



NEW ZEALAND • UNITED STATES • WORLDWIDE

MULTI-PURPOSE REEF FEASIBILITY STUDY AND PRELIMINARY DESIGN



OLD BAR BEACH

Proposal prepared for



ASR MARINE CONSULTING & CONSTRUCTION

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CONTENTS

| | | |
|----------|--|-----------|
| 1 | INTRODUCTION | 4 |
| 2 | MULTI-PURPOSE REEF OVERVIEW | 5 |
| 2.1 | COASTAL PROTECTION AND BEACH STABILIZATION | 7 |
| 2.2 | MARINE HABITAT CREATION | 8 |
| 2.3 | RECREATION ENHANCEMENT | 10 |
| 2.4 | METHODOLOGY FOR MULTI-PURPOSE REEF FEASIBILITY STUDY & DESIGN..... | 10 |
| 3 | COMPANY INFORMATION | 11 |
| 3.1 | ASR BACKGROUND AND CAPABILITIES..... | 11 |
| 3.2 | COMPANY TECHNICAL CAPABILITIES | 11 |
| 4 | PROJECT SCOPE & EXECUTION | 12 |
| 4.1 | METHODOLOGY | 12 |
| 4.2 | OBJECTIVE..... | 12 |
| 4.3 | WORK PROGRAM | 12 |
| 5 | RELEVANT MULTI-PURPOSE REEF CASE STUDIES | 15 |
| 5.1 | KOVALAM MULTI-PURPOSE REEF: KERALA, INDIA..... | 15 |
| 5.2 | BOSCOMBE MULTI-PURPOSE REEF: BOURNEMOUTH, UNITED KINGDOM | 17 |
| 5.3 | NARROWNECK MULTI-PURPOSE REEF: GOLD COAST, AUSTRALIA..... | 19 |

TABLE OF FIGURES

| | |
|--|-----------|
| <i>Figure 1.1 Old Bar Beach, New South Wales, Australia.</i> | <i>4</i> |
| <i>Figure 2.1 Multi-Purpose Reef results/benefits.</i> | <i>6</i> |
| <i>Figure 2.2 Wider beach created by the Narrowneck Multi-Purpose Reef through the formation of a salient.</i> | <i>7</i> |
| <i>Figure 2.3 Before (left), and 5 years after (right) the construction of the Narrowneck Multi-Purpose Reef.</i> | <i>8</i> |
| <i>Figure 2.4. Colonisation by seaweed began the moment the Narrowneck Multi-Purpose Reef was under construction (left – 2 weeks after construction). Over 2 years later, a large variety of marine life inhabits the reef (right).</i> | <i>9</i> |
| <i>Figure 2.5 Similar colonization patterns have been observed at the Mount Maunganui Multi-Purpose Reef.</i> | <i>9</i> |
| <i>Figure 2.6 Surfing on a completed Multi-Purpose Reef.</i> | <i>10</i> |
| <i>Figure 4.1 Numerical modeling of a proposed Multi-Purpose Reef design.</i> | <i>13</i> |
| <i>Figure 4.2 Physical modeling of a proposed Multi-Purpose Reef design in ASR’s in-house wave pool facility</i> | <i>14</i> |
| <i>Figure 4.3 Construction of a Multi-Purpose Reef. (a) The web design for the reef. (b) Attaching geotextile containers to the web. (c) Winching the reef to the seabed. (d) Filling the geotextile containers.</i> | <i>14</i> |

1 INTRODUCTION

This proposal describes the steps needed to undertake a feasibility assessment and produce a preliminary design for the construction of a Multi-Purpose Reef(s) at Old Bar Beach, New South Wales, Australia (Figure 1.1).

The ongoing erosion at Old Bar is believed to be the effect of cross-shore sediment transport during storm activity, which moves sand offshore and out of the beach system faster than it can be naturally replenished. Detached breakwaters, emergent breakwaters and submerged breakwaters (reefs) are typically used along coastlines with small tidal fluctuations to control the cross-shore sand transport processes. As the maximum tidal range at Old Bar Beach is relatively small, it is expected that an offshore detached structure(s) will be effective in providing a new beach control point(s) and widening Old Bar Beach.



