Small Coastal Stormwater Outlets: Literature Review & SA Design Guidelines

by

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Photos: A Theron

IMESA CONFERENCE DURBAN 2019
CONQUERING MUNICIPAL CHALLENGES
2 - 4 OCTOBER 2019 at the INTERNATIONAL CONVENTION CENTRE

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Institute of Municipal Engineering of Southern Africa

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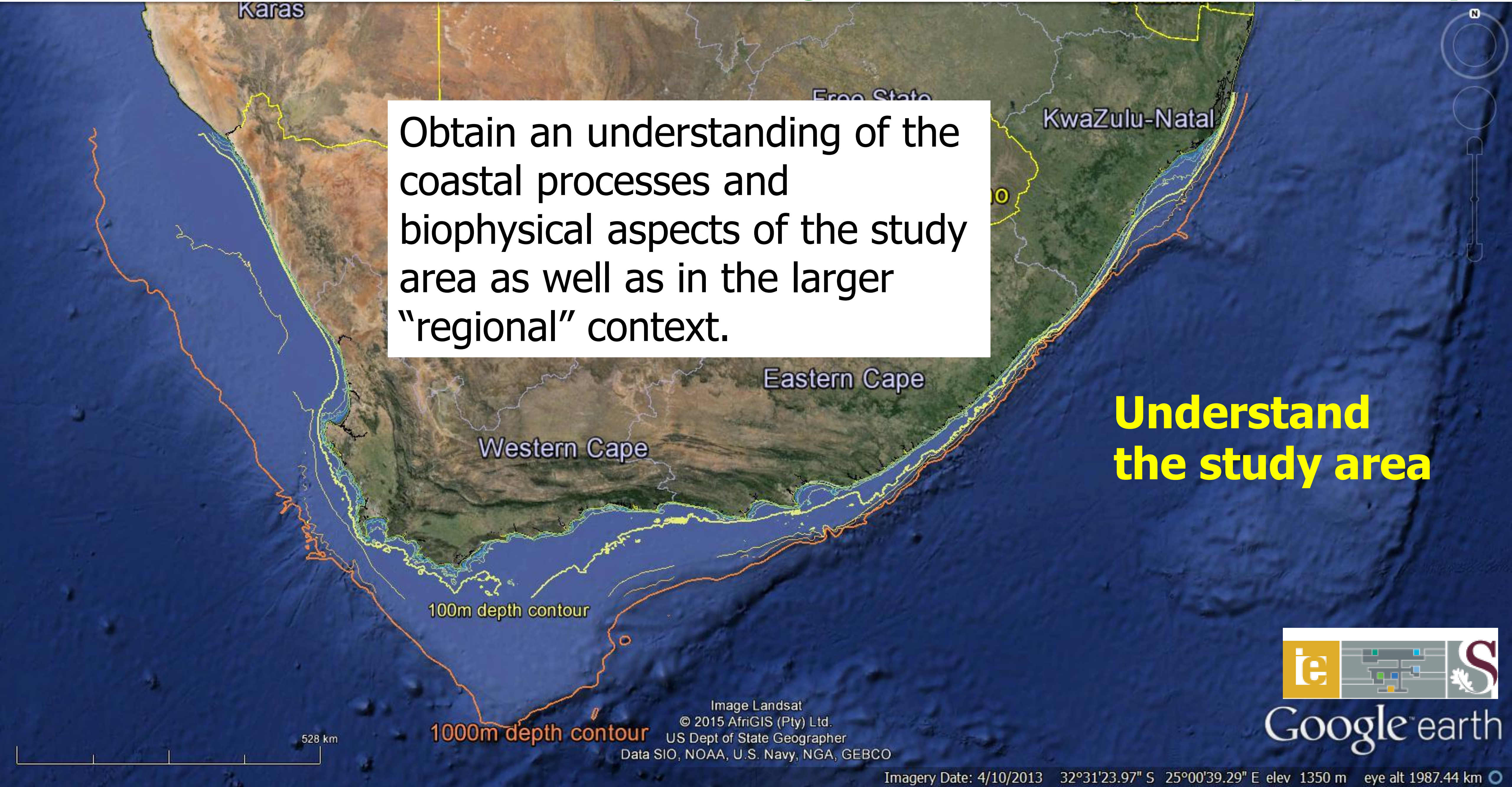
3.5 Conflicting beach usages

2.1 Location of the site (from regional to detail site specific)

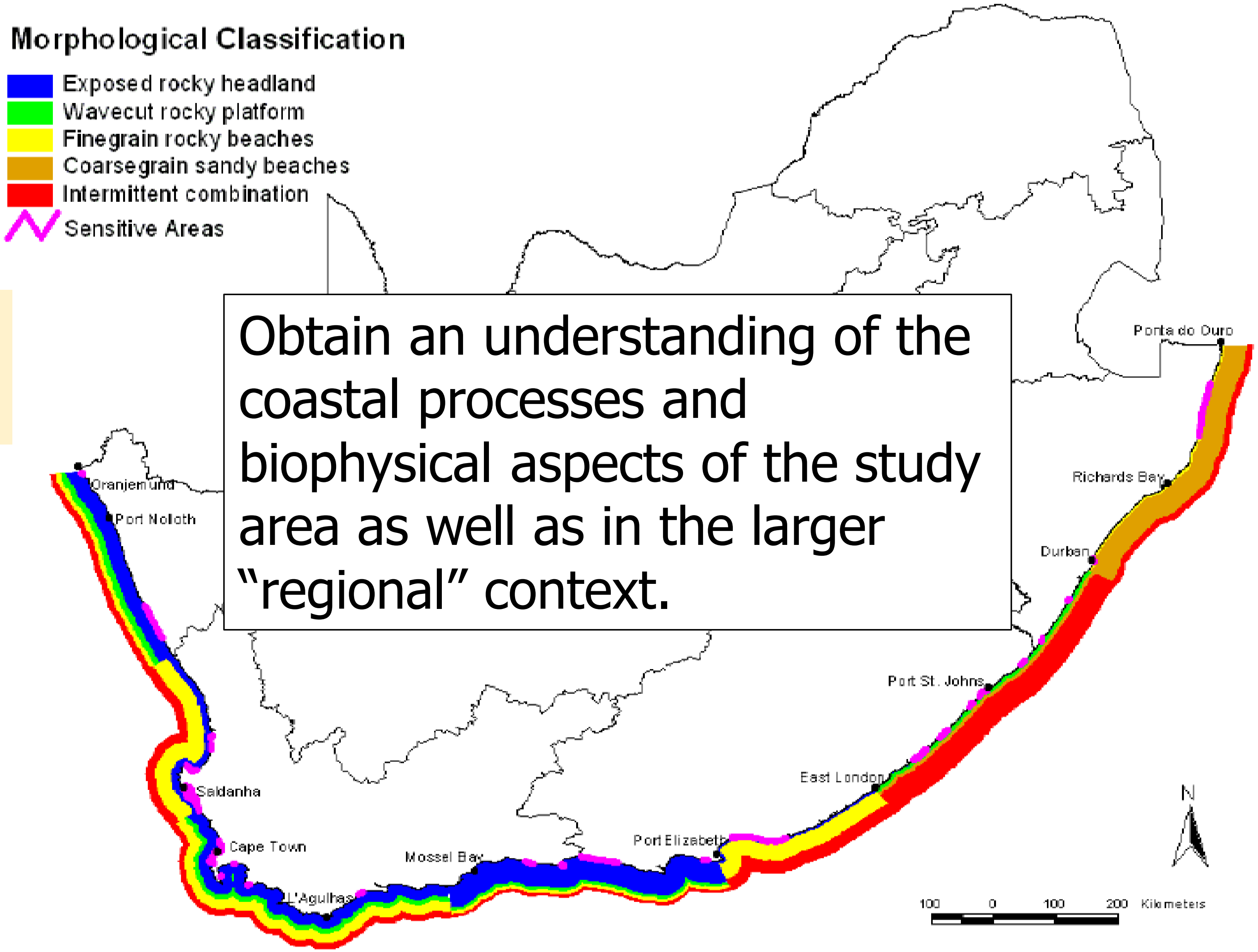


Obtain an understanding of the coastal processes and biophysical aspects of the study area as well as in the larger “regional” context.

Understand the study area

2.1 Location of the site (from regional to detail site specific)

Understand the study area



Obtain an understanding of the coastal processes and biophysical aspects of the study area as well as in the larger “regional” context.

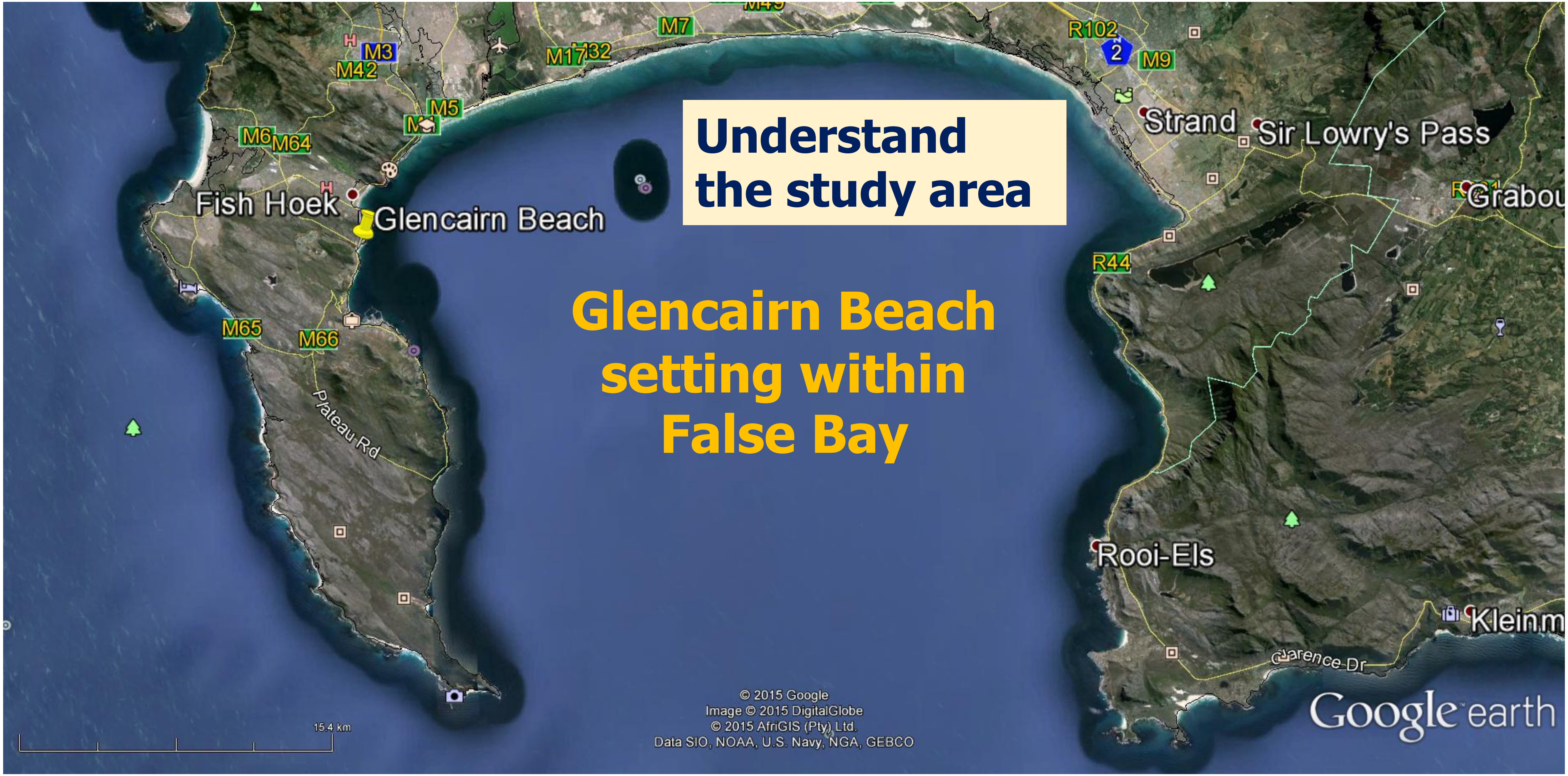
2.1 Location of the site (from regional to detail site specific)

Understand the study area

e.g.: Glencairn Beach
(City of Cape Town)

