. smaller material), rusting away (e.g. car bodies) or washing away during storms (e.g. some tyre reefs). Although the deployment of such opportunistic structures remains the more common option in artificial reef construction, there is a growing trend towards dedicated reef designs (Pickering and Whitmarsh 1997). Concrete is becoming the favoured material in reef design due to its durability and mouldability and there is a focus on optimising location, depth, size and complexity of artificial reefs according to the requirements of the biota which it is hoped they will attract.

2.1.1.3 Artificial Reefs in Australia

Artificial reefs have been constructed in Australia since the mid-1960s. The first was created from concrete pipes laid in Port Phillip Bay (Kerr 1992). Within a few more years there were reefs constructed of various material (tyres, concrete rubble and or car bodies) in NSW, S.A., W.A. and QLD. The first ship sunk in Australia for the purposes of an artificial reef, a Sydney Harbour ferry, was scuttled in 1976 in a depth of 45 m off Long Reef.

Initially, in Australia, artificial reefs were created under the belief that they would be productive areas for recreational fishing. Artificial reefs for recreational fishing continue to be laid today and in NSW, the Department of Industry and Investment is undertaking a program to deploy numerous, small, concrete block artificial reefs in estuaries and is seeking approval to deploy some larger, steel structures offshore (Cardno Ecology Lab 2008).

In recent times, a number of ex-naval vessels have been scuttled in Australian waters. However, rather than creating reefs for fishing the purpose has been to create artificial reefs for recreational scuba divers. Examples include the Ex-HMAS SWAN (in 1997 off Dunsborough, W.A.) the Ex-HMAS HOBART (in 2002 off Yankalilla Bay, S.A), the Ex-HMAS PERTH (in 2001 off King George Sound in Albany, W.A.) and most recently the Ex-HMAS BRISBANE (in 2005

off the Sunshine Coast in QLD). Prior to scuttling, all vessels were prepared so that they were safe to dive on and did not present any hazard to marine life (i.e. through leaching of contaminants) or to divers themselves. All hazardous materials (e.g. antifouling paints, hydrocarbons, toxic paints etc.) were removed and any other debris or loose objects (which could be hazardous to divers) stripped from the vessels. The ships are located at depths of approximately 30 m.

Activities within the newly established dive sites are now strictly controlled and in all cases exclusion zones have been established around the wrecks, prohibiting commercial and recreational fishing activities and also limiting the number of commercial and private dive boats moored in the area at any one time. In the case of the Ex-HMAS Hobart, a 550 m exclusion zone has been placed around the wreck and it is illegal to enter the zone without a permit. It is also illegal to take fish in an area bounded by a circle of radius 0.5 nm from the central point of the wreck.

2.1.1.4 Benthic Ecology

Benthic assemblages on hard surfaces of reefs (natural or artificial) are influenced by a wide range of environmental variables including water depth (Rule and Smith 2007), orientation in relation to prevailing currents (Baynes and Szmant 1989 in Walker *et al.* 2007), orientation of surfaces (Glasby and Connell 2001, Knott *et al.* 2004), complexity of surfaces (Edwards and Smith 2005) and rates of sedimentation (Baynes and Szmant 1989 in Walker *et al.* 2007). Ecological processes such as recruitment (Perko-Finkel and Benayahu 2007) and succession (Nicoletti *et al.* 2007) are also influential.

Comparisons of benthic assemblages on natural and artificial reefs indicate that although they may share many similar taxa, there may be differences in the overall assemblages. Some taxa may be more abundant and diversity may be greater on natural compared to artificial reefs and vice-versa (Edwards and Smith 2005). Diversity of species on new reefs (such as artificial reefs) generally increases through time to a point of relative stability (Ardizzone *et al.* 1989 in Edwards and Smith 2005). Initially, on scuttled vessels colonising species such as hydroids and algae dominate but barnacles, bivalves, bryozoans, sponges, polychaetes and ascidians can establish quickly (Morrison 2001, Walker *et al.* 2007).

Colonisation of sunken vessels by sessile invertebrates has proven to be relatively rapid. For example, the Ex-HMAS BRISBANE became colonised by red, brown and blue/green algae, limpets and goose barnacles within three months of deployment (Queensland EPA 2007). Mobile invertebrates such as crabs, shrimps, crayfish and octopus were recorded within nine months. Approximately 80 species of fish and a diverse assemblage of mobile marine invertebrates including nudibranchs, opisthobranchs, cuttlefish, octopus and starfish were observed around the wreck of the Ex-HMAS HOBART after its deployment in November 2002. Sessile sponges, ascidians, polychaete worms and soft corals are now well established. Biological monitoring of the Ex-HMAS SWAN over a two year period reported initial colonisation by hydroids and these covered approximately 70% – 90% of the area surveyed (Morrison, 2001). On the upper surfaces of the Ex-HMAS SWAN, algal growth dominated the encrusting marine life during summer months. Other sessile groups such as sponges, ascidians, anemones and soft corals were shown to proliferate on shaded portions of the vessel.

Although it is known that reefs may affect the intensity of water movement, currents, erosion or sedimentation, organic content of sediments and the number or type of predators, few studies have investigated the influence of reefs on fauna of nearby soft sediment habitats. While some studies found no differences in densities of macrofaunal assemblages at distances away from a reef (Davis *et al.* 1982) others reported that densities of some species were enhanced, depressed (Ambrose and Anderson 1990) or that assemblages were spatially more variable closer to reefs (Barros *et al.* 2001).

Artificial reefs have potential to alter the trophic structure of nearby fauna by changing the available forage food. This could occur if some of the fish associated with a new deployed artificial reef fed on surrounding soft-bottom habitats. There is evidence that feeding halos can occur around artificial reefs so that abundance and species richness of flora (Randall 1965) or prey items decreases (Bortone *et al.* 1998). This has potential to affect the food of demersal fish living on nearby soft-bottom habitats or natural reefs.

2.1.1.5 Fish Ecology

2.1.1.5.1 Factors Affecting Fish Assemblages on Artificial Reefs

Size, relief, complexity, location and biological factors can all influence assemblages of fishes on artificial reefs (Bohnsack *et al.* 1991, Kim *et al.* 1994).

The influence of reef size on species abundance is an ongoing debate. Where biomass has been measured in association with large artificial reefs, it has been great but composed of not many individuals (Pickering and Whitmarsh 1997). In contrast, greater densities of fish have been reported on smaller artificial reefs (Bohnsack *et al.* 1994).

The relief (or height) of artificial reefs can influence abundance and diversity. In temperate waters, diversity has been shown to be greater on low-relief artificial structures than on natural structures (e.g. Ambrose and Swarbrick 1989) but less on high-relief artificial structures (Burchmore *et al.* 1985). In tropical waters the effects may be different. Some studies have shown no differences between low-relief artificial structures and natural reefs (e.g. Bohnsack *et al.* 1994). Others have shown greater diversity and abundance on high-relief structures (Rilov and Benayahu 2000).

It follows that the more complex an environment, the more ecological niches are created. Artificial structures have potential to be complex in terms of their physical makeup and in how they may affect turbulence and light levels in waters around them. For example, small fish, which need a place to rest may prefer the lee side of artificial structures (Dean 1983 in Pickering and Whitmarsh 1997). Similarly, the amount of crevice habitat may affect diversity (Anderson *et al.* 1989, Carr and Hixon 1997). Regardless of the number of niches created by an artificial reef, they are likely to be different to natural reefs and for this reason it is not uncommon for assemblages on artificial reefs to be different from those on natural reefs (e.g. Lincoln Smith *et al.* 1988).

The location of an artificial reef can influence diversity and abundance (Burchmore *et al.* 1985). Some fish, for example, may not occur at particular depths. Burchmore *et al.* (1985) suggest that the proximity of artificial reefs to existing reefs or the ocean (in the case of estuarine artificial reefs) could increase the chance of recruitment or visitation from neighbouring areas. Further, the proximity to water circulation patterns that provide nutrients or food or substrata that provide sources of food are also likely to be important.

Biological factors can be important. Adult fishes may limit the number of juveniles able to settle (Russell *et al.* 1974) as may other competitors. Encounters with predators have been shown to be less on artificial reefs compared to natural reefs (Sweatman and Robertson 1994) and this may influence mortality (Connell 1997). This effect has potential to be associated with the often isolated nature of artificial reefs.

In terms of other sunken vessels, a diverse assemblage of pelagic and reef fish, marine reptiles and mammals were observed around the Ex-HMAS BRISBANE within the first nine months of scuttling. Surveys of fish on the Ex-HMAS SWAN over a two year period after it was scuttled showed species richness increased from two to 32 species with a shift from omnivorous weed/sand fishes to one dominated by planktivorous and carnivorous reef fishes. The number of taxa and abundance of fishes on the Ex-HMAS SWAN were comparable to nearby control sites but the overall assemblage on the vessel was distinctly different.

2.1.1.5.2 Attraction Versus Production

In assessing the effects of artificial reefs on production, it is essential to explicitly define the region or management area in question (Carr and Hixon 1997) to which a loss or gain in production relates to. The size of a management area as well as the spatial distribution of reefs within that area can influence how effects are interpreted. For example, if natural reef does not exist in a management area where an artificial reef has been placed, then recruitment of obligate reef organisms to the artificial reef has necessarily enhanced production within the area. Clearly, the smaller a management area is, the greater contribution an artificial reef can have. Notably, there also is likely to be a loss of production from habitat that is replaced by an artificial reef (usually soft sediment) but this is seldom taken into account.

The question of whether artificial reefs merely redistribute fishes from surrounding areas, or whether they in fact increase production of reef fish is not clear. To increase overall reef productivity, artificial reefs must provide additional habitat which increases carrying capacity. This could be done by providing:

- new substrata for benthic fauna (food sources of fishes);
- new shelter from predation;
- new habitat to which fishes recruit to; or,
- a reduction of harvesting pressure on natural reefs (Pickering and Whitmarsh 1997).