Figure 1.1 Old Bar Beach, New South Wales, Australia.

In the present case there are several studies that indicate submerged structures will be effective for salient development of the presently eroded beach. The larger scale ‘example’ of Urana Bombora, which results in the large salient that is Old Bar, provides additional evidence to support this approach. Thus, the focus of ASR’s study will be to investigate Multi-Purpose Reefs as a feasible option for beach protection/replenishment by the development of a locally wider beach at Old Bar.

This proposal outlines the benefits of Multi-Purpose Reef technology and how this technology can be applied to Old Bar Beach. This is followed by a description of the specific steps required to perform a feasibility study and preliminary design for the site. The next section provides an overview of the detailed design and construction processes – the next phases of a potential project. The proposal concludes by highlighting recent case studies of Multi-Purpose Reef implementation.

2 MULTI-PURPOSE REEF OVERVIEW

A Multi-Purpose Reef is an offshore, underwater coastal structure that can protect the coastline, reduce erosion, enhance marine habitat, and provide a valuable recreational resource. ASR’s Multi-Purpose Reef designs represent a form of biomimicry, patterned after naturally occurring offshore reefs and the way they beneficially affect shorelines and waterfronts around the world.

One of the key byproducts resulting from the presence a Multi-Purpose Reef is the formation of a salient – a wider, more stable section of beach behind the reef. This effect is a phenomenon that has been well documented and quantified in peer reviewed technical journals and coastal engineering manuals. ASR has merged this concept with our understanding of marine systems and our pioneering work on the science of surfing to develop technology which will protect and stabilize the coastline, enhance marine ecology, and, where the natural conditions will allow, create an enhanced surfing experience.

When compared to traditional solutions like seawalls and groynes, Multi-Purpose Reefs have four distinct benefits:

1. Coastal Protection: Reefs reduce and redirect the wave energy affecting the coast, thereby reducing erosional stress on the shoreline.
2. Beach Stabilization: In addition to producing a salient, reefs are submerged and located offshore, and therefore do not degrade or destroy the natural beauty of the beach.
3. Marine Habitat Creation: Reefs provide a solid substrate which creates habitat for marine animals and promotes biodiversity and enhanced ecosystems.
4. Recreation Enhancement: Reefs create recreation for surfing, fishing, diving, and other water activities.



Figure 2.1 Multi-Purpose Reef results/benefits.

Multi-Purpose Reefs are developed through a synergistic effort bringing together a wide range of disciplines and experts, including coastal scientists, engineers, biologists, planners and environmental managers to create an effective and environmentally sound solution. As a result, ASR’s designs are able to fulfill the demands of the coastal engineering industry while still considering the marine environment, beach users, and the coastal community at large. ASR has proposed designs for over 40 Multi-Purpose Reef projects around the world, with the construction of its most recently completed multi-purpose structures in Boscombe, England and Kovalam, India.

2.1 Coastal Protection and Beach Stabilization

Multi-Purpose Reefs have been developed to address a need for coastal protection solutions that are effective, and at the same time environmentally and socially sensitive. Submerged structures for coastal protection are not a new technology; indeed, they have been used for coastal protection throughout the world for many years and remain an active topic of research in the coastal engineering community. What is relatively new is the design methodology which incorporates world-class numerical and physical modeling to assess functional performance, the incorporation of surfing amenity, and in some cases, species-specific habitat enhancement. Internationally, submerged structures (*i.e.*, submerged breakwaters, artificial or Multi-Purpose Reefs) are recognized as innovative and environmentally sensitive solutions to coastal protection.

ASR's Multi-Purpose Reefs can be part of an integrated beach management solution. Multi-Purpose Reefs stabilize beaches by forming a salient – a wider, more stable section of a beach. These reefs can also be incorporated in conjunction with sand renourishment and dune stabilization projects. As such, these structures actually consider the value that beaches provide to local communities by serving to protect the beach itself. Seawalls and other forms of coastal armoring do not protect the beach; they only protect the land behind it. Beaches are valuable assets to communities as they create a host of benefits from socio-economic, ecological, and coastal protection standpoints.



