

Multi-purpose Ocean Reefs

- Understand
- Innovate
- Sustain

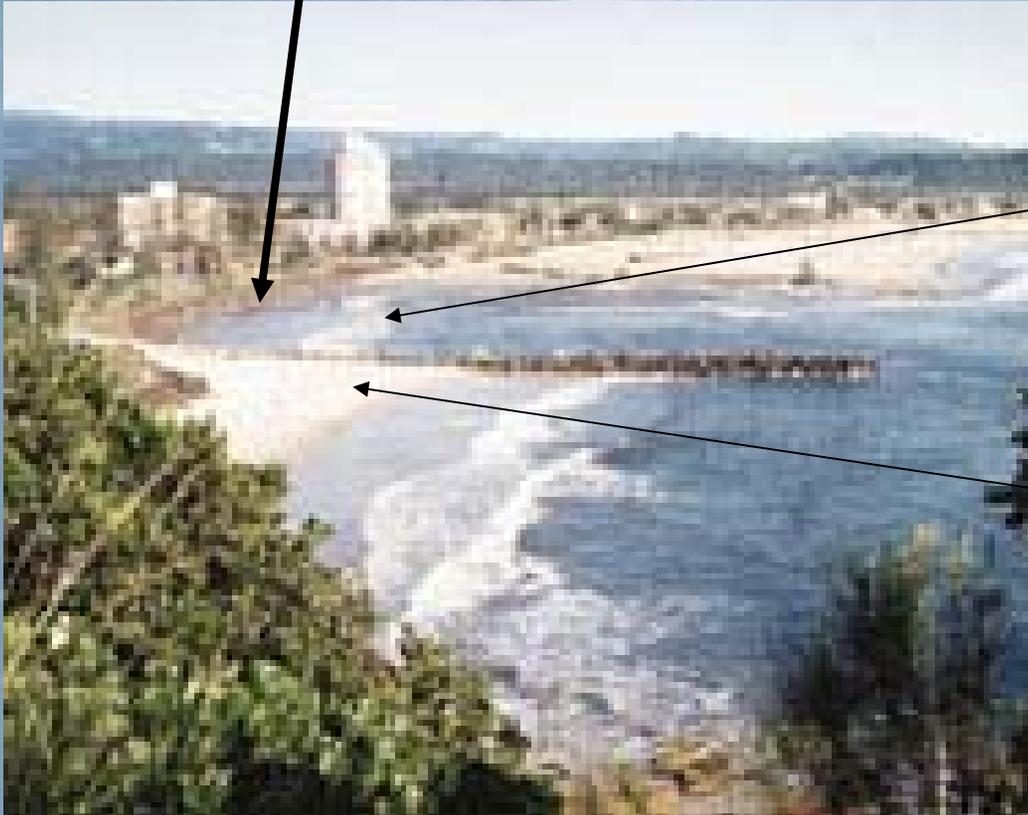


Multi-purpose Ocean Reefs

- Protect the coast
- Create wealth
- Enhance ecology
- Provide recreation

Land or Beach Protection? Often Fails the Coast and the Community

Seawall with no beach



Downcoast Erosion –
starved of sand

The groyne ‘blocks’ sediment
transport alongshore causing
accretion on the upcoast side



Marine and Freshwater Consultants

18 Calvert Road, Whale Bay, Raglan, New Zealand.
P.O. Box 151, Raglan, New Zealand. Ph. +64 7 825 0331, fax. +64 7 858 5036
E-mail asrltd@clear.net.nz Website www.asrltd.co.nz

ASR © 2000

Noosa, Australia, 1967



Noosa, 1978



OPTIONS

‘Traditional’

- Seawalls
- Groynes
- Bulkheads
- Detached Breakwaters

‘Modern’

- Dune Restoration
- Submerged Breakwaters/Reefs
- Renourishment
- Bypassing/Circulation
- Hybrid Solutions

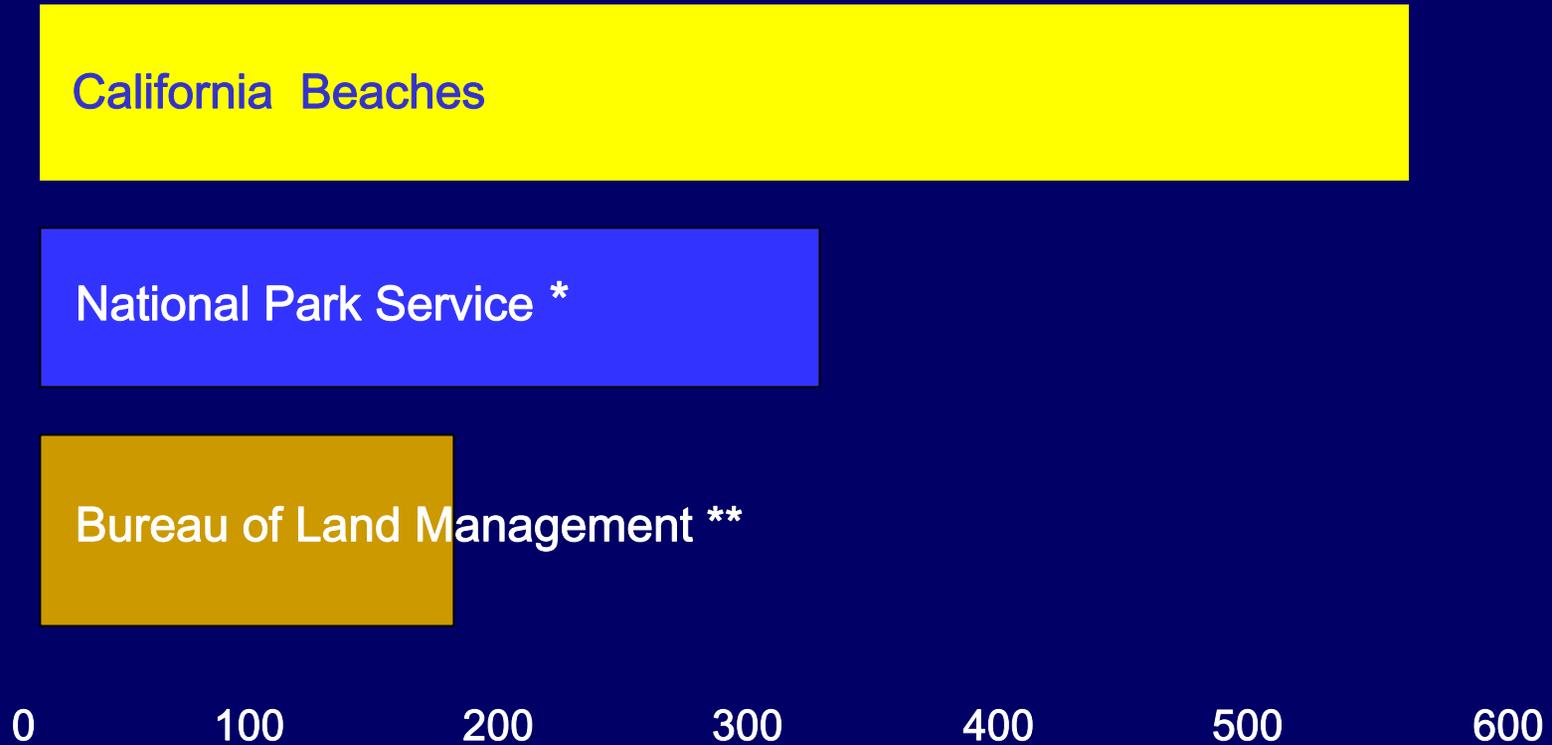
“What’s driving the changes in preference to coastal protection options?”

➤ Values

- Amenity
- Aesthetics
- Understanding
- Economics

Annual Tourist Visits

(Millions)



* Includes national seashores and monuments

** Properties are one-eighth of land in U.S.

*King, 1999
National Park Service, 2001
Bureau of Land Management, 2001*

California State beaches make up just 2.7% of State parks but have 72% of visits.

King, 1999

Beach tourists contribute \$260 billion to the U.S. economy and \$60 billion in Federal taxes.

King, 1999

Clean Beaches Council, 2001

World Travel and Tourism Council, 2001

Beach erosion is the number one concern that beach tourists have about beaches.

Hall and Staimer, 1995

THE ARTIFICIAL REEFS PROGRAM (ARP) - 1995

Program Aim

- * to enhance coastal constructions by incorporation of the multiple use options of surfing, diving, recreational and commercial fishing, navigation and swimming safety

