FINAL REPORT

Artificial Reefs – Design and Monitoring Standards Workshops

John Diplock
Principal Investigator

Project No. 2010/400

Australian Government

Fisheries Research and Development Corporation

2010/400	Artificial Reefs - Design and Monitoring Standards Workshops

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Introduction

This report summarises the outputs of a series of meetings of researchers, fisheries managers and stakeholders held in early 2011to determine the status of artificial reef developments around Australia and to seek consensus on a draft set of principles to guide the future development of artificial reefs.

Since 2001 there has been renewed interest in artificial reefs with a number of programs in place in the eastern states and the Northern Territory, and considerable interest in WA and the other states. There was a general recognition that artificial reefs were here to stay in Australia and that progress in deployment was advancing very quickly in some places. At the same time it appeared that agencies responsible for deployment in each state were facing similar obstacles and there was merit in exchanging ideas. The Australian Fisheries Management Forum therefore supported a national approach.

Non-Technical Summary

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Objectives

1. an up to date status report on the development of artificial reefs in Australia
2. a discussion of the relative merits of artificial reef designs, construction materials and monitoring techniques
3. a consensus on desirable and undesirable features and methods
4. guidelines on designs, materials and monitoring to assist decision makers

Outcomes Achieved To Date

The workshops provided a better understanding of the status of artificial reefs across Australia by providing a description of the designs, materials and methods currently in use, proposed future developments, research methodologies and government policies.

The workshops brought together for the first time managers, researchers and stakeholders interested in artificial reefs and provided the basis for an informed network that will result in better designed, constructed and monitored artificial reefs across Australia that will avoid mistakes made here and elsewhere.

KEYWORDS: artificial reef

Acknowledgements

The author acknowledges the support of the Australian Fisheries Management Forum in initiating the project, and Fisheries Victoria, Recfishwest and the

Queensland Department of Environment and Resource Management for the provision of meeting venues and logistical support.

Background

Artificial reefs are used in more than 50 countries around the world for purposes including enhanced fish and other seafood production, ecosystem recovery, modification of coastal processes and as offsets for reduced access or destruction of fishing grounds. This report focuses on artificial reefs as man-made structures deployed to improve fishing. Warships and other vessels sunk to provide dive sites are not covered in this report.

Artificial reefs have a long history in Australia. In 1992 the Bureau of Rural Resources produced a comprehensive review of the early work[1]. The report noted that artificial reefs had been used in aboriginal aquaculture for thousands of years, but that the construction of "modern" reefs only really started in the 1960s. It listed 72 artificial reefs - 23 in South Australia, 16 in New South Wales, 10 in Queensland, 10 in Victoria, 6 in the Northern Territory, 5 in Western Australia and 2 in Tasmania. The majority (29) of the reefs were constructed of tyres, 22 were sunken vessels and the remainder were made of concrete rock and other materials. Interestingly in New South Wales and South Australia the government fisheries agencies responsible for deploying most of the reefs, with fishing clubs responsible for the remainder.

In March 2001 a comprehensive review of artificial reefs was conducted in Victoria[2]. covering advances around the world and summarising progress in Australia. By that time there were at least 106 purpose-built artificial reefs around Australia. Most of the reefs were still made of tyres (37%) or ships (22%), and only 6% were made of concrete.

Since then there has been no further review of artificial reefs conducted in Australia.

Need

Interest in artificial reefs is growing in Australia, with recently initiated programs in New South Wales, Queensland and Victoria. These have been mostly pilot projects using available basic designs and materails for research purposes or the dumping of materials of opportunity (junk).

However, the progression to dedicated and effective fisheries enhancement programs using artificial reefs has proved difficult. While environmental impact assessment has been extremely costly and time consuming for some jurisdictions, the more fundamental problem of lack of demonstrably effective and appropriate reef designs remains.

In many countries the use of materials of opportunity is now discouraged or even banned, and many require all artificial reef modules to be purpose designed and built to prescribed engineering standards. Korea requires all new artificial reef modules to be

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[1] Kerr, S. (1992). Artificial Reefs in Australia: Their Construction, Location and Function. Bureau of Rural Resources Working Paper No. WP/8/92.

[2] Coutin, P. (2001). Artificial Reefs – Applications in Victoria from a literature review. Marine and Freshwater Resources Institute Report No. 31 (Marine and Freshwater Resources Institute: Queenscliff).

tested and monitored for two years before government assessment determines whether they can be deployed in public waters.

At this time in Australia there are no standards or guidelines to assist in determining appropriate designs or materials for artificial reefs, and no agreed basic research and monitoring requirements to allow their effectiveness to be determined. Without these basic tools we run the risk of duplicating the years of trial and error, sub-optimal performance and possibly failure that plagued some countries, and drove others to introduce their present regulatory schemes.

Objectives

1. an up to date status report on the development of artificial reefs in Australia
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Methods

Workshops were held in Melbourne (25 March 2011), Perth (7 April 2011) and Brisbane (12 May 2011) to bring together people involved or interested in artificial reefs to provide a status report on progress to date, and to assist in the drafting of guidelines to assist future artificial reef developments. The project received strong support from stakeholders and government agencies. A list of attendees for each meeting is attached. Each meeting consisted of 2 parts. The first was a series of presentations by researchers, fisheries managers and stakeholders detailing the status of artificial reefs in their region. The list of meeting attendees is provided in Appendix I. The Status Report is provided in the Conclusions section.

The second component was a workshop examining the major issues affecting the development of artificial reef programs in Australia at the present time. The workshop sessions addressed key management issues related to the merits of artificial reef design, construction materials and monitoring techniques, and discussed desirable and undesirable features and methods. There was general support for the preparation of draft guidelines based on the information provided in the status reports and the discussions in the workshop session. The draft guidelines distilled from these deliberations are presented in the Conclusion section.

Benefits and adoption

The main beneficiaries of the meetings were:

- managers and administrators responsible for artificial reefs being exposed to "state of the art" designs and construction processes
- managers and administrators responsible for artificial reef programs who can consequently make more informed decisions

- researchers who gained exposure to new techniques and can now apply comparable methodologies
- stakeholders who gained a better understanding of the merits of different designs and the availability of more cost effective artificial reefs
- funders who will be better placed to decide on the merits of designs and research
- approving agencies who seek to apply best practice applied in artificial reef design, construction and deployment

Further Developments

New South Wales and Victoria have on-going artificial reef programs with plans to expand with both near-shore and oceanic projects. The Queensland government will continue to augment existing reefs with purpose built and materials of opportunity. The WA government has committed approximately $1.8 million for the inaugural artificial reef project in that state, and there is growing interest from resource companies in WA and Qld in using artificial reefs as offsets for reductions in angler access and amenity caused by infrastructure developments. The NT government intends to continue the use of materials of opportunity for artificial reefs as the opportunity arises. There is strong interest in SA from recreational fishing groups and the peak body to change the current government policy opposing artificial reefs.

It is anticipated that the Status Report on Artificial Reefs in Australia will be updated at regular time intervals.

The draft guidelines will be considered by AFMF with a view to being endorsed as a nationally agreed set of guidelines to facilitate future developments.

Planned Outcomes

The Status Report will be available to interested parties through FRDC.

The Draft Guidelines are considered to be a "living document" to be amended and improved over time. They will be considered by the Australian Fisheries Management Forum.

The network of parties interested in artificial reefs will provide a valuable forum for the exchange of ideas and information into the future and may provide the basis for a more structured reference group.

Conclusions

The Status Report on Artificial Reefs is provided in Appendix II.
The Draft Guidelines for Artificial Reefs in Australia is provided in Appendix III.

References

Couton, P. (2001). Artificial Reefs – Applications in Victoria from a literature review. Marine and Freshwater Resources Institute Report No. 31 (Marine and Freshwater Resources Institute: Queenscliff).

Kerr, S. (1992). Artificial Reefs in Australia: Their Construction, Location and Function. Bureau of Rural Resources Working Paper No. WP/8/92.

Appendix I Meeting Attendees

Melbourne
25/03/11

Bill Lussier	Fisheries Victoria
Brenton Schahinger	SARFAC
Michael Lowry	NSW Industry & Investment
Dan Grixti	Fisheries Victoria
David Kramer	Futurefish Foundation
David Lennon	Reefball Australia
Franz Grasser	VRFish
John Hotchin	VRFish
Kade Mills	Fisheries Victoria
Keith Rowling	Primary Industries and Resources South Australia
Mark Nikolai	Tasmanian Association for Recreational Fishing Inc
Paul Hamer	Fisheries Victoria
Rod Pearn	DPIPWE Tasmania
Ryan Paik	Haejoo Pty ltd
Trevor Buck	VRFish
Trevor Watts	South Australian Recreational Fishing Advisory Council

Perth 7/04/11

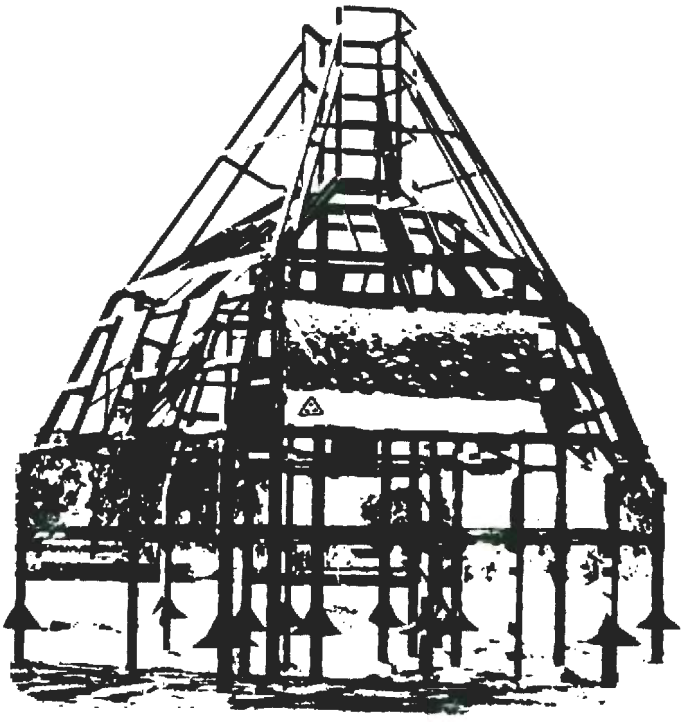
Alex Hesp	Centre for Fish and Fisheries Research Murdoch University
Andrew Matthews	WA Fisheries
Andrew Rowland	Recfishwest
Arani Chandrapavan	WA Department of Fisheries
Ash Fowler	University of Technology Sydney
Belinda Fox	BHP Billiton Iron Ore, Port Hedland
Brad Adams	Two Oceans Abalone Ltd
Brett Molony	WA Fisheries WA Fisheries and Marine Research Lab.
Eve Bunbury	WA Fisheries
Greg Jenkins	Australian Centre for Applied Aquaculture Research
Guy Kestel	888 Abalone Pty Ltd
Ian Sewell	The Western Australian Fishing Magazine
Ian Stagles	West Australian Fish Foundation
Kane Moyle	Recfishwest
Nathan Harrison	WA Department of Fisheries
Neil Loneragan	Centre for Fish and Fisheries Research Murdoch University
Neil McGuffie	WA Fishing Indutry Council
Ryan Paik	Haejoo Pty Ltd
Stuart Smith	WA Department of Fisheries
Tim Nicholas	Minister for Mines and Petroleum; Fisheries; Electoral Affairs

Brisbane 12/05/11

Bill Sawynock	Infofish Australia
Brian Kirkby	QGFA
Heath Folpp	NSW Industry & Investment
Jim Higgs	Qld Department of Environment and Resource Management
John Johnston	SUNFISH Queensland Inc.
Judy Lynne	SUNFISH Queensland Inc.
Julian Pepperell	Pepperell Research
Malcolm Poole	Recreational Fishing Alliance
Max Castle	NSW Advisory Council on Recreational Fishing
Michael Lowry	NSW Industry & Investment
Nicola Udy	Qld Department of Environment and Resource Management
Phil Hall	Northern Territory Fisheries
Phil Kliese	ECOfishers Qld
Ryan Paik	Haejoo Pty Ltd
Steve Hoseck	Queensland Parks & Wildlife Service
Thomas Kang	Haejoo Pty Ltd
Tony Ham	Dept. of Employment, Economic Development & Innovation
Warren de With	Amateur Fishermen's Association of NT

ARTIFICIAL REEFS IN AUSTRALIA STATUS REPORT
JUNE 2011

John Diplock
Hamata Pty Ltd



Australian Government

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BACKGROUND

This report summarises the outputs of a series of meetings of researchers, fisheries managers and stakeholders held in early 2011to determine the status of artificial reef developments around Australia and to seek consensus on a draft set of principles to guide the future development of artificial reefs.