Figure 2.2 Wider beach created by the Narrowneck Multi-Purpose Reef through the formation of a salient.



Figure 2.3 Before (left), and 5 years after (right) the construction of the Narrowneck Multi-Purpose Reef.

2.2 Marine Habitat Creation

Locally enhanced biodiversity is another beneficial result of Multi-Purpose Reefs. Marine habitat provides an added benefit to many areas in the form of an added attraction for diving and snorkeling. One such example is the Narrowneck Reef, Australia, where local tourist operators include the reef as part of a dive tour.

In ecological terms, the principles are simple and well known: a hard stable substrate, such as a reef, results in greater biodiversity and species abundance than mobile sandy substrates. The materials used in the construction of Multi-Purpose Reefs, in addition to being extremely durable, are specially designed to provide an attractive habitat for marine plant life, which in turn makes the structure even more attractive for marine animal life. At the most recent Multi-Purpose Reef site in Kovalam, India, noticeable plant and marine life was documented on the reef within 2 weeks of reef installation. This stood in stark contrast to the surrounding environment, devoid of plant life, where comparatively fewer species (marine worms, crustaceans and bivalves for example) inhabit the abrasive, mobile sandy seabed. The biological enhancement created by the construction of a Multi-Purpose Reef may include increased environmental value (increases in bio-diversity and abundance), increased amenity in the form of a diving and snorkelling venue, and enhanced fisheries through the incorporation of specific habitat.

The majority of species in the oceans are not limited in numbers solely by their quantity of offspring, but also by the availability of habitat for them to colonise and inhabit – there may be hundreds of thousands of larvae in the water, but no suitable substrate to settle and colonize. Creating reefs provides the opportunity to incorporate specific topography for specific species, which opens opportunities for fisheries management, reserves, and recreational amenities. The Narrowneck reef on the Gold Coast reef is a good example. In this case, rapid colonisation of the reef occurred after construction, resulting in the growth of a diverse reef ecosystem. More than 270 different species have been identified living on and around the Narrowneck Reef. Similar results have been observed at the Mount Maunganui Reef in New Zealand.

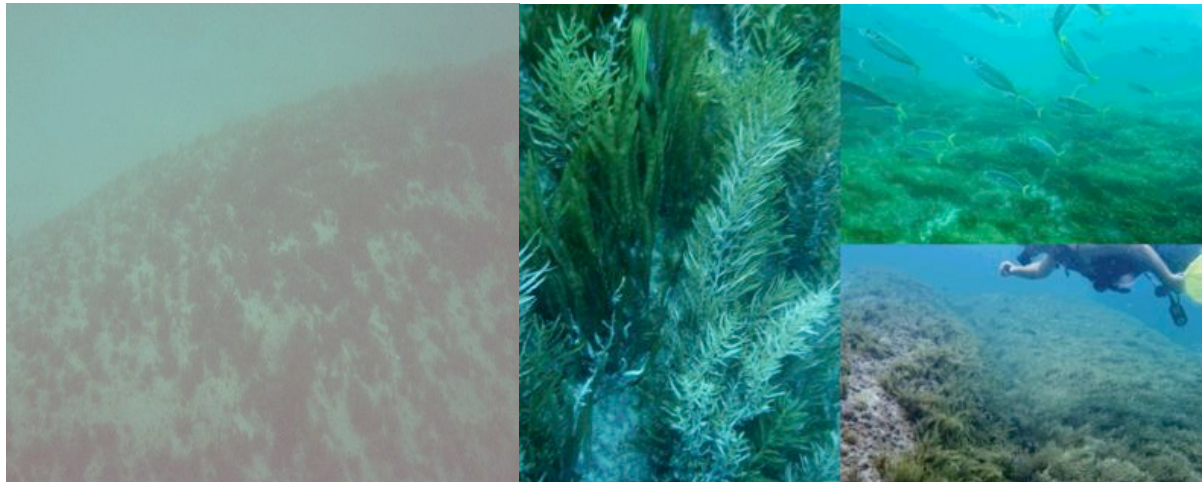


Figure 2.4. Colonisation by seaweed began the moment the Narrowneck Multi-Purpose Reef was under construction (left – 2 weeks after construction). Over 2 years later, a large variety of marine life inhabits the reef (right).