In support of the production hypothesis, artificial reefs have been found to increase the local biomass of benthic invertebrates and fishes (reviewed by Pickering and Whitmarsh 1996) but this does not indicate unequivocally that regional biomass increases as it is difficult to discern whether:

- (1) fishes that settle or are attracted to artificial reefs would have found suitable habitat if these reefs were not present;
- (2) fishes would have better survival, growth or recruitment on artificial reefs than on natural habitats;
- (3) foraging success and food web efficiencies have improved; or
- (4) habitat is vacated by fishes moving from natural habitats to artificial reefs.

Habitat may not be the only limiting factor for populations that are below their carrying capacity. Species most likely to benefit from artificial reefs are those that are habitat limited, demersal, philopatric (i.e. those that return to their place of birth to breed), territorial and live only on reefs.

2.1.1.6 Other Impacts

2.1.1.6.1 Increased Mortality to Fishes

A major concern of artificial reefs is that they could potentially make recreationally and commercially important species more easily harvested by aggregating them in one place, thereby facilitating increased fishing mortality to populations. When reefs are located close to boat ramps and their positions mapped, artificial reefs can increase access, and potentially fishing effort, on hard-bottom surfaces in an area (McGlennon and Branden 1994). This assertion can be made with confidence because artificial reefs are generally placed in areas where there is little hard bottom (Grossman *et al.* 1997). The problem is exacerbated if new reefs attract fishers who previously did not fish hard-bottom areas due to a prior lack of availability.

Another potentially adverse effect may occur if there is increased predation on fish associated with artificial reefs that leads to an overall increase to natural mortality of prey (Leitao *et al.*

2008). This has potential to decrease recruitment to populations if predators and prey are attracted to artificial reefs and prey items have a greater vulnerability there. Notably, the opposite has also been reported (i.e. where abundance of predators on artificial reefs compared to natural reefs is less, Section 2.1.1.5.1).

2.1.1.6.2 Contamination of the Local Environment

Artificial reefs in the marine environment tend to corrode over time potentially affecting water quality, sediments and by providing surfaces of unnatural material for species to attach to.

Many organisms can accumulate contaminants from surrounding waters, sediment or their food, some of which may persist within their tissues for long periods of time or are transferred to consumers higher up the food chain (i.e. bioaccumulate) (Amiard-Triquet *et al.* 1993). Where contaminated organisms also function as habitat (e.g. kelp forests), there is potential for accumulated contaminants to effect associated epifauna (Roberts *et al.* 2008).

The ocean has great dispersive properties but there is potential for accumulations of contaminants to be locally significant. Monitoring of the sediment around the Ex-HMAS SWAN after it was scuttled indicated marked increases of aluminium, chromium, copper, iron, lead and zinc (Morrison 2001). This was attributed to corrosion of the superstructure and leaching from antifouling paints. Although these metals do not generally cause toxicity at low concentrations or accumulate in food chains, others such as mercury and tin may (Clark 1997). The effects of leachates from tyre reefs in freshwater (e.g. Nelson *et al.* 1994) and coal fly ash reefs in the marine environment (Norton 1985, Kress 1993) have been investigated with mixed results.

Antifouling paint was last applied to the hull of the Ex-HMAS ADELAIDE in 2003, with the paint used being a Tributyltin (TBT) free, self-polishing copolymer technology developed to provide controlled biocide release. It is understood the Vessel would usually have been dry docked every five years and the hull painted to maintain the effectiveness of the antifoulant.

Some studies have suggested that metal toxicity to organisms attached to metal surfaces can be problematic. For example, some damselfishes prefer artificial substrata for their nests and in doing so can expose their larvae to lethal metal toxicity if the substratum is metal (Kerr 1996).

2.1.1.7 Sunken Vessels and Diving Tourism

Scuba diving is popular around sunken vessels. Diving around sunken naval vessels is strictly controlled (Section 2.1.1.3). In the case of the Ex-HMAS HOBART it is illegal to damage the wreck or remove relics from it. Divers are issued with permits and must abide by conditions. In the case of the Ex-HMAS BRISBANE, a 35.3 ha marine conservation park (managed under the *Nature Conservation Act 1992* and the Queensland Parks and Wildlife Service) has been established around the wreck (Queensland EPA, 2007). Within this area, access to the site and diving activities are regulated and general tourism operations, fishing, boating and other water craft activities are not permitted.

2.1.1.8 Stakeholder Perception

In a recent review of stakeholder perceptions regarding the environmental and socio-economic impacts of the Algarve artificial reefs (Ramos *et al.* 2007) the overall perception of the environmental effects revealed that artificial reefs were an incentive to users and that the structures were perceived as a satisfactory tool to support the local fishery and its management. As expected, different stakeholder groups had somewhat different opinions but interestingly scientist and divers were the strongest supporters.

2.1.2 Existing Information on the Study Area

2.1.2.1 Soft Bottom Areas

Sediments offshore from Avoca Beach at the proposed placement zone consist of fine to medium grained, golden sand (PWD 1989). These extend seaward to a depth of approximately 36 m where they give way to coarser, orange coloured inner shelf sediments (typically with 40% shell) (Figure 1). Sediment composition of samples collected by Coastal and Marine Geosciences (1999) showed a mean grain size of 0.34 mm for beach samples and 0.28 mm for shoreface samples and mean carbonate content of 14.3% and 16.2% for beach and shoreface samples respectively. Shoreface samples collected on the 30 m depth contour (offshore from Avoca Beach) had a mean grain size of 0.23 mm carbonate content of approximately 16.2%.

MHL (2002) reported seabed sediment (sand) thickness between Macmasters Beach and Forresters Beaches. The investigation consisted of a high resolution seismic reflection (Boomer) survey done in 1998. Boomer seismic techniques enable stratification of the seabed to be interpreted. Interpretation of seabed thickness is combined with GPS data which allows the construction of a sediment 'isopach' map of the study area (Figure 2). According to MHL (2002) the seismic data collected during the survey correlated well with the existing seabed data mapped previously by the Public Works Department in 1989 (PWD 1989). The isopach map illustrates the relatively thin (>5 m) cover of seabed sediments over bedrock in water depths < 40 m. Relatively thicker deposits occur along the channels of old drainage channels (bedrock valleys) that extend seaward of each beach system and are particularly pronounced for the Avoca Beach system within the study area. Innershelf sediments are relatively thick (>10 m) in the ancient drainage channels and offshore of Avoca Beach in water depths of 40 m - 50 m (3 km - 4 km). More recent investigations of sediment thickness by Douglas Partners in 2008 indicate 5 – 6 m of sediment in the proposed placement zone.

In general, subtidal sediments support a large variety of invertebrates. The invertebrates include 'infauna' which burrow to depths of about 50 cm into the sediments, and 'epifauna' which live on the surface of the sediments. Benthic infauna are being investigated for this proposal by WorleyParsons.

Compared to reef habitats, sandy habitats have less physical structure. The variation observed in fish assemblages among sandy areas, however, suggests that fishes do discriminate among them (Lincoln Smith and Jones Underwood and Chapman 1995). In NSW a few common groups make up the fish fauna of sandy areas (Connell and Lincoln Smith 1999). The elasmobranchs are often represented by stingarees (Urolophidae). There may also be many small planktivorous fishes. Other common and commercially important groups are the flatheads (Platycephalidae), which are voracious predators and whiting (Sillaginidae), which are benthic feeders.

2.1.2.2 Rocky Reef Areas

Habitats mapped by Breen *et al.* (2005) and marine surveys done in 1989 by the Public Works Department (PWD 1989), show reef shoal nearby the proposed placement zone. Rocky reefs separate the sandy sediment offshore from Avoca Beach from the adjacent sandbodies of Macmasters and Terrigal/Wamberal embayments. In addition, there is sand-covered reef within 500 m of the placement zone to the north-west and to the north-east. Subtidal rocky reefs extending out from rocky headlands to the north and south of Avoca Beach occur at ~500 m to the north and ~ 400 m to the south of the proposed placement zone (Figure 1).

Subtidal rocky reefs support very different communities to sandy habitats. They also show some degree of 'stratification', with turfing macroalgae and kelp occurring in shallower waters,

bare rock (which is actually covered by encrusting red algae) at intermediate depths and 'sponge gardens' in deeper water (Underwood *et al.* 1991).

Very few ecological surveys have been done within the study area, although some studies on shallow subtidal reefs have been completed at Crackneck Point (approximately 4 km north of Terrigal) Pelican Point (approximately 19 km north of Terrigal) and on subtidal sands within Broken Bay (approximately 13 km south of Terrigal). WBM Oceanics Australia (1997) investigated impacts of sewage effluent outlets at Norah Head and Wonga Point (north of the study area). Two control sites at Crackneck Point and Pelican Point were used to compare long term monitoring results. It was concluded that, at both locations, subtidal rocky habitats were typical of Australian east coast temperate shallow rocky subtidal communities (Underwood and Kennelly, 1990, Dakin 1987). Horizontal rock surfaces were dominated by alga including *Eklonia radiata* (kelp), *Phyllospora comosa* and *Sargassum* spp., lithothamnion pavement, turfing and coralline algae. Lithothamnion pavement, an association of hard coralline algae, other encrusting algae and macrofauna, were observed beneath the canopy of *E. radiata* and *P. comosa* and also alongside turfing algae. Areas of boulders and rock were also extensively covered by the lithothamnion. Beneath the algal canopy a variety of sponges, anemones, hydroids, ascidians, echinoderms and a few corals were present. Overall, subtidal rocky benthos communities were diverse, patchy and exhibited variation between locations and seasons, but remained essentially similar over a period of almost two decades (WBM, 1997). These variations were considered to be natural fluctuations typical of benthic communities of these habitats (WBM, 1997).