Centre of Excellence in Coastal Oceanography and Marine Geology



The
University
of Waikato
*Te Whare Wānanga
o Waikato*

Understanding

- Scientific research
- Practical examples (case studies)
 - Monitoring

Scientific measurements



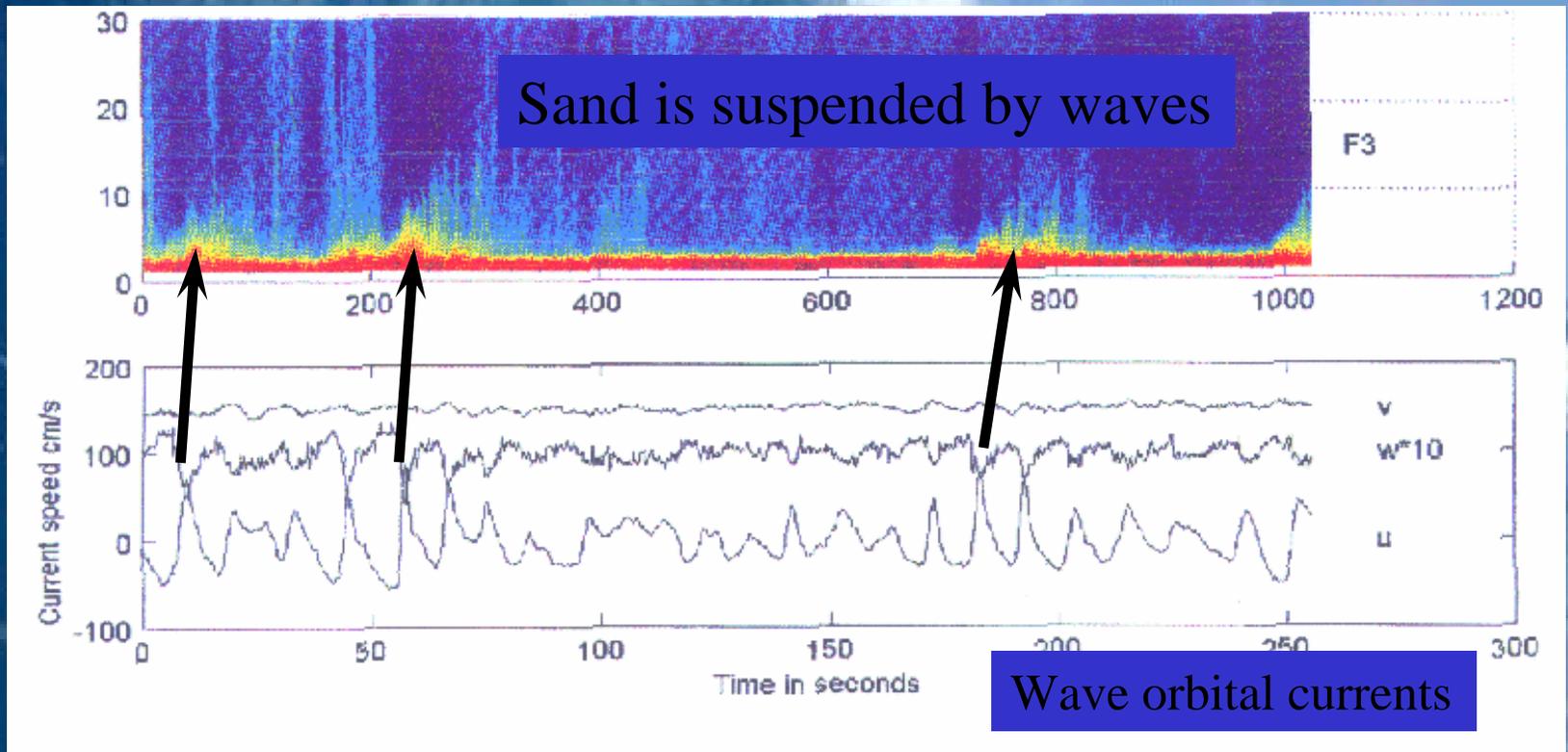
Sea sled



Automated HydroCamel water samplers

Science

High-resolution sediment concentrations recorded within millimetres of the sea bed



Numerical Models

3DD Computational Marine and Freshwater Laboratory

3DD Suite - Main Menu

Models Help

The 3DD Computational Marine and Freshwater Laboratory

ASR

3DD

POL3DD

WGEN

WBEND

2DBEACH

GENIUS

SUPPORT

HELP

The 3DD Computational Marine and Freshwater Laboratory is a unique suite of models that have evolved over 25 years of numerical case studies and scientific research. With its exceptional capabilities, the 3DD suite is the ideal modeling tool for management, science and applied research.