Since 2001 there has been renewed interest in artificial reefs with a number of programs in place in the eastern states and the Northern Territory, and considerable interest in WA and the other states. There was a general recognition that artificial reefs were here to stay in Australia and that progress in deployment was advancing very quickly in some places. At the same time it appeared that agencies responsible for deployment in each state were facing similar obstacles and there was merit in exchanging ideas. The Australian Fisheries Management Forum supported a national approach and FRDC provided funding.

INTRODUCTION

Artificial reefs are used in more than 50 countries around the world for purposes including enhanced fish and other seafood production, ecosystem recovery, modification of coastal processes and as offsets for reduced access or destruction of fishing grounds. This report focuses on artificial reefs as man-made structures deployed to improve fishing. Warships and other vessels sunk to provide dive sites are not covered in this report.

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[4] Coutin, P. (2001). Artificial Reefs – Applications in Victoria from a literature review. Marine and Freshwater Resources Institute Report No. 31 (Marine and Freshwater Resources Institute: Queenscliff).

New South Wales

Estuarine Reef Deployment

In New South Wales the first documented artificial reef was a tyre reef sunk in Lake Macquarie in 1966 by NSW Fisheries. This was followed by more tyre reefs in Lake Macquarie, Port Stephens, Port Hacking and Batemans Bay during the period up until 1978. No formal monitoring of these reefs was conducted, but anecdotal reports indicate they were popular fishing spots until they eventually broke up or were covered with sediment.

Tyre modules assembled for deployment in Lake Macquarie NSW

From 1976 to 1992 12 vessels and concrete pontoons were scuttled in ocean waters off Long Reef north of Sydney Harbour. These wrecks are still fished today. Again, no scientific monitoring was conducted on these reefs, although divers and fishers reported large aggregations of fish. From 1992 the artificial reefs program was discontinued due to lack of funds.

A general recreational fishing licence was introduced into New South Wales in 2001 and funding was allocated to investigate the "concept" of design specific artificial reefs, and the construction of small pilot reefs. A dedicated scientific monitoring program was undertaken to investigate their effectiveness as a recreational fisheries enhancement tool. Using specially designed artificial reef concrete modules, 5 large artificial reefs with an average reef size of ~2500 m2 (~400m3) have been constructed since 2005 in five coastal estuaries (Lake Macquarie, Botany Bay, St Georges Basin, Lake Conjola and Merimbula Lake).

The *Meggol* sunk off Sydney NSW

The first deployment in Lake Macquarie was in December 2005, followed by Botany Bay in June 2006 and St Georges Basin in February 2007. This was followed by Lake Conjola in November 2008 and Merimbula Lake in May 2009. The reefs were instant successes in terms of fishing, and anglers across the state wanted the program expanded. Consequently the reef in Lake Macquarie was expanded in September 2009. The expansion of the Botany Bay reefs was completed in May 2011. The first stage of the St Georges Basin reef augmentation was completed in November 2010. The St Georges Basin Reef is scheduled for completion in August 2011 and will be the largest constructed to date, made up of over 40 individual reef patches covering an area of almost 5 hectares. In total more than 2,700 concrete modules have been deployed in NSW since 2005.

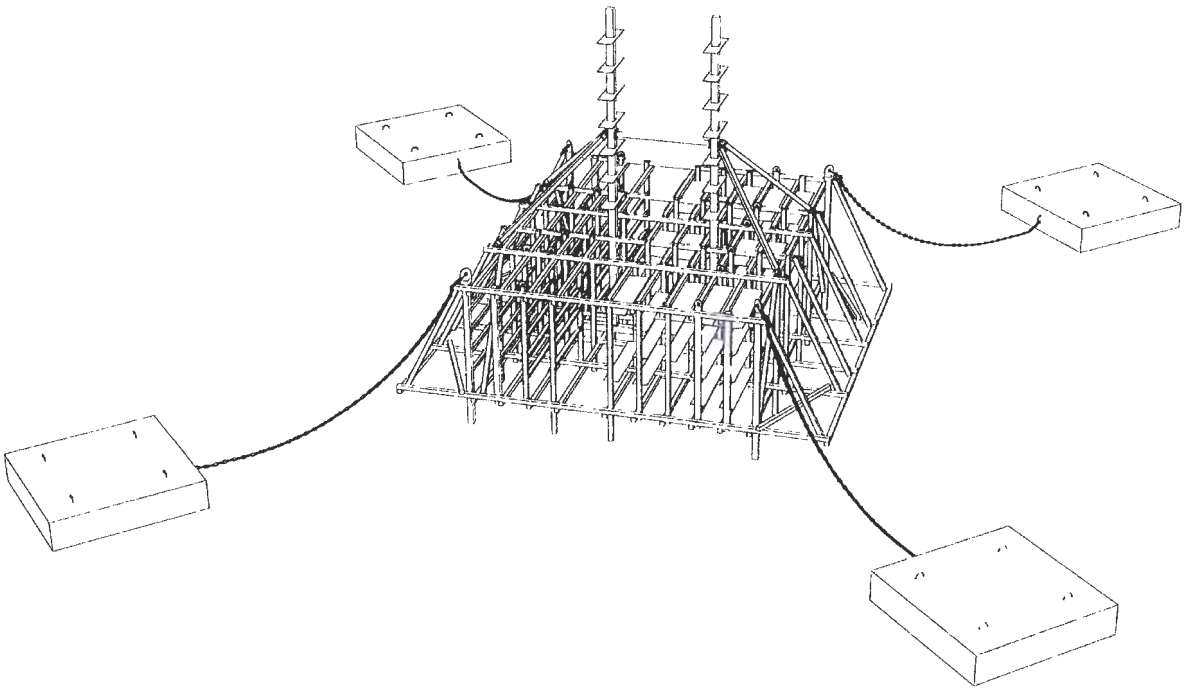
The approvals process for estuarine artificial reefs involved approval from relevant Government agencies for each location. An associated environmental assessment was undertaken by DPI and submitted to the relevant consenting authority. All artificial reef construction and research is funded using funds from the sale of the recreational fishing licence.

Reef ball 0.7m x 0.5m weighing approximately 80kg deployed in NSW

Offshore Reef Deployment

The NSW offshore artificial reef commenced in 2007 and fisheries management staff conducted a study tour of Korea and Japan funded by FRDC. They saw a wide diversity of designs and materials, and began to tap into the long history of research and development that underpins the large, ongoing artificial reef programs in those countries. Unlike New South Wales, Korea and Japan had continued to build their artificial reefs programs since the 1960s and Korea alone almost $80 million is spent on artificial reefs every year. As a result they have developed sophisticated concrete and steel designs suitable for deployment in enclosed and ocean waters. Korean artificial reef designs provided the basis for the offshore artificial reef program in New South Wales.

Korean steel artificial reef module



Indicative design for NSW offshore artificial reefs

In 2007, the DPI – Fisheries proposed to build a series of large offshore artificial reefs off 3 major metropolitan locations (namely Newcastle, Sydney and Wollongong). The approvals process for offshore artificial reef (OAR) proposal involved the completion of a preliminary environmental assessment (PER). The (OAR) proposal was deemed to be a Major Development under the New South Wales *Environmental Planning and Assessment Act 1979*. (EP&A Act) and consequently required a full Environmental Assessment (EA). The OAR proposal was determined to be a 'controlled action' under Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC) legislation and as such, required assessment of the project following the development of a detailed Public Environmental Report (PER). The draft EA/PER were completed in September 2009[5] and following an extensive consultation process. Final project approval was received in March 2011 (including the required Commonwealth *Environmental Protection (Sea Dumping) Act 1981* Permit and approval to disturb the sea bed in the vicinity of a Major Port issued by the Sydney Ports Authority). Other relevant legislation considered during the EA process included the Commonwealth *Historic Shipwrecks Act 1976;* the *NSW Threatened Species Conservation Act 1995; NSW Fisheries Management Act 1994; NSW Coastal Protection Act 1979 and the NSW Crowns Lands Act 1984.*

A detailed design of the OAR was completed in January 2010. The OAR unit is designed to last 30 years and withstand a 1/100 year storm which could generate wave heights of up to 18 m. The structure will be deployed in 38 m of water just south of the southern headland at the mouth of Sydney Harbour. The unit weighs approximately 42 mt, is 12 m high and 12 x 15 m wide with an internal volume of approximately 700 m^3. There is high complexity in the lower 4 m of the structure and

[5] http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/348861/OAR-Submissions-Report.pdf

two upper tower sections are designed to attract pelagic fish. The modules will be anchored to the seafloor at each corner to ensure stability. The Sydney reef will be built first and monitored for three years to determine the effectiveness prior to DPI building other reefs.

Other approval conditions include:

- a Construction Environmental Management Plan (CEMP) is to be provided prior to construction
- an Environmental Management Plan (EMP) must be submitted prior to construction
- prescribed detailed monitoring must be undertaken
- annual reports must be provided to the Department of Planning

Commonwealth approval conditions include:

- a site specific EMMP must be submitted to DEWHA prior to deployment providing details on deployment, post-placement monitoring and management, environmental monitoring, contingency measures, and reporting.

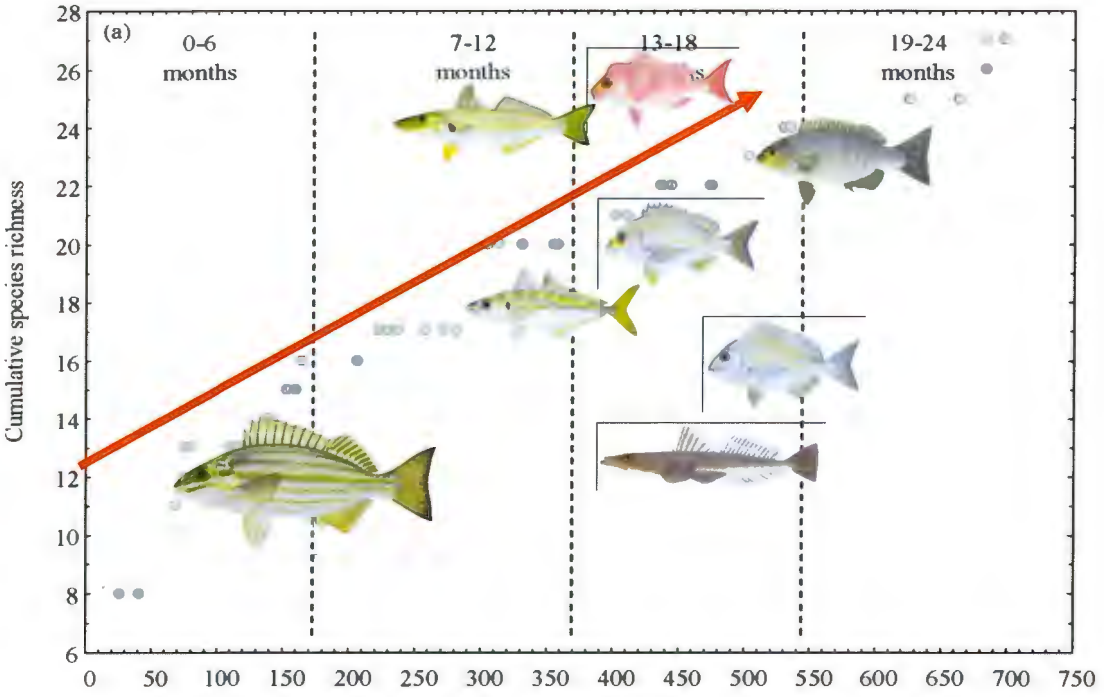
NSW Research

The monitoring program for estuarine artificial reefs compared natural (control site) reefs with the artificial reefs. The basic monitoring tools are:

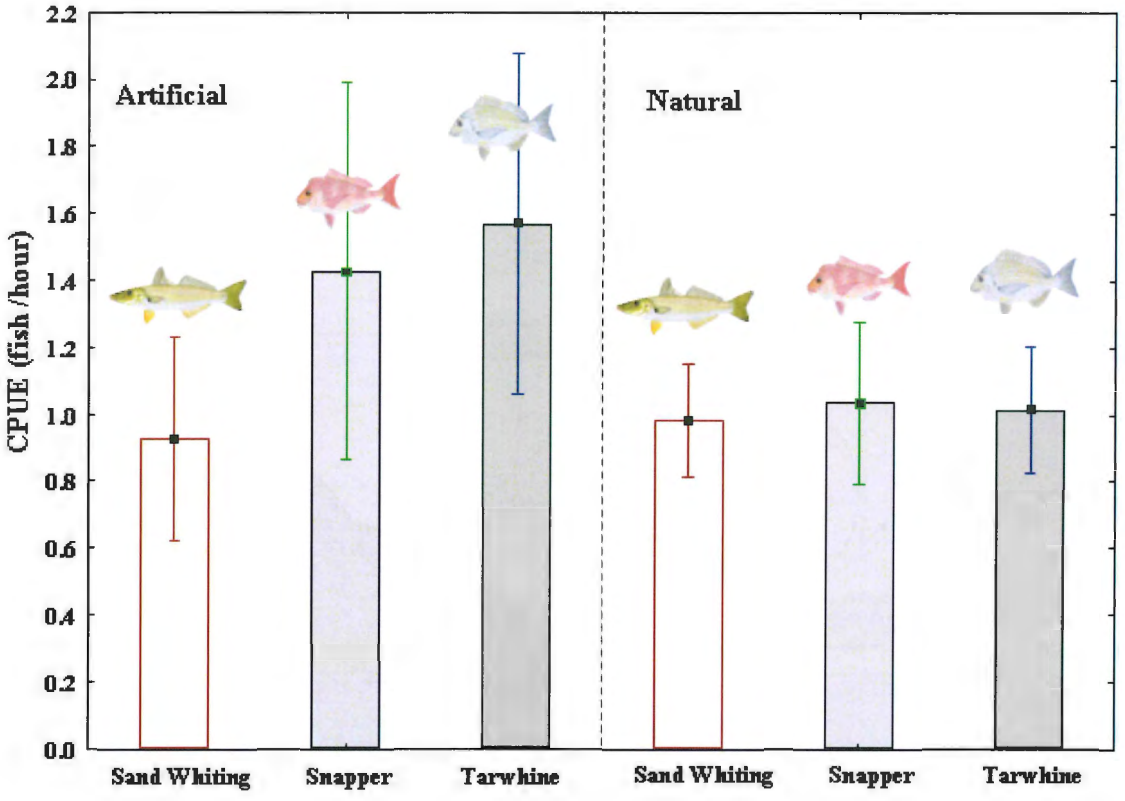
- baited underwater video
- diver surveys
- catch rate surveys
- photographic survey

Photographic survey Lake Macquarie NSW
(Courtesy of M. Lowry NSW I&I)

Baited underwater video
(Courtesy of M. Lowry NSW I&I)



Succession monitoring Lake Macquarie NSW 21 species in Yr 1.
(Courtesy of M. Lowry NSW I&I)



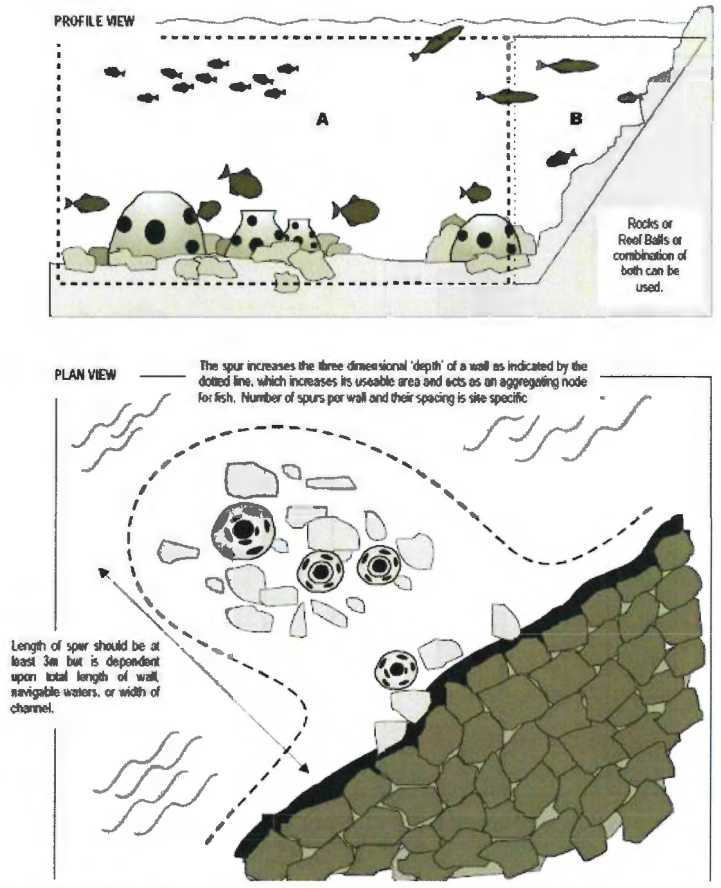
Catch rate monitoring Lake Macquarie NSW
(Courtesy of M. Lowry NSW I&I)

After more than 2 year the Lake Macquarie study found ongoing differences between the natural and artificial reef sites. This may be reflective of the fundamental differences in physical complexity between the systems.

Future Developments

The existing estuarine artificial reefs will be expanded and enhanced with larger concrete modules.

Constraints mapping has been completed for sites in Sydney Harbour and Pittwater. Deployment at the Pittwater site is scheduled for 2011/12. NSW Industry & Investment is currently examining the feasibility of deploying artificial reef modules along break walls to provide improved access for land based fishers.



Enhancement of existing and proposed artificial structures NSW
(Courtesy of M. Lowry NSW I&I)

Victoria

The trial of artificial reefs for recreational fishing enhancement in Victoria commenced in 2008 in Port Phillip Bay with the following objectives:

- Provide new fishing opportunities
- Assess the benefits of 'Recreational Fishing Reefs' to anglers
- Assess implications of 'Recreational Fishing Reefs' in Port Phillip Bay for fisheries management
- Assess effects of the 'Recreational Fishing Reefs' on local marine communities

The trial was designed as a scientific experiment, with comprehensive sampling of the artificial reef sites, and control reef and sediment sites, before and after the reefs were installed. The outcomes of the trial will be used to contribute to the development of guidelines and policy for the use of artificial reefs to enhance recreational fishing in Victoria and to highlight any management issues both in relation to fishery sustainability and the local environment. The experience gained form the pilot project

will be valuable for planning and design of future small-scale recreational fishing reef projects in Victoria.

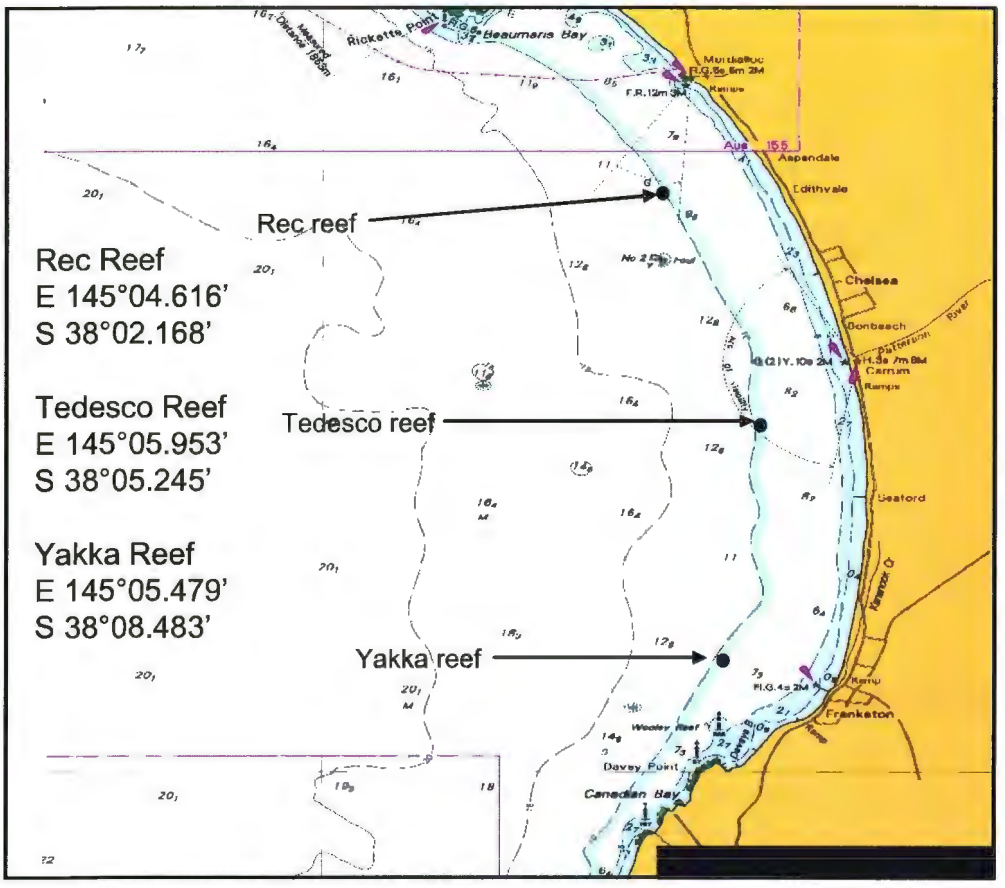
The trial was one component of Victoria's broader 'Enhanced Recreational Fishing Program'. The trial occurred over a three year period and involved three artificial reefs. The project budget was approximately $1 million. The trial was guided by an initial stakeholder forum and the formation of an inter-agency steering committee comprised of representatives of the Department of Primary Industry and Department of Sustainability and Environment (DSE). This was followed by a workshop with national and international artificial reef experts.

A timetable for deployment was set, and the reef locations, materials and reef design were determined. Constraint mapping was conducted to determine suitable locations in Port Philip Bay, and three sites were chosen on the north-east side of Port Phillip Bay on sandy substrate between two areas of inshore fringing natural reef (see figure below).

Consent for the reefs to be deployed was required under the *Coastal Management Act* administered by the Department of Sustainability and Environment (DSE) and a *Works Authority Permit* issued by the Port Manager – Parks Victoria. The monitoring program began in November 2008, with the reefs being deployed in May 2009. A 1 km buffer around each of the artificial reefs was closed to commercial fishing by a Fisheries Notice. A communications strategy was developed prior to deployment of the reefs.