Subtidal rocky reefs harbour fishes that depend on this habitat for food, shelter and/or spawning sites at some stage during their lives. Many species are affected by the topography of the reef and are more abundant in areas of greater physical complexity, perhaps because this provides more shelter. It is also clear that many species are affected by the presence of kelp. Huge variations in abundances of reef fishes between place to place or from time to time have been observed. Associated with deeper rocky reefs is a diverse range of fish species from a range of functional groups. Carnivores dominate, including species that feed on invertebrates living on or adjacent to the reef or associated algae and fishes foraging for zooplankton above the substratum (Lincoln Smith and Jones *in* Underwood and Chapman 1995). Herbivorous fishes are by no means rare and usually make up about 20 – 30% of the species and individuals found on temperate rocky reefs (Jones and Andrew 1990). Some reef fishes may be very active, including wrasses and leatherjackets, and can traverse large areas of reef. There are also many less mobile, reef associated, species, which spend most of their time on or near the bottom and cryptic species that remain within caves, overhangs and crevices. Bottom dwelling fish include Serranidae and Scorpaenidae while species which inhabit caves and crevices include Pempheridae, Moridae and Muraenidae. Rocky reefs also support a range of highly mobile fishes which visit these reefs but range over a much greater area. Examples include Carangidae and Carcharhinidae.

Many larvae of rocky reef species use sensory cues to settle on to suitable habitat (Kingsford *et al.* 2002). For many species, the Vessel is likely to provide an environmental signal to induce settlement.

2.1.2.3 The Pelagic Environment

The pelagic environment includes the water mass between the surface and the seabed. This water is inhabited by a diverse range of organisms including plankton, planktivorous and predatory fishes and marine mammals and reptiles.

Plankton is made up of two general groups: meroplankton, which spend part of their life in the plankton, usually as larvae; and holoplankton, which spend their entire life in the plankton (Kingsford 1995). A study of plankton in the region sampled near the bottom (i.e. where the bulk of the Vessel would sit) and at a comparable depth contour (The Ecology Lab, unpublished data) is summarised below. There was generally more invertebrate plankton than

ichthyoplankton near the seabed. Copepods and decapod larvae were found to be the numerically dominant animal groups, with mysids and fish larvae generally the third and fourth most abundant groups. In that study, along with the groups noted above, planktonic polychaetes were recorded in all seasons but mollusc and echinoderm larvae occurred more sporadically, being restricted to autumn and autumn plus winter, respectively. There were also differences between assemblages between samples in winter and these differences were attributed to the extent to which cool Tasman seawater, the dominant water mass in winter, impacts on the inshore shelf region. Fish larvae accounted for between 2.0% and 5.3% of the total plankton per survey. The larval fish component of the plankton samples included representatives from five targeted economically and recreationally important families and 31 non-targeted fish families. These assemblages were much less diverse than those found in other studies near the surface (99 taxa, mostly identified to family level) and at mid-water levels (130 taxa) at inshore locations off the coast of Sydney (Gray and Miskiewicz 2000).

In addition to spawning times and seasonal differences in encroachment of the East Australian Current and Tasman Sea water into the Sydney shelf region, there are other abiotic and biotic factors of important influence which may affect the taxonomic composition and relative abundances of individual planktonic taxa (Gray and Miskiewicz 2000).

Ocean currents that flow past isolated reefs (the Vessel would act as one of these) form a wake or zone of flow disturbance in the lee of the obstacle (e.g. Rissik *et al.* 1997). Where deep water is involved, flow disturbance can uplift cool, nutrient-rich water in the eddies thereby increasing production of phytoplankton there and zooplankton that feed on them (Rissik *et al.* 1997).

The Vessel would be unlikely to increase nutrient levels by this process because of its location and depth. Nevertheless, and despite large holes cut in the Vessel (that would allow water to flow through some parts of the Vessel rather than around it) it is likely that some retention zones would be formed that would trap water and particulates behind the Vessel for significant periods of time and this may facilitate increased concentrations of plankton. Although this phenomenon has been reported only for large island masses (e.g. Hernandez-Leon 1988) a smaller scale, but similar, effect is predicted to result from placement of the Vessel.

Planktivorous fishes have potential to congregate where concentrations of plankton are greater (as has potential to occur in the lee of the Vessel) as they may feed more successfully in these areas (Rissik and Suthers 2000). Such concentrations of fishes on the Vessel (which may be prey to some species) are likely to attract, on occasion, large, predatory fish that live in the pelagic environment. Such predators would include, most commonly, yellowtail kingfish (*Seriola lalandii*), Australian bonito (*Sarda australis*) and tailor (*Pomatomus saltatrix*), but many other large, pelagic fish are likely to visit the Vessel as has been reported for other sunken vessels (Queensland EPA 2007, see also Section 2.1.1.5.1).

Marine turtles and marine mammals live in the pelagic environment, often passing close to shore where the Vessel would be situated. Some of these have potential to occur in the study area all year round (i.e. marine turtles, seals and dolphins) while others such as the much larger baleen whales (e.g. humpback whale, *Megaptera novaeangliae*) and southern right whale, *Eubalaena australis*) are seasonal. Many of these species are threatened or protected and as such are described in more detail in the following section and in Appendix 1.

2.2 Threatened or Protected Species and Areas of Conservation Significance

In order to trigger legislation there must be a likelihood that one or more threatened species occur in, or encroach upon, the study area which could then be affected by the proposal. Threatened or protected marine species scheduled in the *TSC Act*, *EPBC Act* or the *FM Act* that have potential to occur in the general area are listed in Table 1. Only those species having specific habitat requirements in the study area were assessed further. Consideration was also

given as to the potential impact associated with the presence of the scuttled Vessel as this would create new habitat for some threatened or protected species.

2.2.1 Database Searches for Threatened or Protected Species and Areas of Conservation Significance

A search of the BIONET database held by NSW Government was done using the 'Gosford' Local Government Area search option. This search focused on threatened species listed under the *FM Act 1994* and *TSC Act 1995* that have been recorded within estuaries and coastal habitats along the central coast of NSW.

A search was also made, using the 'Protected Matters' search tool, for threatened and migratory species and areas of conservation significance with relevance to the proposal, listed under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*.

Searches were made on 5 September 2008.

These searches were combined with other information about the known distribution of species to get a list of threatened or protected species potentially affected by the proposal.

Species with relevance were assessed according to State (Assessments of Significance) or Commonwealth (Administrative Guidelines on Significance) guidelines. Three species of cartilaginous fishes, one species of fish, four species of marine reptiles, five species of marine mammals in the endangered or vulnerable species schedules of the *TSC Act* or the *FM Act* were identified for assessment (Table 1). Some of these species (e.g. marine turtles and marine mammals) were also listed under the *EPBC Act*. Four species of marine reptile and eight marine mammals in the endangered, vulnerable or migratory species schedules of the *EPBC Act* were identified for assessment (Table 1).

2.2.2 Outcomes of Assessments

Individual and generic (group) assessments for species can be found in Appendix 1. These assessments concluded that the proposal is unlikely to affect the listed threatened species of fish, marine mammals or marine reptiles that occur in, or encroach upon, the study area. Hence, there is no need to prepare a Species Impact Statement under state legislation or refer the proposal to the Federal Minister for the Environment for further consideration and approval. In addition, the proposal would provide new foraging and sheltering habitat for threatened species of fish, marine reptiles and seals.

Notwithstanding this, threatened species encroaching upon the area when the Vessel is scuttled have potential to be injured when the cutting charges are used to blow additional holes in the hull. It is understood that there would be procedures in place in the Scuttling Plan (i.e. to avoid setting charges when marine mammals are sighted) that would prevent injury occurring.

It is noteworthy, that a grey nurse shark was recorded by the University of Newcastle using BRUVS ~ 1 km from the proposed location of the Vessel on the edge of reef (North Reef Near location; Figure 1). This sighting indicates that grey nurse sharks use the area and that potentially, the reef may be an aggregation site where sharks can be found on a regular basis. It is understood that the University of Newcastle will be investigating this possibility.

2.2.3 Separate Considerations

In addition to the species considered in the sections above, there are a number of other species listed for consideration in the legislation. These species are not considered to be at risk because of the proposal. The reasons for this are specified in this section.

2.2.3.1 Other Listed Marine Species, Cetaceans and Migratory Species (EPBC Act)

Listed Marine Species constitute a diverse group of marine animals. Some of them may occur in the study area – e.g. sea snakes. Whilst they are reported from time to time their rarity in the study area suggests that any disturbance caused by the proposal would be highly unlikely to affect populations of these species.

One group that does require some consideration are the marine mammals. Safeguarding measures to avoid injuring these species from explosive charges would need to be considered during scuttling.

2.2.3.2 Protected Species (FM Act)

Under the *Fisheries Management (General) Regulations 2002* provision is made for listing of species as protected. The protected status reflects the susceptibility of the species to capture (for food, sport or display in aquariums) rather than known susceptibility to other types of disturbance or known rarity. Assessments of significance are not required for these species. In addition to seahorses and pipefishes there are six marine species that are totally protected in NSW Waters. They cannot be captured or harmed by any means and therefore should be considered, if likely to be harmed as part of the proposal. Database searches and other information about the known distribution of protected species of fish indicated that many of these species are likely to occur in the study area (Table 1).

Some protected species would potentially be affected by the proposal but only because new habitat would be created for them. This would be a benefit of the project.

2.2.4 Areas of Conservation Significance

There are no sensitive aquatic habitats (i.e. seagrass, saltmarsh and mangrove) located nearby the placement area that would be affected by the proposal.

2.2.5 Key Threatening Processes

Several key threatening processes are identified under the *TSC* and *FM* Acts. None of these are associated with the proposal.