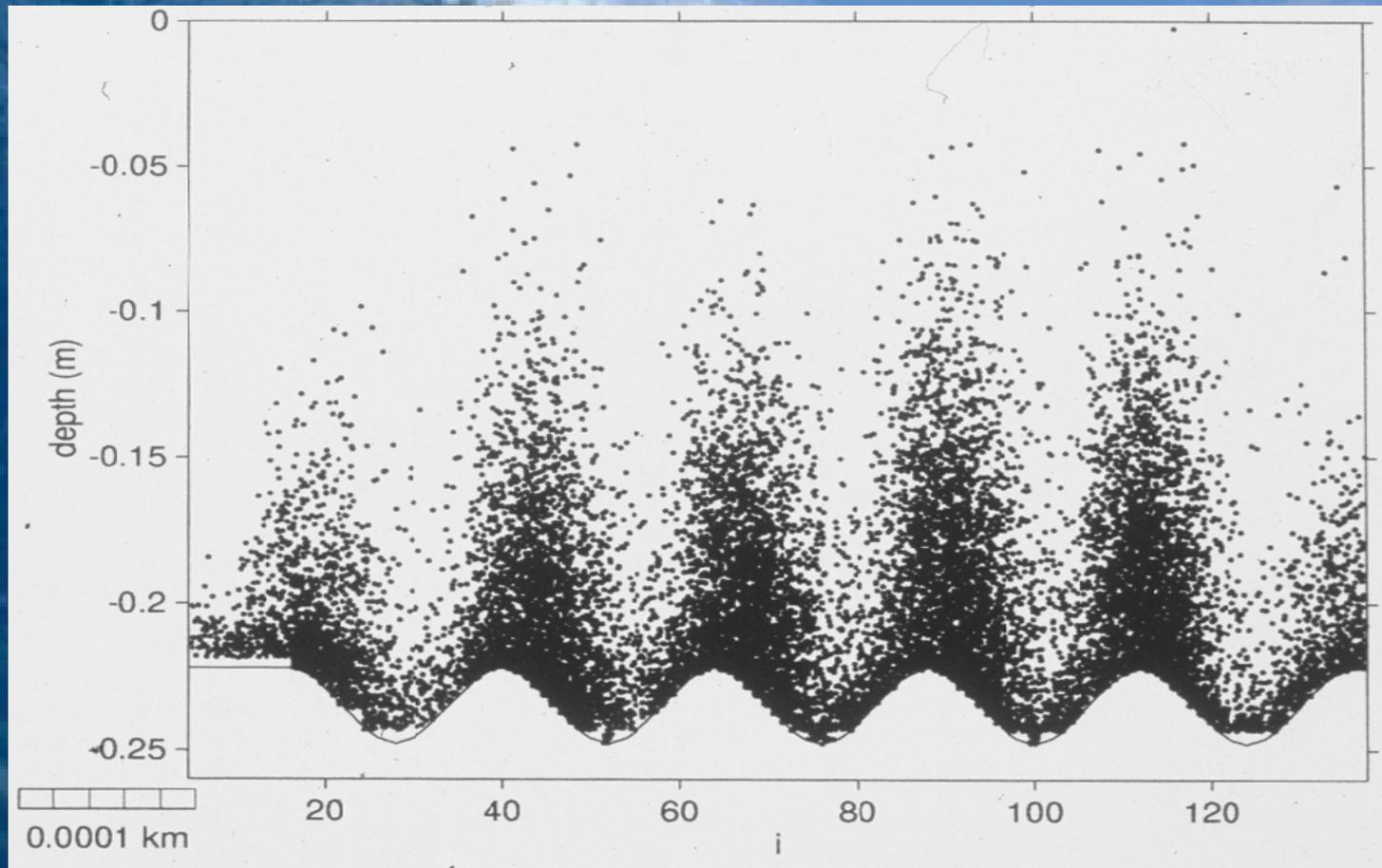
Terminate Acknowledgements

©Dr Kerry Black, 2000, Version 4.05



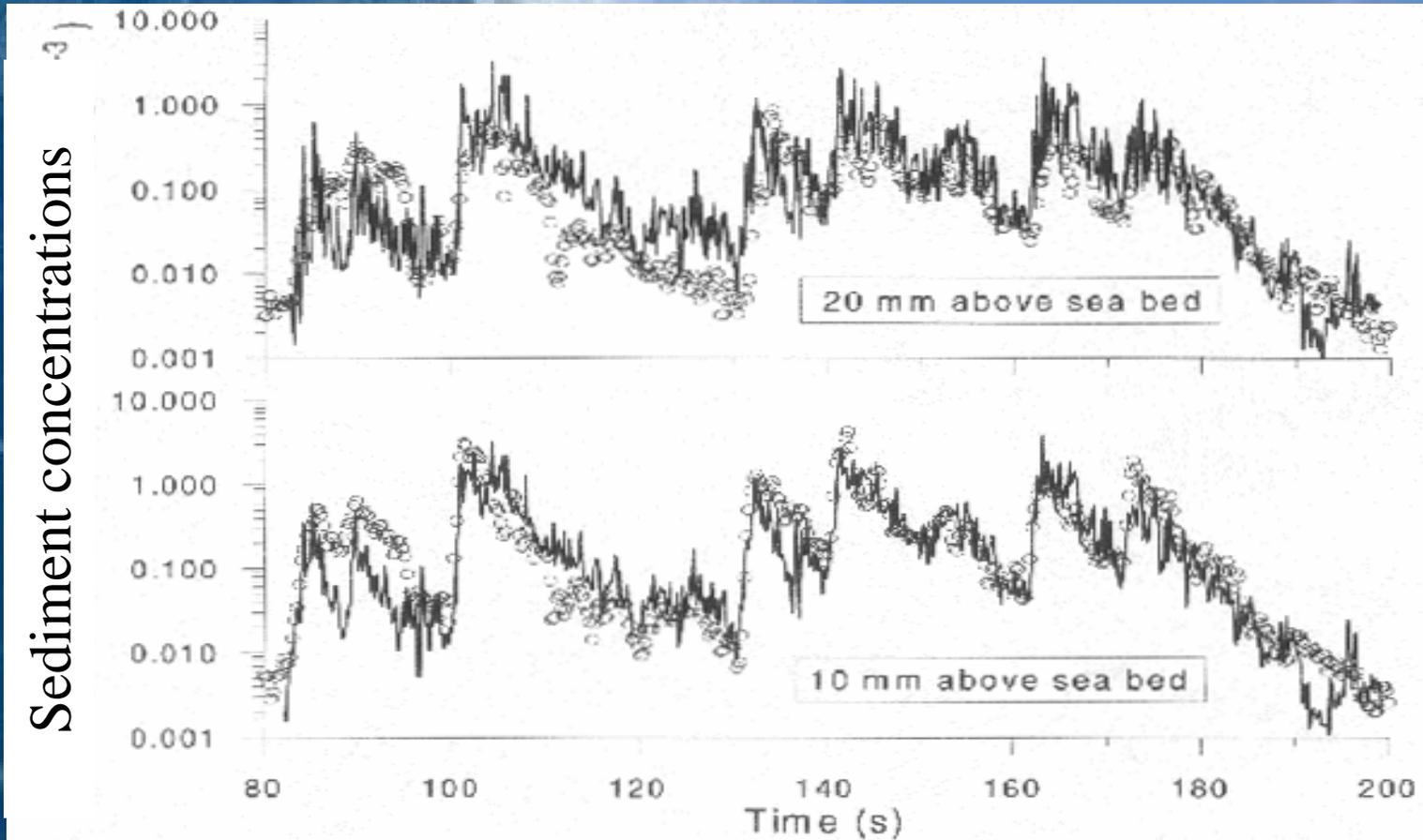
Numerical models

Micro-scale suspension over ripples is modelled in leading research



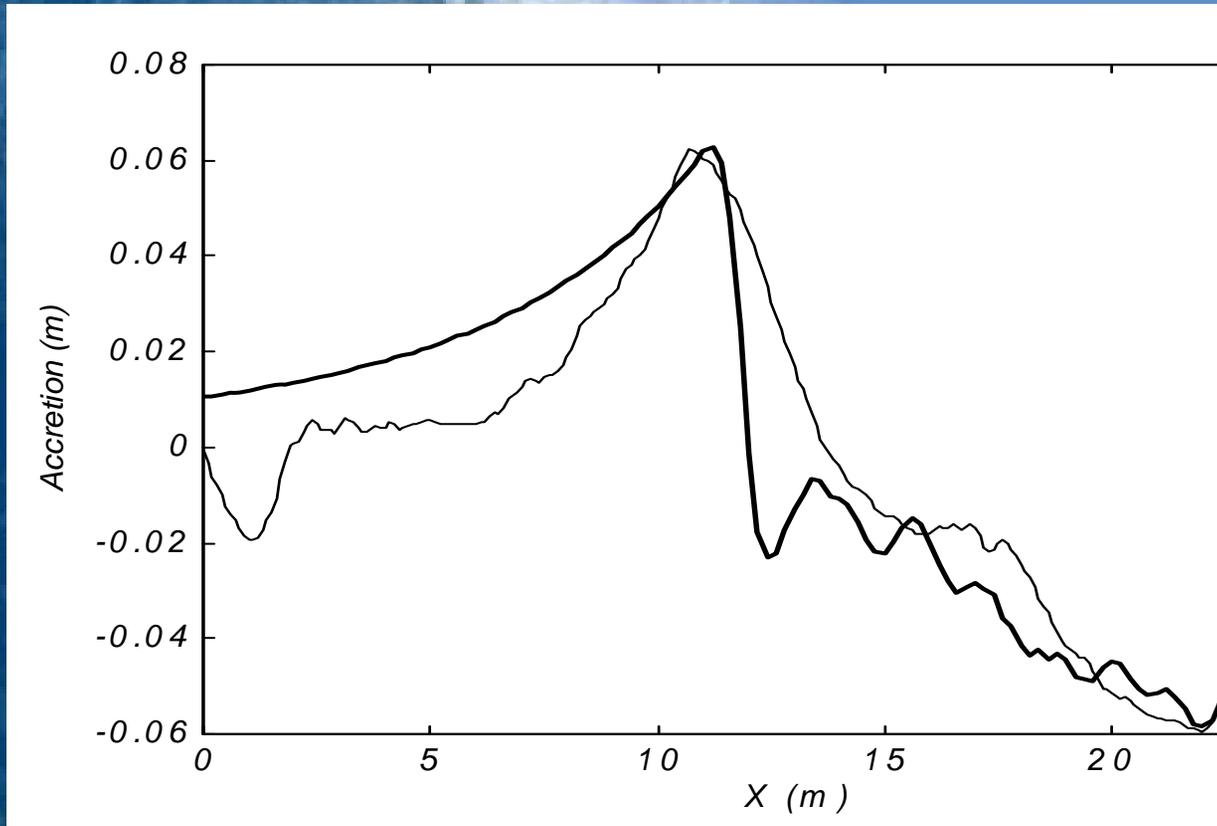
Numerical models

World's first accurate predictions of micro sediment suspension during the wave cycle

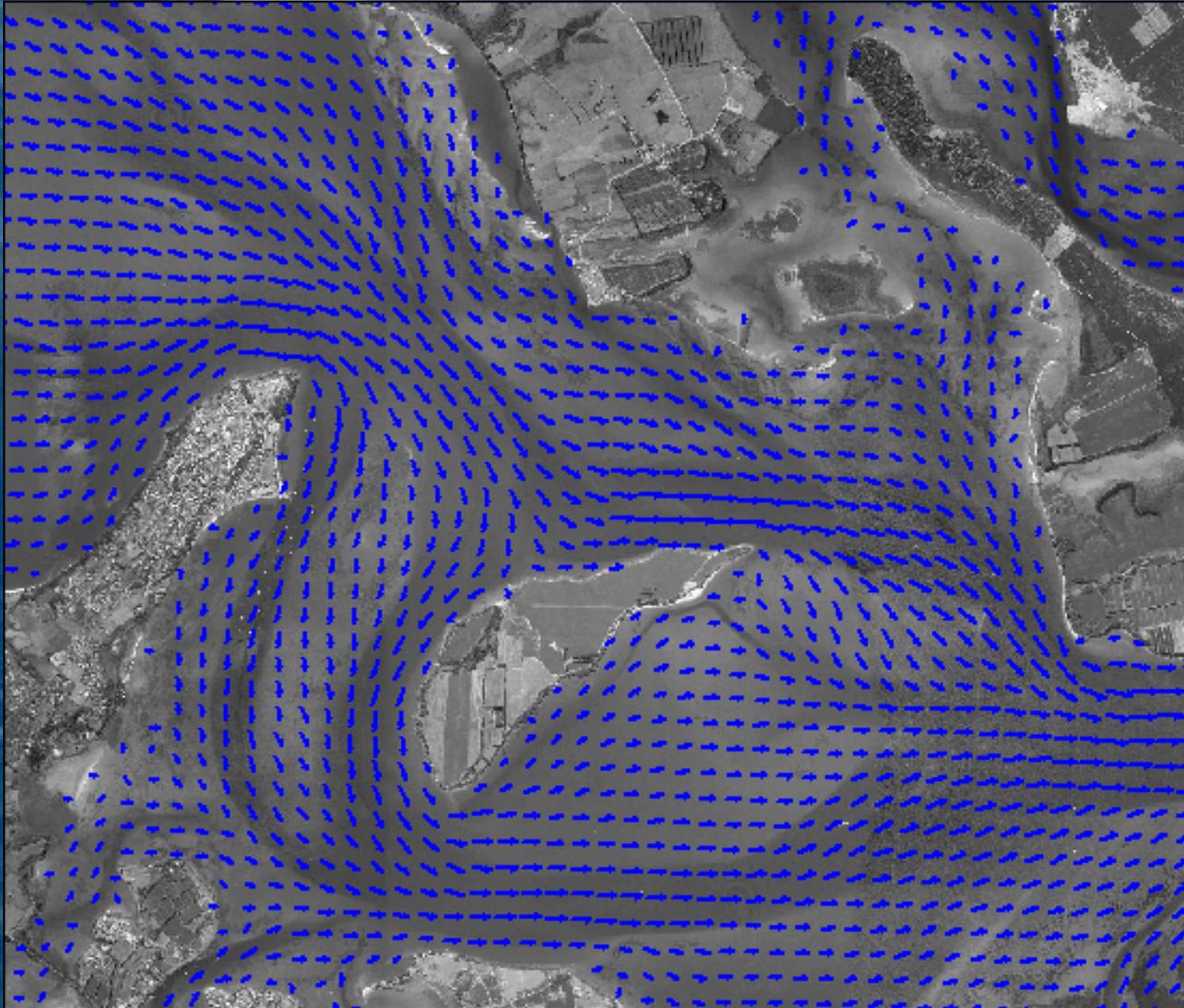


Numerical modelling

Measured beach evolution is predicted



Model output blended with GIS for public understanding



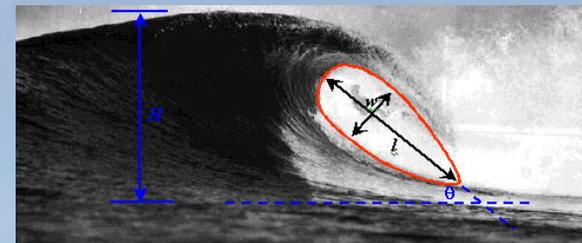
‘Combining years of experience in coastal research and numerical modeling with focused studies.’