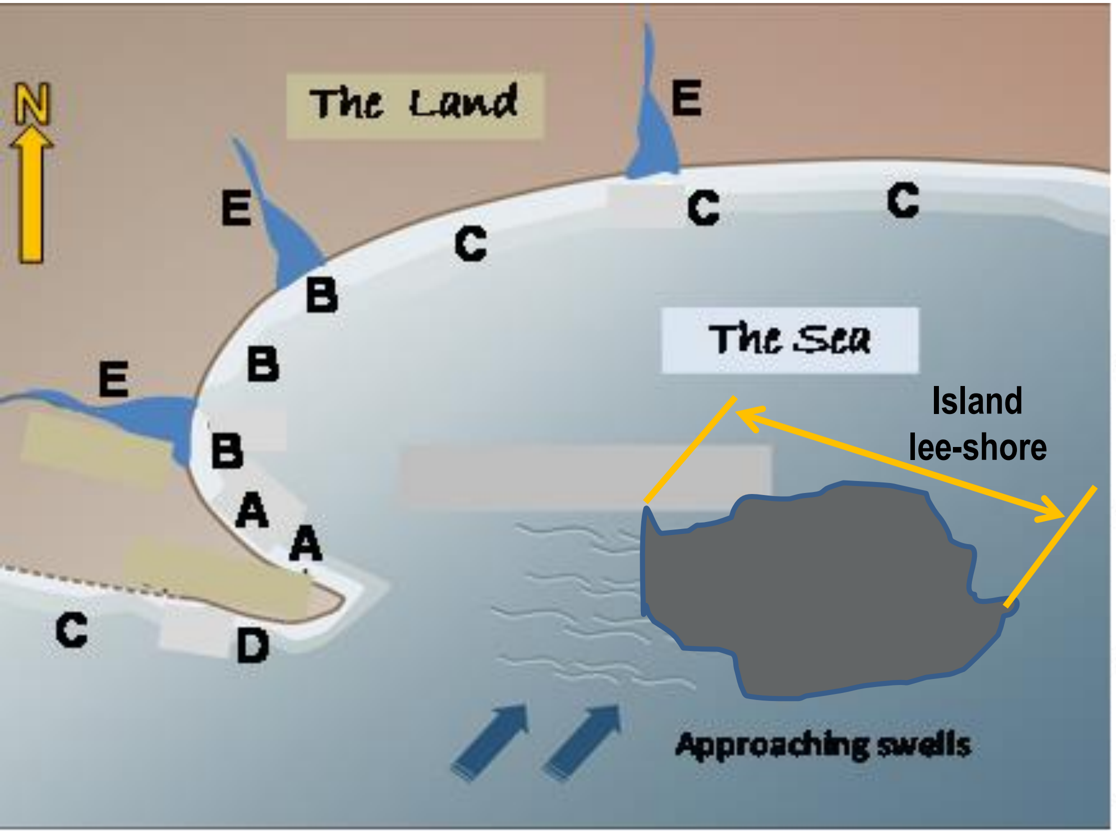
<u>Site visits too!!</u>

2.1 Location of the site (from regional to detail site specific)

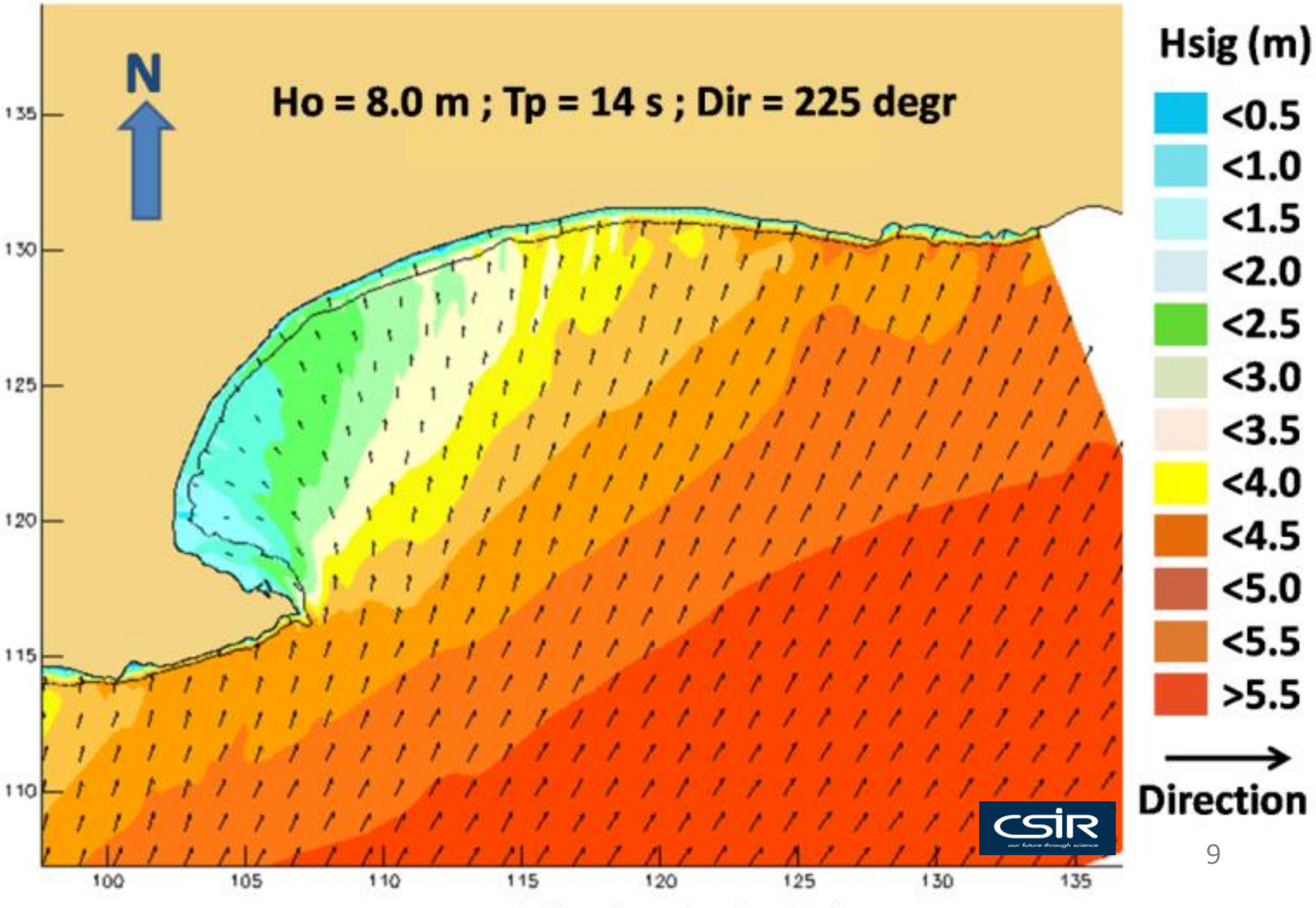


Exposure to wave energy: (site location, coast configuration, bathymetry)
Degree to which specific site is exposed to prevailing ocean swells determines wave energy impacting on shoreline.
Thus, sites A to E have different specific vulnerabilities.

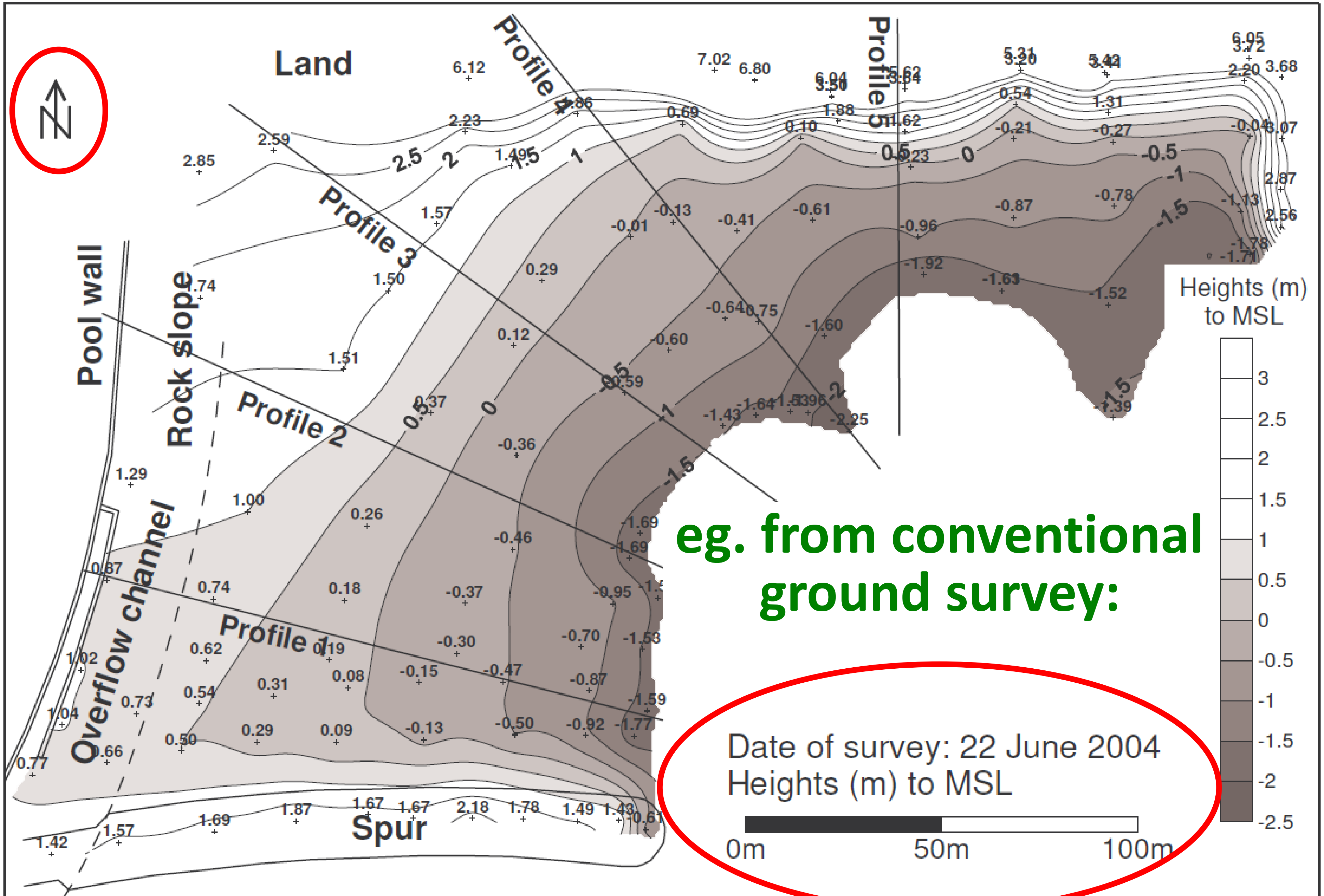
Understand the study area



<u>Example:</u> wave exposure
SWAN (wave) model output at Mossel Bay



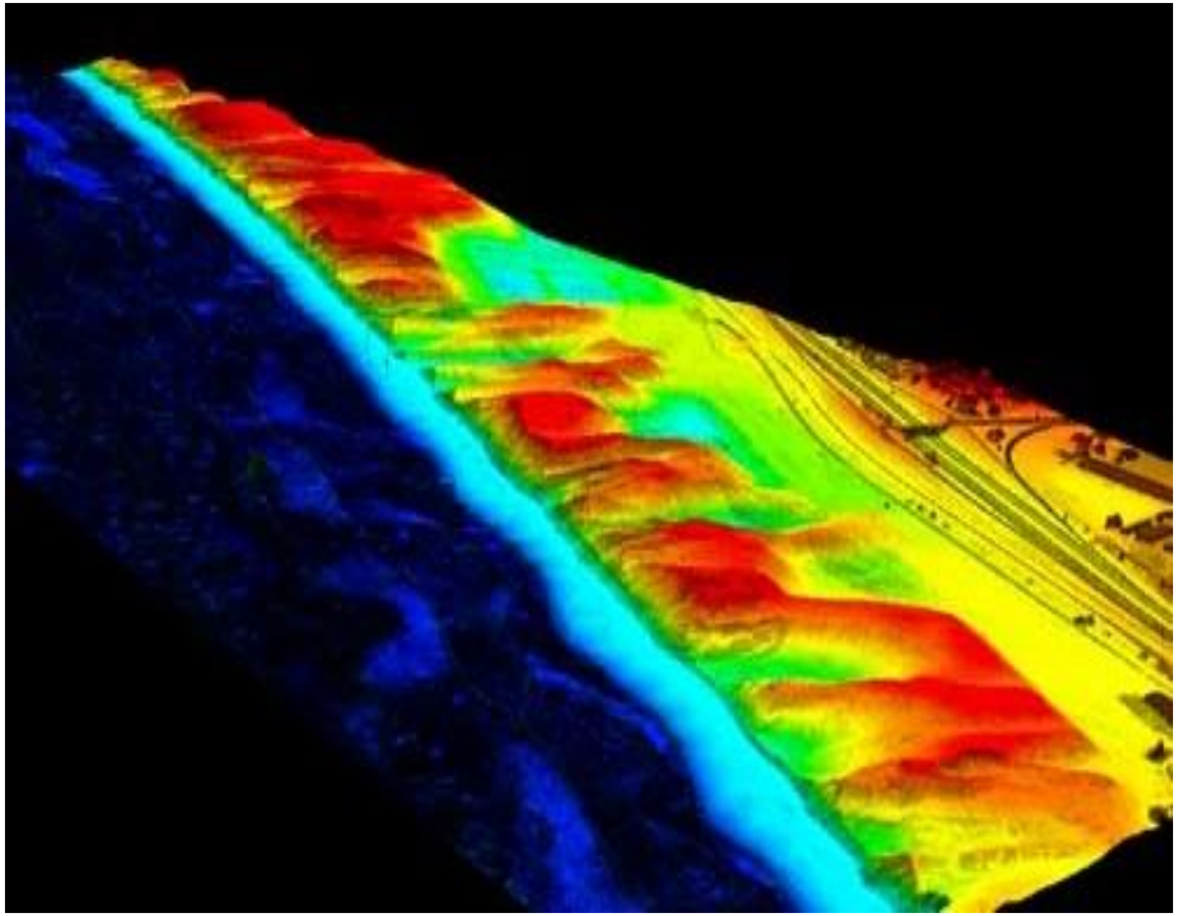
2.2 Bathymetry & Topography – required information

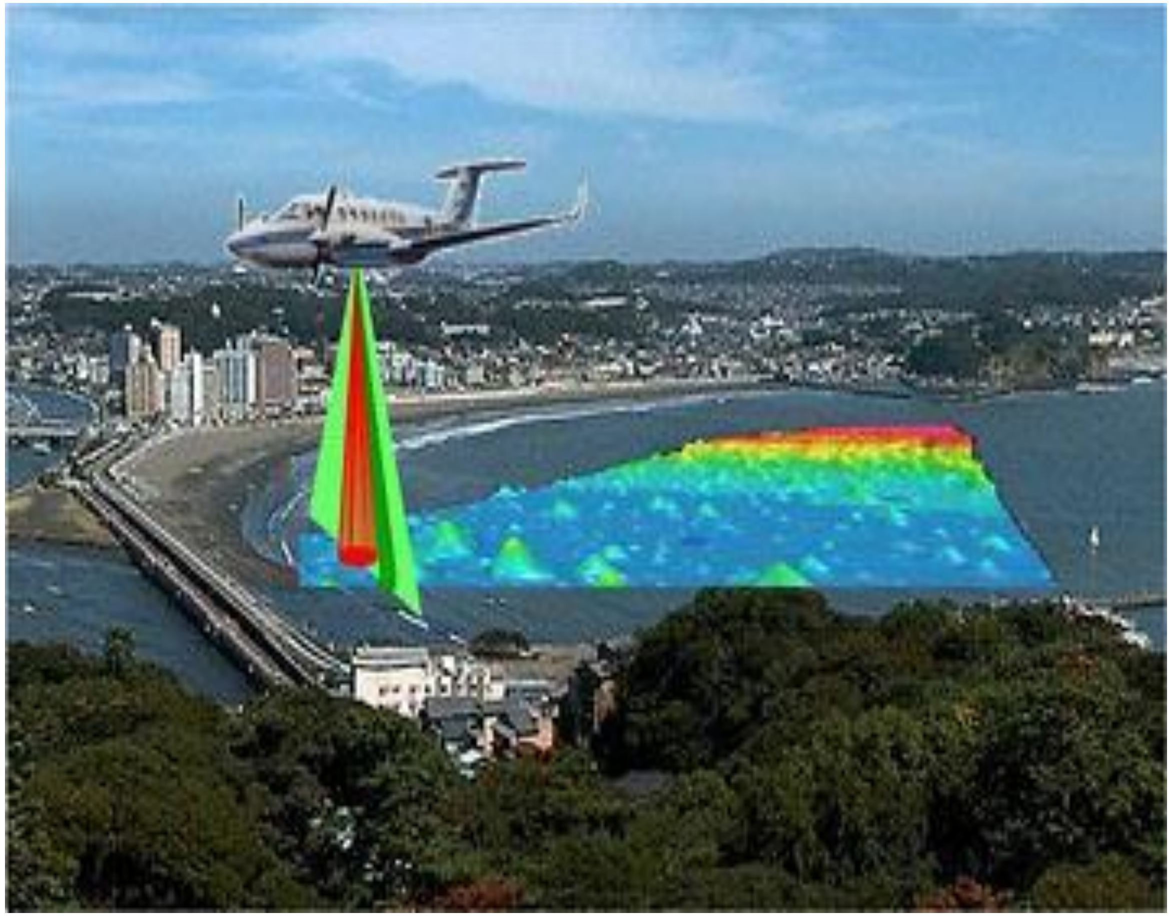


2.2 Bathymetry & Topography – required information

[1]

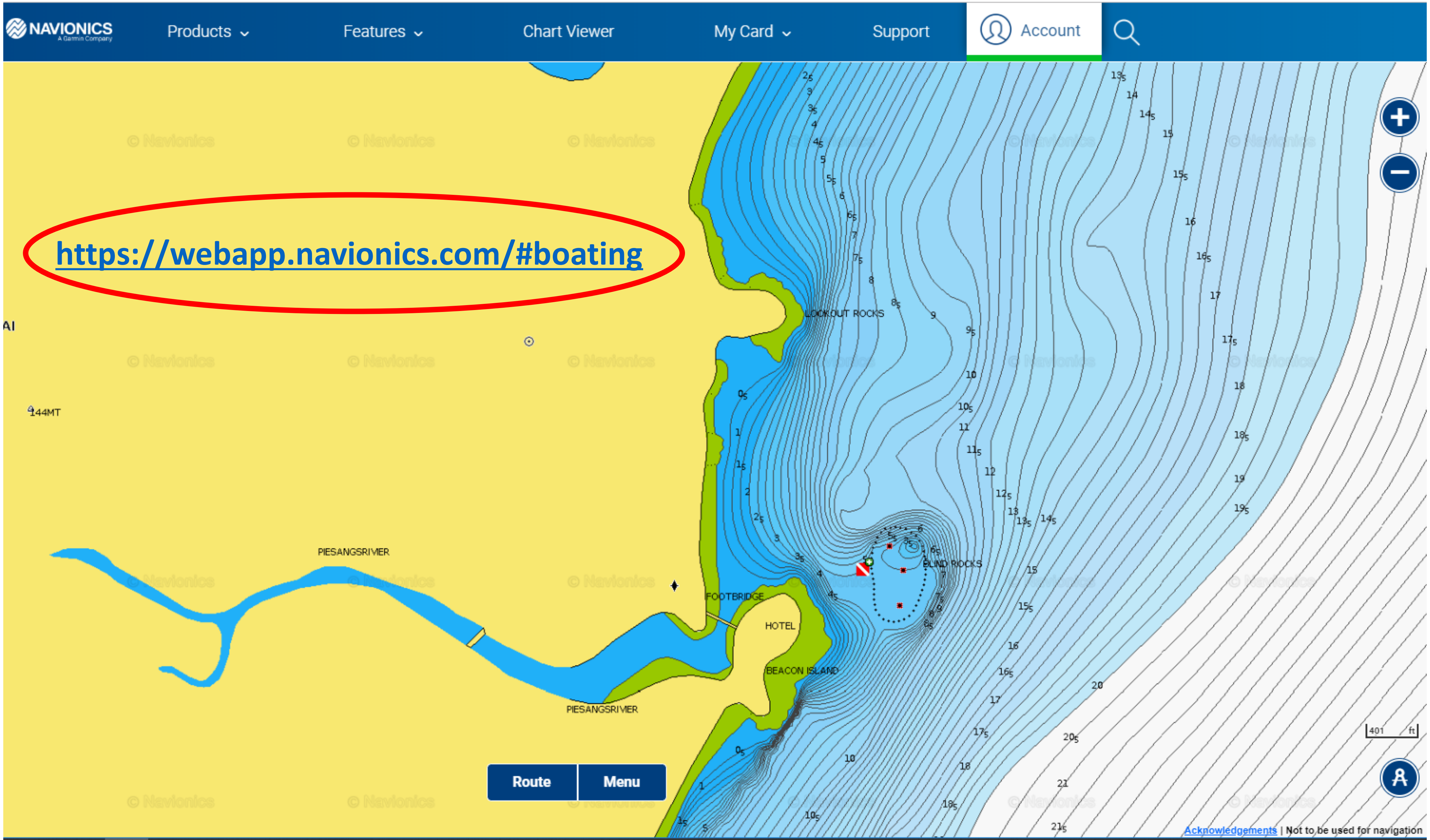
E.g. Topography from Coastal LiDAR (~50% of SA coast)