2.3 Introduced Species

Introduced marine species are those species moved to locations outside their natural range by human-mediated dispersal. Biological invasions can be either accidental or intentional introductions, and can arise from a wide variety of private and commercial practices. These organisms may be released at a distant port when ballast water is unloaded. Some organisms can also be transported via the water in other internal seawater systems, such as engine cooling systems, toilet/bathroom systems (if they use saltwater) and on-board aquarium systems (Bax *et al.* 2001). Transport of encrusting organisms via fouling of vessels (e.g. hulls, propellers, intake grates and cavities) and other gear (e.g. nets, cages, lines, floats and anchors) is also an important vector. Fouling as a vector has increased in importance in recent years due to an increase in international small boat traffic and because the use of the anti-fouling biocide tributyltin is being out-phased due to its detrimental effects on aquatic organisms. Fouling organisms can also be transported via attachment to floating debris. Other transport vectors include accidental or intentional releases from the aquarium industry,

aquaculture activities (e.g. intentional releases, stock, gear or food movement, discarded packing materials) and movement of species through canals.

If introduced species become established they may propagate within an area. However, not all introduced species are considered pests, especially if they do not threaten human health or environmental and economic values.

Introduced pests differ from most other marine issues in three important ways:

- pests may spread widely to the limits of their physiological tolerances - this is apparently because introduced species escape from their natural enemies and are less parasitised;
- prospects for the complete eradication of pests are poor, especially if they can disperse over large distances; and
- the ecological impacts of invasive species often cannot be predicted.

Some known impacts of invasive species (Web Reference 1) include:

- 1) Direct predation of native species e.g. Northern Pacific seastar (*Asterias amurensis*) and green crab (*Carcinus maenas*);
- 2) Competition for space and food, in some cases resulting in competitive exclusion of native species and changes in habitat structure e.g. Seastar (*Patiriella regularis*). Local modifications to seagrass areas have also been reported;
- 3) Nuisance fouling species e.g. barnacles;
- 4) Harmful blooms and the bioaccumulation of toxins in shellfish, fish, molluscs and other species e.g. toxic dinoflagellates *Gymnodium* and *Alexandrium* sp.; and
- 5) Disruptions to aspects of nutrient cycling. These may include alterations to benthic denitrification (e.g. by fanworms) and changes in the patterns of organic matter settling.

The Vessel would provide a large area of hard surface for the colonisation of introduced species.

A search was made of the NIMPIS database (Web Reference 1) for introduced species that could utilise the Vessel (i.e. those that occur on hard substrata in coastal waters and in the depth range of the sunken ship) and have been found in NSW waters (Table 2). The list includes one species of algae, one fish, one polychaete, two barnacles, one amphipod, one isopod, one crab, six bryozoans, three ascidians, five hydroids, one kamptozoan and three gastropods. General impacts from these species have potential to include competition for space and food, nuisance fouling and disruptions to aspects of nutrient cycling.

2.4 Commercial and Recreational Fishing

2.4.1 Commercial Fishing

Total commercial catch landed at Terrigal Haven in 1999/2000 was 60 tonnes at a value of \$284,000 (Tanner and Liggins, 2001). At that time, 11 fishers operated out of Terrigal. In general, total catch (tonnes), fishing effort and number of fishers appear to have declined in the region over the past 5 years.

There is a lack of published information available on the specific locations where fishing effort is concentrated. This is mostly due to the confidential nature of fisheries log book data and the large scale over which catches are reported. Consultation was undertaken with commercial fishers to provide spatial fisheries information for the study area.

State fisheries likely to operate within, or close to, the placement zone include the Ocean Hauling Fishery, the Ocean Trawl Fishery and the Ocean Trap and Line Fishery. The Lobster,

Abalone, Sea Urchin and Turban Shell fisheries operate on shallow reefs close to the shore and are not considered any further.

Commercial fisheries under the jurisdiction of the Commonwealth of Australia with potential to operate in the area would be the Eastern Tuna and Billfish Fishery, Southern and Eastern Scalefish and Shark Fishery, Jack Mackerel (Small Pelagics) Fishery, Southern Squid Jig Fishery, Eastern Skipjack Tuna Fishery and the Southern Bluefin Tuna Fishery. As these fisheries operate mostly outside of state waters, they are not considered further, although it is noted that some operators in the Commonwealth tuna fisheries may catch bait (yellowtail, slimy mackerel and pilchards) within 3 nm of the coast under a permit issued in terms of Section 37 of the NSW *FM Act*.

2.4.1.1 The Ocean Trap and Line Fishery

The Ocean Trap and Line Fishery is a multi-method, multi-species fishery targeting demersal and pelagic fishes along the NSW coast (NSW DPI, 2006a). Snapper (*Pagrus auratus*), spanner crabs (*Ranina ranina*), yellowtail kingfish (*Seriola lalandii*), leatherjackets (Monacanthidae), bonito (*Sarda australis*) and silver trevally (*Pseudocaranx dentex*) form the bulk of the commercial catch. Other key species include rubberlip morwong (*Nemadactylus douglasi*), blue-eye (*Hyperoglyphe antarctica*), gummy shark (*Mustelus antarcticus*), bar cod (*Epinephalus septemfasciatus*) and yellowfin bream (*Acanthopagrus australis*). In 2000/01 an estimated 1,742 t of fish were caught in the whole fishery with an estimated value of \$10 million at first point of sale (Web Reference 2). The fishery uses a variety of methods, most commonly involving a line with hooks, or traps. Demersal fish trapping and line-fishing (for snapper, rubber-lipped morwong and leatherjackets) does occur nearby the placement location on top of, or on the edge of, reef. As the placement location is on sand it is unlikely that fishers would be active within it unless fishers were handlining for schooling baitfish such as yellowtail.

2.4.1.2 The Ocean Hauling Fishery

The Ocean Hauling Fishery targets approximately 20 finfish species using commercial hauling and purse seine nets from sea beaches and in ocean waters within 3 nautical miles of the NSW coast. On average 3,500 t of fish is taken by the whole fishery each year; mainly sea mullet (*Mugil cephalus*), luderick (*Girella tricuspidate*), yellowtail scad (*Trachurus novaezelandiae*), blue mackerel (*Scomber australasicus*), pilchards (*Sardinops neopilchardus*) and sea garfish (*Hyporhamphus melanochir*). The total catch is worth around \$6 million at first point of sale (Web Reference 3). Purse seining for garfish, yellowtail scad and blue mackerel would possibly occur occasionally within the placement zone.

2.4.1.3 The Ocean Trawl Fishery

2.4.1.3.1 The Prawn Trawl Sector

The Ocean Prawn Trawl Fishery is the most valuable fishery in NSW and is worth around \$32 million at first point of sale each year (Web Reference 4). In 2000/01 the total catch for the fishery was 3,411 t with 1,739 t of that being prawn catch only.

Prawn trawlers use trawl nets to target prawns on soft sediments. Incidental catches of other species of fish may also be landed. A total of 312 fishing businesses hold endorsements to operate in one or more sectors of the Ocean Prawn Trawl Fishery in NSW. Of these, 267 are endorsed to trawl for prawns in the inshore sector of the fishery (from the coast to three nautical miles to sea), where the main species harvested are school prawns (*Metapenaeus macleayi*), school whiting (*Sillago flindersi*) and eastern king prawns (*Penaeus plebejus*). Prawn trawling would rarely be done in the study area, if at all.

2.4.1.3.2 The Fish Trawl Sector

The Ocean Fish Trawl Fishery uses the demersal otter trawl to target a large number of species, such as silver trevally, tiger flathead (*Platycephalus richardsoni*), redfish (*Centroberyx affinis*), john dory (*Zeus faber*) and numerous species of sharks and rays. Total catches reported by fish trawl operators from NSW managed waters in 2000/01 were 1,171 t, valued at \$4 million at first point of sale (Web Reference 5). A total of 99 fishing businesses hold endorsements to operate in the Ocean Fish Trawl Fishery. Fish trawling has occurred in the study area in the past (see below).

Consultation with Trawler Operators

Trawler operators were met with at Sydney Fish Market on 6 March, 2009 to obtain advice on trawling operations in the study area. Richard and Paul Bagnato provided advice on behalf of the operators of the seven vessels that comprise the Sydney trawler fleet .

Cardno Ecology Lab was advised that fishing grounds in the vicinity of the proposed placement site for Ex-HMAS ADELAIDE are worked by trawler operators from Sydney but not those from Newcastle, who prefer grounds further north. The main species targeted in the vicinity of the proposed scuttling site are: yellowfin bream, flatheads (Platycephalidae), school whiting, silver trevally and boarfish (Pentacerotidae). Trawlers generally work along a depth contour in deeper waters than the proposed placement site. They work about 180 days / yr and can make between 1 – 10 shots / day.

On rare occasions, Richard Bagnato (and occasionally other operators) make a west-east shot on the sand between subtidal reefs offshore from the northern and southern ends of Avoca Beach. The shot, done maybe 20 times / yr, begins in shallow water behind the breakers at Avoca Beach and ends in deeper water to the east of the proposed placement site. The nets have a spread of 120 m, but it was advised that a 300 m gap between the reef extending subtidally from First Point (i.e. the headland to the south of Avoca Beach) and the Vessel would be required to run the shot safely. The gap between the reef and the proposed placement site is estimated to be about 400 m.

2.4.2 Recreational Fishing

Recreational fishing in the study area is popular, with three Department of Industry and Investment listed charter vessels operating out of the Terrigal Haven (Web Reference 6) and a number of other vessels operating from the surrounding suburbs (National Oceans Office, 2004). Department of Industry and Investment listed vessels (those wishing to be listed) represent approximately 70% of all registered vessels operating in the area, so the actual figure is likely to be greater. Chartered recreational fishing vessels operating out of Terrigal Haven are equipped for estuary, nearshore, deep sea bottom fishing and gamefishing. Details of chartered recreational fishing vessels operating out of Terrigal Haven, the Hunter, Lake Macquarie, Brisbane Water and the Hawkesbury/Pittwater are listed in The Ecology Lab (2008).