Figure 2.5 Similar colonization patterns have been observed at the Mount Maunganui Multi-Purpose Reef.

2.3 Recreation Enhancement

ASR's Multi-Purpose Reefs can be specifically designed to improve surfing conditions. Using extensive surveying, computer modeling, physical modeling, and a unique knowledge of surfing science, ASR can design and construct our reefs to effectively mimic surfing reefs found naturally. ASR's consultants have been at the forefront of surfing science with the majority of its employees being active surfers and oceanographers. Together with ASR's world-class 3DD Suite of numerical models, ASR's team are the world-leaders in surfing reef design. In Addition to surfing, Multi-Purpose Reefs also provide an excellent location for fishing, diving, kayaking, and other recreational activities.



Figure 2.6 Surfing on a completed Multi-Purpose Reef.

2.4 Methodology for Multi-Purpose Reef Feasibility Study & Design

Wave and shoreline response to submerged structures is entirely dependent on the local, site-specific processes, so "one size does not fit all". Thus, a thorough understanding of the site is required to ensure that the design will perform optimally in terms of meeting the customer's desired combination of coastal protection, beach stabilization, marine habitat creation, and the best quality surfing waves under the widest possible range of conditions. This is achieved through the collection and analysis of detailed, on-site oceanographic data followed by application of numerical models to combine the various sources of existing data, experience and the application of the available research.

3 COMPANY INFORMATION

3.1 *ASR Background and Capabilities*

ASR has a wide range of expertise and experience in multi-disciplinary consulting and research in the aquatic environment (marine and freshwater). ASR also actively collaborates with other national and international research institutes and universities such as CESS (India), MAFRI (Australia), and Plymouth University (England) for projects related to coastal processes such as Multi-Purpose Reefs. The company has flourished as a fully independent consulting and coastal engineering group, making decades of academic and research experience, as well as project management experience, readily available to clients. Directors and senior staff have PhD's or extensive experience in coastal processes and oceanography and noteworthy scientific, consultancy and popular article publication lists.

The company specialises in numerical modelling and coastal field studies of outfalls, fish larvae, waves, beaches, ports and harbours etc, but ASR is particularly well known for its world leadership in Multi-Purpose Reef design and offshore coastal protection.

Further details on ASR's expertise, experience, project management structure, projects and personnel can be accessed at www.asrltd.com.

3.2 *Company Technical Capabilities*

ASR possesses the technical capacity to undertake a broad range of projects, and has successfully done so for over a decade. ASR has a complete range of equipment available for fieldwork including drop-cameras, Acoustic Current Doppler Profilers (ACDP's - Workhorse *Sentinel ADCP* and SonTek), transportable bathymetry survey systems, FLNTU turbidity sensors (Combination Chlorophyll Fluorometer and Turbidity Sensor), LISST (Laser In-Situ Scattering and Transmissometry) particle analyser, salinity gauges for plume dispersal deployments (FSI and Odyssey), Aquadopp Wave/Current Meters, field GPS units, temperature thermistor strings, video sled for seabed transects (used to over 120 m depths), equipment sleds for data collection in moving water (surfzone and river studies), diving equipment, a 5 x 10 m wave basin and a variety of other sampling devices, mounts, frames and measuring instruments.

ASR's in-house computer modelling capabilities represent the most advanced and powerful tools available to the modern coastal engineer/scientist. Its flagship 3DD suite of numerical models are coupled, state-of-the-art, hydrodynamic and sediment transport models that are utilized in a wide range of projects to expand the 'point-source' data acquired by instruments to enable understanding of large areas and assess impacts of coastal structures, oil spills, effluent dispersal, etc.