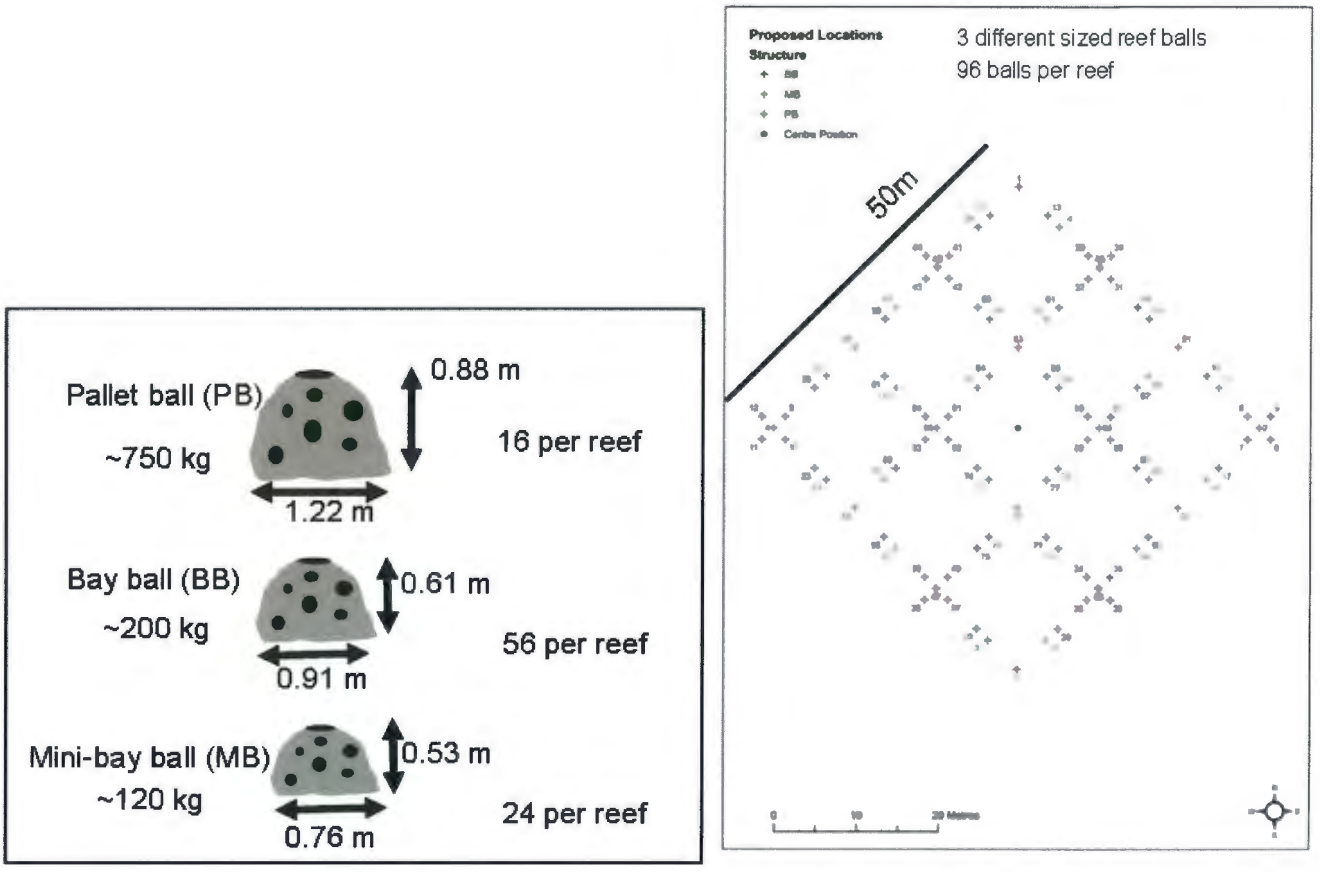
Reef balls were chosen for this trial because they were readily available, long-lasting, movable and removable, and had been tested elsewhere in similar environments with similar fish species.

The reef layout was designed with a focus on snapper, *Chrysophrys auratus*, the key recreational target species in Port Phillip Bay, and consisted of three different sized reef balls deployed in a grid pattern. Each Reef consists of 96 balls made up of 16 pallet balls, 56 Bay balls and 24 mini-bay balls (see figure below). Co-ordinates were provided for each reef ball and these were mapped into a DGPS plotter on the deployment vessel to assist with accurate deployment of each module.



Map of north-eastern Port Phillip Bay showing locations of the three trial artificial reefs with co-ordinates for the centre point of each reef.

Reef balls ready for deployment in Port Phillip Bay Victoria
(Photo courtesy of P. Hamer Fisheries Victoria)



Artificial reef modules (left) and reef layout (right) for the trial recreational fishing reefs in Port Phillip Bay Victoria

(Schematic courtesy of P. Hamer Fisheries Victoria)

Victorian Research

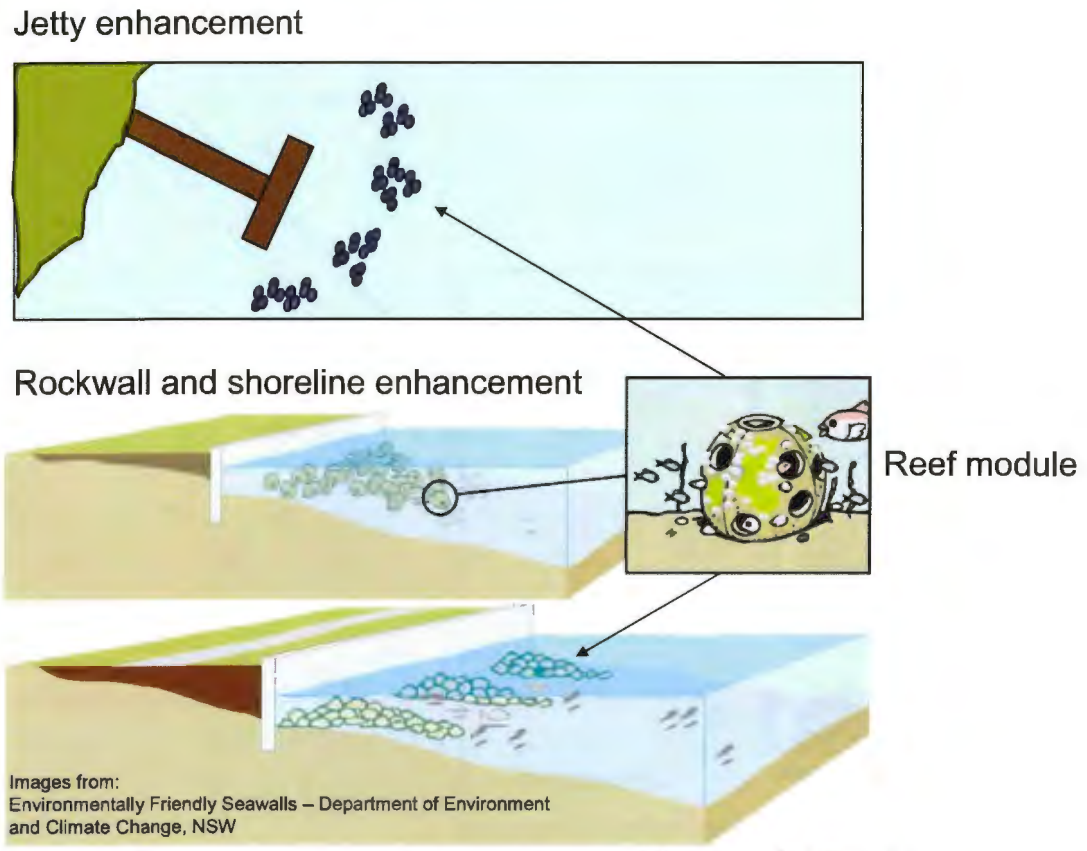
The monitoring and assessment employed a 'Before After Control Impact' design with three control sites on each of nearby sandy bottom and natural reef habitat. The program used a range of survey methodologies:

:

- Underwater visual census of fish, and macro-invertebrates, including exotics
- Baited underwater video (BUV)
- Structured research angler program to measure recreational catch rates
- Boat ramp survey to asses angler satisfaction and perceptions
- Photo-quadrats to assess development of fouling communities
- Assessments of rubbish, disturbance and resilience

Future Developments

The artificial reefs program is set to expand with funding from the Recreational Fishing Licence Trust in Victoria to trial the deployment of near-shore reefs close to piers and rockwalls to improve access for non-boating fishers (see figure below) This trial will also occur in Port Phillip Bay, with the reefs planned to be deployed in September 2011, subject to the relevant approvals be granted.



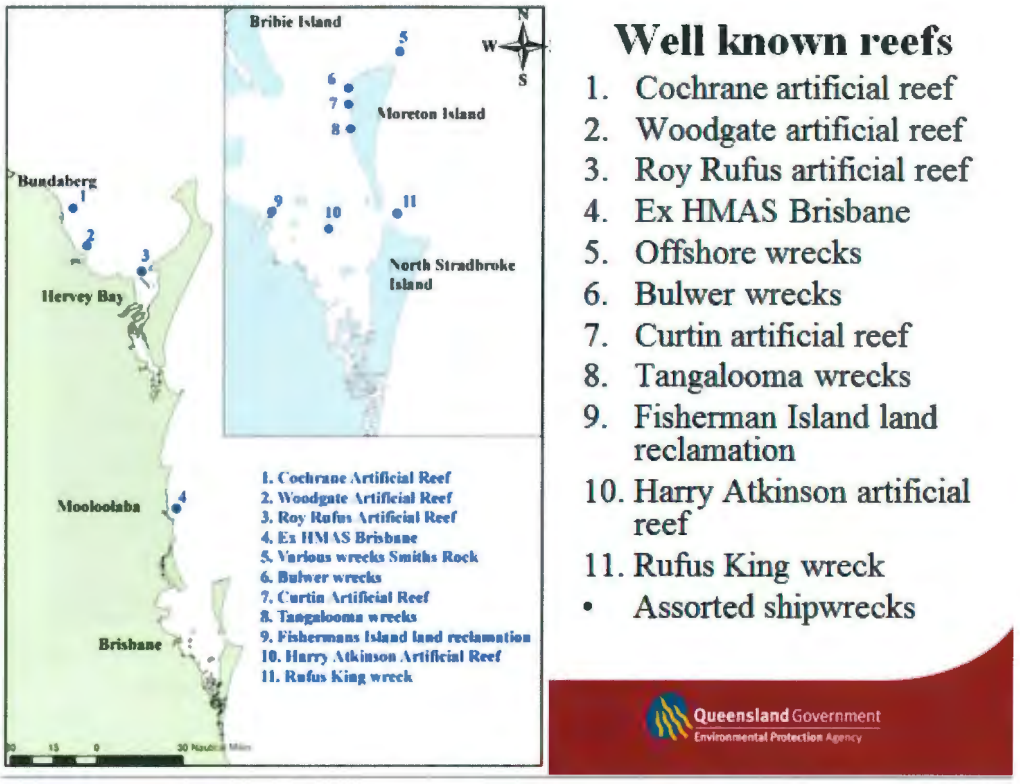
Proposed concept for near-shore artificial reefs Victoria

(Schematic courtesy of P. Hamer Fisheries Victoria, and Department of Environment and Climate Change, NSW)

Queensland

Southern Queensland is home to a number of substantial and long-standing artificial reefs. There are three in Hervey Bay and three in Moreton Bay. There are also a large number of wrecks scattered about within and outside Moreton Bay that provide good fishing opportunities. Interestingly, all six artificial reef sites predate and are now fully contained within the Great Sandy and Moreton Bay Marine Parks.

In Hervey Bay the Cochrane artificial reef was commenced in 1992 with both Federal and State government approval. There is a long-term management plan in place for the reef which is constructed of ships, planes, building materials and purpose-built structures. The direct economic return to the community from this reef has been estimated to be between one and two million dollars. There are no limits on the activities permitted on this reef.



Location of artificial reefs in southern Queensland
(Courtesy of Eddie Jebreen)

The Woodgate artificial reef in Hervey Bay dates back to the 1960s. It has been a community managed Reef with both Federal and State government approval. It consists of tyres, car bodies, cane trains and steel waste. It is perceived as a valuable asset by the community. Spearfishing is restricted at the site.

Construction on the Roy Rufus artificial reef in Hervey Bay commenced in 1968. This reef was also community group managed with Federal and State government approval. It consists of car bodies, tyres, barges, concrete and waste steel material. There has been long-term monitoring since 1966 which includes pre-deployment. This reef is seen as valuable by the community, and spearfishing is restricted.