Range of Integrated Studies Undertaken for the ARP

- Shoreline response to offshore obstacles
- Relationship between wave breaking and reef slope
- Collection of a Database of World-Class Surfing Breaks (44)
- Wave Peel Angle Assessment
- Surfing Reef Bathymetries
- Wave Breaking Intensity Analysis
- Numerical Modeling of Surfing breaks and Salient Formation
- Computer Aided Reef Design

Ongoing Research

- Length of a ‘Surfable Sections
- Relating Section Speed (Peel Angle) to Surfing Maneuvers
- The Downcoast Impacts of Offshore Submerged Reefs
- Offshore Wave Focusing
- Amalgamating Construction Engineering with Design



$$Y = 0.065X + 0.821$$

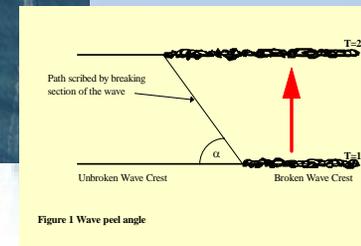


Figure 1 Wave peel angle

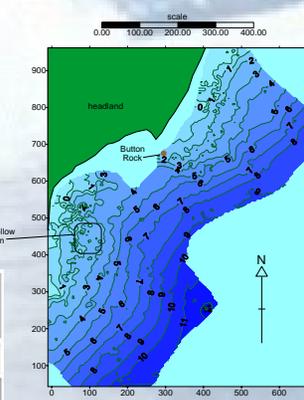
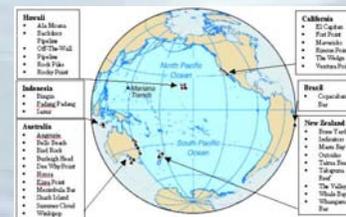
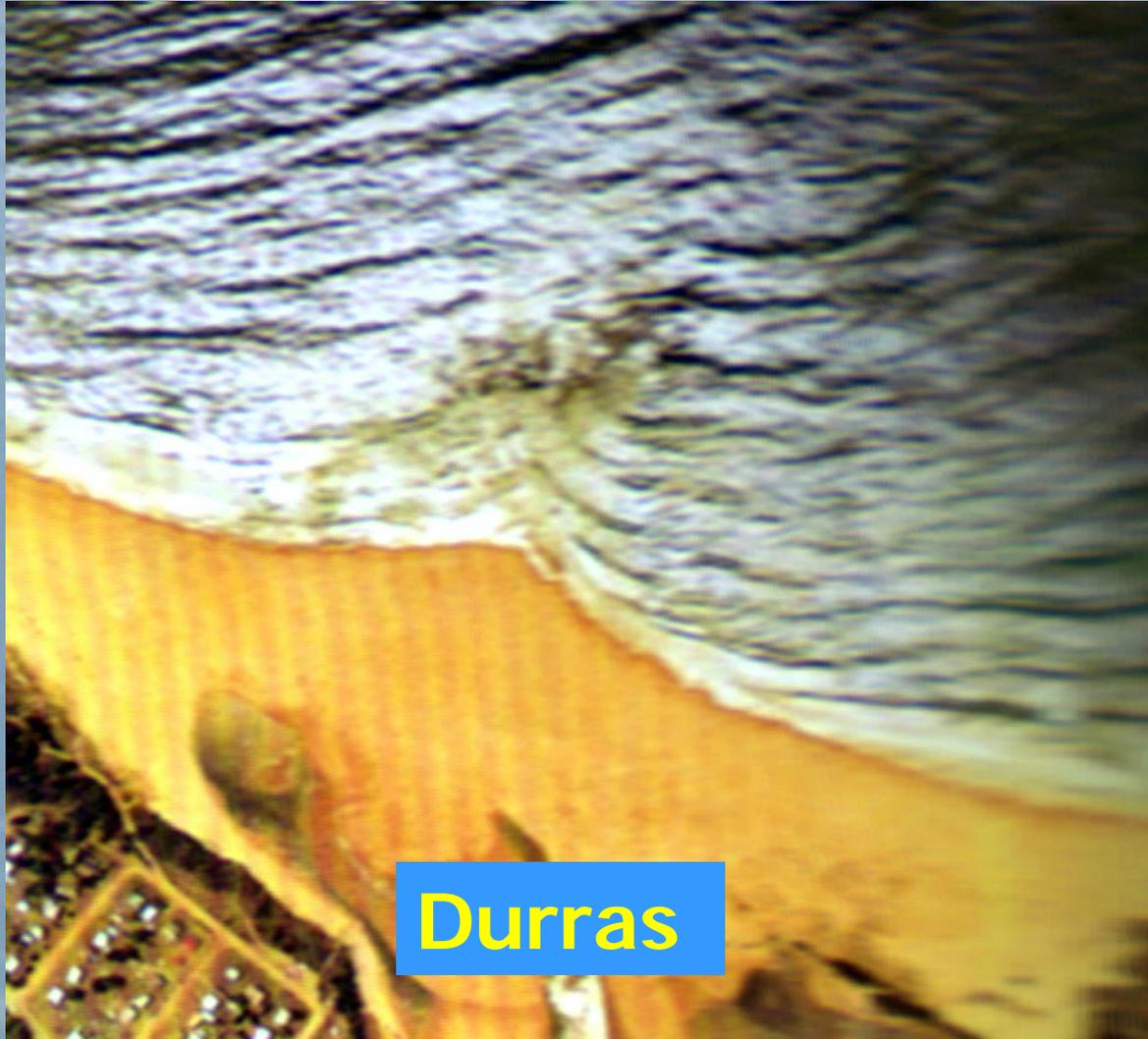


Figure 2. Contour map of Bells Beach and Winkipop, Victoria, Australia. Surveyed 21 November, 1997.

A large, powerful ocean wave is breaking, with white foam and spray visible. The water is a deep blue, and the sky is a lighter blue with some clouds. The wave is the central focus of the image, with its crest curling over.