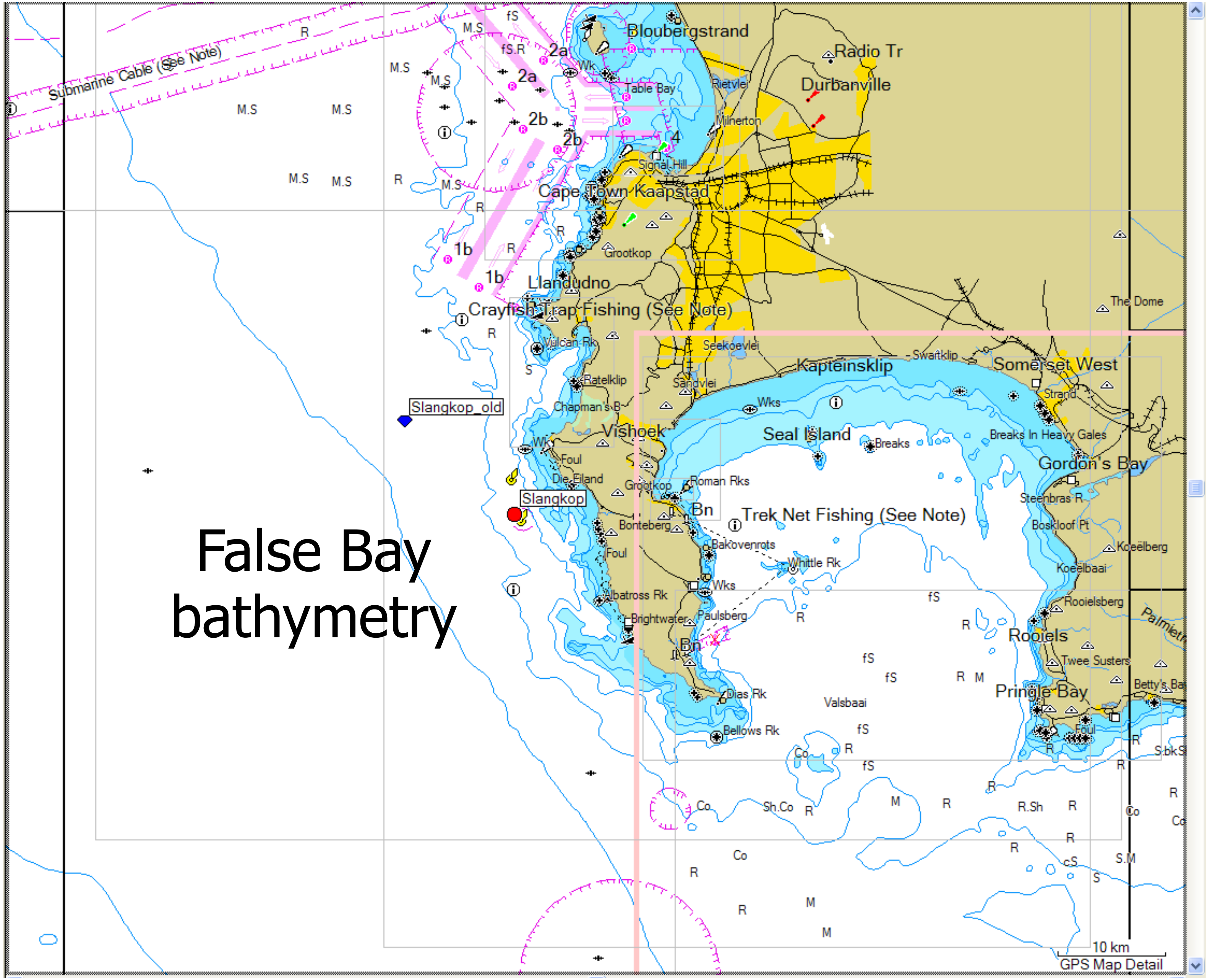
[1] http://sanctuarysimon.org/news/wp-content/uploads/2012/07/whats_lidar_04.jpg
[2] http://www.nauticalcharts.noaa.gov/staff/news/images/headline-lidar.jpg

2.2 Bathymetry & Topography – required information, e.g.:



2.2 Bathymetry & Topography – required information

e.g.: From SAN charts /maps (or other)



2.3 Nature of shoreline and seabed

e.g.: sandy shores with low relief

(e.g. Table Bay hummock dunes)

The low-energy St Helena Bay shoreline (Source: A Theron)

2.3 Nature of shoreline and seabed

(Photo A Theron)

e.g.: sandy shores with dunes

Beware high steep dunes!!

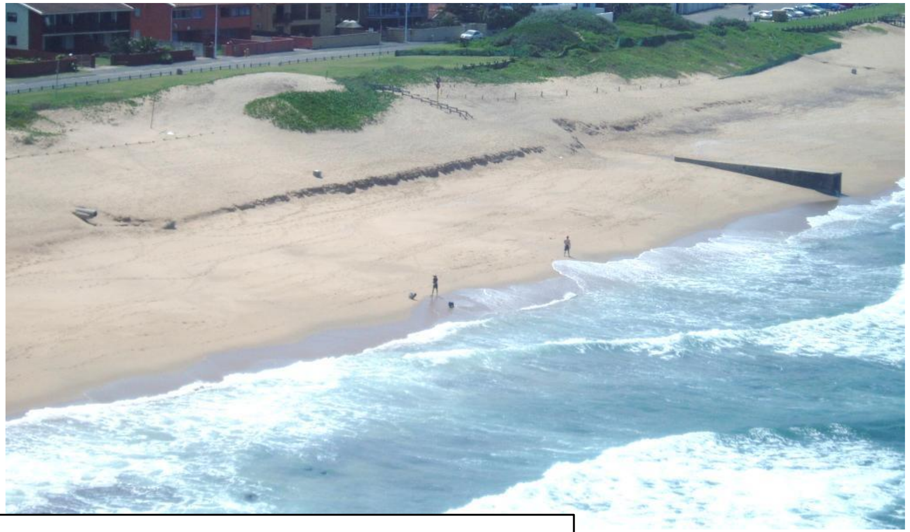
Dune slips near Richards Bay

Thus, slopes & geotechnical information are also required

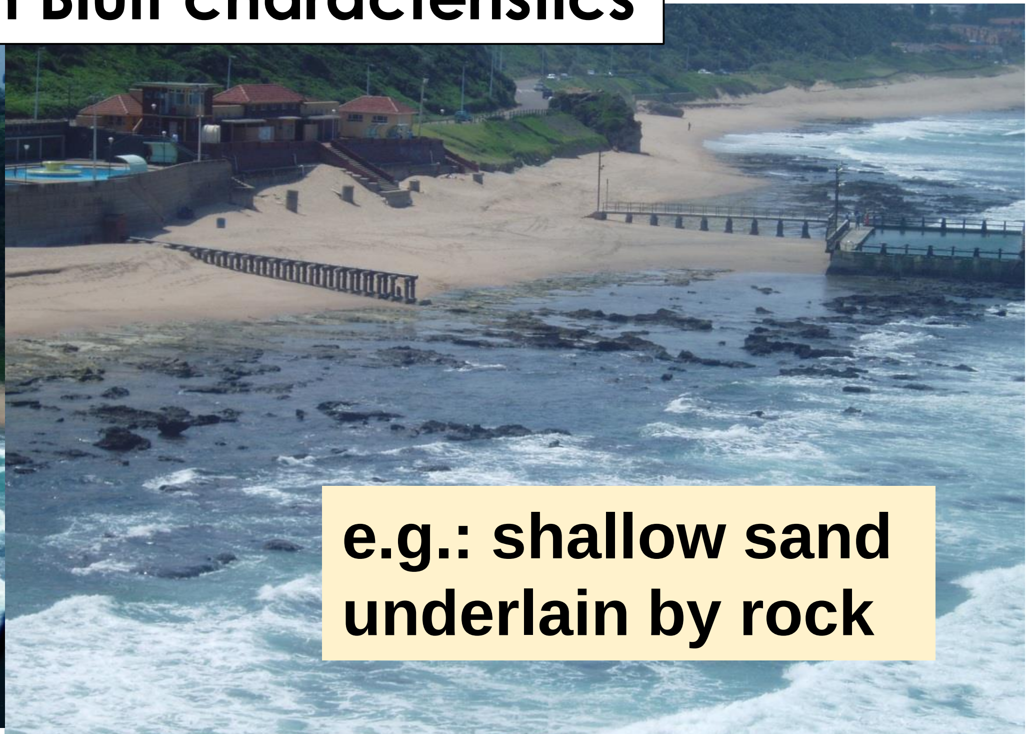
2.3 Nature of shoreline and seabed

e.g.: rocky intertidal shores

2.3 Nature of shoreline and seabed



Durban Bluff characteristics

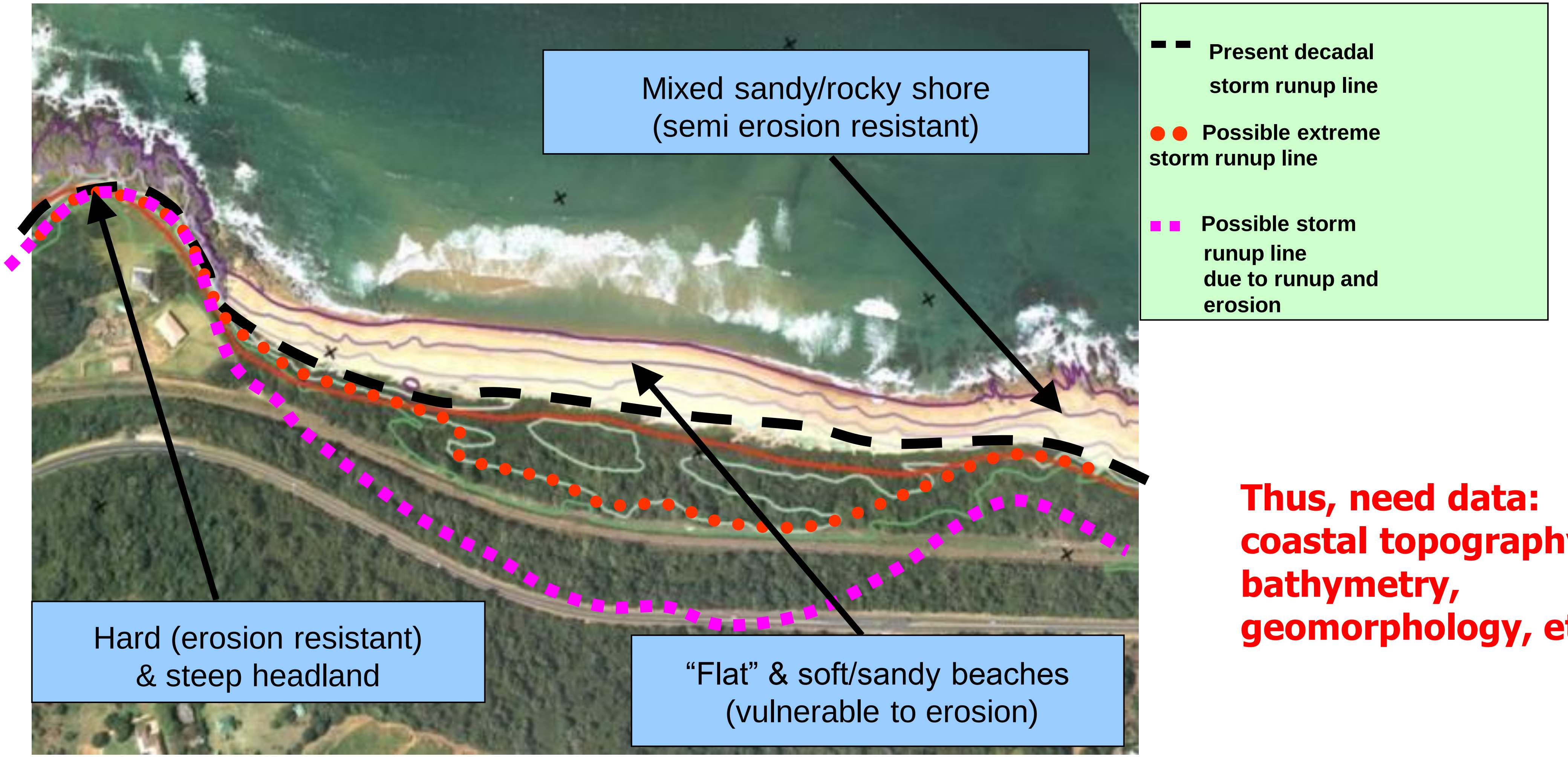


e.g.: shallow sand underlain by rock

2.3 Nature of shoreline and seabed

Different coastal characteristics

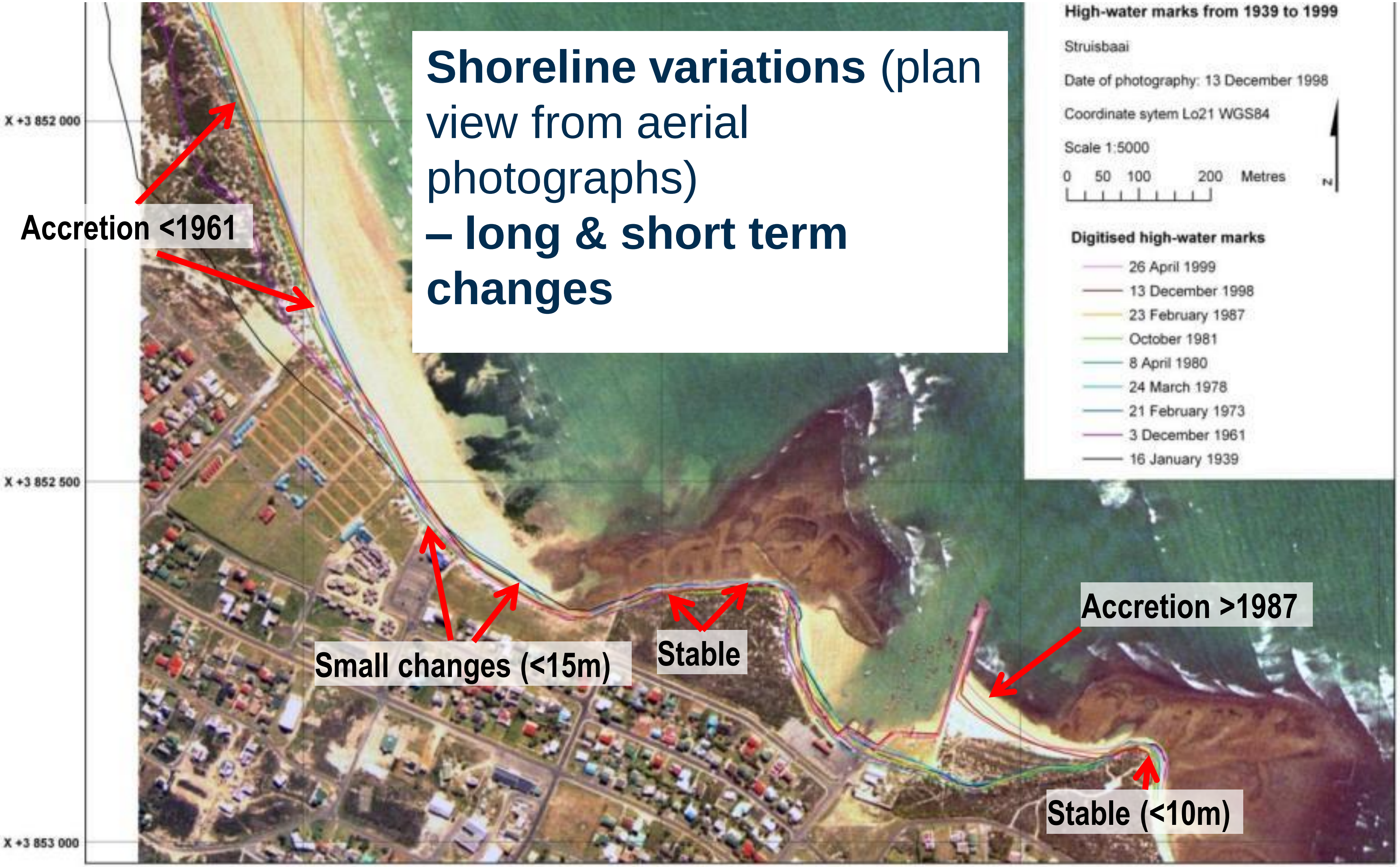
e.g. erodability & slope affect shoreline stability.