4 PROJECT SCOPE & EXECUTION

4.1 Methodology

While ASR is known world-wide for its development of Multi-Purpose Reefs for coastal erosion control and enhanced amenity and aesthetics (when compared to land-based hard engineering), ASR is comprehensive in its approach to coastal management. Indeed, the company is involved with coastal projects that use renourishment, detached breakwaters, sand by-passing, submerged reefs, groynes, or dune management among other options. Quite often, hybrid solutions that incorporate a range of solutions are needed to obtain the required response for a particular situation. Our approach to any coastal issue is to first understand and quantify the existing physical processes operating at the site of interest. Each site is different and has its own specific processes operating, so there is no generic solution that can be applied to every beach.

4.2 Objective

As we understand it, the objectives in this case are to:

1. Prevent the continued erosion of the Old Bar Beach and provide a buffer against future storms and strong wave activity. This is the primary objective.
2. Create an enhanced recreational experience associated with the reef including surfing, bodyboarding, diving, and fishing. This is the secondary objective.

4.3 Work Program

The overall project would incorporate three parts (this proposal encompasses Part 1):

Part 1: Reef Feasibility Study and Preliminary Design

- ASR works with the customer to fully understand their requirements and goals from a Multi-Purpose Reef.
- ASR collects/reviews existing data on swell, tide, currents, weather, bathymetry, geology, ecology, etc for the proposed site.
- ASR conducts field studies as necessary to supplement and calibrate existing data.
- Drawing upon our world-class scientists and our in-house modeling software, ASR conducts preliminary numerical modeling of the proposed reef site to determine project feasibility.
- ASR develops preliminary design plan(s) and costing for a Multi-Purpose Reef.
- ASR produces a report which assesses viability of a reef in the proposed location and outlines the steps for proceeding with final design & construction.

Part 2: Final Reef Design and Modeling

- ASR deploys instruments on-site to collect additional data about the site as necessary.
- ASR develops detailed numerical models of the Multi-Purpose Reef site, performing extensive calibrations of the models using historical and actual field data.
- ASR develops a design for a Multi-Purpose Reef.
- Reef design is tested via physical modeling in our own laboratory facilities to verify the numerical modeling results prior to finalizing our solutions.
- A detailed final design report and cost estimate for construction is delivered to customer.

Part 3: Reef Construction

- After the Multi-Purpose Reef is completely designed, construction can begin. ASR uses specifically engineered geotextile mega-containers to build the reef.
- Each section of the reef is precisely deployed, anchored into place, and filled with sand using hydraulic pumps by ASR's specialized construction team.
- Each reef is built to optimize its performance based on the criteria from the client, be it coastal protection, recreational enhancement, marine habitat, or a combination thereof.

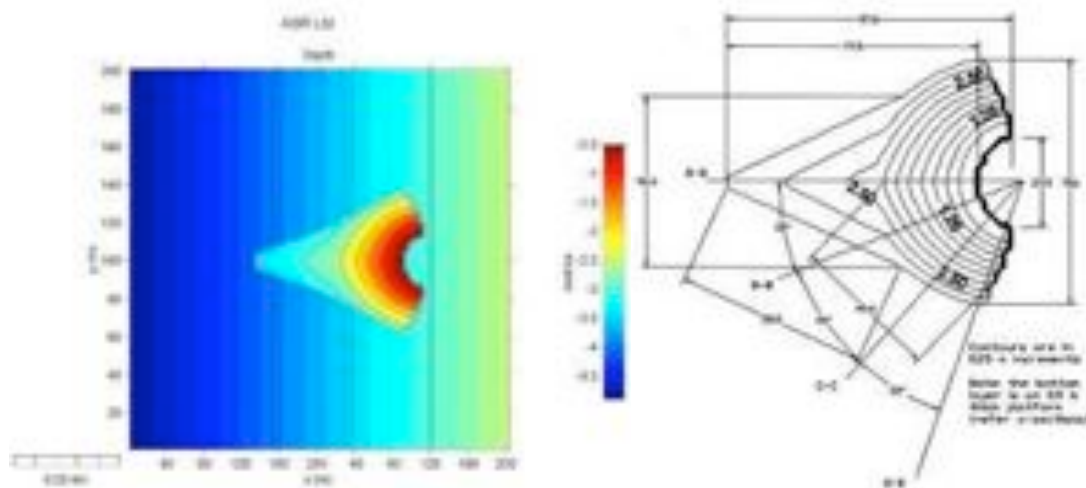


Figure 4.1 Numerical modeling of a proposed Multi-Purpose Reef design.