Multi-Purpose Reefs For Coastal Protection

Natural Examples of Submerged Reefs



Durras

Natural Examples of Submerged Reefs



Hills Beach

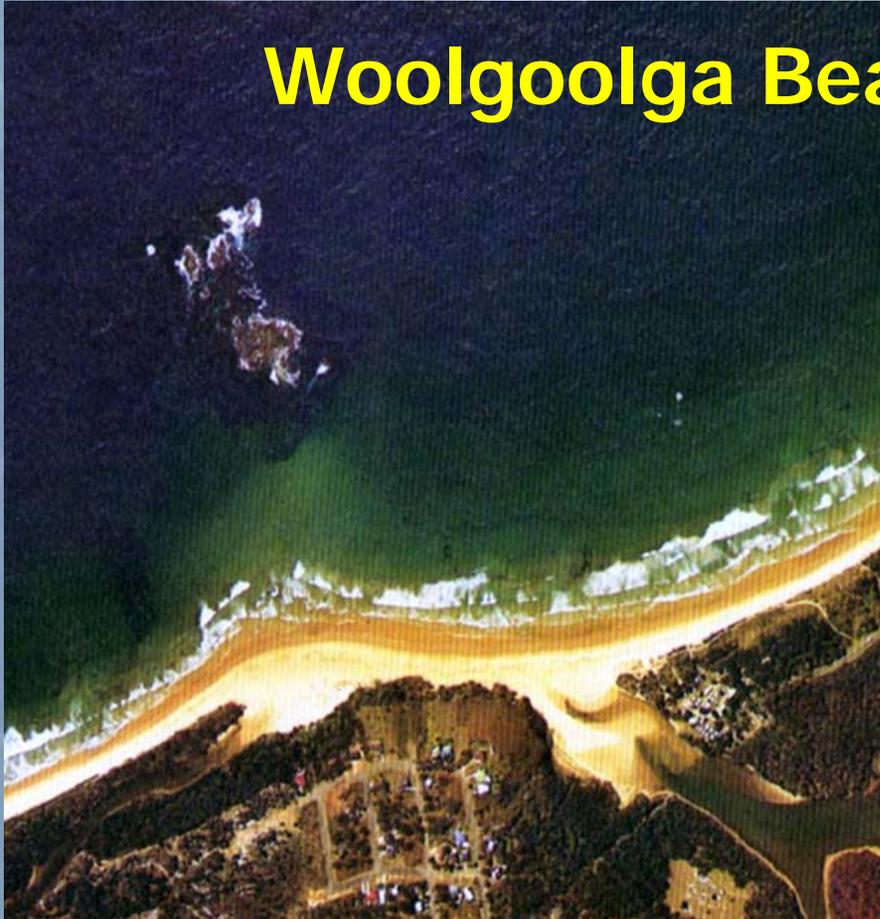
Natural Examples of Submerged Reefs

Maine, USA

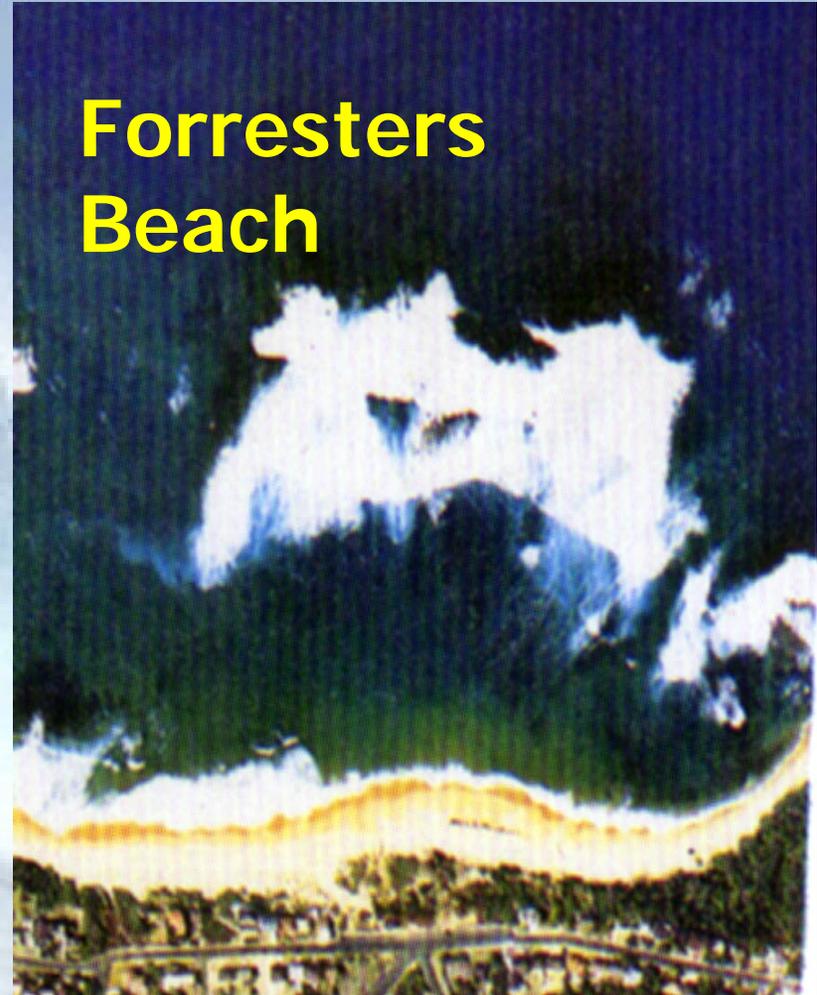


Natural Examples of Submerged Reefs

Woolgoolga Beach



Forresters Beach



Natural Examples of Submerged Reefs

Budgewoi, Australia



Multi-Purpose Reefs



Man's way. Fails in many ways

➤ Coastal Protection

➤ Surfing

➤ Diving

Multi-use aspects



➤ Swimming

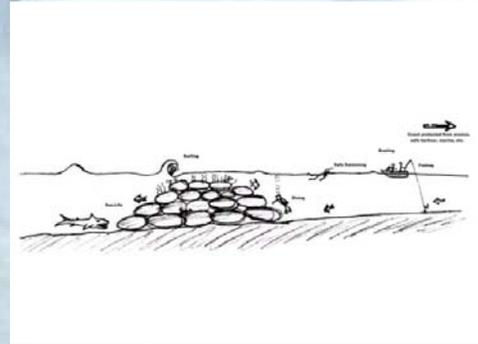
➤ Windsurfing

➤ Fishing

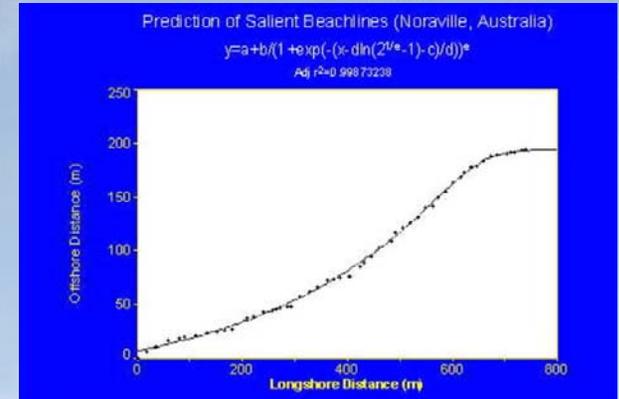
A technology inspired by Nature



Nature's way. Offshore reefs naturally protect the coast

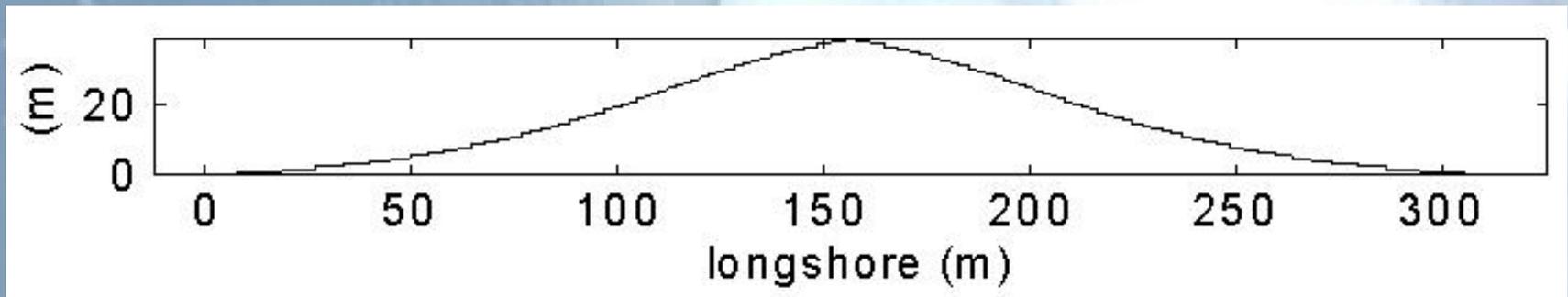


Shoreline Response



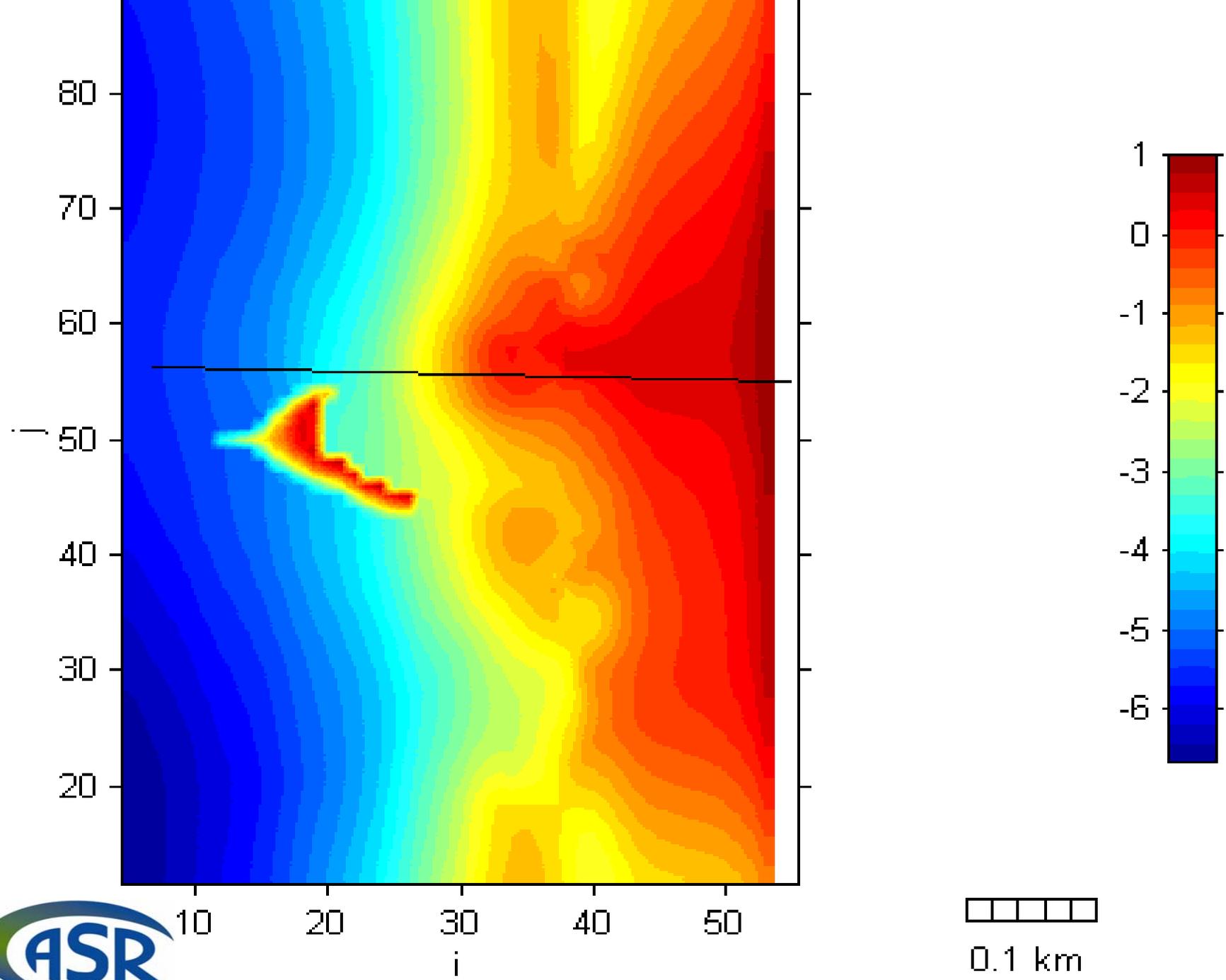
$$y = -0.052 + \frac{1.317}{\left(1 + \exp \left(- \frac{\left(x' - 0.356 \ln \left(2^{\frac{1}{0.356}} - 1 \right) - 2.249 \right)}{0.356} \right) \right)^{0.356}}$$

Black & Andrews (2001a,b)