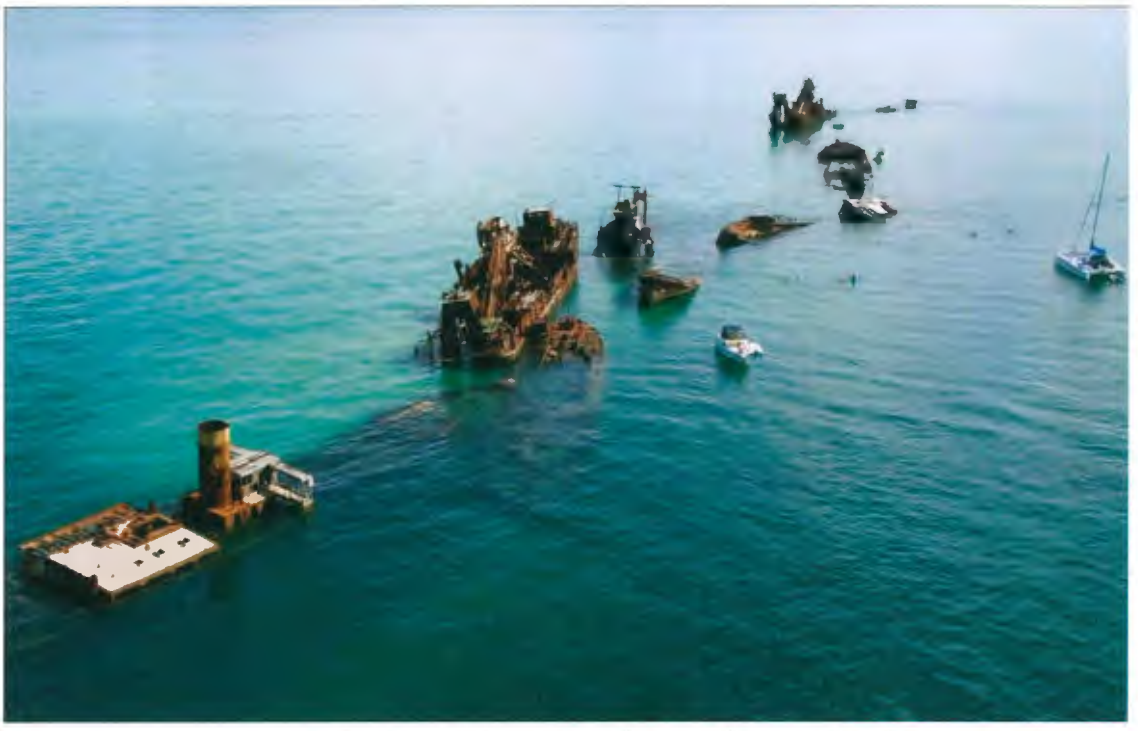
Since 1963 a number of wrecks have been placed at Tangalooma on the western side of Moreton Island in Moreton Bay. Providing some shelter for vessels they also provide excellent fishing. Spearfishing is prohibited on these wrecks. Additional wrecks were placed north of Tangalooma at Curtin artificial reef to provide recreational fishing and diving opportunities.

Materials of opportunity dumped at Roy Rufus artificial reef Hervey Bay Queensland
(Photo courtesy of Bundaberg and Districts Artificial Reef Association)

Car bodies Roy Rufus artificial reef Hervey Bay Queensland
(Photo courtesy of Maryborough Skin Diving Association)

The Curtin Artificial reef has a thirty year history of deployments from 1968 to 1998, with almost 60 vessels, pontoons and barges up to 50 metre, thousands of concrete

pipes, 5000 types and a small number of car bodies and assorted steel structures. The Curtin Artificial reef was established by the Underwater Research Group with assistance of the barge and tug companies, the Queensland Department of Transport and the Armed Services



Sunken ships Tangalooma Queensland
(Photo courtesy of Eddie Jebreen)

The latest addition to sunken vessels in Moreton Bay was the *Tiwi Pearl* deployed as an addition to the Harry Atkinson artificial reef. The Harry Atkinson artificial reef was established in Moreton Bay in 1975 with additional material added until late in the 1980s. It was initiated by the Moreton Bay Trailer Boat Club with Federal and State government approval. It consists mostly of tyres, cars and assorted machinery. More than 17,000 tyres were deployed over a five-year period and in 1987 200 shopping trolleys were placed on the reef. Since the rezoning of the Moreton Bay Marine Park in 2008, there have been a large number of concrete pipes and a load of natural rock added to the reef.

The most recent artificial reef development in Moreton Bay has come about through the expansion of green (sanctuary) zones in the Moreton Bay Marine Park. In order to partially offset recreational fishing opportunities lost through the rezoning, the Queensland government committed to create new recreational fishing opportunities through the establishment of three new artificial reef sites. This project was extended by a further three new sites during the recent state election.

Some reef balls had been used in sheltered areas inside the bay, however the choice of exposed ocean sites required more sophisticated designs.

Tiwi Pearl was sunk in Moreton Bay Marine Park Queensland
(Photo courtesy of Steve Hoseck)

Tyres dumped at Harry Atkinson artificial reef Moreton Bay Queensland
(Photo courtesy of Hilda Atkinson/Moreton Bay Trailer Boat Club)

Three large steel artificial reef structures each weighing 14.4mt (Haejoo[6] Fish Caves) will be deployed at the Wild Banks site between Caloundra and the northern tip of Moreton Island. Off Moreton Island and north of the Southport Seaway more than 70 concrete cubes (Haejoo Fish Box) will be deployed in ocean waters of the Marine Park.

Haejoo Fish Cave Moreton Bay Marine Park Queensland

Haejoo Fish Box Moreton Bay Marine Park Queensland
(Photo courtesy of Steve Hoseck)

[6] www.haejoo.com.au

Northern Territory

The Japanese bombing of Darwin that commenced in 1942 left a considerable amount of wreckage in Darwin Harbour. However many of the vessels' superstructures were salvaged during 1959 and 1960 leaving little structure remaining above the bottom and reducing their effectiveness in attracting fish. Cyclones and misadventure have added other ships and planes. Many of these wrecks are still popular fishing spots.

The Northern Territory government has been actively deploying artificial reefs since the 1980s. The deployments have been targeted to specified areas to build larger scale artificial reef complexes.

The Song Saigon artificial Reef complex is located in central Darwin Harbour and was commenced in 1982. It is composed of four steel vessels from 27 to 38 metres length roughly 50 metres apart. It was built by the Northern Territory Government in conjunction with the Amateur Fishermen's Association of the Northern Territory. The most recent component, the *Medkhanun 3*, was added in 2008.

The 27 metre confiscated foreign fishing vessel, *Medkhanun 3*, being scuttled to expand the Song Saigon artificial reef complex in Darwin Harbour

The Fenton Patches artificial reef complex is located 17 nautical miles north-west of Darwin. There are seven sites set in a circular pattern each one nautical mile apart. Five sites are comprised of large steel and/or timber vessels. One consists of 200 large concrete pipes and the remaining site is composed of steel shipping pontoons and concrete bus shelters. This complex was commenced in 1987.

The 20 metre former fishing vessel, *Antares 2*, being scuttled to expand the Fenton Patches artificial reef complex located 17 nautical miles north-west of Darwin

The Lee Point artificial reef complex is situated 3 kilometres north of Casuarina Beach near Darwin's northern suburbs. Its development commenced in 1996. This complex includes 3 artificial reef sites comprising decommissioned vessels, shipping containers and other steel and concrete components. The most recent components added were 200 x 6m long concrete culverts in June 2011.

Concrete culverts destined for the Lee Point artificial reef complex near Darwin

The NT Government provides annual funds to conduct recreational fishing infrastructure projects such as the deployment of artificial reefs. Historically, the NT government has used suitable materials of opportunity (such as confiscated vessels) for reef components.

In response to recent concerns about the impacts of increasing reef fishing effort in Territory waters and the relative significance of artificial reefs, the NT government is looking to increase available reef habitat by expanding existing artificial reef complexes e.g. the recent addition of 600 concrete culverts to the existing Lee Point complex. A monitoring system is being introduced to study the pattern of colonisation of the new reef and to monitor species abundance and diversity. In addition to reef structures, the NT will also be exploring fishing opportunities for pelagic fish species in order to enhance the recreational fishing experience.

All Northern Territory Government artificial reef sites have legislated commercial fishing exclusion zones ranging from .5 nm to 2 nm in diameter.

More information on the locations of artificial reefs in and around Darwin can be found at http://www.nt.gov.au.

Tasmania

Tasmania has many sunken ships that constitute valued fishing locations. There are not as yet any purpose-built artificial reefs for fishing. There is one small reef ball reef constructed by the Leven Scuba Club as a dive reef. In January 200150 reef balls were deployed off Moorlands Beach near Port Sorell at a depth of 20 Metres. The Tasmanian peak recreational fishing body TARFish received a commitment in March 2010 from the Tasmanian state government to discuss further the feasibility of implementing artificial reefs and TARFish have successfully applied for a Community Grant to look at artificial reefs for Tasmania. There is no recreational fishing licence required for fishing in saltwater and possible funding sources for future artificial reefs include grant schemes, state and federal governments, the private sector (tourism), the recreational sector or the commercial fishing sector.

There is currently no state government policy in relation to artificial reefs in Tasmania, and the approvals process is unclear. There are large areas with no rocky reefs close to popular recreational fishing communities that could be suitable for artificial reef investigation. TARFish expects that future artificial reef developments will be focused on ocean rather than estuarine areas.

South Australia

Artificial reefs have a long history in South Australia with 19 locations currently provided on the PIRSA Fisheries website[7]. There have also been many unauthorized artificial reefs deployed, often with scant regard for commercial trawling grounds.

PIRSA Fisheries has installed several artificial reefs to provide new fish habitats. Two different types of artificial reefs have been established:

[7] www.pir.sa.gov.au

- a tyre module reef designed by the South Australian Research and Development Institute (SARDI). Each module consists of 28 used car tyres strapped together into a tetrahedron and ballasted with concrete.

- redundant barges or dredges, towed to selected sites and scuttled.

Several other artificial reefs have been installed by other organisations. Approval to install private artificial reefs must be sought in writing from PIRSA Fisheries as well as other relevant government agencies.

Since 1993, PIRSA Fisheries has taken the conservative approach and discouraged the construction of any additional artificial reefs in State waters on the grounds that the construction of any new reefs could increase the potential catch for species such as snapper and King George whiting possibly without enhancing stocks. PIRSA maintains that further research is needed into the effects of artificial reefs on the availability of fish and the ecology and productivity of the marine ecosystem in South Australian waters before any future reef building projects should be considered.

The peak recreational fishing body SARFAC supports the introduction of well designed, purpose-built artificial reefs in South Australian waters and has identified a number of suitable sites. However, without a recreational fishing licence a suitable funding source remains problematic.

Western Australia

To date artificial reefs for fisheries enhancement have been limited to a commercial abalone ranching experiment at Albany.

The need for habitat and fish stock enhancement have been repeatedly raised by recreational fishers as a priority and pursued by the peak recreational fishing body Recfishwest. The aggregation of popular angling species like Sampson fish on scarce pinnacles and wrecks has encouraged speculation about the possibility of providing artificial aggregation sites not only to provide better fishing opportunities but to assist in dispersing concentrated fishing effort to prevent overfishing and to enhance spawning. Previously, materials of opportunity have been considered as possible artificial reef materials, but were rejected due to concerns about ineffectiveness and possible pollution. Although a small number of reef balls have been used in a canal development at Mandurah, the lack of suitable designs for ocean deployment restricted further development. Artificial reefs have been employed in Western Australia for environmental, diving and surfing benefits, but the objectives of these deployments mean there is limited information on the related outcomes of fisheries enhancement.

This changed when Mr Ryan Paik from Haejoo Pty Ltd visited Perth in June 2010 showing a suite of new steel and concrete artificial reef modules designed for Australian conditions and fish species. The opportunity to use tailor-made designs

reignited interest in the possibilities for fish stock enhancement and the use of artificial reefs as offsets for major developments impacting recreational fishing.

However, a number of doubts remained about the effectiveness of artificial reefs in general, and particularly whether they simply aggregated fish or whether they genuinely increased fish production. Consequently the government sent a delegation to South Korea and China in November 2010 to investigate. The report of that study tour[8] provided strong evidence for the effectiveness of artificial reefs in enhancing stocks of fish and other marine life and recommended the government proceed with an artificial reefs program. The 2010 study tour was followed up with a delegation of WA researchers to China in April 2011, and a delegation will go to Korea and Japan in July 2011 to foster collaborative research on artificial reefs.

The Department of Fisheries then developed legislative amendments to clarify the determining authority for future reef deployments. Since then there have been numerous presentations of the study tour findings to interested groups, and presentations of finding to Department of Fisheries' staff and the Minister for Fisheries.