Figure 4.2 Physical modeling of a proposed Multi-Purpose Reef design in ASR's in-house wave pool facility

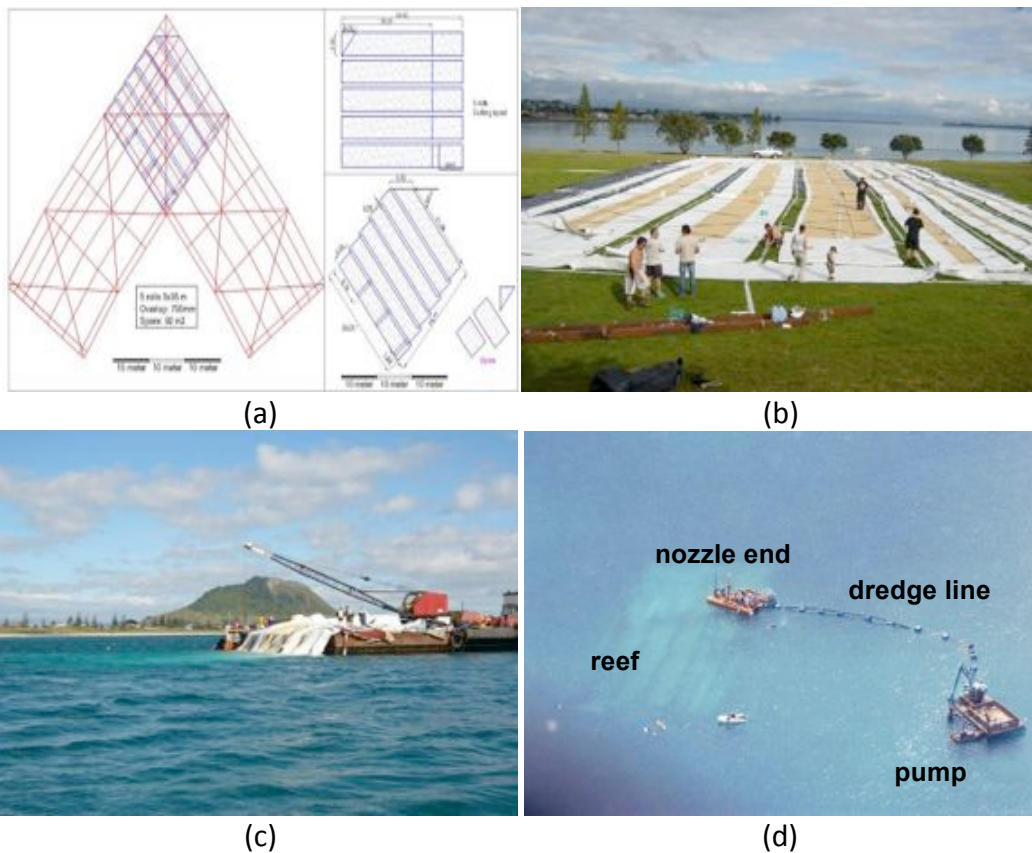

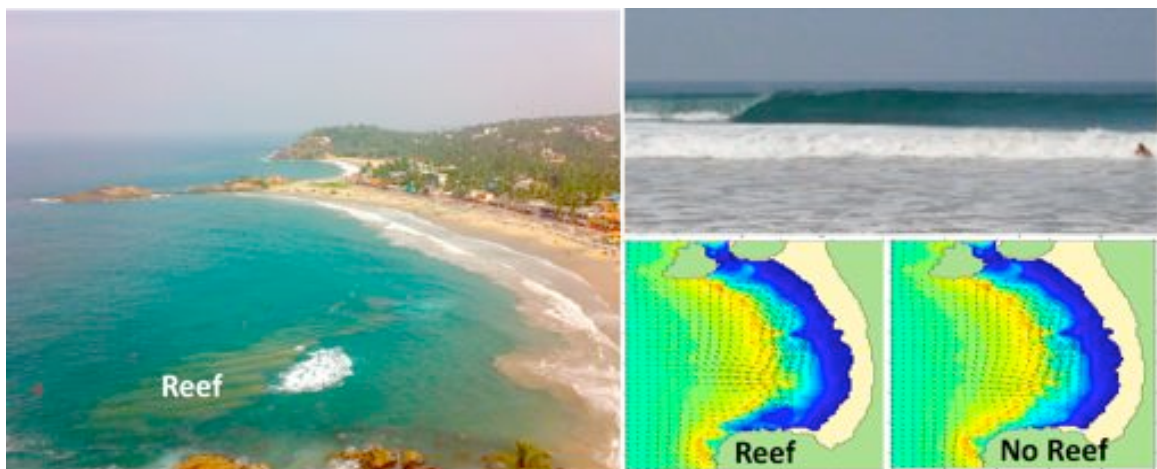


Figure 4.3 Construction of a Multi-Purpose Reef. (a) The web design for the reef. (b) Attaching geotextile containers to the web. (c) Winching the reef to the seabed. (d) Filling the geotextile containers.

5 RELEVANT MULTI-PURPOSE REEF CASE STUDIES

5.1 Kovalam Multi-Purpose Reef: Kerala, India

| | | |
|------------------------|--|---|
| Location | Kovalam, Kerala, India |  |
| Type of Project | Multi-Purpose Reef Design and Construction | |
| Client | Harbour Engineering Department, Government of Kerala, India | |



Clockwise from upper left: Aerial view of the Kovalam Multi-Purpose Reef; high quality surfing wave breaking along the reef; wave height models after and before construction illustrate how the reef both shapes surf and redirects erosive wave energy offshore and away from the beach.

Project Overview – Kovalam has been one of southern India’s most popular tourist destinations since the 1930’s. However due to rapid development in recent years, the Kovalam shoreline has suffered from severe coastal erosion during the monsoon season which has led to the loss of a valuable beach amenity. The Kerala Department of Tourism commissioned ASR to design and construct an offshore Multi-Purpose Reef at Kovalam to protect the beach while improving ecology and enhancing tourism growth through the introduction of a water sport such as surfing.

Project Outcomes – After conducting extensive field studies, developing numerical and physical models, and performing exhaustive calibrations and testing, ASR completed construction of the Kovalam Reef in February 2010.