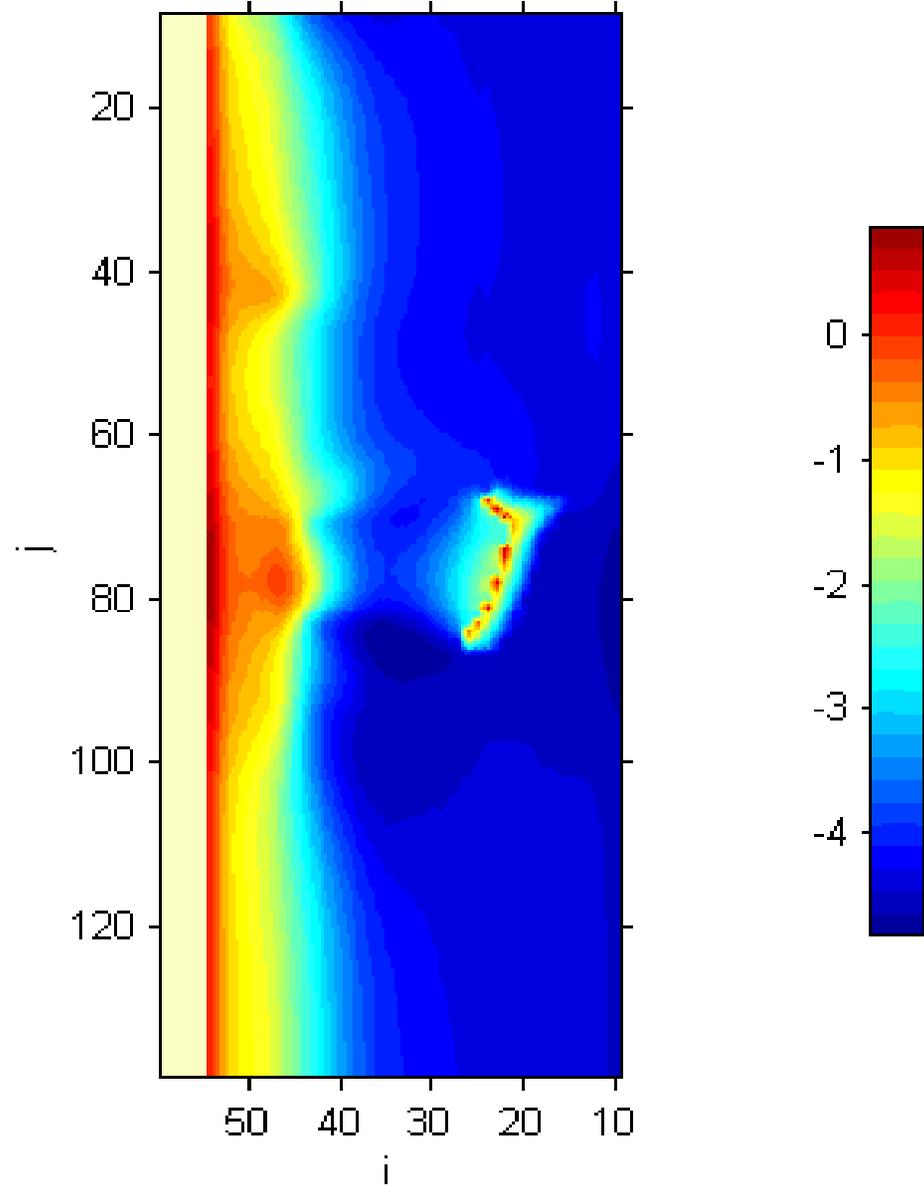
Kuta Beach, Bali





ASR Model 2DBEACH

Salient prediction



Comparison of predictions

Reef	Amplitude	Length
Lyall Bay, Wellington	Model 100	Model 530
	Emp 90	Emp 520
63rd St, Miami	Model 100	Model 750
	Emp 120	Emp 720
Oil Piers, Calif.	Model 110	Model 400
	Emp 90	Emp 560



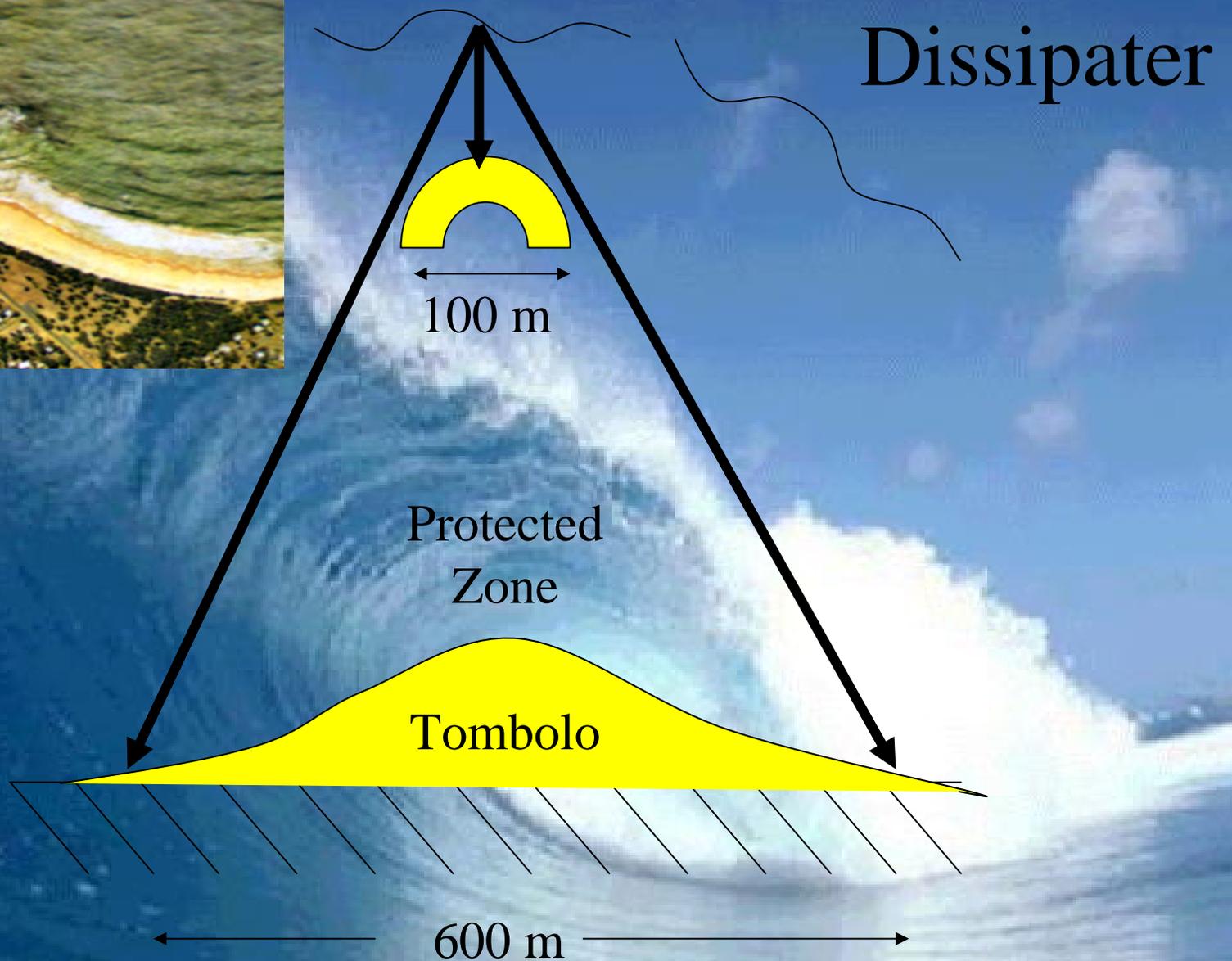
Offshore Submerged Reefs – Function

➤ Dissipaters

- Acts to reduce wave energy at the shoreline by breaking waves offshore

➤ Rotators

- Re-aligns wave crests and/or spreads wave energy to reduce wave driven-currents



One reef of 100 m protects 400-600 m of coast



Rotator



Wave rotated to stop
longshore drift

Tombolo

600 m

One reef of 100 m protects 400-600 m of coast

Submerged Breakwaters/Multi-Purpose Reefs - Function



Acts to reduce wave energy at the shoreline by breaking waves offshore

Re-aligns wave crests and/or spreads wave energy to reduce wave driven-currents





Innovating

- 
- Solutions
 - Practice
 - Innovative construction

Understand – Innovate – Sustain

New Zealand

- Surfing Reef and Shore Protection, Mt Maunganui*
- Surfing Reef, Opunake*
- Port Walls and Surfing Reef, Gisborne Port
- Coastal Amenity (Surfing and Beach), New Plymouth*
- Surfing Reef and Shore Protection, Wellington*
- Surfing and Shore Protection, Orewa*
- Shore Protection and Surfing, St Clair
- Shore Protection and Surfing, Napier
- Shore Protection, Wairoa
- Shore Protection, Makara
- Shore Protection, Bay View

Australia

- Shore Protection and Surfing, Sunshine Coast
- Shore Protection and Surfing, Gold Coast
- Surfing Reef, Geraldton*
- Shore Protection and Surfing, New Castle
- Shore Protection, Palm Beach

India

- Shore Protection and Public Use, Kerala*

Costa Rica

- Coastal Amenity (Surfing and Beach), Rio Oro*

USA

- Shore Protection and Surfing, Miami Beach*
- Shore Protection and Surfing, Ventura*
- Shore protection and surfing, New Jersey

Understand – Innovate – Sustain

World View...



England

- Surfing, Bournemouth*
- Shore Protection and Surfing, Southbourne
- Surfing Reef, Newquay*
- Shore Protection and Surfing, Borth
- Shore Protection, Poole Bay

Indonesia

- Shore Protection and Surfing, Bali

Malaysia

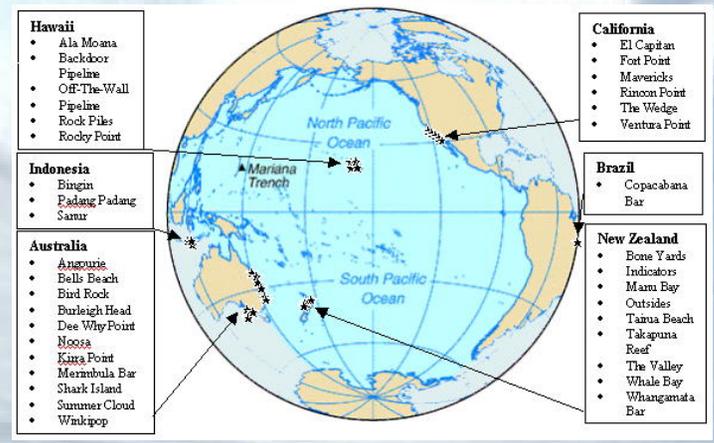
- Hotel Beach Development (Surfing and Beach), Sarawak*