Recreational fishers use hook and line to target demersal reef species such as yellowfin bream, silver trevally, mulloway (*Argyrosomus hololepidotus*), snapper and kingfish on offshore reefs and species such as leatherjackets (Monacanthidae) and flathead (Platycephalidae) on sandy areas. Between Terrigal and south Avoca there are a number of options for offshore recreational fishing. GPS Positions, target species and names of known offshore recreational fishing locations are listed in The Ecology Lab (2008). There are three popular offshore reef sites within the study area, namely Avoca Drop Off, Avoca Reef and The Pips. The general environment and fishing operations in these areas would be unaffected. Recreational fishing for flathead would no longer be possible in the vicinity of the scuttling site, however this represents only a small reduction in the local area available for flathead fishing.

Spearfishing and lobster gathering is popular on headlands and reefs between Maitland Bay in the south (near Broken Bay), up to the Entrance. In NSW, these activities are permitted using

snorkel (i.e. no SCUBA or surface air supply) and are normally done on reef in waters of 20 m depth or less. Given the depth of the Vessel and that there is no reef in the proposed placement location this type of fishing is unlikely to occur there.

3 FIELD STUDY OF FISH

3.1 Methods

3.1.1 Survey Objectives and Site Descriptions

As part of this environmental assessment, Cardno Ecology Lab was engaged to survey fish occurring at the site of the proposed wreck. There were two aims to the fish survey:

- 1) to describe assemblages to assist in this REF, and
- 2) to provide some baseline data for the Long-Term Management Plan.

In particular, the following objectives were considered:

- 1) Investigations of assemblages of fish living in sand habitat at the placement location, as these may become less similar to assemblages of fish living in unaffected sand habitat once the Vessel is scuttled.
- 2) Investigations of assemblages of fish living in reef habitat nearby the placement location, as reef fish attracted to the Vessel would be more likely to come from nearby reefs than from reefs located further away.

To address objective (1), two control locations were selected on sand in a similar water depth to the placement location (33 – 34 m): 'North Sand Control' (~3.1 km north of the placement location); and 'South Sand Control' (~4.0 km south of the placement location - Figure 1). The depth of the sand controls ranged between 29 – 33 m.

To address objective (2), two reefs were selected between 400 – 500 m from the placement location ('North Reef Near' and 'South Reef Near') and two were selected 3 – 4 km from the placement location ('North Reef Far' and 'South Reef Far' - Figure 1). All locations were at depths between 27 and 33 m.

Fish were sampled using underwater video, described as follows.

3.1.2 BRUVS Rationale, Components and Design

Fish were surveyed using Baited Remote Underwater Video Stations (BRUVS), which consist of a video camera in an underwater housing which is attached to a frame. The camera faces a container dispensing bait used to attract fish and other mobile animals into the camera's field of view (Plate 1). The effectiveness and advantages of BRUVS as a technique to survey fish assemblages is well described in recent literature (see Cappo *et al.* 2003 and Cappo *et al.* 2006 for review). BRUVS provide benefits over traditional capture survey techniques, such as trawling and trapping, in that it is non-destructive. In addition, the use of BRUVS has been shown to provide comparable estimates of fish abundance and diversity to alternative techniques such as diver surveys (Willis and Babcock 2000, Watson *et al.* 2005, Stobart *et al.* 2007), and are not limited by depth or available bottom time to the extent of these.

The Vessel placement location comprises flat sandy habitat in deep water that offers limited opportunity for diver surveys. The ship itself, however, will have a high vertical relief and there will be spaces in its hull where fish may reside. Although BRUVS will be limited in their ability to survey fish on the higher areas of the ship, or within it, they do have the ability to record cryptic species, especially cryptic predators and scavengers, attracted by the bait into view (Malcolm *et al.* 2007). Notwithstanding this, BRUVS can be biased due to the potential for sampling to underestimate diversity of fish as some may not be attracted to the bait. Thus while this method has been shown to be highly effective for sampling fish assemblages, the limitations of BRUVS need to be recognised.

Four identical BRUVS were assembled using a design based on Cappo *et al.* (2004).

The BRUVS frames were built from solid aluminium, and consisted of four legs, a cradle to hold and secure the housed video cameras, and a tube to set in place the removable bait arm. Units were deployed with 2.7 kg of lead weight attached to each leg as ballast to provide stability in surge or current (total ballast for each unit = 10.8 kg). A 45 m length of silver rope was attached to each corner of the frame, with a 30 cm polystyrene float and fluorescent orange flag attached to the surface end of the rope to improve visibility from the surface, and allow location and retrieval of the unit.

The cameras used were Sony HDR-HC5E high-definition (1080i) digital video cameras, fitted with x0.6 wide angle conversion lens, and 60 minute Sony MiniDV digital tapes. High-definition cameras were essential for the purposes of this study as they provide greater resolution in the low-light situations found at depths of greater than 20 m. Cameras were housed in custom-built underwater housings tested to depths of 200 m. Underwater housings were made from pressure resilient 'Blue Rhino' PVC pipe, with clear acrylic ports fixed to the front and back of the housing by self-locking stainless steel latches. When underwater and operational the cameras capture footage from an area measuring approximately 1.8 m wide and 1.1 m high at the bait (1.5 m from the camera lens). Cameras were set on 'auto' mode which automatically adjusted focus and exposure to suit conditions on the seafloor.

Baits used with the BRUVS were housed in nylon mesh bags measuring approximately 15 cm x 40 cm. The mesh prevents fish from directly accessing the entire bait. The bait was fixed to the end of a bait arm made of PVC pipe fixed 1.5 m from the camera lens and elevated approximately 15 cm above the seafloor. Approximately 500 – 750 g of whole pilchards were used for each deployment.

3.1.3 Deployment and Retrieval of BRUVS

3.1.3.1 Deployment

In this survey, four replicate video samples (see below) were collected at each location between 17 – 19 December 2008 (Table 3). This was determined to be a short enough period to limit any potential bias due to variation in temporal activity of fishes, as any potential shifts in fish assemblages are thought to occur over longer periods (Willis *et al.* 2006).

Previous work in the region by the University of Newcastle and The Ecology Lab (unpublished data) has indicated that there is very little increase in the diversity of species and maximum numbers of species after 30 minutes on reef or after 45 minutes on sand, so these sampling times were used. Initially, all four BRUVS were deployed within the same location simultaneously but afterwards BRUVS were spread between locations. All BRUVS were deployed between the hours of 0700 and 1330.

It was important that each replicate video sample was independent of others as multiple replicates were sometimes collected from different parts of locations simultaneously. While no available research to date has directly estimated the area of attraction caused by bait plumes (and therefore the distance required between replicate samples to ensure independence), some evidence indicates that for species up to 200 mm long, replicate sets at distances greater than 100 metres apart were independent for 10 minute videos (Ellis and DeMartini 1995). The distance of separation required for independence of samples may be greater when sampling larger species, over longer time periods, or in areas with current (Cappo *et al.* 2006). In this study, we separated videos taken at reef locations by 200 m.

Ideally, during surveys after the Vessel is scuttled, videos would need to be placed as close to the ship as possible to record the fish assemblage associated with the ship. Due to the dimensions of the ship (138 m long and narrow), a smaller separation distance was required at the ship placement location (125 m), and associated sand controls. The approach when

sampling at the ship would be to deploy two videos 125 m apart on either side of the ship, as close to the superstructure as possible. By doing this the superstructure would provide a wall between videos deployed on each side of the ship that would provide some degree of independence.

The location, depth, water clarity (visibility), and date/time of each video sample are shown in Table 3. Visibility was estimated subjectively from video footage by experienced divers familiar with local conditions. The 1.5 m long bait arm in the foreground of video footage, which runs approximately parallel to the sea floor, was used as a guide when estimating visibility. In some instances, visibility was limited by reef structure rather than water clarity.

At each deployment, the time, depth and position (UTM, WGS84) were recorded once the camera had reached the sea bed. Depth was measured using a single beam echosounder, and position estimated using a handheld Garmin 72 global positioning system (GPS).

3.1.3.2 Retrieval

On retrieval of each BRUV the video was briefly reviewed to ensure that the unit had been set in an appropriate position and the footage was suitable for identifying fish. Some samples collected during each survey were unsuitable for analysis, due to the unit settling incorrectly on the seafloor (e.g. upside down, on its side, bait arm pointing up, etc.) or poor focus. In these instances, the video footage recorded was discarded, and the unit re-deployed with fresh bait. The deployment process was repeated until at least four suitable samples had been recovered from each location. Video footage samples were deemed suitable when they met the following criteria:

- Visibility was at least 3 - 4 m;
- Bait was not more than 50 cm above the seafloor;
- Bait was intact and visible;
- More than half the field of view was unobscured by reef, kelp, or otherwise;
- Bait remained for at least 30 minutes; and
- Footage was in focus and clear enough to allow identification of most fish to species level.

3.1.4 Interpretation of Video Footage

Video footage was analysed using the BRUVS Tape Reading Interface program developed at the Australian Institute of Marine Science (AIMS). This program is run as a Microsoft Access database which is specifically designed as a user-friendly interface for entering and storing data relating to fish abundance and diversity from BRUVS, and allows standardisation of data collected at different research agencies. The video footage was played back using a digital video camera, which was connected simultaneously to a television set using AV cables and a computer through a firewire (1394) port. The television display was used to observe and identify species, while the computer connection provided a link to the BRUVS Tape Reading Interface program.