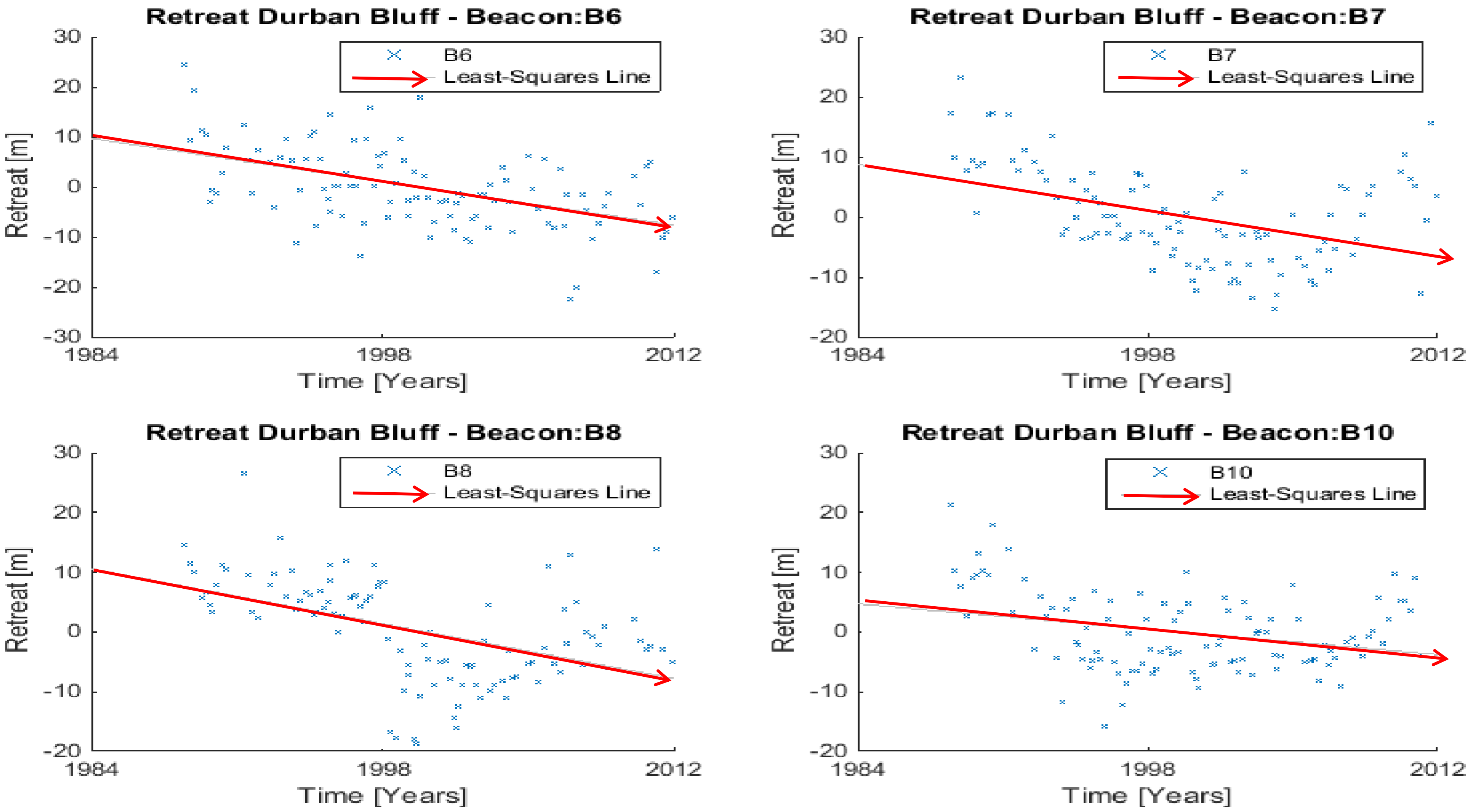
Thus, need data: coastal topography bathymetry, geomorphology, etc.

2.3 Nature of shoreline and seabed

2.4 Historic shoreline changes



Erosion of Durban Bluff since 1984 (surveyed profiles)

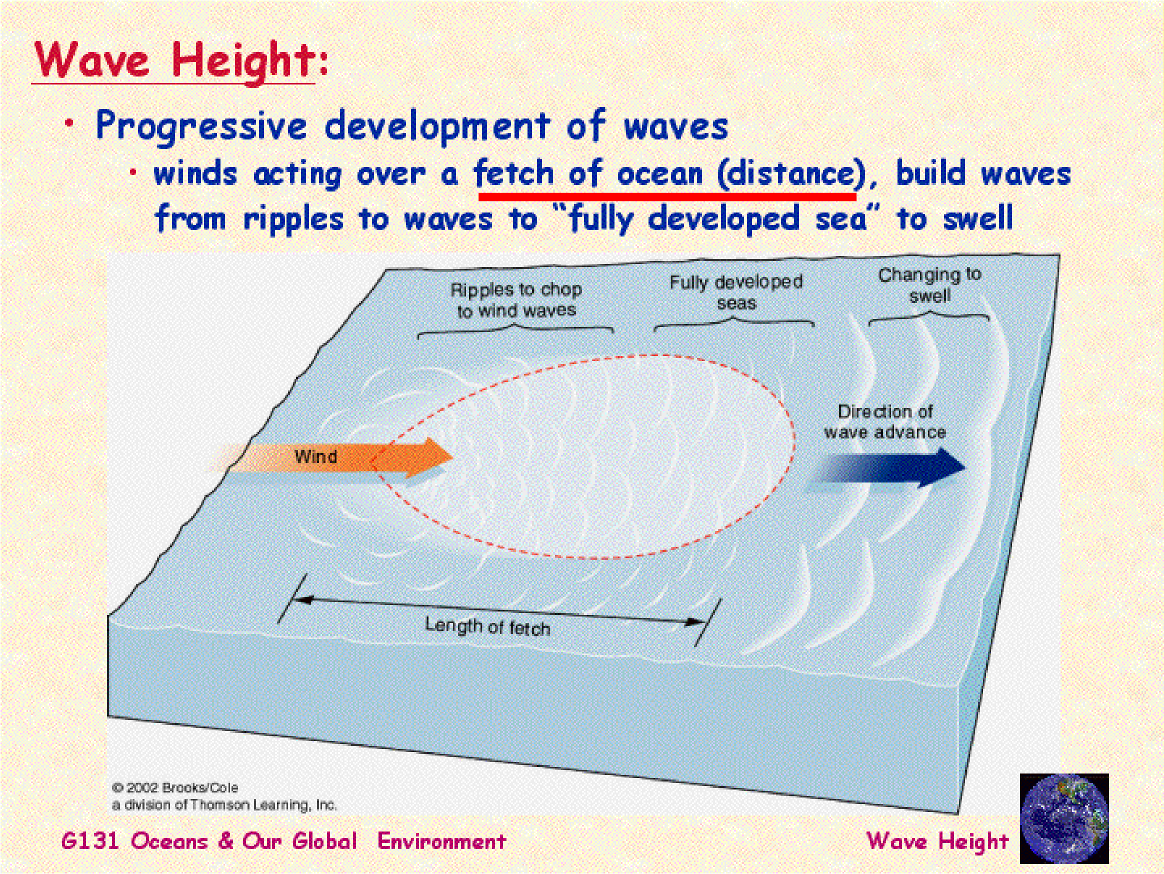


Durban Bluff (4 of 5 points) show ±1m/y retreat over 23 years

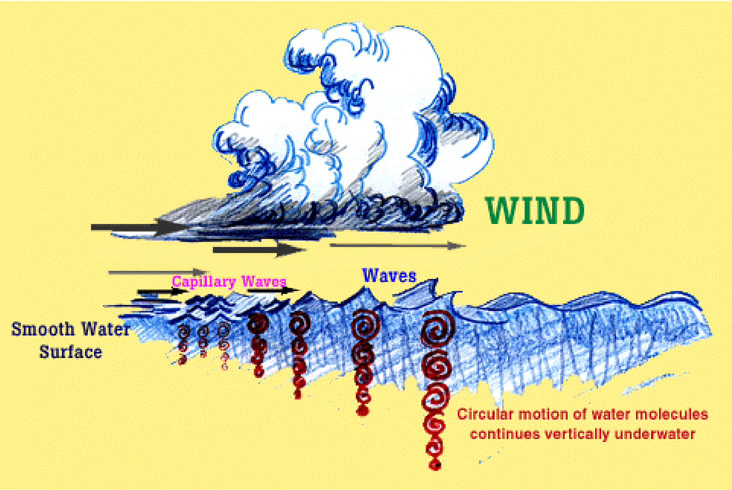
Slide adapted from Habets 2015 (pers com)

2.5 Winds, Waves, Currents (3 main drivers)

Winds ⇨ wave generation



www.indiana.edu



Source: Naval Meteorology & Oceanography Command
- Ocean Quest website

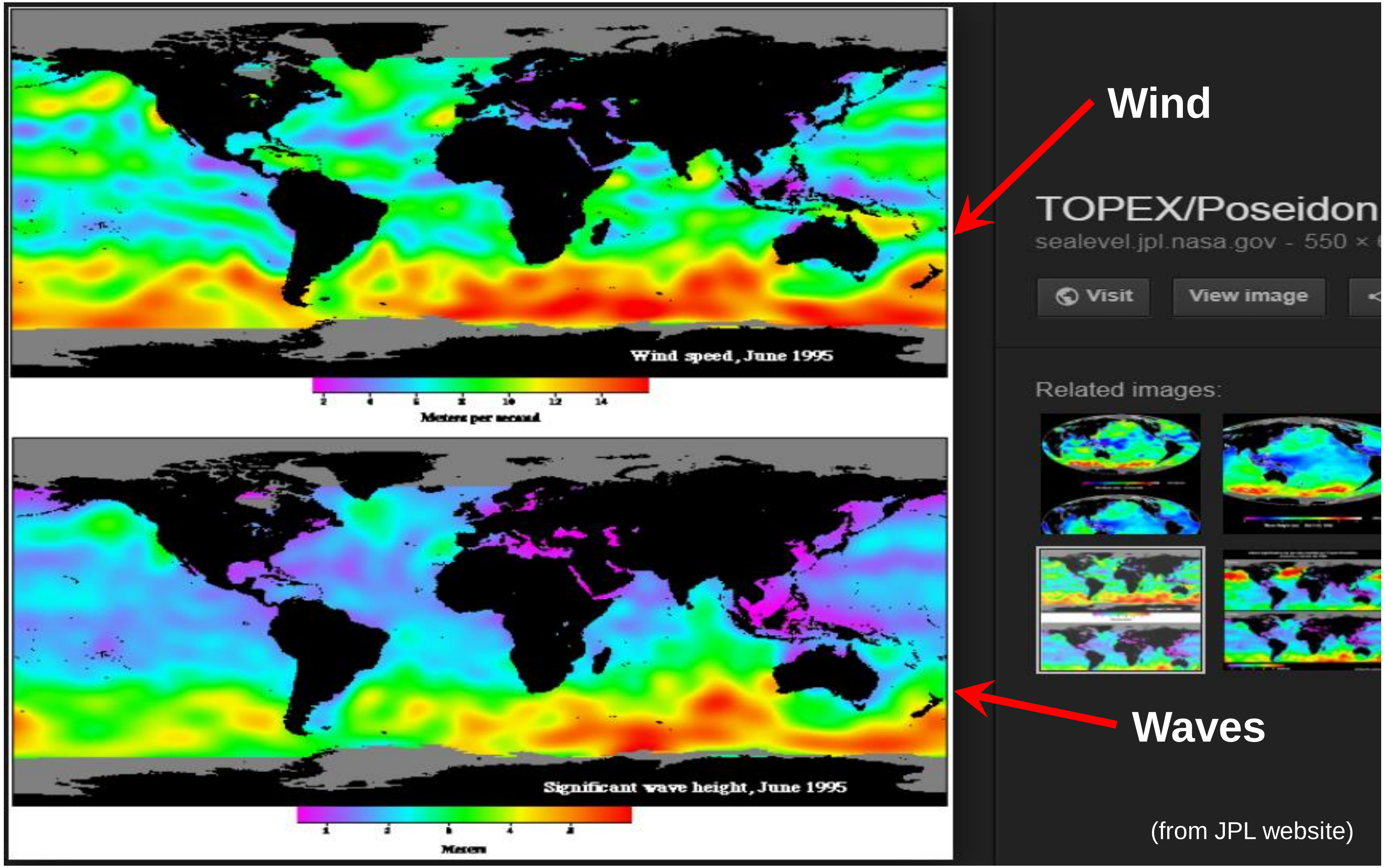
2 types of waves:

Wind waves (windgolwe):
in generation area

Swell waves (deining):
outside generation area

SA: High wave energy climate due to oceanic wind climate

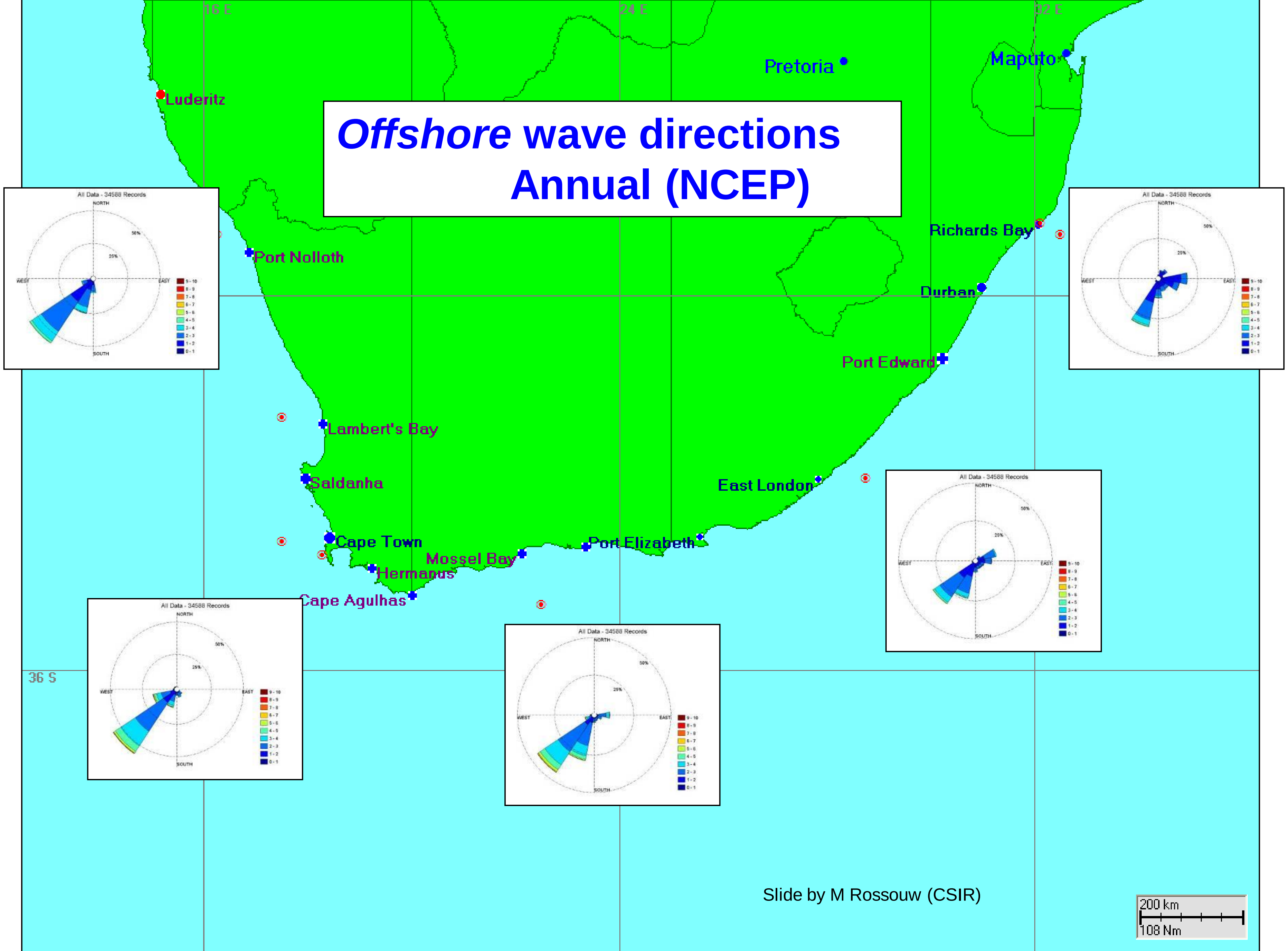
SA metocean climate results in SA wave climate



(from JPL website)

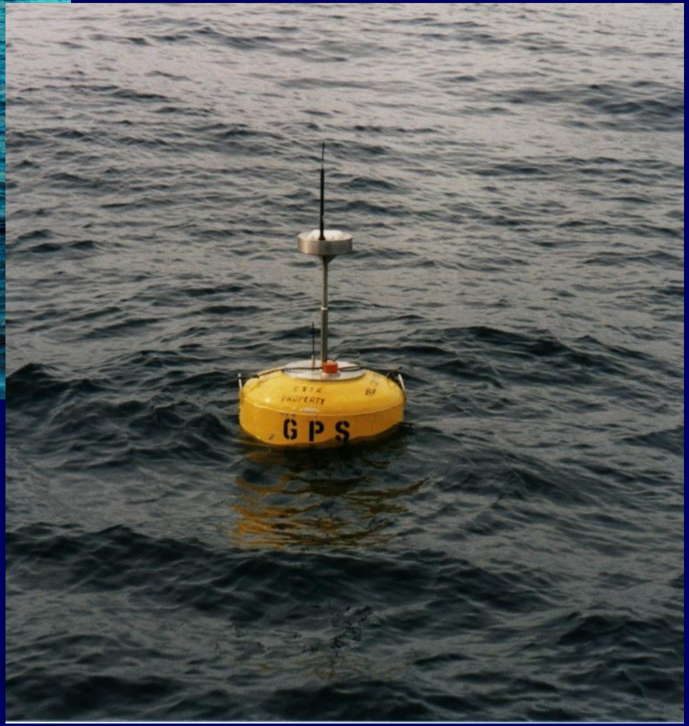
- 1:100 year wave south of continent Hs =12m / Hmax ~24m
- Long period swells dominate, Tp ≥10 to 18 s
- Main offshore swell direction SW'ly

Offshore wave directions Annual (NCEP)



Slide by M Rossouw (CSIR)

Wave recording buoys



Slide by M Rossouw (CSIR)

our future through science

national ports authority

http://wavenet.csir.co.za

Home | NEW: Mobi Home | History | Measuring Instrumentation | Online/Realtime Waves and Weather

Cape Point - Wave Data

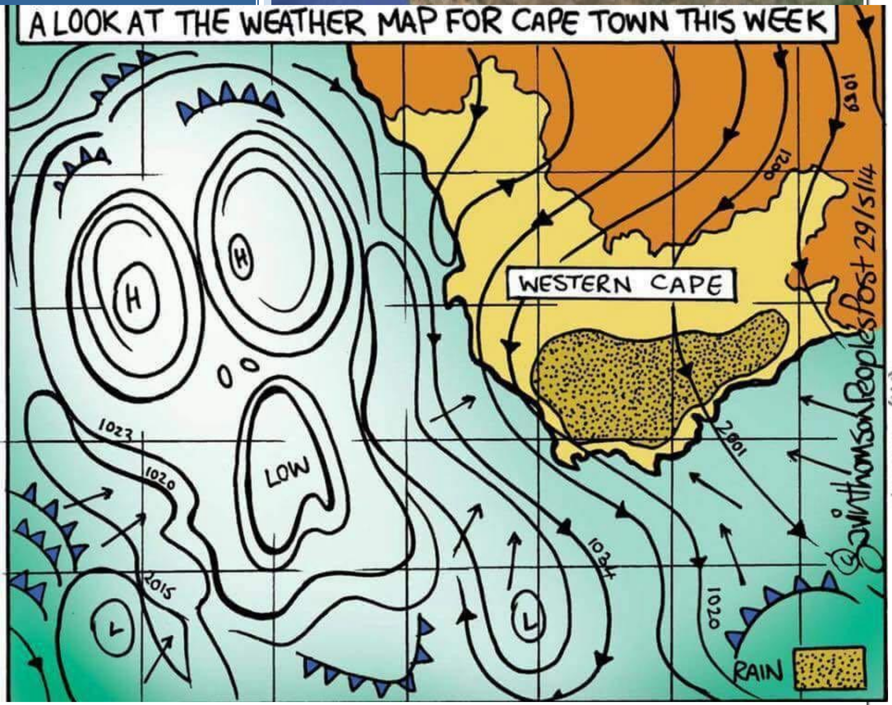
Last Page Update: 2018-01-19 16:05

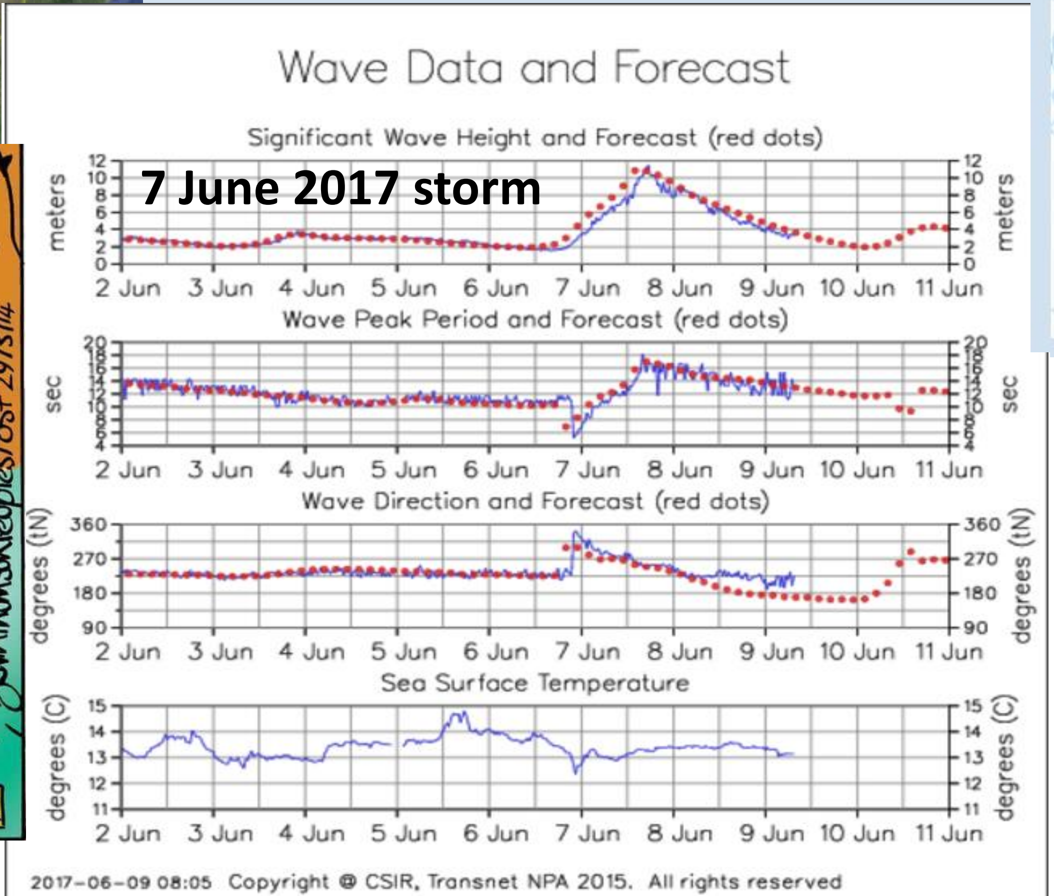
Last Data Update: 2018-01-19 15:00

About

Wave Data

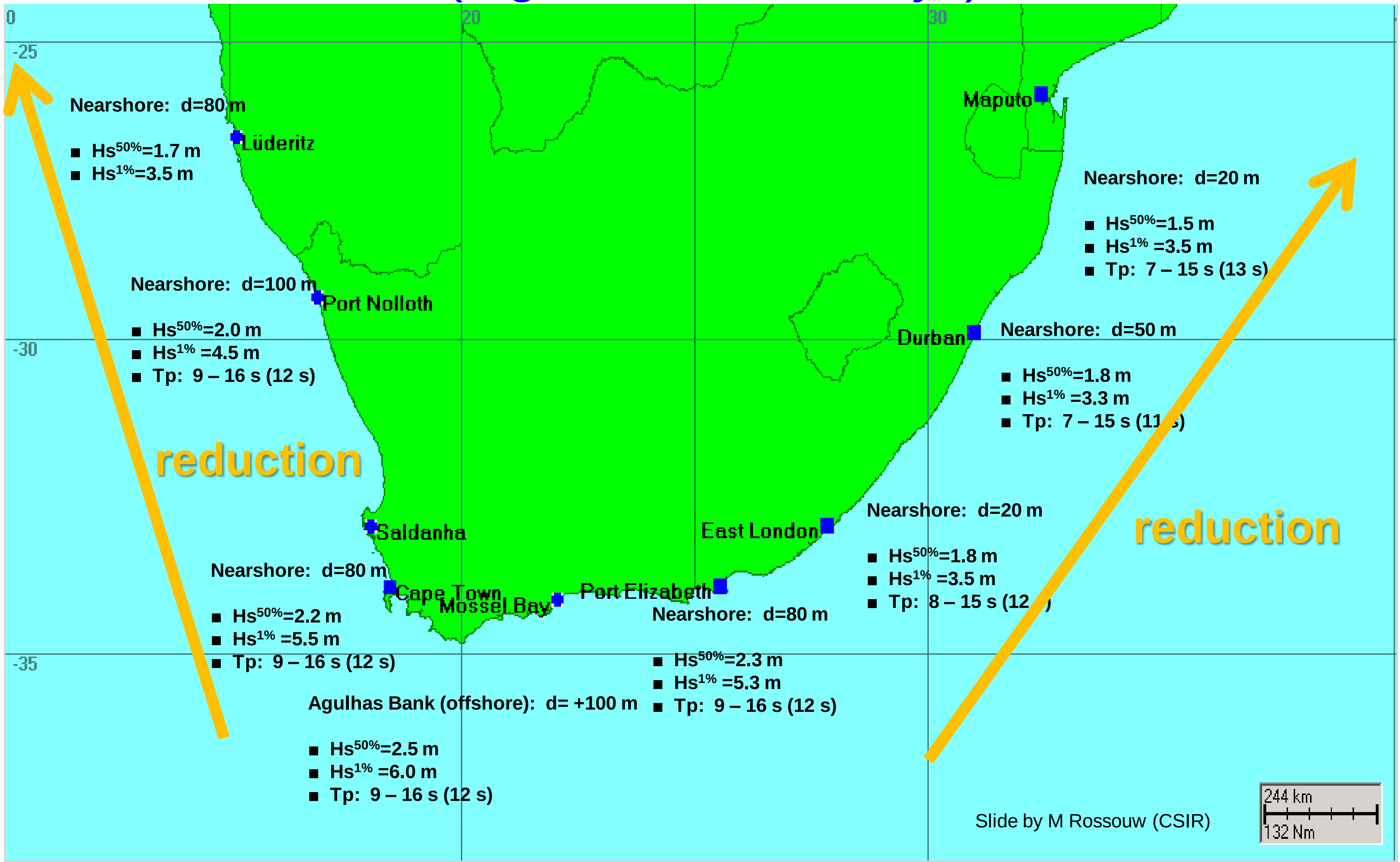
● CSIR WAVENET



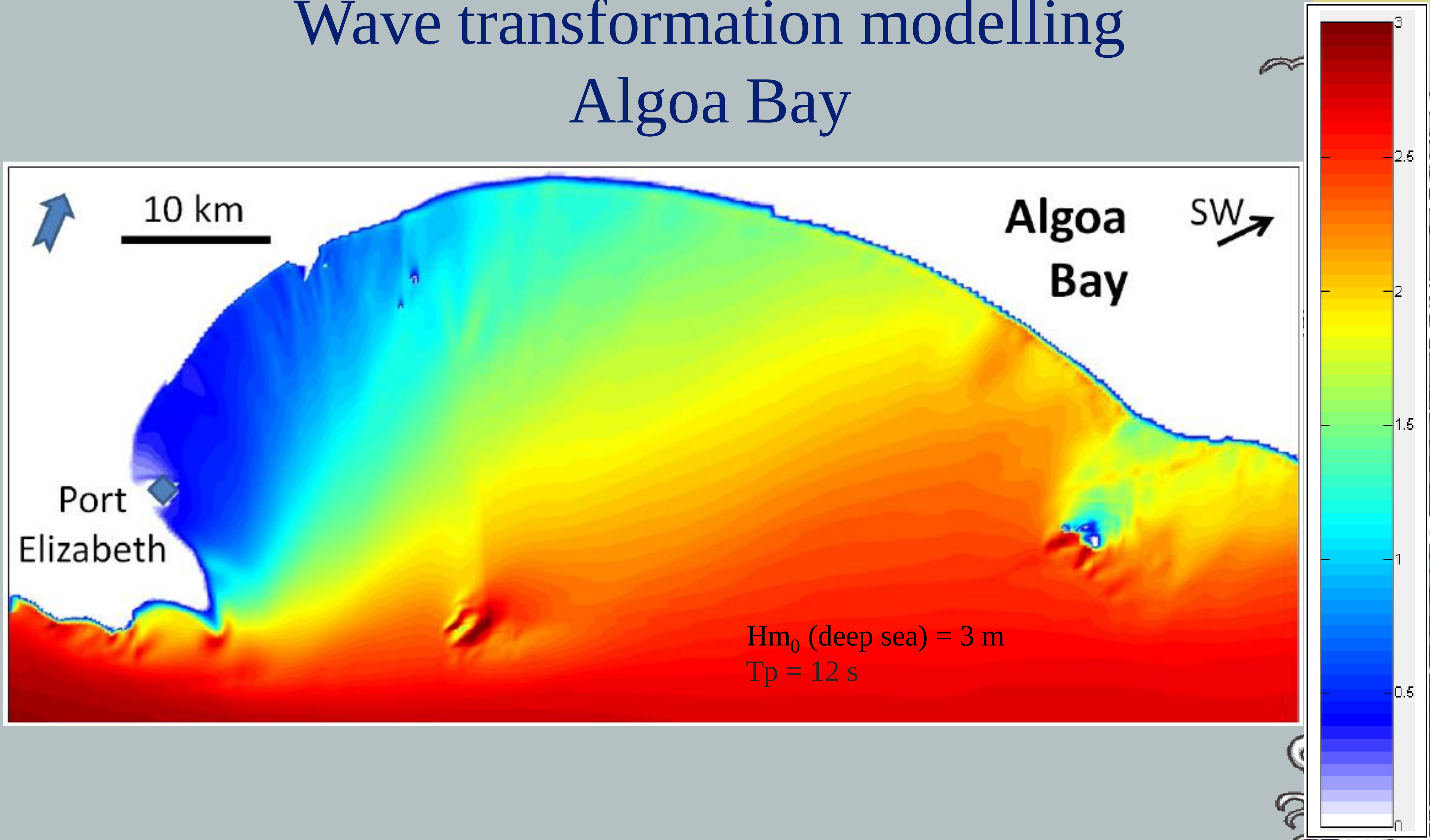


Nearshore wave climate: SA coast

(e.g. Waverider buoys)