There has been widespread interest from industry groups in using artificial reefs as offsets for the loss of recreational fisher access and amenity resulting from port construction and other infrastructure development. Industry is also interested in using artificial reefs to provide new fishing grounds to mitigate the impact of increasing fishing effort from burgeoning populations in remote areas as a result of industrial growth.

The study tour findings have been presented to the major mining and oil and gas companies operating in Western Australia, together with local government authorities, environmental regulators, tourism authorities, regional development bodies and angling clubs. There has also been wide and positive media coverage of the study tour including ABC radio national & local, West Australian, Sunday Times, Fishing Magazines and Community Newspapers.

Summary of Western Australian delegation findings

- China has been using ARs widely and successfully for hundreds of years, while Japan has also used them for 100 years and South Korea 40 years. They are not new and are widely accepted and are actively being deployed.
- There is a consensus amongst Korean and Chinese scientists and government officials that artificial reefs increase production, and are not merely aggregation devices. Productivity of ARs has been measured at anywhere between 5 – 50 kg/m3 though performance is influenced by many factors.

[8] http://www.recfishwest.org.au/content/submissions/files/2644_final_south_korea__china_report.pdf

- The commercial value of the increased production on its own is sufficient to justify substantial investment in artificial reefs. In Korea, for example, the Government has invested over AU$885M in its AR program to increase productivity over the past 40 years and this is increasing based upon the success of the program.
- A research project conducted over 25 years, at King Harbor in California, has found that the AR has a higher carrying capacity, and its population is self-maintaining and does not draw from natural reefs (Pondella *et al.*2002).
- Research suggests that well designed artificial reefs provide better production outcomes than natural reef, based upon monitoring of commercial catches and the use of ARs over time.
- No apparent environmental downside as ARs provide productive additional habitat for many non-target and unfished species. Indeed ARs can be deployed for environmental benefits associated with increased habitat and biodiversity.
- Adding artificial reef structure to the coastal benthic environment has also been documented repeatedly to increase species abundance and diversity at the reef site (Seaman 2008).
- ARs should be purpose built for the marine environment and circumstances into which they are deployed. While alternatives like sinking boats may have some beneficial effects the impacts are less certain and likely to be significantly diminished.
- Deployment should follow appropriate benthic mapping and other environmental considerations.
- Site assessments for shallow water ARs should include investigation of potential impact on coastline (sedimentation or erosion) if placed in a location that modifies current and/or wave action.
- Local communities, including fishers and other interest groups, should be consulted on appropriate deployment sites.
- An appropriate regulatory and monitoring regime should be in place prior to deployment.
- The fishery and environmental objectives should be clearly defined prior to deployment (site, species, use) as part of the regulatory regime.
- New South Wales and Victoria already have successful ARs deployed, and Queensland is to have three more shortly.
- South Korea and China both agree that initial fishing closure of between 1-2 years is advisable to allow the reef to establish and populate itself.
- In conjunction with the deployment of ARs both the Koreans and the Chinese are actively restocking a suite of fish species and also cultivating and replanting seagrasses, kelp and algae.
- ARs will be productive without stocking, although stocking may increase their effectiveness and speed production.
- Resource sharing between the sectors in Western Australian fisheries is different to the challenges in South Korea and China as it will be important for

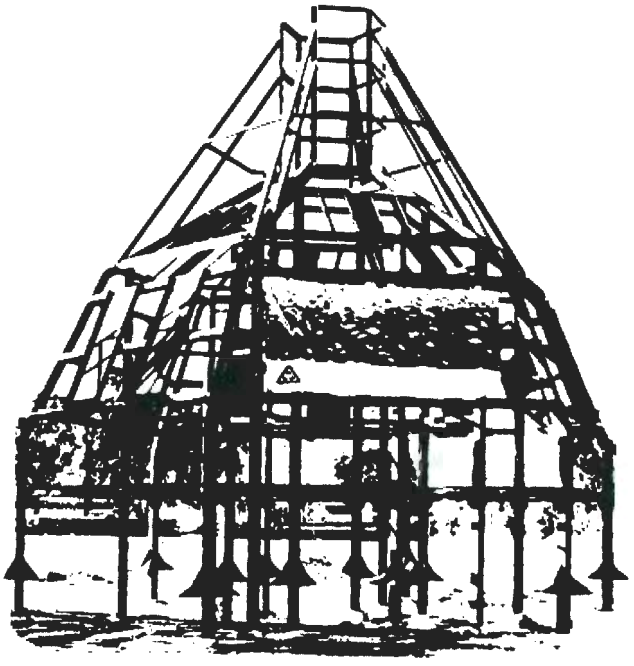
the West Australian Government to determine up front who is able to access the ARs.

- Recognising that the deployment of ARs will likely result in increased fish numbers the additional fish produced will have to be considered in the context of either formal or informal allocations between the sectors.
- Artificial reef research and technology appears to have developed sufficiently for regulators to be confident in the potential for deployment in WA.
- The Delegation is also confident that ARs will provide marine environment benefits in West Australian waters when deployed in appropriate locations.
- Western Australia would benefit from further research collaboration with Korean and Chinese researchers in regard to ARs.

DRAFT GUIDELINES FOR ARTIFICIAL REEFS

JUNE 2011

John Diplock
Hamata Pty Ltd



Australian Government

Fisheries Research and Development Corporation

OVERVIEW

There are numerous prescriptive guides to the process of constructing and deploying artificial reefs, increasing in sophistication over time as reefs have become more complex and environmental assessment requirements have grown[9,10]. The environmental assessment for offshore artificial reefs in New South Wales[11] provides a comprehensive examination of possible environmental consequences and also details the approvals process and stringent requirements for monitoring. These materials provide detailed manuals to ensure proponents responsibly and rigorously address the environmental requirements for new projects.

It is not the purpose of this report to duplicate the existing instruction manuals or to prescribe a new set of standards for artificial reefs. Rather, this report brings together the informed views on issues considered most important by those involved in, or interested in, artificial reefs around Australia.

This report summarises the outputs of a series of meetings of researchers, fisheries managers and stakeholders held in early 2011 to determine the status of artificial reef developments around Australia and to seek consensus on draft guidelines to assist the future development of artificial reefs. The objectives for this segment are shown in Appendix I. A list of key issues discussed by workshop participants is provided in Appendix II. A list of meeting attendees is provided in Appendix III.

BACKGROUND

Interest in artificial reefs is growing in Australia, with recently initiated programs in New South Wales, Queensland and Victoria. These have been mostly pilot projects using available basic designs and materials for research purposes, or the dumping of materials of opportunity (junk).

Queensland and the Northern Territory have longstanding artificial reefs programs utilising "materials of opportunity" and NSW has had an expanding program since 2003 using purpose-built modules. Victoria has a pilot project using available basic designs and purpose-built materials for research purposes. However, the progression to dedicated and effective fisheries enhancement programs using artificial reefs has proved difficult. While environmental impact assessment has been extremely costly and time consuming for some jurisdictions, the more fundamental problem of lack of demonstrably effective designs tailored for local conditions impeded developments until the establishment of a dedicated artificial reef design, construction and deployment company in 2009 (Haejoo Pty Ltd).

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[9] Lukens R. and C. Selberg. 2004. Guidelines for Marine Artificial Reef Materials. Joint publication of the Gulf and Atlantic States Marine Fisheries Commissions No.121 198pp.

[10] Lindberg, W.J. and W. Seaman (eds). 2010. Best Management Practices (BMPs) for Artificial Reef Siting, Usage, Construction and Anchoring in Southeast Florida. Florida Department of Environmental Protection. Miami, FL. i-viii and 154 pp.

[11] http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/348861/OAR-Submissions-Report.pdf

In many countries the use of materials of opportunity is now discouraged or even banned, and many require all artificial reef modules to be purpose designed and built to prescribed engineering standards. Korea requires all new artificial reef modules to be tested and monitored for two years before government assessment determines whether they can be deployed in public waters.

At this time in Australia there are no standards or guidelines to assist in determining appropriate designs or materials for artificial reefs, and no agreed basic research and monitoring requirements to allow their effectiveness to be determined. Without these basic tools we run the risk of duplicating the years of trial and error, sub-optimal performance and possibly failure that plagued some countries, and drove others to introduce their present regulatory schemes.

DESIGN

The key to effective artificial reefs is good design. Artificial reef modules should be designed for the particular species, or suite of species, that the reef is intended to benefit. This mean the dimensions of modules should present the optimum combination of appropriately sized voids, surfaces, shadows, refuges and profiles. The effects of currents, wave and tides must be incorporated into the design to produce the appropriate turbulence, vortices and static flow zones for the target species. The configuration of the reef groups and sets must be designed to maximise the biological effects while permitting orderly fishing. Wherever the expertise is not locally available expert advice should be sought.

There was general agreement that artificial reefs where ever possible should be purpose-built incorporating design features appropriate for the species targeted and the proposed environmental conditions. This will deliver the most effective outcomes and provide the best value for money.

The effects of the scale of the artificial reef, and the minimum effective size were discussed. In Korea the minimum effective volume of for artificial reef is approximately 800 m^3. For a low profile reefs a minimum area of 500 m^2 is recommended. While there are significant differences in the environmental conditions between Australia and Korea the concept of an effective threshold is important and should be the subject of further study here. It was noted that a number of the estuarine artificial reefs in NSW were approaching the Korean minimum volume, and the offshore steel module design will fulfil the Korean volume criterion.

The design of new artificial reefs, or the extension of existing reefs should seek to achieve a minimum effective volume of 800 m^3.

A design life of 30 years was considered reasonable for artificial reefs.

CONSTRUCTION

All modules should be constructed of reinforced concrete or welded steel, particularly in energetic environments. Artificial reef modules should be constructed to

engineering standards to ensure maximum design life and safety in deployment. Module collapse, movement or breakage were considered highly undesirable, and likely to provoke official sanction where strict permit conditions are applied, or fuel opposition to future programs from government agencies and other interested groups. Therefore modules should be designed with stability and anchorage appropriate to the prevailing conditions and likelihood of extreme events.

Wherever possible the tender for design, construction and deployment of artificial reefs should be combined to deliver economies of scale and to facilitate production. Similarly, the statutory approvals process including environmental assessment should cover as many reef sites as possible at the one time to minimise duplication and reduce costs.

However it was also noted that artificial reef materials should be selected on a case-by-case basis, particularly where budgetary constraints prevent the use of purpose-built materials. Situations will continue to arise where, without the use of materials of opportunity, no artificial reefs would be deployed. This is particularly relevant where revenue from recreational fishing licences is not available, and is unlikely to become available in the near future. It is also clear that materials of opportunity have provided useful outcomes in certain circumstances, although critical comparisons between this these and purpose-built materials are not available.

There was agreement that materials such as tyres, asbestos and any polluting material should be prohibited from use in artificial reefs.

There was recognition that fisheries and environmental agencies may not be best placed to deliver end to end artificial reef solutions and that professional advice should be sought for each stage of the project.

MONITORING

The monitoring programs instigated in NSW and Victoria combine baited underwater video, diver census, photographic sequencing and fisher catch rate surveys in recognition of the limitations of each. Both have incorporated pre-deployment surveys to establish a baseline for post-deployment comparison, and have monitored control sites of natural reef and undisturbed substrates similar to the artificial reef sites. While there was strong emphasis on research and monitoring early in the artificial reef programs in both states, it was agree that the intensity of monitoring could be reduced over time, and for future artificial reefs placed in similar environments. The exhaustive monitoring stipulated in the approval process for offshore artificial reefs in NSW which requires 3 years monitoring before the second phase (site no. 2) can proceed was considered excessive.

Monitoring artificial reefs in northern waters presents particular difficulties. Turbidity and strong currents preclude all methods outlined above except catch rate surveys.

There was strong agreement that some form of pre and post-deployment monitoring was essential if the effectiveness of new artificial reefs was to be demonstrated. One approach would be to conduct cost benefit analyses to determine value for money. There was support for increased communication between researchers, both here and overseas to ensure access to state-of-the-art methodologies, and to facilitate comparison of results. The results of overseas research are scarce in the English language literature, and difficult to access in the foreign refereed and grey literature. Improved access to foreign research may preclude the need to conduct some basic research here.