Each video sample was given a unique identifying code, called an OPCODE which contained information defining survey period, location and replicate (sample no.). This code was then used to create a unique record for each video sample in an Access database linked to the BRUVS Tape Reading Interface program. During tape reading, the following attributes were recorded in the database for each video sample:

- Tape reader;
- Date, time and GPS position of sample;

- Time at which the unit reached the seafloor;
- Habitat/Habitats in view;
- Time at first appearance;
- Activity (feeding/scavenging/passing);
- Time at first feed;
- Maximum number (MaxNum); and
- Time at maximum number for each species.

In instances where large numbers of a species were present in a single frame, the video was paused and a still image used to count numbers of individuals in view at any one time (MaxNum).

For most of the species identified, a still screen image was captured from video footage. These images were used as a quality control mechanism to ensure consistency of species identification between tape readers, and to build a reference image collection of species observed.

All mobile species, large enough to be accurately identified, recorded on video during this study, including Osteichthyes (fish), Chondrichthyes (sharks and rays), and cephalopods (squid, octopus, and cuttlefish), were used in the analyses. Sedentary and sessile species such as echinoderms (starfish, sea urchins) and ascidians (sea squirts) were not included in this study.

3.1.5 Data Analysis

Raw data from all surveys were extracted from the BRUVS Tape Reading Interface database. From this dataset, the mean abundance (MaxNum) and standard error of each species at each site was calculated. The total number of species observed at each site, and number of species observed during the survey was also recorded.

To assess the suitability of control sites, multivariate techniques were used. These compared fish assemblages among reef location and those at the placement location with sand controls. Multi Dimensional Scaling (MDS) based on a Bray-Curtis dissimilarity matrix of the untransformed data (Clarke 1993, Warwick 1993) was used to provide a graphical representation of assemblages based on their similarity within and among places or times sampled. In MDS plots, samples with similar sets of taxa cluster closer together than those containing different sets. The stress value for each plot indicates how well the data fit the representation. The lower the value, the better the fit of data, and values lower than 0.2 were considered acceptable (Clarke and Warwick 2001). MDS plots included the data from each replicate BRUVS drop separately.

The statistical significance of any apparent groupings identified in MDS plots were determined using the ANOSIM (Analysis of Similarities) permutation test (Clarke and Green 1988). Similarity analyses (SIMPER) were used to determine the relative contribution that a particular species or taxa made to the dissimilarity among sites (Clarke 1993). ANOSIM *R* values are scaled between -1 and 1; *R* approaches 1 when all pairs of replicates within a group are more similar to each other than they are to pairs of replicates from another group (i.e. groups differ); *R* approaches 0 when, on average, pairs of replicates within and between groups are equally similar (i.e. groups do not differ); and *R* approaches -1 when pairs of replicates from each group are more similar to each other than are pairs of replicates from the same group. (Clarke 1993).

3.1.6 Quality Control

All data contained in the Access database linked to the BRUVS Tape Reading Interface program were checked prior to being extracted and analysed to ensure accurate data. This was done at several stages during the data entry and querying process.

Where MaxNum of a species was over 40, a second staff member counted individuals to validate the initial count. If the difference between counts was less than 10% the initial count was accepted. If the difference was $\geq 10\%$, a count was done simultaneously by both staff members.

Identification of a species for the first time was validated by at least one other staff member experienced with fish identification. Initial identification of species was done primarily using Kuitert (2000), Edgar (2000), and The Australian Museum's Fish website (Web Reference 7) as reference guides.

Following extraction of data from Access via customised queries, datasets were subject to spot-checking against raw data to ensure that no errors had occurred in the query and the database was operating correctly. This spot-checking consisted of comparing species lists and MaxNum values against raw data for at least one video sample from each site. In addition, all data transferred into Excel were checked against raw outputs from Access to ensure that no formatting errors had occurred.

3.2 Results

3.2.1 General Outcomes

Generally, BRUVS were deployed and retrieved without incident. Video footage from all samples was clear, in focus, and allowed species level identification of most fishes observed. Visibility varied among samples, ranging between 3 - 10 m. Even in situations of low light or poor visibility, the high-definition cameras captured clear footage which allowed species-level identification of fishes, with four exceptions. These included a stingaree which could not be identified past the family level (Urolophidae), and a shovel-nosed ray (*Aptychotrema* sp.), a flounder (*Pseudorhombus* sp.) and a bullseye (*Pempheris* sp.) which could not be resolved beyond genus.

In some instances, a rocky outcrop or reef ledge limited the field of view and consequently reduced the ability to observe fish swimming past the area. This was unavoidable in certain areas, and samples were deemed to be acceptable if less than half of the field of view was unobscured and the bait was visible.

The BRUVS sampled a broad suite of species which included carnivorous, herbivorous and omnivorous fishes and some cephalopods. They also recorded actively swimming pelagic species and cryptic, sedentary and less mobile species. This indicates that the use of BRUVS was a suitable method for sampling the fish and cephalopod assemblages of the sand and reef locations by recording a representative sample of the assemblages, which included a variety of dietary and behavioural groups.

3.2.2 Species Abundance and Diversity

3.2.2.1 The Placement Location and Sand Controls

In total, 22 species representing 16 families were recorded in sand habitat (Table 4a). This included six species of sharks and rays. No squid, octopus or cuttlefish were recorded on sand. Many of the species recorded were typically benthic and known to occur on sand (e.g. the flatheads, *Platycephalus* spp. and the school whiting, *Sillago flindersi*). Also recorded were

some typically pelagic species (e.g. yellowtail, *Trachurus novaezelandiae* and longfin pike, *Dinolestes lewini*) and some demersal species normally associated with reef (e.g. red rock cod, *Scorpaena cardinalis* and sergeant baker, *Aulopus purpurissatus*).

Yellowtail, school whiting and long-spine flathead (*Platycephalus longispinis*) were the most common species observed at the Ship Placement and South Sand Control locations. Yellowtail were also abundant at the North Sand Control but at this location, long-spine flathead were much less abundant and school whiting were not recorded. Some species were only recorded in the North Sand Control. Those of most notable abundance were snapper (*Pagrus auratus*) and silver trevally (*Pseudocaranx dentex*). Some other species not normally associated with sand habitat were also recorded in the North Sand Control including the red rock cod, sergeant baker, old wife (*Enoplosus armatus*), maori wrasse (*Ophthalmolepis lineolata*) and the leatherjackets *Meuschenia flavolineata* and *Meuschenia scaber*. These differences between the North Sand Control and the other two locations were apparent in the MDS plot (Figure 3) and from ANOSIM (Table 5). SIMPER ranked school whiting, snapper, long-spine flathead and silver trevally as the top four species contributing to these differences (Table 6).

3.2.2.2 Reef Locations

In total, 47 species representing 28 families were recorded in reef habitat (Table 4b). This included eight species of sharks or rays and two species of cephalopods. The species recorded were a mixture of benthic, demersal and pelagic reef species common to the region. Chondrichthys were observed mostly in the southern reef locations. Only one species of chondrichthys (the eagle ray *Myliobatis australis*) was recorded at the North Reef Near location and none were recorded at the North Reef Far location. Cephalopods were rare, with one southern calamari (*Sepioteuthis australis*) observed at the North Reef Near location and one giant cuttlefish (*Sepia apama*) at the South Reef Near location.

Yellowtail was the most abundant species observed at all of the reef locations. Maori wrasse was the second most abundant at locations apart from the North Reef Near location where it was the fourth most abundant. Other species of notable abundance at one or more locations were moray eels (*Gymnothorax prasinus*), longfin pike, hula fish (*Trachinops taeniatus*), silver trevally, snapper, sweep (*Scorpius lineolata*), one-spot puller (*Chromis hypsilepis*) and blue morwong (*Nemadactylus douglasi*). The mean maximum number of all other species observed at locations was less than 1.5.

The number of species observed at the North Reef Far location (15 species) was much less than the others (ranging between 28 – 34). From the MDS plot (Figure 4), no clear separation between assemblages at locations was evident although ANOSIM results suggest a difference between the North Reef Far and South Reef Near locations (Table 7). SIMPER ranked maori wrasse, yellow-stripe leatherjacket (*Meuschenia flavolineata*), black-banded seaperch (*Hypoplectrodes annulatus*) and longfin pike as the four species contributing to these differences, although the contributions of each were very small (Table 8).

3.3 Discussion

Sand and reef locations surveyed supported fish assemblages typical of these habitats in the region (The Ecology Lab 2006). In addition, observations by staff of Cardno Ecology Lab who frequently dive in the region indicate that several species were recorded on BRUVS footage that are not usually observed while SCUBA diving. These include large, active species such as snapper, squid and eagle rays and small cryptic species such as bullseyes and black-banded seaperch.

The results of the multivariate analyses showed some spatial variability (i.e. between locations) between the fish assemblages in sand and reef habitat. In the sand habitat, the placement location was different to one of the control locations. The main species contributing to this difference were school whiting, snapper, long-spine flathead and silver trevally. As most of

these species are highly mobile and have potential to school it is not surprising that patchiness at the scale of locations was detected. Similarly, assemblages at two of the reef locations (North Reef Far and South Reef Near) were different. In this case, the difference was not due to any particular species but rather a great difference in species richness between locations.

Overall the results indicate that the methodology used in this study has been successful in sampling a diverse range of fish species representative of sand and reef habitats around the area in which the Vessel is to be placed. The data collected provide some baseline information for the Long-term Management Plan and future research opportunities.

4 ASSESSMENT OF IMPACTS

4.1 Description of Proposal

The Vessel was a long-range escort frigate (Frigate Fast Guided Missile 7 Class), 138.1 m in length, with a beam of approximately 14 m, a displacement of 4100 tonnes and draft of approximately 7 m. Assuming no burial into the seabed or removal of masts or superstructure, the sunken Vessel's deck, superstructure, foremast and mainmast would extend approximately 12 m, 18 m, 24 m and 39 m respectively above the seabed. Preliminary advice from NSW Maritime recommends a depth clearance from the water surface of 6 m at lowest astronomical tide to allow for the navigational safety of vessels operating in the area. To achieve this clearance, part of the main mast of the Vessel was removed.