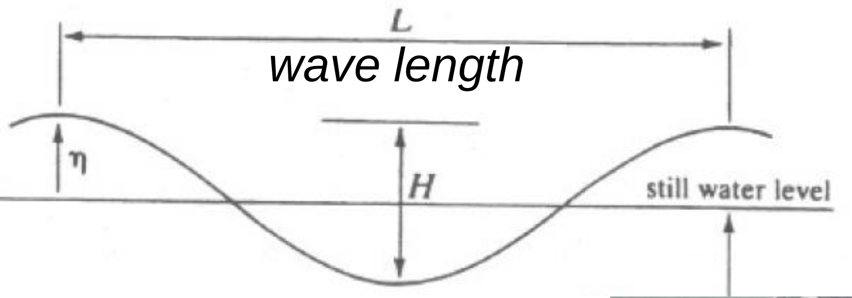
Wave transformation modelling
Algoa Bay



Short period wind waves ('sea') *[windgolwe]* in generation area.

on top of

Long period swell waves *[deining]* from outside of generation area.

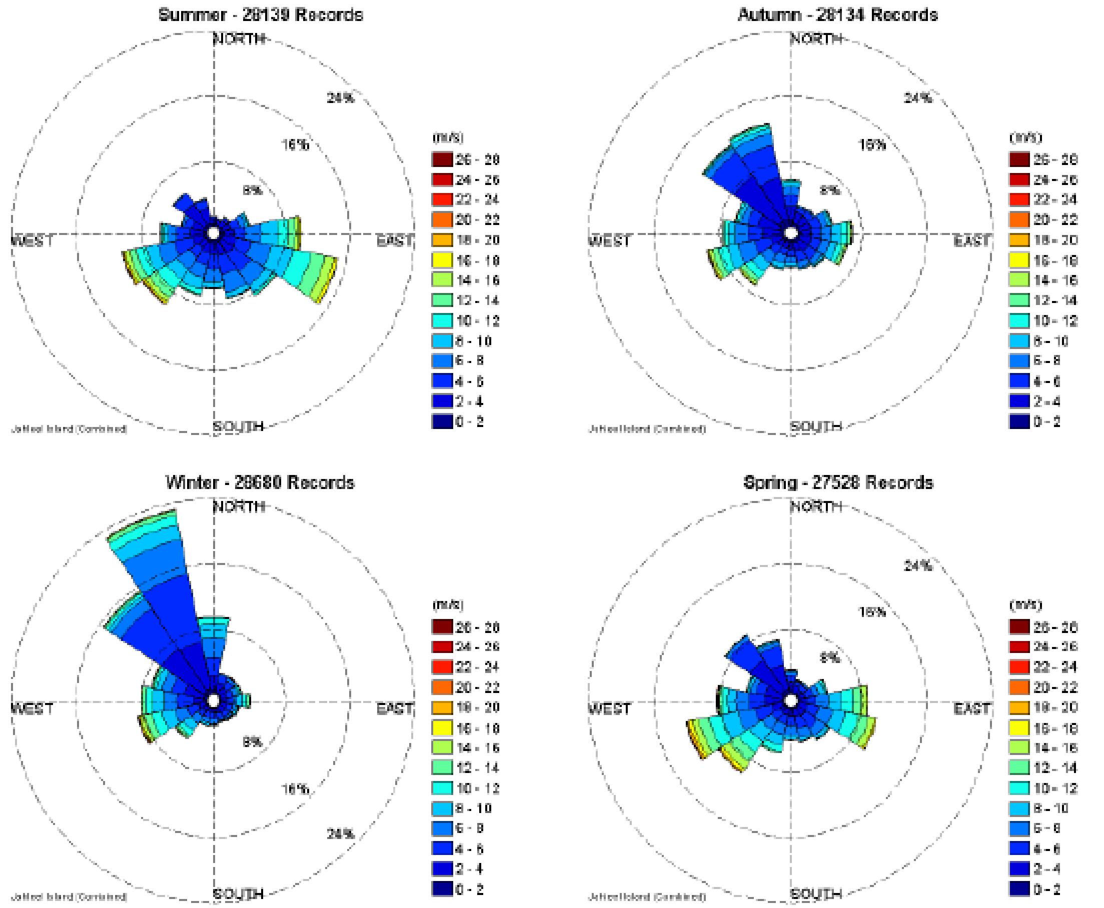


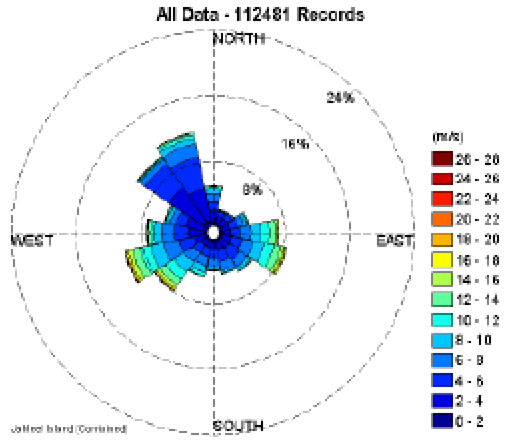
Wind waves:

Size of wind waves:

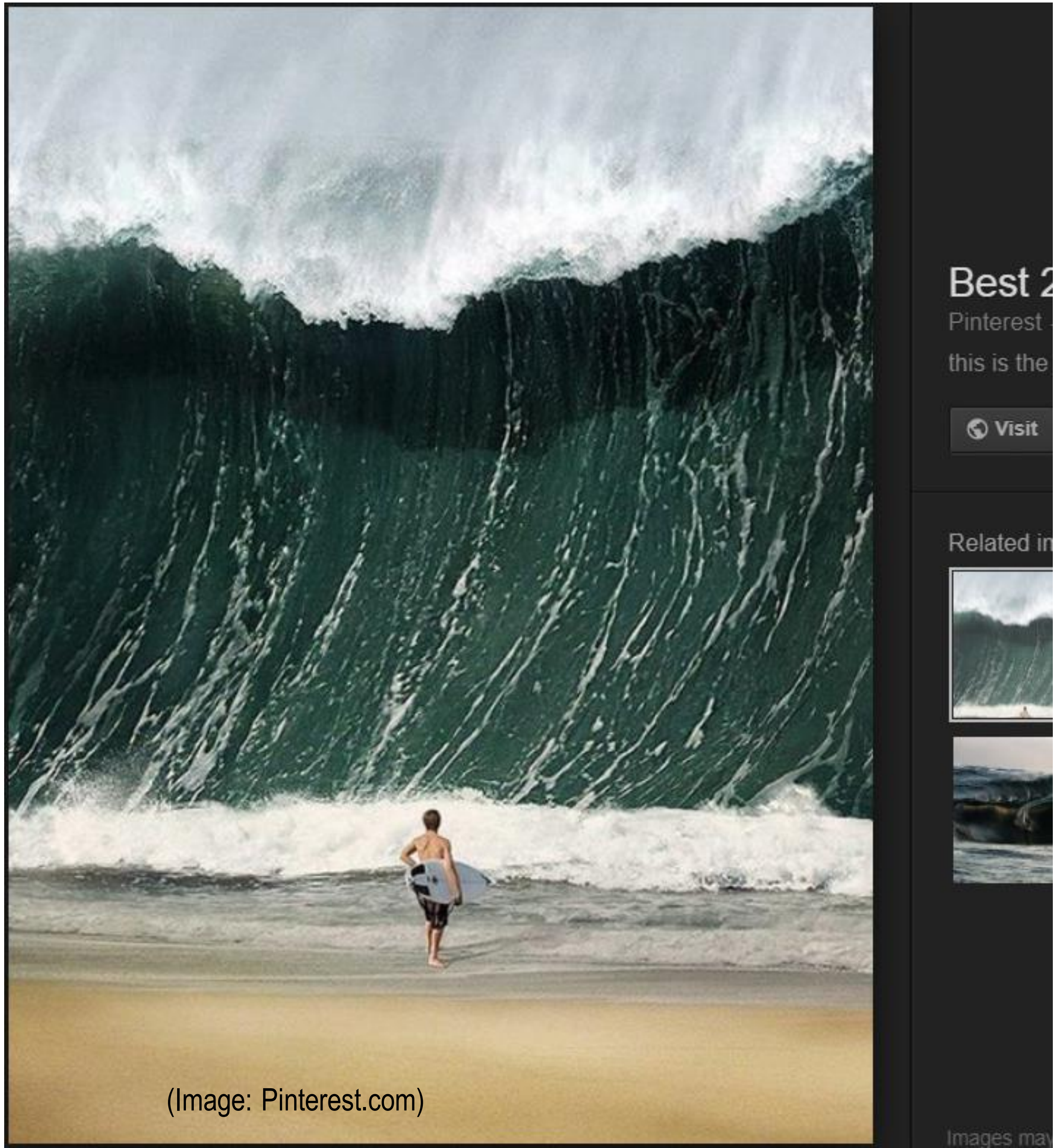
velocity, duration, fetch

Local winds (recorded)
e.g. Jahleel Island
>> wind waves in Algoa Bay





Period	1998-11-26 to 2011-11-22
Station	Jahleel Island (Combined)
Position	33.804 S, 25.70468 E
Height above surface	6.0 m
Records	112481



(Image: Pinterest.com)

Shallow water breaking wave criterion:

$$H_b/d_b \cong 0.78$$

(Wave height /water depth)

Thus, photo is distorted or "fake news"

/photo shopped

Wave Breaking Type

Breaker types. Breaking waves may be classified as one of three types, as shown in Figure 8.16. The type can be approximately determined by the value of the surf similarity parameter (or Iribarren no.)

$$\xi_b = \tan\beta / \sqrt{H_b / L_b} \qquad (8.35)$$

where tan β = beach slope, and for

spilling breaker	$\xi_b < 0.4$
plunging breaker	$0.4 < \xi_b < 2.0$
surging breaker	$\xi_b > 2.0$

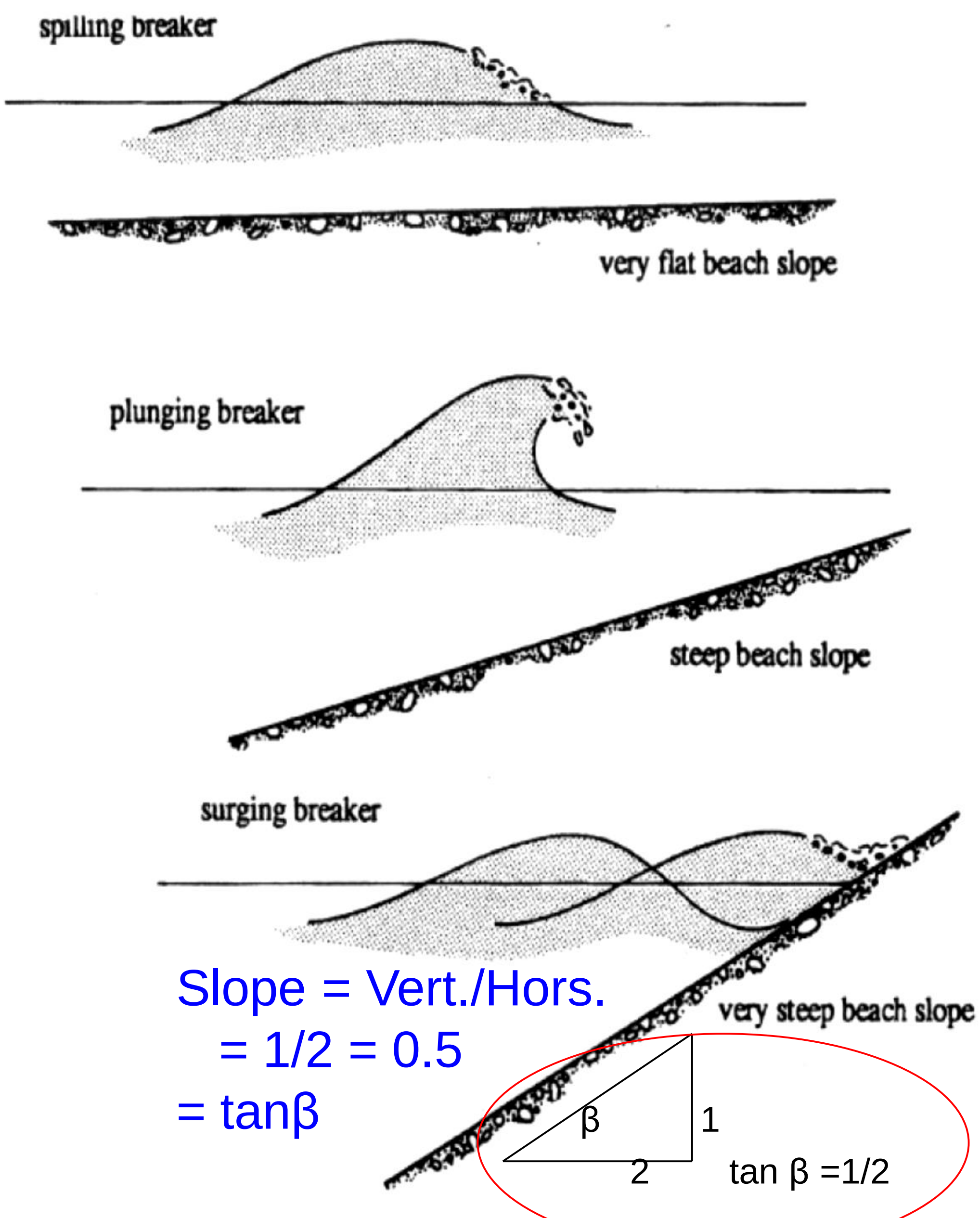
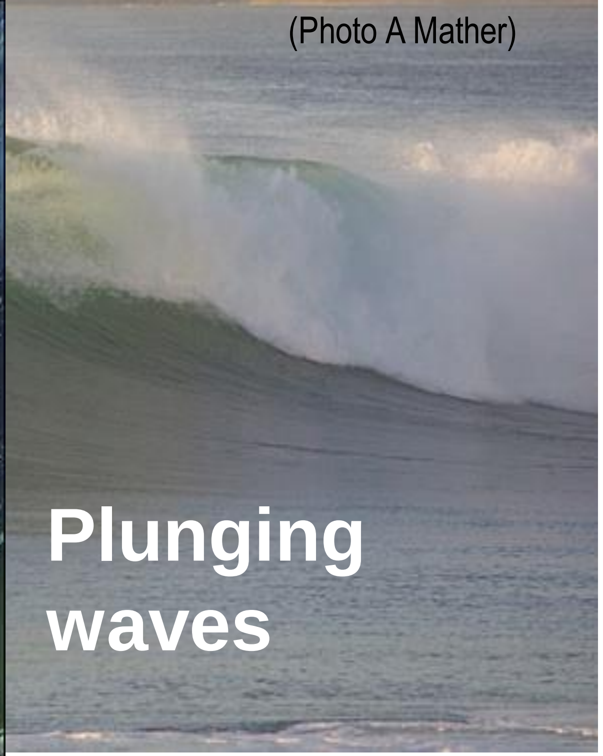


Figure 8.16 Principal types of breaking waves.