Monitoring should continue for at least one year to cover any seasonal variations, but three years was considered sufficient for familiar designs. Monitoring for up to 5 years could be considered the new designs. Monitoring through voluntary angler reporting could be ongoing to provide usage information. Monitoring of social and economic parameters was also supported.

AGGREGATION VS PRODUCTION

Although the aggregation versus production (AvP) issue appears to have been resolved in favour of production in many other countries, it continues to concern some interest groups here.

Monitoring was considered a key component in resolving the AvP argument. Artificial reefs, like natural reefs, are considered to both aggregate fish, and increase production depending on the age of the reef, the species of interest, the season and the local conditions. However, the significance of increase production is obviously related to the scale of reef deployment, with very small reefs adjudged to contribute little in the way of increased production.

The AvP issue could be addressed through gross measures of changes in fisheries production, and/or primary or secondary productivity. Other ways include research comparing fish numbers and condition factors between artificial and natural reefs, through feeding studies and tagging studies. Comparison of fished and unfished artificial reefs could also prove useful.

The concentration of fishing effort on artificial reefs was also considered an issue if aggregation was more important than production. Options to manage fishing effort include disbursement of artificial reef units, and locating reefs sufficiently far from port to reduce effort.

As fish stocks are generally undertaken on a stock wide basis, the impact of local aggregations of fishing effort was considered manageable. Given the mobile, and often migratory behaviour of many targeted fish species the use of the ordinary management tools such as bag and size limits, and area and seasonal closures were considered both adequate and preferable to reef specific measures.

Research conducted by universities could provide good value for money and supplement full-time research undertaken by government agencies.

OWNERSHIP AND MANAGEMENT

Due to the likely scale of construction, the need for long-term responsibility and monitoring, and the possible need for ongoing management and compliance, ownership of artificial reefs should be vested in the government. Governments are best placed to manage issues such as liability and removal (if required). This is especially so if the users are recreational fishers. However, there may be opportunities for private leasing of the sea floor for commercial operations such as abalone ranching where compliance issues can be adequately managed.

Whether the reefs were open to both commercial and recreational fishing was considered best addressed on a case by case basis. In Victoria and the Northern Territory there were closures to commercial fishing covering artificial reefs. In NSW all artificial reefs to date had been deployed in Recreational Fishing Havens where commercial fishing is prohibited. The NSW experience with FADs showed there was little, if any, conflict between these sectors, but there was conflict over access between spear-fishers and anglers.

It was agreed that artificial reefs, especially the large, complex designs present clear dangers to divers through entanglement, but also a potent attractant due to the aggregations of marine life. The management of artificial reefs however present some difficulties where activities inimical to the intended purpose such as scuba diving cannot be managed under fisheries legislation even when the ownership is clear. In NSW the broader management of non-fishing activities may be achieved through the declaration of Crown Reserves over the artificial reef sites, and the use of the far reaching Crown Reserves management powers to ban such activities.

Codes of conduct were considered useful tools the management of artificial reefs, and may be used to address conflict between anglers and spear-fishers. Anchoring on artificial reefs should be prohibited. Recreational scuba diving should be prohibited on artificial reefs constructed for fishing.

CONSULTATION

Preliminary community consultation must be detailed and comprehensive. The relative scale of the proposed artificial reef structures and the area affected should be made clear from the start, preferably visually. Sufficient information exists from overseas studies and experience, and from the New South Wales environmental assessment to provide reassurance that all significant issues have been, and will be, considered. The risk assessment undertaken in New South Wales provides a sound process to address different local situations. The flow of peer-reviewed research papers from New South Wales and Victoria will also be useful in reassuring stakeholders and other interested parties of the quality of monitoring undertaken.

The very positive engagement shown through these meetings demonstrated the need for ongoing linkages and communication between researchers, managers and stakeholders interested or involved in artificial reefs around Australia. The establishment of an artificial reefs network would facilitate this process.

RECOMMENDATIONS

- the objectives for artificial reef development and the means of evaluation must be clearly stated at the outset
- artificial reefs should be designed and located to suit the specific objectives
- artificial reefs should be purpose built (wherever possible) to maximise the benefits
- the minimum size of artificial reef complexes should be at least 500 m^3 for low profile reefs and 800m^3 for high profile reefs
- the design life should be 30 years or more
- preferred materials are reinforced concrete and welded steel
- tyres, car bodies and other polluting materials should be prohibited from use in artificial reefs
- pre-deployment and post-deployment monitoring, and reporting of outcomes to determine effectiveness should be mandatory
- post-deployment monitoring should continue for at least one year using complementary techniques (e.g. baited underweater video, diver census and creel survey)
- further research would assist in resolving the AvP issue
- governments should own and manage artificial reefs used for recreational fishing
- recreational scuba diving should be prohibited on artificial reefs constructed for recreational fishing
- community consultation for new artificial reefs should be detailed and comprehensive
- a national artificial reefs network should be established to provide ongoing communication between interested parties.

APPENDIX I

OBJECTIVES

The key objectives for this component of the project are:

1. informed discussion of the relative merits of artificial reef designs, construction materials and monitoring techniques

2. a consensus on desirable and undesirable features and methods

3. guidelines on designs, materials and monitoring to assist decision makers

APPENDIX II

KEY ISSUES FOR CONSIDERATION

The following issues were provided to stimulate discussion, but discussion was in no way limited to these points.

Materials and Designs

- Should any materials be prohibited e.g. tyres?
- Should there be a clear distinction between structures sunk as scuba dive sites and fishing reefs? If so, how?
- Should the use of "materials of opportunity" be discouraged?
- Are there situations where "materials of opportunity" could or should be used?
- What are the preferred materials for different environments?
- Is there a minimum effective area for artificial reefs?
- How can we get the best value for money in design and construction?

Usage and management of user conflict

- Who should own the reefs – government, fishing clubs, commercial enterprises?
- How do you deal with liability, maintenance and removal?
- Who should be allowed to fish them?
- How do you manage inter (commercial vs recreational) and intra (spearos vs line fishers) sectoral conflicts?
- Should they be closed to scuba diving?
- Should there be restrictions on anchoring on artificial reefs?
- Should there be special rules for reefs to avoid overfishing (closed seasons, permits to manage the no. of boats, different bag limits)?

Monitoring

- How can the aggregation vs production bogey man be resolved?
- Should pre-deployment surveys be mandatory?
- How long should you survey before deployment to adequately capture the variability in the system?
- What methods provide useful results?
- How long should you survey after deployment?
- Should provision of catch data be compulsory when fishing artificial reefs?

- If so, how would it work?
- What other monitoring is important e.g. non-fished biodiversity, threatened species, invasive species?

APPENDIX III

Melbourne 25/03/11

Bill Lussier	Fisheries Victoria
Brenton Schahinger	SARFAC
Michael Lowry	NSW Industry & Investment
Dan Grixti	Fisheries Victoria
David Kramer	Futurefish Foundation
David Lennon	Reefball Australia
Franz Grasser	VRFish
John Hotchin	VRFish
Kade Mills	Fisheries Victoria
Keith Rowling	Primary Industries and Resources South Australia
Mark Nikolai	Tasmanian Association for Recreational Fishing Inc
Paul Hamer	Fisheries Victoria
Rod Pearn	DPIPWE Tasmania
Ryan Paik	Haejoo Pty ltd
Trevor Buck	VRFish
Trevor Watts	South Australian Recreational Fishing Advisory Council

Perth 7/04/11

Alex Hesp	Centre for Fish and Fisheries Research Murdoch University
Andrew Matthews	WA Fisheries
Andrew Rowland	Recfishwest
Arani Chandrapavan	WA Department of Fisheries
Ash Fowler	University of Technology Sydney
Belinda Fox	BHP Billiton Iron Ore, Port Hedland
Brad Adams	Two Oceans Abalone Ltd
Brett Molony	WA Fisheries WA Fisheries and Marine Research Lab.
Eve Bunbury	WA Fisheries
Greg Jenkins	Australian Centre for Applied Aquaculture Research
Guy Kestel	888 Abalone Pty Ltd
Ian Sewell	The Western Australian Fishing Magazine
Ian Stagles	West Australian Fish Foundation
Kane Moyle	Recfishwest
Nathan Harrison	WA Department of Fisheries

Neil Loneragan	Centre for Fish and Fisheries Research Murdoch University
Neil McGuffie	WA Fishing Indutry Council
Ryan Paik	Haejoo Pty Ltd
Stuart Smith	WA Department of Fisheries
Tim Nicholas	Minister for Mines and Petroleum; Fisheries; Electoral Affairs

Brisbane 12/05/11

Bill Sawynock	Infofish Australia
Brian Kirkby	QGFA
Heath Folpp	NSW Industry & Investment
Jim Higgs	Qld Department of Environment and Resource Management
John Johnston	SUNFISH Queensland Inc.
Judy Lynne	SUNFISH Queensland Inc.
Julian Pepperell	Pepperell Research
Malcolm Poole	Recreational Fishing Alliance
Max Castle	NSW Advisory Council on Recreational Fishing
Michael Lowry	NSW Industry & Investment
Nicola Udy	Qld Department of Environment and Resource Management
Phil Hall	Northern Territory Fisheries
Phil Kliese	ECOfishers Qld
Ryan Paik	Haejoo Pty Ltd
Steve Hoseck	Queensland Parks & Wildlife Service
Thomas Kang	Haejoo Pty Ltd
Tony Ham	Dept. of Employment, Economic Development & Innovation
Warren de With	Amateur Fishermen's Association of NT

FAUNA

The eastern grey kangaroos, red-necked wallabies and swamp wallabies are the common macropods of the area, using the refuge provided by the National Park. Their tracks are often seen on the beaches or they can be disturbed napping under bushes throughout the park.

Brush-tailed and ring-tailed possums inhabit the thick scrub of the National Park. Echidnas poke their noses into sandy places for ants and long-nosed bandicoots lie snug in their hollows under casuarina debris. Keen eyes may spot marsupial mice (Antechinus) or native bush rats that provide the staple diet for local goannas and snakes. You may also see the occasional pest animal such as a fox or rabbit.

Threatened species that have been detected in the area include the greater broad-nosed bat, the grey-headed flying fox, both glossy black and gang gang cockatoos, the powerful owl and the masked owl.

You may spot some threatened shorebirds that use the local area. Resident pairs of red-billed pied oystercatchers can be seen all year round combing the beaches and lagoon shores for shellfish. In the warmer months you may be very lucky to see the vulnerable sanderling or endangered sooty oystercatchers, or perhaps hooded and red-capped plovers. Along estuaries are the more common wading and fishing birds, elegant egrets, high-stepping white faced herons and 'wait and watch' cormorants.

THE NATURAL SETTING

While reflecting the soil types of their individual habitats, present vegetation communities are almost all regrowth which have lost much of the detail and biodiversity of their original character. Over time, if left undisturbed, these areas should revert to forest.

Above the cliffs at the Congo end of the track, only the area immediately behind the cliffs was cleared for pasture, and this has gradually reverted to heathland. The mature bangalay, or coastal mahogany, forest further inland along the track was never cleared because the sandstone soils were too infertile for farming.

The landscape you pass through on the walking track has formed from the interaction of geology, the resulting soils and vegetation, and the history of land use. There are quite noticeable changes from stunted black ash and sparse ground cover with swathes of low sword grass on the plateau, into slopes and depressions carrying species of eucalypt such as woolybutt, forest red gum and bangalay with its generous spread of canopy. Parts of the cliff edges have flora of coastal heath, bright guinea flowers and purple native iris.

An important community is the wetland/lagoon system which collects water from its land catchment and occasionally the sea. Known as ICOLLS (Intermittently Closing and Opening Lake and Lagoon Systems), there are four in the area - Kelly's Lake, Grey Rocks Creek, Mullimburra Lagoon and Meringo Lagoon. After heavy rain or high seas they can open and flush out fresh water as well as fish, crustaceans and worms. Within a range of 'normal' conditions, if closed for some time, they can become smelly and full of algae. The brackish water supports plants adjusted to variable salt and water levels. The coastal lagoons are enclosed by casuarinas concentrations with sedges and salt-marsh plants.