In preparing the ship for scuttling, it is understood that the following steps would include:

- Removal of all fuels, oils and greases (hydrocarbons) from the Vessel; removal of other hazardous materials including heavy metals, batteries, asbestos, PCBs, and paints containing heavy metals and other marine-hazardous material; cleaning the Vessel to the Department of Environment, Water, Heritage and the Arts (DEWHA) standards;
- Disposal of all hazardous materials in an environmentally safe manner, meeting relevant guidelines and statutory requirements;
- Removal of superstructure if required (see above);
- Design and implementation of ship modifications to produce a safe dive site, including cutting diver access holes into the sides of the hull, cutting holes in the floors and ceiling to allow extra vertical access between decks, cutting openings to allow light to penetrate, and sealing off areas where diver access would not be permitted for safety reasons;
- Making the ship safe as a dive site – e.g. by removing all machinery, cabling, insulation, non-structural partitions, hatches/doors, floatable material and other items that could create a diver hazard or entanglement, and all objects that could break loose during the scuttling process or over time and block access ways or compartments;
- Preparing the ship to the standard required for compliance with the *Environment Protection (Sea Dumping) Act 1981* and relevant guidelines and other statutory requirements, and in accordance with environmental and planning approvals for the project.

In addition, the design and implementation of the scuttling process is to address the following:

- The design of the scuttling process is to ensure the Vessel settles to the seabed with its structural integrity maintained, in an upright position in the correct location and orientation;
- The process to prepare the ship for scuttling will include cutting holes for air to escape during scuttling; ballasting and finally setting cutting charges to make further holes in the Vessel below the waterline so that water floods the hull and sinks the Vessel.
- The contractor engaged to prepare and scuttle the vessel would prepare a Scuttling Management Plan addressing issues such as security, management of the sinking area, danger area/cordon, warning signals, and protection of marine life during the scuttling process;
- After scuttling the ship, any debris would be retrieved and a post-sinking safety inspection would be undertaken by suitably qualified divers to confirm the safety and security of the Vessel on the seabed; and

- A navigation/marker buoy would be installed to mark the location of the Vessel to the requirements of NSW Maritime.

4.2 Predicted Effects on Habitat, Flora and Fauna

4.2.1 The Placement Area

4.2.1.1 Soft Bottom Areas

The soft sediment habitat and associated fauna located directly beneath the ship would be smothered by the Vessel, hence there would be a localised loss of sandy habitat and associated fauna equivalent to the area of the footprint of the ship. In terms of the impact at a regional scale, the severity would be dependent on how unique the habitat and fauna of the placement location are in relation to surrounding areas. For example, if the habitat and fauna were typical of sandy sediments in the region then a localised loss would be negligible at a regional scale. On the other hand, if the habitat and associated fauna were unique within the region there would be greater environmental consequence.

Sandy sediment habitats occur elsewhere in the region and surveys of fish indicated that assemblages were typical of others nearby. The direct loss of sandy habitat and fish from placement of the ship is small and equates to a negligible loss overall in the region.

In addition to direct impacts to habitat and biota occurring as a consequence of being covered by the ship, assemblages of fauna near the Vessel would potentially be changed because reefs (in this case the Vessel) are known to alter assemblages in adjacent soft sediment (Section 2.1.1.4). Feeding halo effects of reefs can be confined to areas very close to a reef (within a few metres) or extend over a much larger area and may depend on the size of the reef and/or the trophic structure of fish on the reef. For example, if the ship were colonised by many fish that fed on infauna or preyed on fishes living on sand, the size of the feeding halo may be much greater than if the ship were colonised by very few of these fish.

There would also be potential for contamination of adjacent soft sediment from corrosion of the hull and superstructure. Most heavy metals would have little effect on species or food chains, even at elevated levels. However, water, sediment and bioaccumulation monitoring would be undertaken to identify any contamination issues that required further investigation. The monitoring program (included in the Long-term Management Plan) would be in accordance with relevant guidelines and to the satisfaction of DEWHA.

4.2.1.2 Superstructure of the Ex-HMAS ADELAIDE

The superstructure of the Vessel would provide a surface for settlement of many species of invertebrates and algae. Based on studies of Ex-HMAS BRISBANE (Section 2.1.1.4), colonisation by algae and sessile invertebrates would be relatively fast with filamentous and foliose algae, limpets, barnacles and hydroids most likely appearing within the first three months of deployment. Colonisation by sponges, ascidians, polychaete worms and soft corals would soon follow. Mobile invertebrates (e.g. cuttlefish and octopus) would also colonise the reef. As was observed for the Ex-HMAS SWAN, assemblages may change with the seasons with some taxa (e.g. algae) being more common in summer months and on upper surfaces (Section 2.1.1.4). Surveys of Ex-HMAS SWAN also found sessile groups such as sponges, ascidians, anemones and soft corals to proliferate on the shaded portions of the Vessel.

However, there would be some potential for the habitat created by the superstructure of the ship to provide new structure for the settlement and establishment of introduced species. The risk of colonisation, however, would be no more than for any natural rocky reef that had been scoured of old growth by a storm or from sand. While many of the species with potential to settle on the

ship are non-invasive (Section 2.3, Table 2) there are some that could compete for food and space and exclude native species and potentially interfere with nutrient cycles. Further, if introduced species became established on the ship they may propagate within the area. It is not known whether new surfaces would increase the chances of settlement for these species but some monitoring and procedures for control should be considered in the Long-Term Monitoring Plan.

It is known from the placement of other artificial reefs that reef and pelagic fish can be attracted to them for various reasons (Sections 2.1.1.5 and 2.1.2.3). There would be a limit (carrying capacity) to the diversity and abundance of fish attracted to the Vessel and this is also likely to change through time as environmental conditions change. Monitoring of the fish community on the Ex-HMAS SWAN over a two year period after it was scuttled showed an average increase in richness from 2 to 32 species with a shift from omnivorous weed / sand fishes to one dominated by planktivorous and carnivorous reef fishes (Morrison 2001). Similar to other sunken vessels, the Ex-HMAS ADELAIDE would most likely attract some of the large species that were observed in the video surveys on nearby reefs. As has been the case for other sunken vessels, however, the community composition on the Vessel is likely to be distinctly different from nearby reefs.

There is potential for some epibiota and egg cases of invertebrates and fish to experience metal toxicity if attached to the ship. Lethal effects to damselfish larvae attached to metal surfaces have been observed overseas (Kerr 1996) but there have been no reports of such effects to assemblages associated with sunken vessels in Australia. Nevertheless, potential toxic effects should be considered when monitoring.

4.2.2 Rocky Reef Areas

The origin of fish attracted to artificial reefs often is not precisely known, or whether possible attraction from natural reefs causes noticeable depletions to those source reefs. The least potential for impact would be if fish were to come from many reefs as sourcing would most likely be spread over a great area. A greater potential for impact would be if fish were attracted from a small number of reefs (e.g. those closest to the artificial reef) because many fish could be sourced from a single reef. Another potential impact to populations on nearby reefs could occur if predators and prey items were attracted to the ship and prey items had a greater vulnerability there.

Mapping of habitats indicated that reef is widespread in the region. The fish survey indicated that assemblages of fish on reefs nearby the placement location are typical of those in the region. Hence, even if depletions of some species on nearby reefs were to occur, a localised loss would equate to a negligible loss to the region. Further, with no fishing permitted on the Vessel, it is possible that natural recruitment and movement of fish would replenish natural populations over time in any depleted reefs.

4.2.3 The Pelagic Environment

As discussed in Section 2.1.2.3, if concentrations of plankton were to occur in small eddies around the structure in the lee of ocean currents. Such concentrations would be localised and affect only a minute fraction of regional populations. They would also attract planktivorous fishes and their predators to the Vessel. Increased diversity and abundance of fish at the Vessel would be attractive to recreational divers.

4.3 Threatened or Protected Species and Areas of Conservation Significance

Some threatened or protected species occur on reefs close to the proposed location of the Vessel (e.g. grey nurse sharks), and would forage in the proposed location prior to and following scuttling. Thus, the Vessel would potentially provide new foraging and sheltering habitat for such species.

4.4 Commercial and Recreational Fishing

Some commercial (purse seining or handlining for yellowtail, slimy mackerel etc., trawling) and recreational (drifting for flathead) fishing activity would potentially be excluded from a small area around the Vessel. Trawler operators advised that they would need approximately 300 m between the southern reef and the Vessel for their trawl shot out from Avoca Beach. Not taking into account an exclusion zone, there is about 400 m between the southern reef and the proposed scuttling site.

In addition, attraction of fish to the Vessel could cause depletions of targeted species on nearby reefs. As discussed in Section 4.2.2, if depletions of some species on nearby reefs were to occur, a localised loss would be negligible given that the local assemblages of fish are well-represented in other parts of the region. Further, it is likely that, over time, natural recruitment and movement of fish would replenish natural populations in any depleted reefs.

On the other hand, there is potential that the Vessel may increase overall production of reef fishes in the region. It is feasible that the new habitat created by the ship would increase the carrying capacity of the region and species would recruit to the Vessel. Although fishers would have no direct access to the Vessel itself, some fish would become available to fishers when they move away from the ship.

Given that there are many similar areas nearby where these fishing activities could, and do occur, fishers would not be greatly disadvantaged by the proposal. However, the fishing requirements of trawlers should be considered when planning the size and allowable uses within the Ex-HMAS ADELAIDE Reserve.