Plunging waves


Photograph: Clark Little

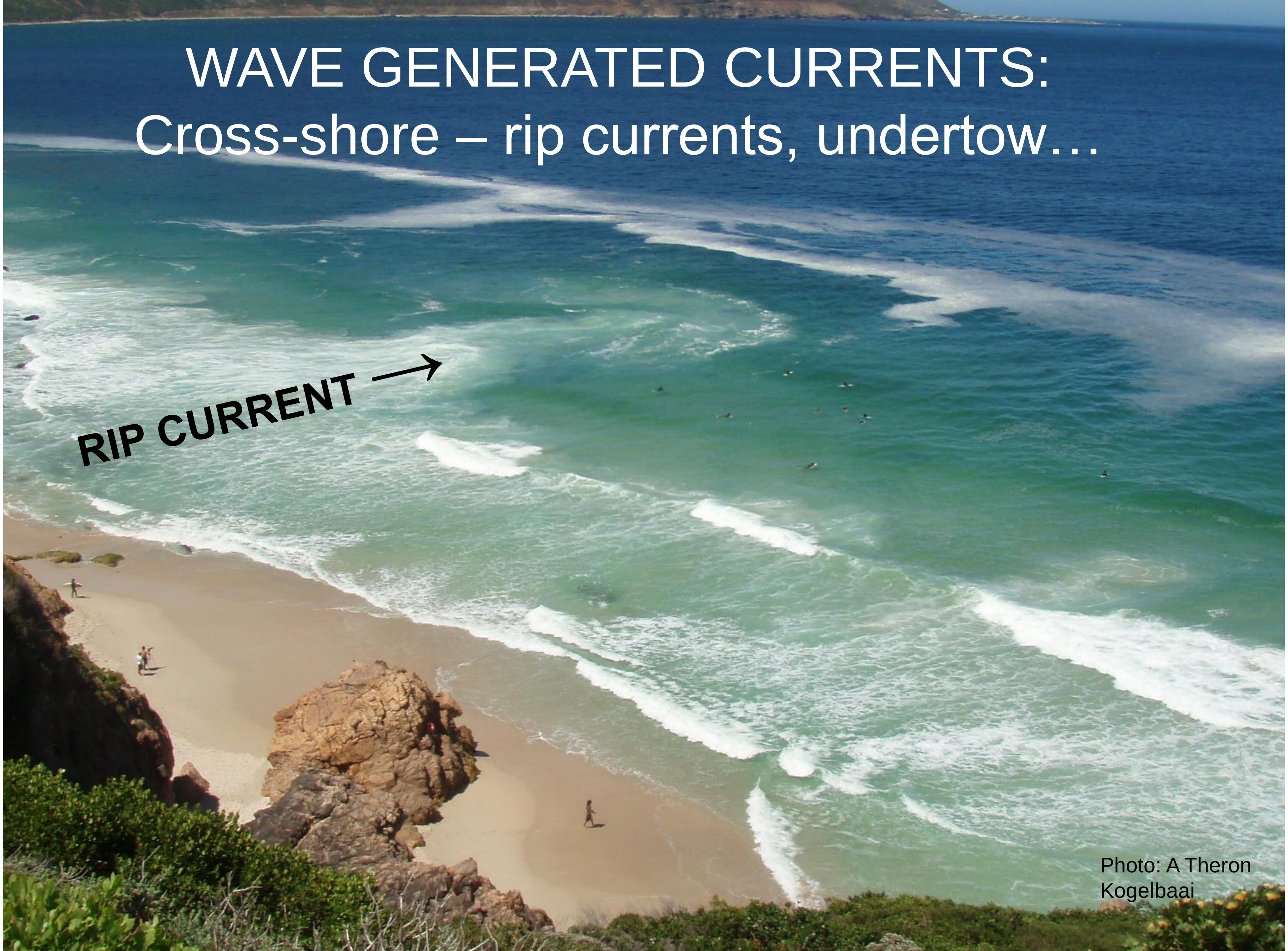

(Photo A Mather)


(Photo D Theron)

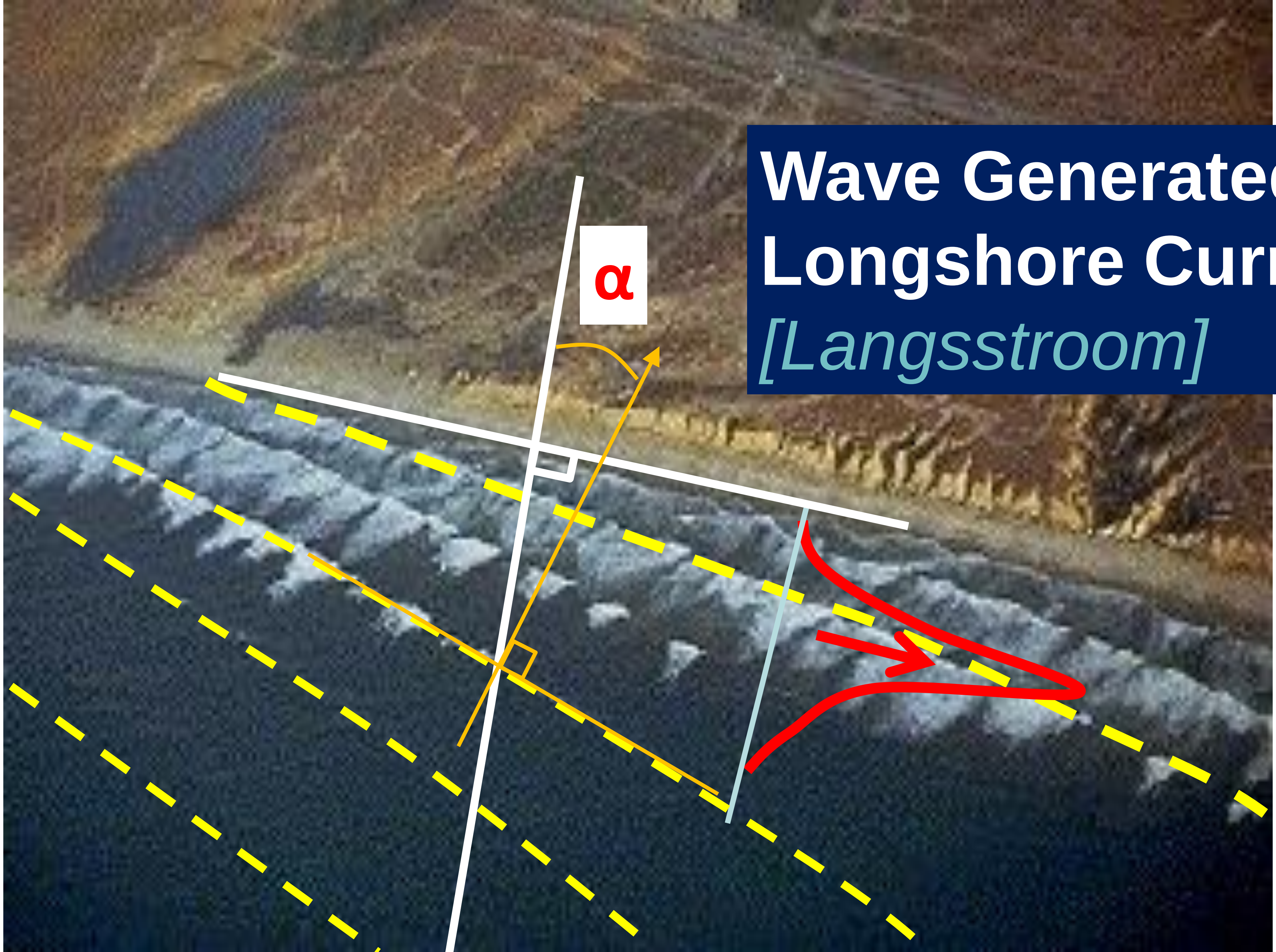
Spilling waves

Currents: General…

- Ocean currents: Benguela and Agulhas
- Tidal currents: Estuaries / river mouths,
  port / harbour entrances
- Wind driven currents
- **Wave generated currents:**
  Cross-shore currents (e.g. undertow)
  Longshore currents *(langsstrome)*
    Obliquely incident waves
      (Skuinsinvallende golwe)
    Longshore variation in wave height

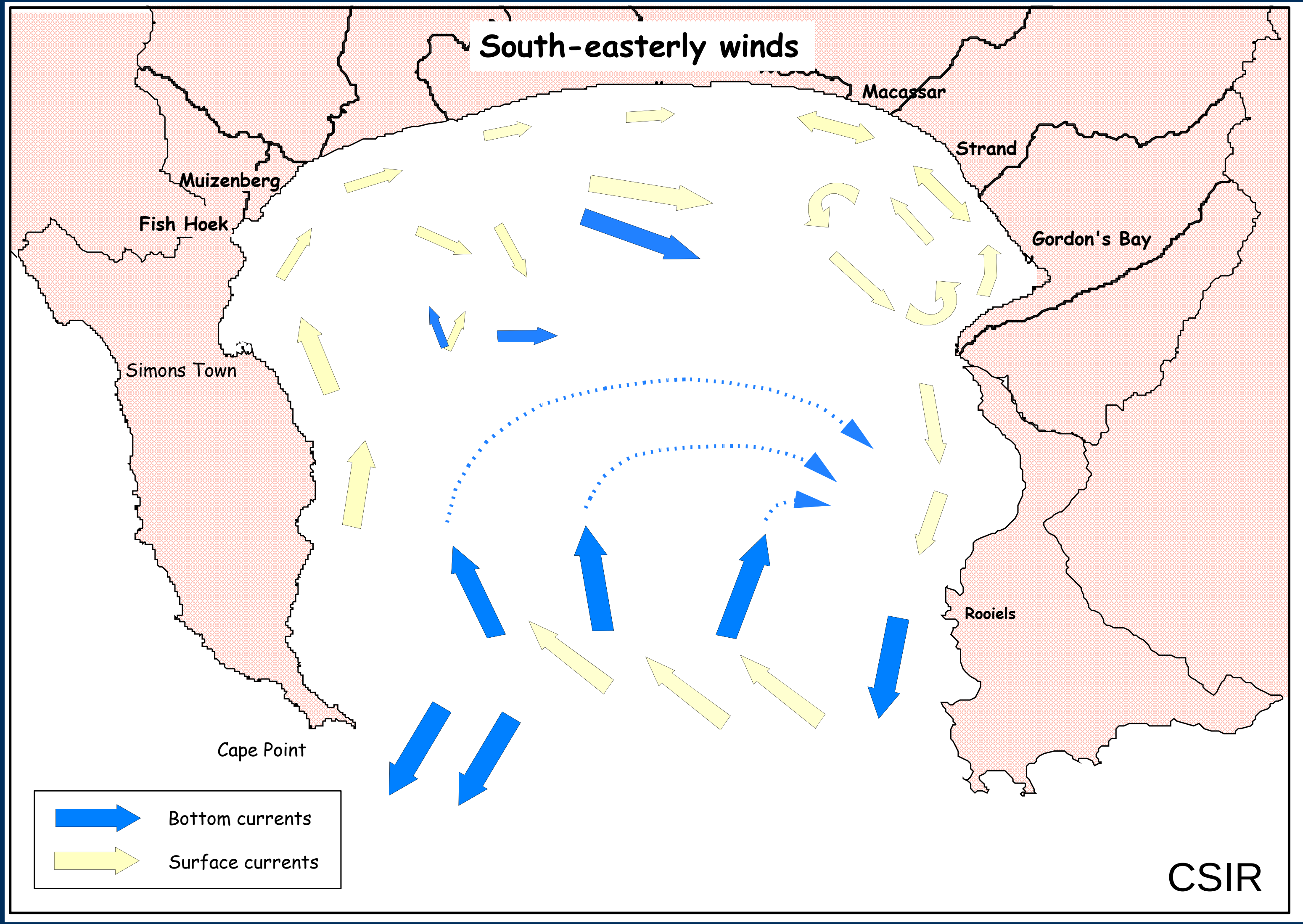

WAVE GENERATED CURRENTS:
Cross-shore – rip currents, undertow…
RIP CURRENT
Photo: A Theron
Kogelbaai

Wave Generated Longshore Current *[Langsstroom]*

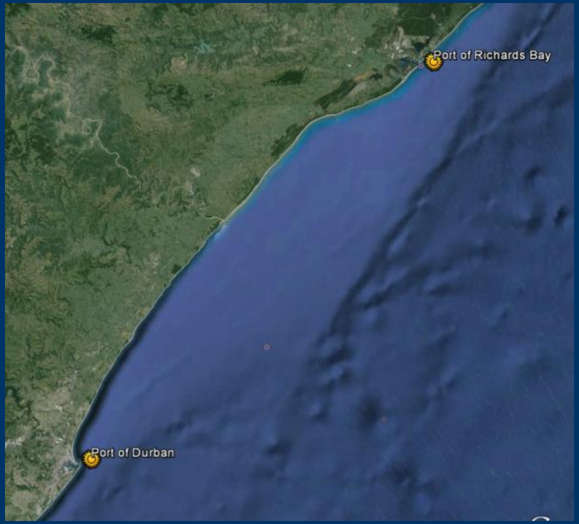


Wind driven currents

Circulation – S/SE winds…



Inshore Currents: Port of Richards Bay



WSP | PARSONS BRINCKERHOFF CSIR

Thank you!

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Stellenbosch University

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7. Case studies & Discussion
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3. Coastal processes to consider & information required for design & construction:

- ✓ 2.1 Location of the site (from regional to detail site specific)
- ✓ 2.2 Bathymetry & Topography
- ✓ 2.3 Nature of shoreline and seabed
- ✓ 2.4 Historic shoreline changes
- ✓ 2.5 Winds, Waves, Currents

3.1 Seawater-levels, wave run-up

3.2 Sediment transport: longshore, cross-shore, aeolian

3.3 Environmental issues

3.4 Effluents & water quality; dilution & dispersion

3.5 Conflicting beach usages

3.1 Seawater-levels, wave run-up

Will the sea reach up to the stormwater outlet?