Canada

- Surfing Reef, Ucluelet Peninsula*

Bahrain

- Ecological Enhancement (Tourism and Fisheries), Bahrain*



Costs/Benefits



Miami



March 1999



March 2002

Gold Coast

Site	Cost:Benefit Ratio	Annual Spend/Value	Surfing Competitions	Reference
*Gold Coast, Australia	1:70	-	AU\$2.2M	Raybould and Mules, 1998; McGrath, 2002
†Mount Maunganui, New Zealand	-	NZ\$0.5M	-	Gough, 1998
‡Cornwall, England	-	£21M	-	Ove Arup & Partners International, 2001
†Noosa Beach, Australia	-	-	AU\$1M	Jackson <i>et al.</i> , 1999
‡Florida, USA	-	US\$84.63M	-	Johns <i>et al.</i> , 2001
†Lyall Bay, New Zealand	1:24	-	-	Baily and Lyons, 2003
†Bournemouth, UK	1:20	-	-	Black <i>et al.</i> , 2000
**Miami Beach, USA	1:500	-	-	Houston, 2002
§Californian's Beaches	-	US\$5.5B	-	King <i>et al.</i> , 2001
‡Geraldton, West Australia	-	AU\$1.5M	-	Rafanelli, 2004

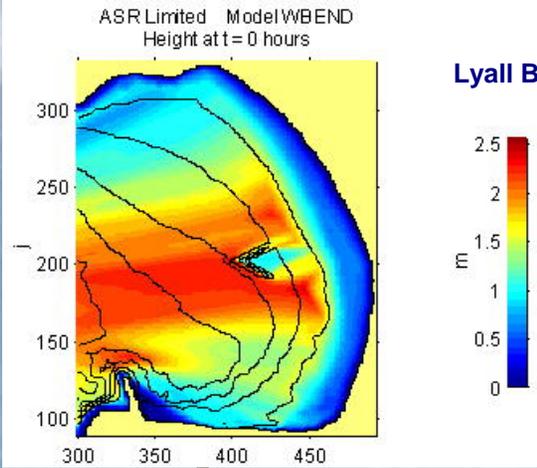
*Based on the 'beach' amenity and associated businesses

†Based on additional income from attracting surfers

‡Based on revenue from all sources associated with surfing (e.g. hospitality, boat sales, equipment rental, etc.)

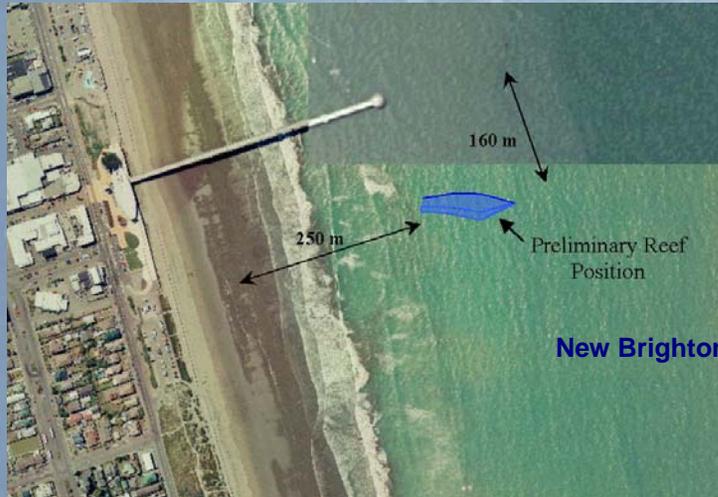
**This figure relates to the economic benefits of beach nourishment in Miami (i.e. is not associated with artificial reefs, although they can be used to greatly increase the success of nourishment projects).

§This is not an economic impact estimate of artificial reefs, but rather an estimate of the loss of GNP if beaches are not maintained in California, i.e. the present economic value of beaches in California.

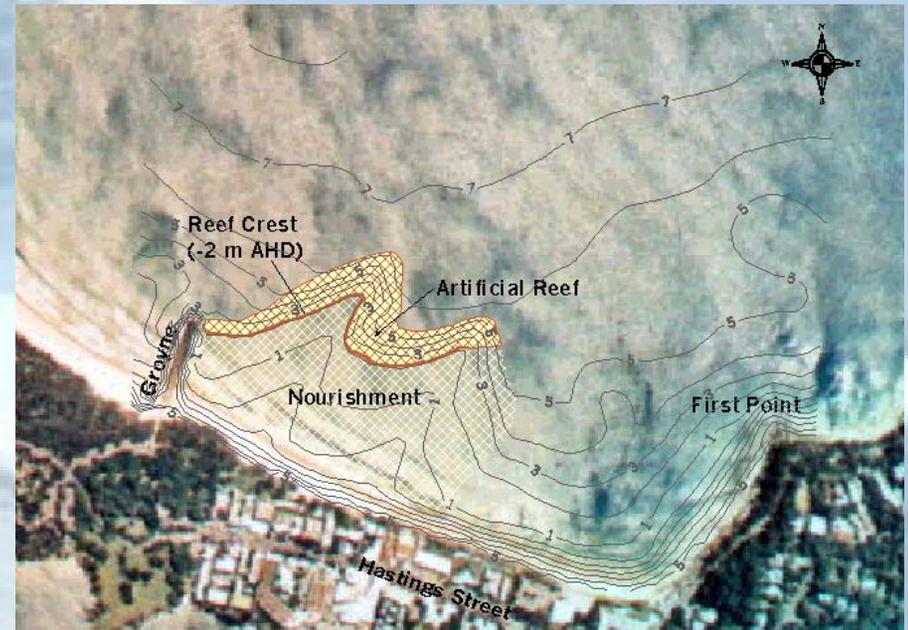


Lyall Bay Artificial Reef

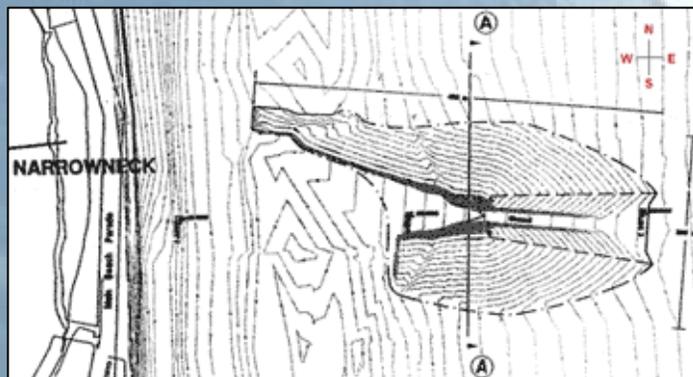
Multi-purpose reef designs vary widely from case-to-case in response to the local environment (coastal processes) and local needs (e.g. surfing wave type, enhancement for particular species, etc)



New Brighton Artificial Reef



Noosa Artificial Reef



Gold Coast Artificial Reef

Narrowneck Reef – Gold Coast

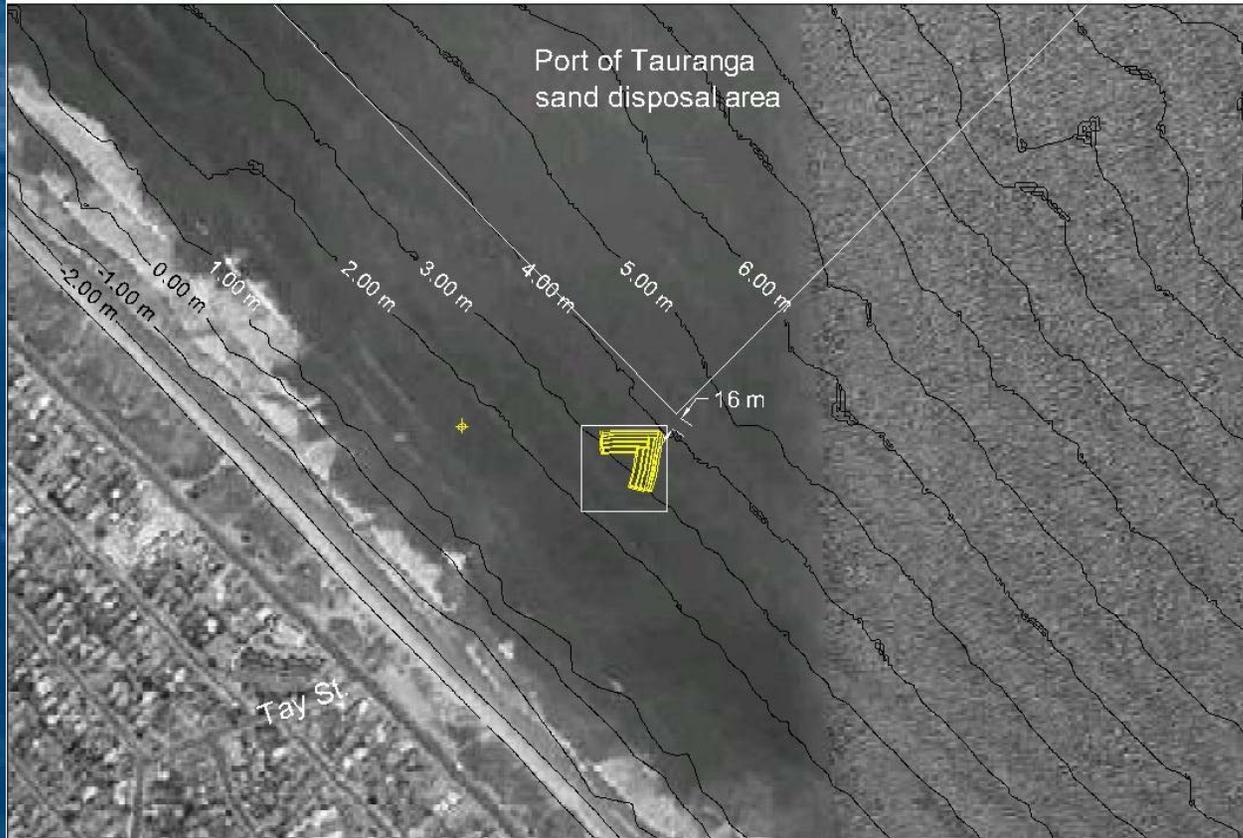


March 1999

June 2003



Mt Maunganui Reef



Notes:

NZMS 260 U14:
9260-9030

Reef 250 m
offshore of Chart
Datum = Port of
Tauranga Datum

Mt Maunganui Surfing Reef

Location Plan

Scale 1:200000 (at A4)

File No 1 B

Date 17/05/2005

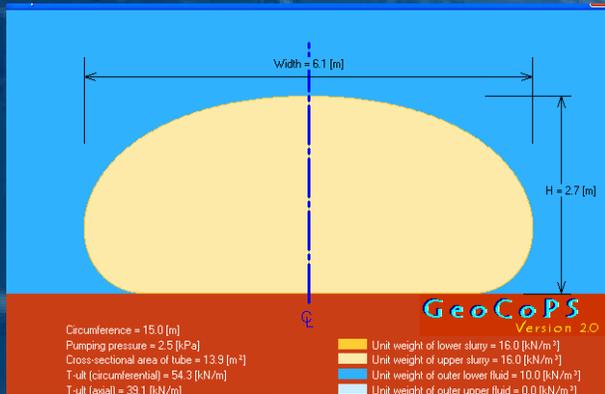
Designer K. Black & S. Mead

Rev

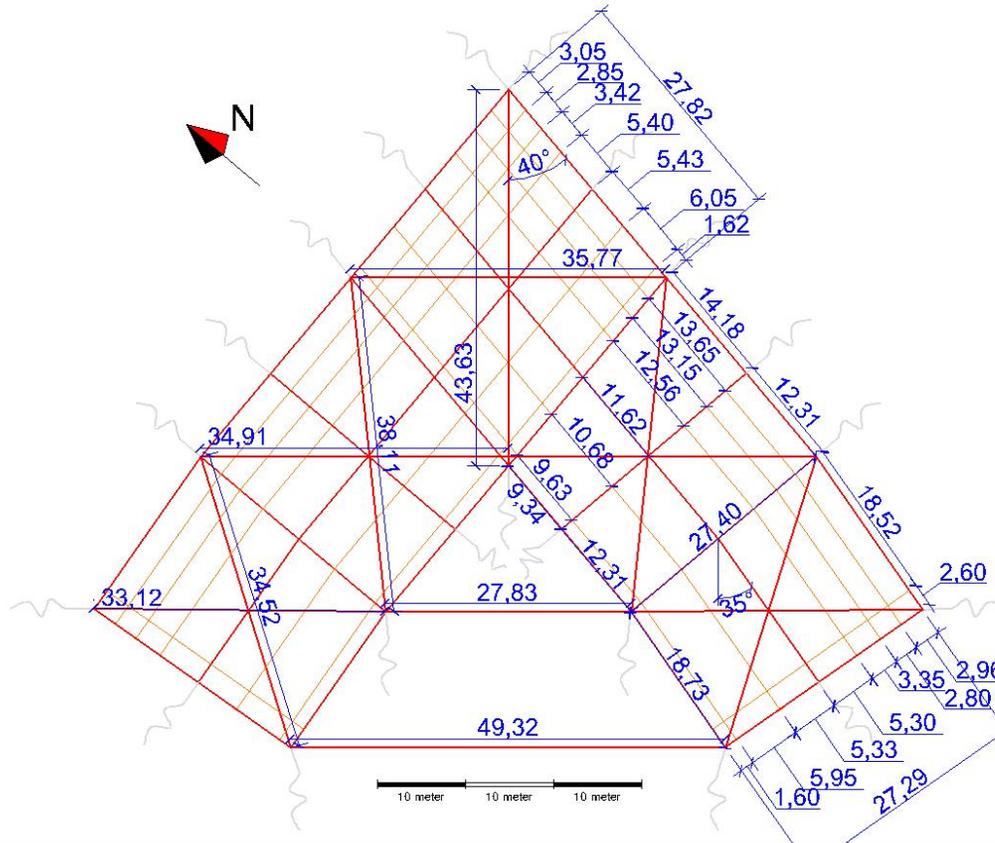


Marine Consulting and Research
1 Mainui Road, Raglan.
PO Box 67 Raglan
New Zealand
+64 7 925 0380
www.aerltd.co.nz

Mt Maunganui



Mt Maunganui Reef



Mt Maunganui Surfing Reef

Web design and dimensions in m



Marine Consulting and Research
 1 Mainui Road, Raglan,
 PO Box 67 Raglan
 New Zealand
 +64 7 825 0380
 www.asrltd.co.nz

Scale 1:600 (at A4)

Fig. No. 6

Date 13/06/2005

Designer K. Black & S. Mead

Rev.

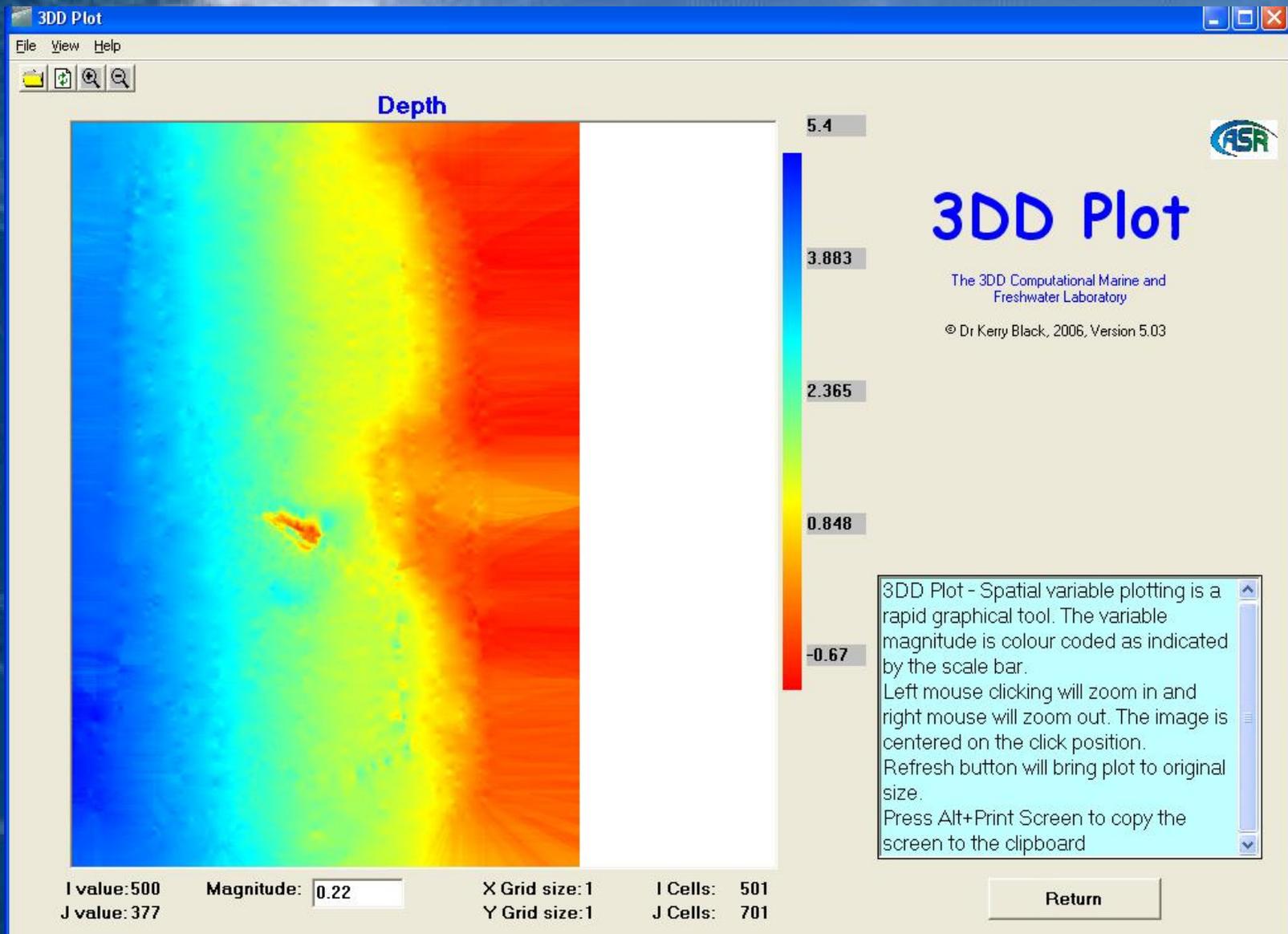
Mt Maunganui Reef



Photo by Chris Parker



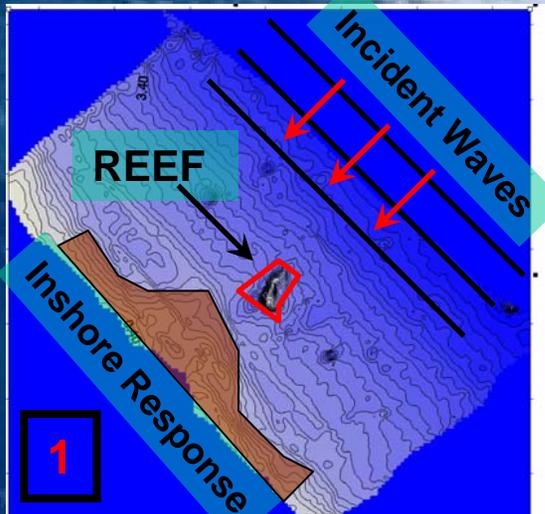
Mt Maunganui Reef



Mount Maunganui Reef

DESIGNED AND BUILT BY ASR – January 2006

Bay of Plenty, New Zealand



Salient is growing at a great rate.
Proof that the coast protection works.

Surfing growing at a great rate.
Proof that the surfing works

Outcomes are very similar to predictions.
Proof that our modeling works.



Biology is growing at a great rate.
Proof that the marine ecology works.

Engineering has gone really well.
Proof that our construction methods work

Mt Maunganui



Save Beaches



h e l p p e o p l e



ASR's world-wide reef technology
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