The reef has been specifically designed to cause the region’s often powerful waves to break offshore, thereby minimizing the erosive effects of those waves on the beach. Additionally,

the reef is positioned to redirect the currents that have been partially responsible for the historical reduction of beach size in Kovalam.

The reef has also received extensive praise for shaping world-class surfing waves, and has been featured by organizations including Patagonia, Surfline, and Quicksilver.

ASR continues to monitor reef performance, and is working closely with the local stakeholders to maximize the reef's benefit to the community.

5.2 Boscombe Multi-Purpose Reef: Bournemouth, United Kingdom

| | |
|------------------------|--|
| Location | Boscombe, Bournemouth, England |
| Type of Project | Multi-Purpose Reef Design and Construction |
| Client | Bournemouth Borough Council, England |



Clockwise from upper left: Model of the Boscombe Reef; Urban Reef Restaurant – an economic offshoot of the reef project; tourism and new building developments along the beach adjacent to the Boscombe Reef; surfing and body-boarding on the Boscombe Reef.

Project Overview – As part of an effort to revitalize the Bournemouth waterfront, ASR was contracted by the Bournemouth Borough Council to design and construct an offshore, Multi-Purpose Reef.

Project Outcomes – After conducting extensive field studies, developing numerical and physical models, and performing exhaustive calibrations and testing, ASR completed construction of the Boscombe Reef in October 2009.