5 RECOMMENDATIONS AND SAFEGUARDES

Subject to approval of the proposal, an Environmental Management Plan (EMP) and/or Scuttling Plan will be prepared by the scuttling contractor. Measures should be incorporated into such a plan to safeguard against potential impacts of scuttling, where they have been identified, on biota, benthic habitats, threatened or protected species and commercial and recreational fishing. These would include:

- All care to be taken in managing the potential for spills from vessels assisting with scuttling the Vessel and search and recovery of any dislodged material made.
- A procedure for minimising the potential disturbance to marine mammals during scuttling, particularly migrating cetaceans, for stopping or scaling down noisy activities when marine mammals are approaching the area of operation. Firing charges to cut holes in the hull should not occur when marine mammals are near. Many species of dolphins, seals and small whales could potentially encroach upon the area at any time. Humpback whales may come close to shore in their northward migration in early May – July and with calves from late September – early December. Southern right whales have potential to rest and calve in Bulbararing Bay in winter.
- Contacting commercial fishermen currently operating, or with potential to operate, in or nearby the placement location to notify as to when scuttling would be occurring so that fishing gear (particularly fish traps) is not damaged by, or gets entangled with large vessels. The local DPI office would be able to provide a list of fishermen currently operating, or with potential to operate, in the area at the time of scuttling.

The Long-Term Management Plan for the dive site should include the following measures to safeguard against potential impacts that could occur after the Vessel is scuttled:

- As the ship may be colonised by introduced species, a process for identifying any pest species and for their removal should be considered.
- Monitoring for elevated levels of appropriate heavy metals (in sediment and biota) should be done until levels in the sediment stabilise or dissipate and, where appropriate, a process for their removal should be considered.

6 ACKNOWLEDGEMENTS

This report was written by Dr Craig Blount and reviewed by Dr Marcus Lincoln Smith. Craig Blount, Rick Johnson and Steve Lindfield (University of Newcastle) undertook field work. Craig Blount prepared the tables, figures and maps and did statistical analyses.

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TABLES

Table 1. List of scheduled marine species and populations listed under the *Fisheries Management (FM) Act*, *Threatened Species Conservation (TSC) Act* and the *Environment Protection and Biodiversity Conservation (EPBC) Act* where species or species habitat may occur within the area of the proposal.

Table 2. Introduced species with potential to colonise the Ex-HMAS ADELAIDE.

Table 3. Sampling details for the first baseline survey of fish assemblages

Table 4. Mean maximum number (MaxNum) and standard error (S.E.) of species recorded at each location during the first baseline survey.

Table 5. One-way ANOSIM comparing assemblages among locations on sand.

Table 6. SIMPER results from sand locations indicating the species that contributed most to the dissimilarity between locations where significant differences were determined from ANOSIM.

Table 7. One-way ANOSIM comparing assemblages among locations on reef.

Table 8. SIMPER results from reef locations indicating the species that contributed most to the dissimilarity between locations where significant differences were determined from ANOSIM.

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Table 1. List of scheduled marine species and populations listed under the *Fisheries Management (FM) Act*, *Threatened Species Conservation (TSC) Act* and the *Environment Protection and Biodiversity Conservation (EPBC) Act* where species or species habitat may occur within the study area. CE = critically endangered, E = endangered, V = vulnerable. M = migratory, L = listed, Cet = cetacean and P = protected. Relevance to the proposal in this preliminary assessment is indicated by High, Mod (Moderate), Low or negligible (Neg).

Scheduled Species:	Common name	Status under TSC /FM/NP&W Acts	Status under EPBC Act	Relevance to the Proposal
Marine Reptiles				
<i>Caretta caretta</i>	Loggerhead turtle	E	E, M, L	Mod
<i>Chelonia mydas</i>	Green turtle	V	V, M, L	Mod
<i>Dermochelys coriacea</i>	Leathery turtle	V	V, M, L	Mod
<i>Eretmochelys imbricata</i>	Hawksbill turtle	V	V, M, L	Mod
<i>Pelamis platurus</i>	Yellow-bellied sea snake		L	Low
Marine Mammals				
<i>Eubalaena australis</i>	Southern right whale	V	E, M	Low
<i>Megaptera novaeangliae</i>	Humpback whale	V	V, M	Low
<i>Arctocephalus pusillus doriferu</i>	Australian fur-seal	V	L	Low
<i>Arctocephalus forsteri</i>	New Zealand fur-seal	V	L	Low
<i>Hydrurga leptonyx</i>	Leopard seal	P	L	Low
<i>Balaenoptera acutorostrata</i>	Dwarf minke whale	P	M	Low
<i>Dugong dugon</i>	Dugong	E	M	Neg
<i>Balaenoptera edeni</i>	Bryde's whale	P	M	Low
<i>Caperea marginata</i>	Pygmy right whale	P	M	Low
<i>Orcinus orca</i>	Killer whale	P	M	Low
<i>Lagenarhynchus obscurus</i>	Dusky dolphin	P	M	Low
<i>Delphinus delphis</i>	Common dolphin	P	Cetacean	Low
<i>Grampus griseus</i>	Risso's dolphin, Grampus	P	Cetacean	Low
<i>Stenella attenuata</i>	Spotted dolphin, Pantropical spotted	P	Cetacean	Low
<i>Tursiops aduncus</i>	Indian ocean bottlenose dolphin	P	Cetacean	Low
<i>Tursiops truncatus s. str.</i>	Bottlenose dolphin	P	Cetacean	Low
Fish				
East coast population of <i>Carcharias taurus</i>	Grey nurse shark	E	CE	Mod
<i>Carcharodon carcharias</i>	Great white shark	V	V, M	Low
<i>Pristis zijsron</i>	Green sawfish	E	V	Neg
<i>Rhincodon typus</i>	Whale shark		V, M	Neg
<i>Epinephelus daemeli</i>	Black cod	V		Mod
<i>Epinephelus coioides</i>	Estuary cod	P		Mod
<i>Epinephelus lanceolatus</i>	Queensland groper	P		Mod
<i>Anampses elegans</i>	Elegant wrasse	P		Mod
<i>Paraplesiops bleekeri</i>	Eastern blue devil	P		Mod
<i>Chaetodontoplus ballinae</i>	Ballina angelfish	P		Mod
	Seadragons and pipefish	P (21 spp.)	L (21 spp.)	Mod
Birds				
	Marine birds	V (10 spp.), (31 spp.), E (2 spp.)	P V (9), E (1), M(19), L (27)	Neg

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Table 2. Introduced species with potential to colonise the Ex-HMAS Adelaide (Source: NIMPIS database).

Phyla	Class	Species	Common name	Description	Potential Impact
ALGAE					
Chlorophyta	Chlorophyceae	<i>Codium fragile ssp tomentosoides</i>	-	<i>Codium fragile ssp. tomentosoides</i> is a large, dark green macroalga with one to several, thick upright branches arising from broad, spongy, basal disc attached to the substrata. The dichotomous branches are usually 3-10mm in diameter and 15-20cm high but have been recorded reaching 1m in length.	<i>Codium fragile ssp. tomentosoides</i> is regarded as a pest because of its invasive capabilities and its reported impacts on shellfish farms in the northwest Atlantic. It is recorded as preventing the re-establishment of native algal species in New Zealand but can not competitively exclude them. In Australia it is reported to settle on native algae and shellfish and to foul commercial fishing nets. In some areas large wracks of the algae accumulate and rot on beaches after storms.
FISH					
Chordata	Osteichthyes	<i>Tridentiger trigonocephalus</i>	Trident goby	<i>Tridentiger trigonocephalus</i> is a goby with white speckles on its head and is grey-brown colour with two characteristic black stripes. This species is found in estuaries and rocky reef areas.	<i>T. trigonocephalus</i> has specific habitat requirements and it is therefore possible that it will compete with species sharing their preferred habitat.

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Table 2. (continued)

Phyla	Class	Species	Common name	Description	Potential Impact
INVERTEBRATES					
Annelida	Polychaeta	<i>Sabella spallanzanii</i>	European fan worm	<i>Sabella spallanzanii</i> is a large tube dwelling worm with a crown of feeding tentacles formed in two layers. It is generally found in shallow subtidal areas between 1-30m depth, preferring harbours and embayments sheltered from direct wave action. It colonises both hard and soft substrata, often anchored to hard surfaces within the soft sediments. In Australia, the worm is usually found in harbours where it readily colonises man-made hard surfaces such as wharf piles and facings, channel markers, marina piles and pontoons, and submerged wrecks.	There has been little work done on the possible impacts of <i>S. spallanzanii</i> on marine systems. There is some evidence to suggest that dense beds of <i>S. spallanzanii</i> may intercept settling organic material and thus interfere with nutrient cycles. Experiments have shown that recruitment of some species to settlement panels is reduced under <i>S. spallanzanii</i> canopies, however no species were excluded all together in areas with <i>S. spallanzanii</i> . Tubes of <i>S. spallanzanii</i> support a rich epifauna that would not otherwise occur in Corio Bay (Victoria) and Cockburn Sound (WA). At high densities, it may impact other filter feeding organisms.
Arthropoda	Crustacea	<i>Megabalanus rosa</i>	Acorn barnacle	<i>Megabalanus rosa</i> has a smooth, pinkish red coloured shell, which is occasionally white. It grows to no more than 50mm in height.	Unknown
Arthropoda	Crustacea	<i>Megabalanus tintinnabulum</i>	Acorn barnacle	<i>Megabalanus tintinnabulum</i> is a medium sized barnacle, growing to a height of 50mm and having a diameter of about 65mm. It is often striped and ribbed longitudinally along the shell, which is a pinkish-white to pinkish-purple in colour.	<i>M. tintinnabulum</i> is a cosmopolitan fouling species, and one of the most common species of barnacle found fouling vessels.
Arthropoda	Crustacea	<i>Monocorophium sextonae</i>	Corophiid amphipod	<i>Corophium sextonae</i> is a dorso-ventrally flattened amphipod. It is whitish grey, with two dark bars across each segment, antennae and head.	Fouls surfaces such as harbour pylons, rafts and buoys by building mud tubes. Can reach high abundances on sediments or where silt and detritus accumulate among fouling communities.

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