BACKGROUND

Aborigines have occupied the Bingi-Congo area since well before the sea reached its present level about 6,000 years ago. Archaeological sites mostly date from the last few thousand years. These include campsites where artefacts were manufactured and used. The area is rich in stone flakes, stone quarry sites and shell middens where the remains of meals of fish and shellfish have accumulated over thousands of years.

European farmers first settled the area in the late 1840s. By the 1880s the original rich forest vegetation on the granite and basalt headlands between Bingi and Meringo were cleared for dairy farming, cattle raising and crops. Timber such as woolybutt and blackbutt was shipped from Moruya and ironbark was milled for railway sleepers.

Coastal reserves have been created over the last thirty years and these and other lands were absorbed into the existing Eurobodalla National Park in 1995. Shortly before and since the establishment of Eurobodalla NP, grass plantings by landcare groups and park managers have re-stabilised the foredunes and controlled major infestations of the introduced weed 'bitou bush'.

GEOLOGY

Bingi and Grey Rocks Points have formed on granites, Mullimburra Point on metamorphosed shales and sandstones, and the headlands and cliffs between Meringo and Congo are formed from basalt. Between the headlands, beach and dune sands have accumulated since the sea reached its present level. These sands have trapped small perched coastal lagoons (or ICOLLS). The track crosses four of these.

At the back of the cliffs between Meringo Lake and Congo the basalt is covered with younger quartz-rich sandstone and gravels, some of which has been cemented to form silcrete. Most of the Aboriginal stone artefacts on the South Coast were made from silcrete and the Congo area was a major source of this stone.

ABORIGINAL HISTORY OF THE TRACK

The Bingi-Congo coastal walk follows part of the Dreaming Track utilised by Brinja-Yuin people prior to European development. The word Bingi means stomach in Dhurga - the Aboriginal language spoken south of Nowra to Narooma - and when repeated as in Bingi Bingi Point indicates abundance.

Dreaming Tracks traditionally linked every place visited by local Aboriginal people, then extended to connect every place utilised by neighbouring clans so that all Aboriginal people in Australia were connected by these unique highways.

Dreaming Tracks are sometimes referred to as song lines, as individuals had to know the songs to successfully navigate the area, particularly if they were visiting another's country. At times however, they fulfill an entirely different function, particularly in ceremony.

It is the belief of Aboriginal people that the Spirit Ancestors of the people created the Dreaming Tracks in the journey of Creation across the land and therefore have a deep spiritual significance for them.

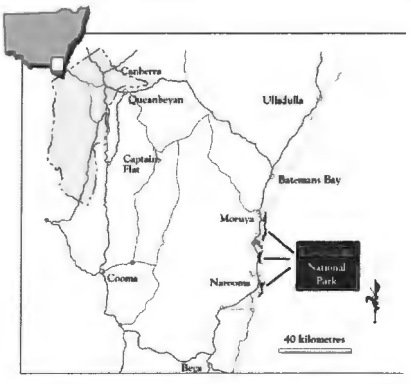
Historic journals have recorded European settlers using these tracks as trade routes and encountering groups of Aboriginal people in camps, or in transit gathering food and other materials.

The Bingi Dreaming track brings you close to shell middens, stone quarries, knapping sites, camp sites and fresh water sources. There are also beacon sites for sending smoke signals and lookouts traditionally used to spot schools of fish and visitors (wanted or unwanted).

While enjoying this unique experience please respect the land and her dwellers for we are all one.

Information provided by
Patricia Ellis
Cobowra Local Aboriginal Land Council

LOCATION



The Bingi Dreaming Track is an Australian Government Envirofund funded project instigated by Bingi Landcare with the valuable help of Congo Landcare, Cobowra Local Aboriginal Land Council, Eurobodalla Shire Council and NSW National Parks & Wildlife Service.

NATIONAL PARKS & WILDLIFE SERVICE

LANDCARE BINGI

COBOWRA LOCAL ABORIGINAL LAND COUNCIL

AUSTRALIAN Government envirofund

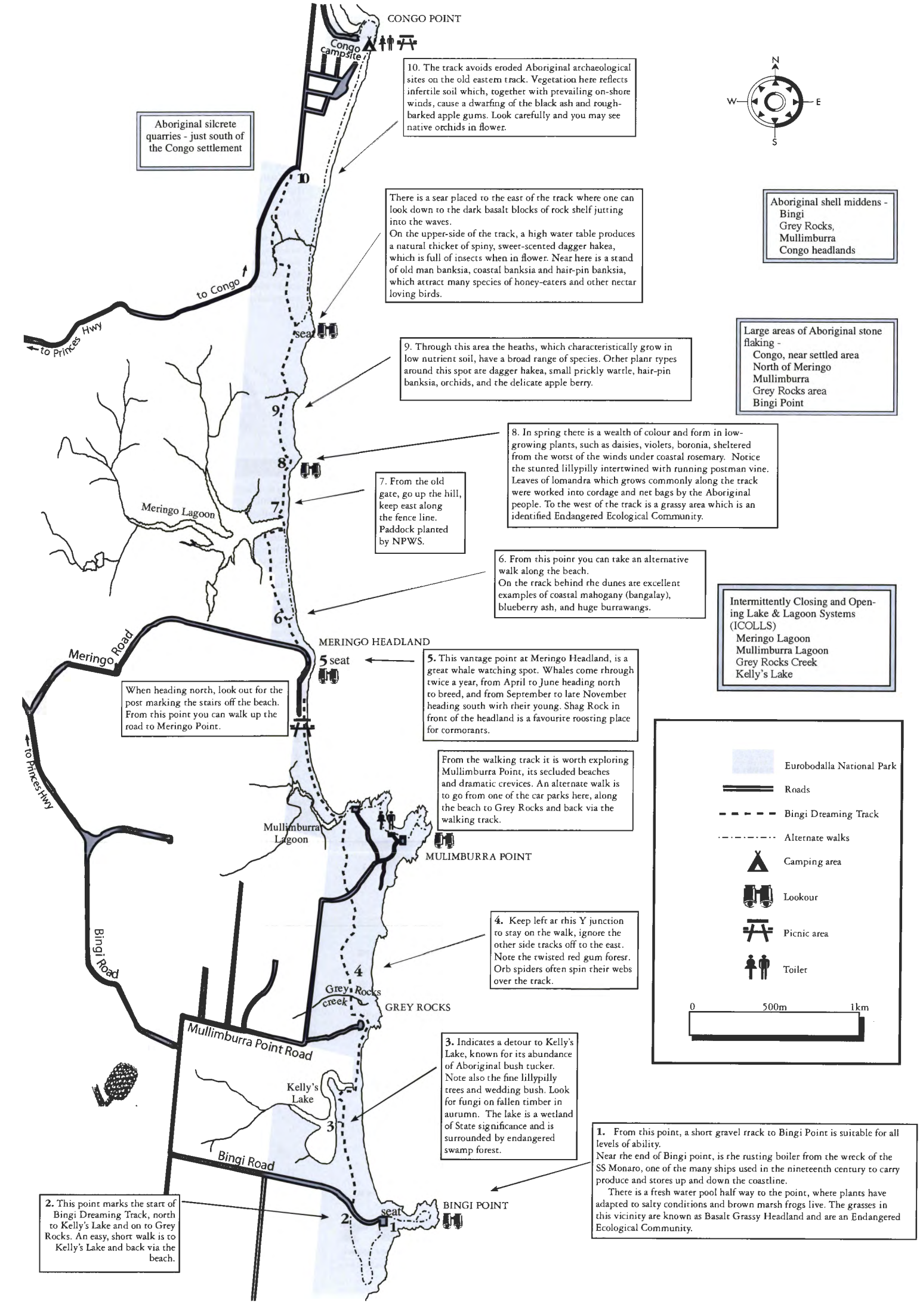
EUROBODALLA SHIRE COUNCIL
Good Government, better living

VISITORS' GUIDE

Eurobodalla National Park

BINGI DREAMING TRACK

This walking track is a Bingi Landcare project that marks largely existing tracks over 7.5 km of coastline between Bingi and Congo. The track winds its way through many different and spectacular landscapes providing an opportunity to appreciate the natural resources of the Bingi area.


CONGO POINT
Congo campsite
10. The track avoids eroded Aboriginal archaeological sites on the old eastern track. Vegetation here reflects infertile soil which, together with prevailing on-shore winds, cause a dwarfing of the black ash and rough-barked apple gums. Look carefully and you may see native orchids in flower.
Aboriginal silcrete quarries - just south of the Congo settlement
N
W
E
S
10
There is a seat placed to the east of the track where one can look down to the dark basalt blocks of rock shelf jutting into the waves.
On the upper-side of the track, a high water table produces a natural thicket of spiny, sweet-scented dagger hakea, which is full of insects when in flower. Near here is a stand of old man banksia, coastal banksia and hair-pin banksia, which attract many species of honey-eaters and other nectar loving birds.
Aboriginal shell middens -
Bingi
Grey Rocks,
Mullimburra
Congo headlands
to Congo
to Princes Hwy
seat
9. Through this area the heaths, which characteristically grow in low nutrient soil, have a broad range of species. Other plant types around this spot are dagger hakea, small prickly wattle, hair-pin banksia, orchids, and the delicate apple berry.
Large areas of Aboriginal stone flaking -
Congo, near settled area
North of Meringo
Mullimburra
Grey Rocks area
Bingi Point
9
8
8. In spring there is a wealth of colour and form in low-growing plants, such as daisies, violets, boronia, sheltered from the worst of the winds under coastal rosemary. Notice the stunted lillypilly intertwined with running postman vine. Leaves of lomandra which grows commonly along the track were worked into cordage and net bags by the Aboriginal people. To the west of the track is a grassy area which is an identified Endangered Ecological Community.
Meringo Lagoon
7
7. From the old gate, go up the hill, keep east along the fence line. Paddock planted by NPWS.
6
6. From this point you can take an alternative walk along the beach.
On the track behind the dunes are excellent examples of coastal mahogany (bangalay), blueberry ash, and huge burrawangs.
Intermittently Closing and Opening Lake & Lagoon Systems (ICOLLS)
Meringo Lagoon
Mullimburra Lagoon
Grey Rocks Creek
Kelly's Lake
MERINGO HEADLAND
Meringo Road
5 seat
5. This vantage point at Meringo Headland, is a great whale watching spot. Whales come through twice a year, from April to June heading north to breed, and from September to late November heading south with their young. Shag Rock in front of the headland is a favourite roosting place for cormorants.
When heading north, look out for the post marking the stairs off the beach. From this point you can walk up the road to Meringo Point.
to Princes Hwy
From the walking track it is worth exploring Mullimburra Point, its secluded beaches and dramatic crevices. An alternate walk is to go from one of the car parks here, along the beach to Grey Rocks and back via the walking track.
Mullimburra Lagoon
MULIMBURRA POINT
Eurobodalla National Park
Roads
Bingi Dreaming Track
Alternate walks
Camping area
Lookout
Picnic area
Toilet
0
500m
1km
Bingi Road
4
4. Keep left at this Y junction to stay on the walk, ignore the other side tracks off to the east. Note the twisted red gum forest. Orb spiders often spin their webs over the track.
Grey Rocks creek
GREY ROCKS
Mullimburra Point Road
Kelly's Lake
3
3. Indicates a detour to Kelly's Lake, known for its abundance of Aboriginal bush tucker. Note also the fine lillypilly trees and wedding bush. Look for fungi on fallen timber in autumn. The lake is a wetland of State significance and is surrounded by endangered swamp forest.
Bingi Road
1. From this point, a short gravel track to Bingi Point is suitable for all levels of ability.
Near the end of Bingi point, is the rusting boiler from the wreck of the SS Monaro, one of the many ships used in the nineteenth century to carry produce and stores up and down the coastline.
There is a fresh water pool half way to the point, where plants have adapted to salty conditions and brown marsh frogs live. The grasses in this vicinity are known as Basalt Grassy Headland and are an Endangered Ecological Community.
2. This point marks the start of Bingi Dreaming Track, north to Kelly's Lake and on to Grey Rocks. An easy, short walk is to Kelly's Lake and back via the beach.
2
seat
1
BINGI POINT