The Boscombe reef has had a profound economic effect on the local community. It has become the focal point of Boscombe’s multi-million pound civic regeneration effort and generated worldwide attention. An independent economic impact assessment suggested that the Boscombe reef has created an image value of £10 million per year resulting purely from publications and media interest. Moreover, Boscombe’s regeneration project has created 91 new long-term jobs to date and tourism has jumped 32 percent since the completion of the reef.

The reef has created an entirely new and exciting recreational amenity for surfers, body-boarders, divers, fishermen, and other water enthusiasts. Additionally, less than a year after completion, the reef has transformed into a diverse and abundant marine habitat covered with algae, crustaceans, and fish. Lastly, the reef serves as an excellent coastal

protection structure. Preliminary monitoring indicates that the reef has created a noticeable salient, or wider section of beach, onshore from where it is positioned.

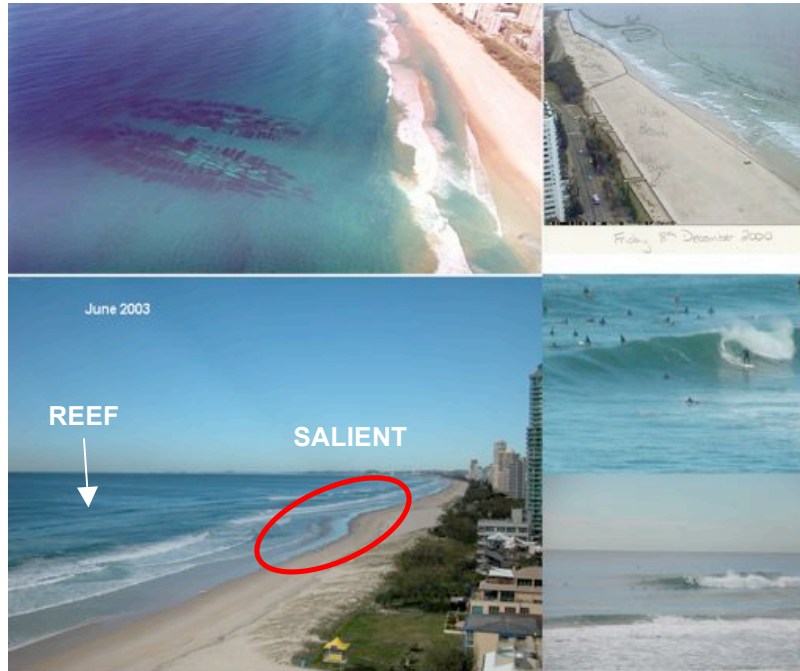
ASR continues to monitor reef performance, and is working closely with the Bournemouth Borough Council to maximize the reef's benefit to all stakeholders involved.

5.3 Narrowneck Multi-Purpose Reef: Gold Coast, Australia

Location Gold Coast, Queensland, Australia

Type of Project Multi-Purpose Reef Design

Client Gold Coast City Council



Clockwise from upper left: The Narrowneck Reef, evidence of shoreline response in December 2000, images from some good surfing days and an obvious salient in June 2003.

Project Overview – The Gold Coast is one of Australia’s greatest tourist destinations, with the wide sandy beaches a big part of the attraction. The erosion problem along the Gold Coast was most evident at Narrowneck, where only a thin strip of sand separated the lagoon from the sea. This barrier island had been breached several times in the previous century and coastal protection was proposed as part of the Gold Coast Beach Protection Strategy to address this problem.

Project Outcomes – Traditional coastal protection methods were considered (e.g. groynes, rock riprap, etc.). However, in the interest of preserving the beach without creating blight, the council commissioned ASR Ltd to design an offshore submerged reef. The main purpose of the Narrowneck reef was to retain sand nourishment material that was pumped onto the beach. The results of extensive studies have shown that the reef is effective in dissipating wave energy and that the Narrowneck reef has become an erosion control point along this section of the coast. An independent socio-economic assessment has found that for every dollar spent on enhancing the beach \$60-80 was returned via tourism-related benefits.