March 2007 – KZN: Max. wave run-up +10.5m MSL

3.1 Will the sea reach up to the stormwater outlet?

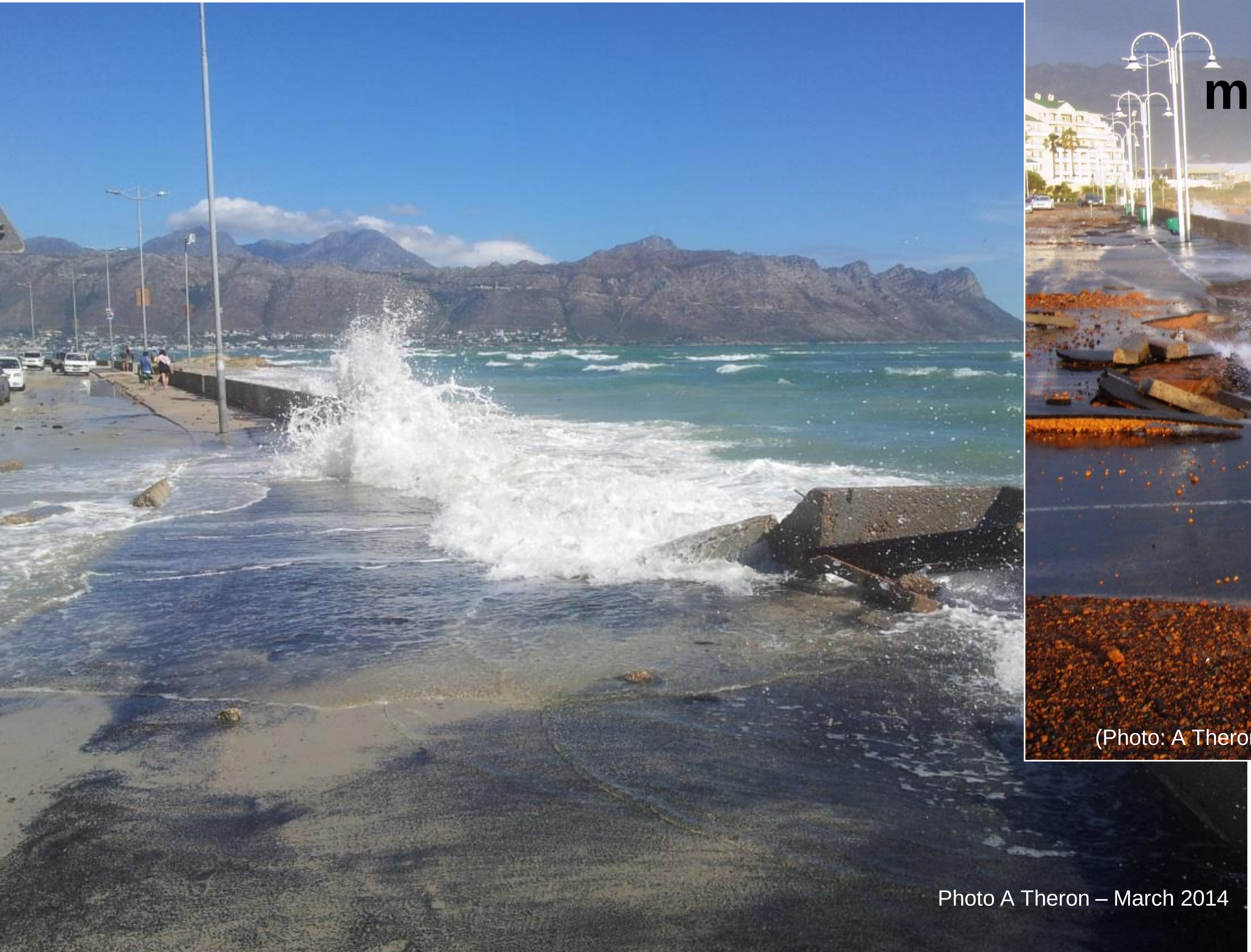


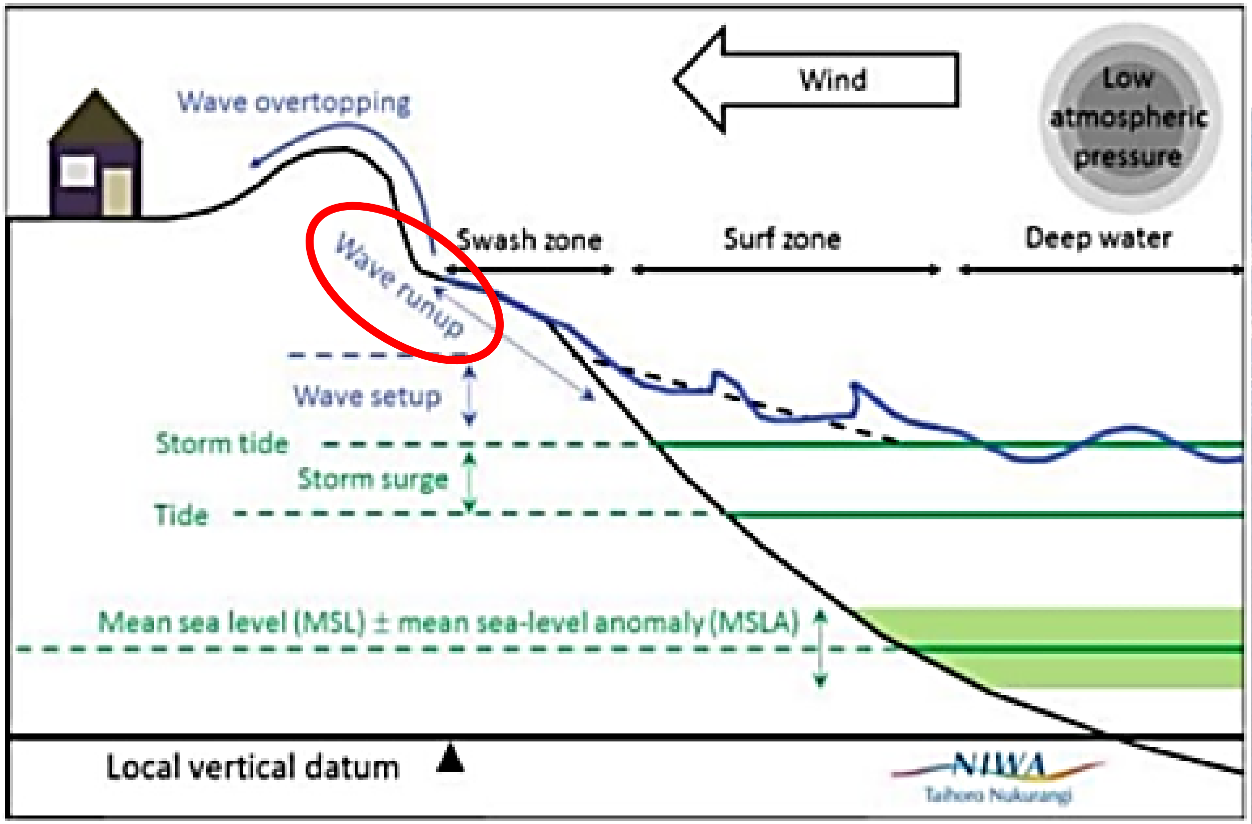
Photo A Theron – March 2014

(Photo: A Theron 31 Aug 2008)

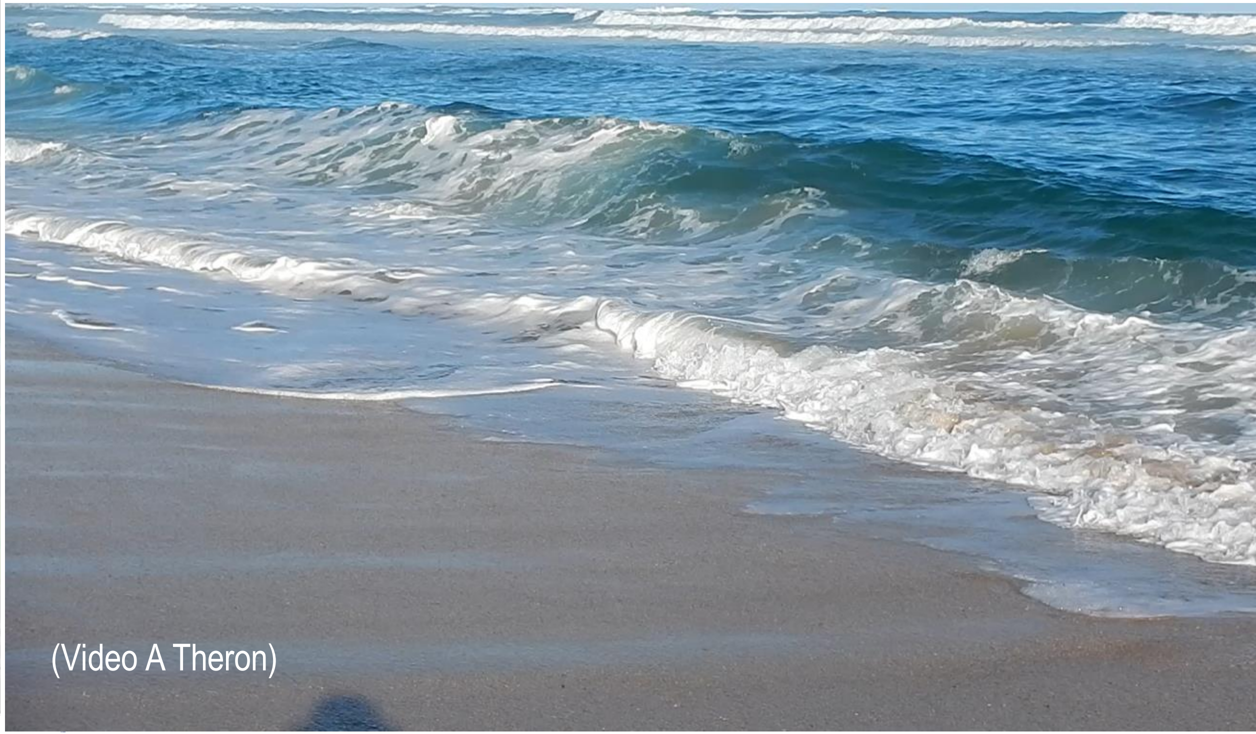
3.1 Coastal flooding levels

<u>Components</u> of **<u>extreme inshore seawater levels</u>**
causing **coastal inundation/flooding:**

http://coastalinundation.waikatoregion.govt.nz/



Wave Run-up
(& draw down)



Summary of <u>tidal levels</u> around SA coast (m to CD = Chart Datum)

(SANHO - SA Navy Hydrographic Office & CSIR)

(MLWS =mean low-water spring) (MHWS =mean high-water spring)

Location	LAT	MLWS	MLWN	MHWN	MHWS	HAT
Port Nolloth	0	0.28	0.78	1.40	1.91	2.25
Saldanha Bay	0	0.24	0.70	1.27	1.75	2.03
Cape Town	0	0.25	0.70	1.26	1.74	2.02
Simon's Town	0	0.24	0.73	1.29	1.79	2.09
Hermanus	0	0.27	0.75	1.29	1.78	2.07
Mossel Bay	0	0.26	0.88	1.46	2.10	2.44
Knysna	0	0.22	0.82	1.32	1.91	2.21
Port Elizabeth	0	0.21	0.79	1.29	1.86	2.12
East London	0	0.23	0.78	1.25	1.82	2.08
Durban	0	0.21	0.87	1.36	2.01	2.30
Richards Bay	0	0.27	0.97	1.48	2.11	2.47

CD (Chart Datum) ≅ LAT (Lowest Astronomical Tide)
LLD (Land Levelling Datum) = MSL (Mean Sea Level ≅0.9m above CD)

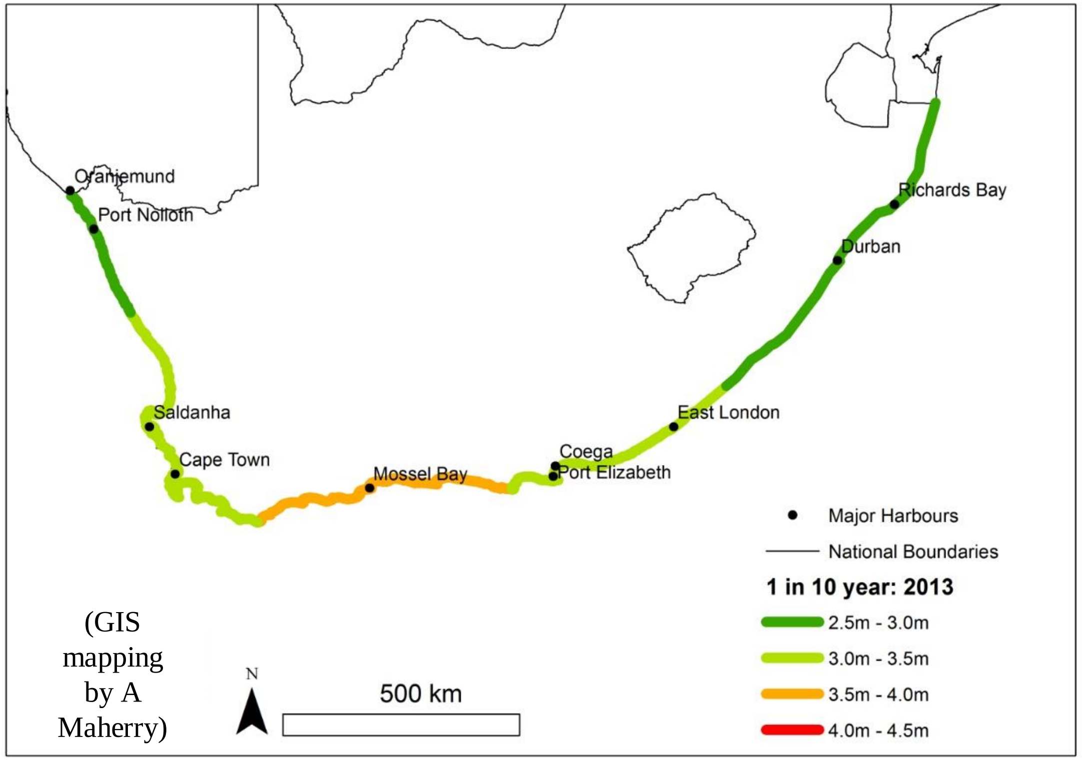
→ Extreme ***open*** coast SA "storm surge" levels

MHWS + residual & setups & Sea Level Rise (SLR), but ***excluding* wave run-up**

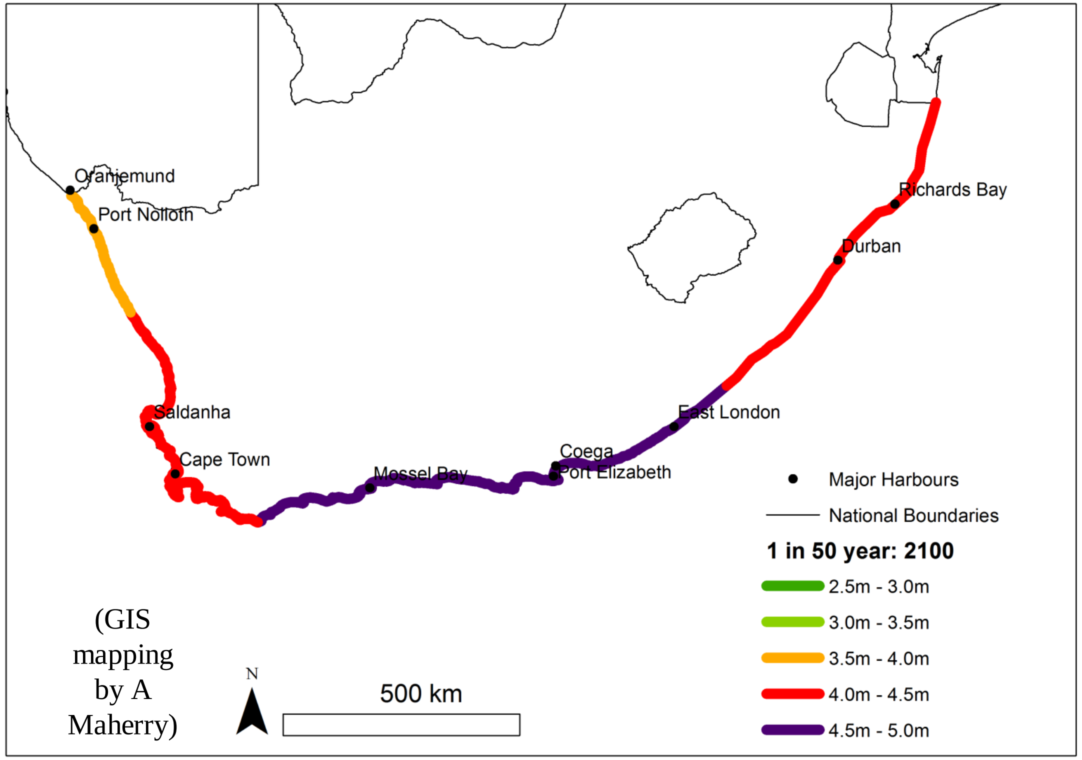
(**some setups not applicable within bays**)

Examples:

SA regional coastal storm surge levels for 1-in-10 yr wave return period and 0 m SLR scenario



SA regional coastal storm surge levels for 1-in-50 yr wave return period and 1 m SLR scenario

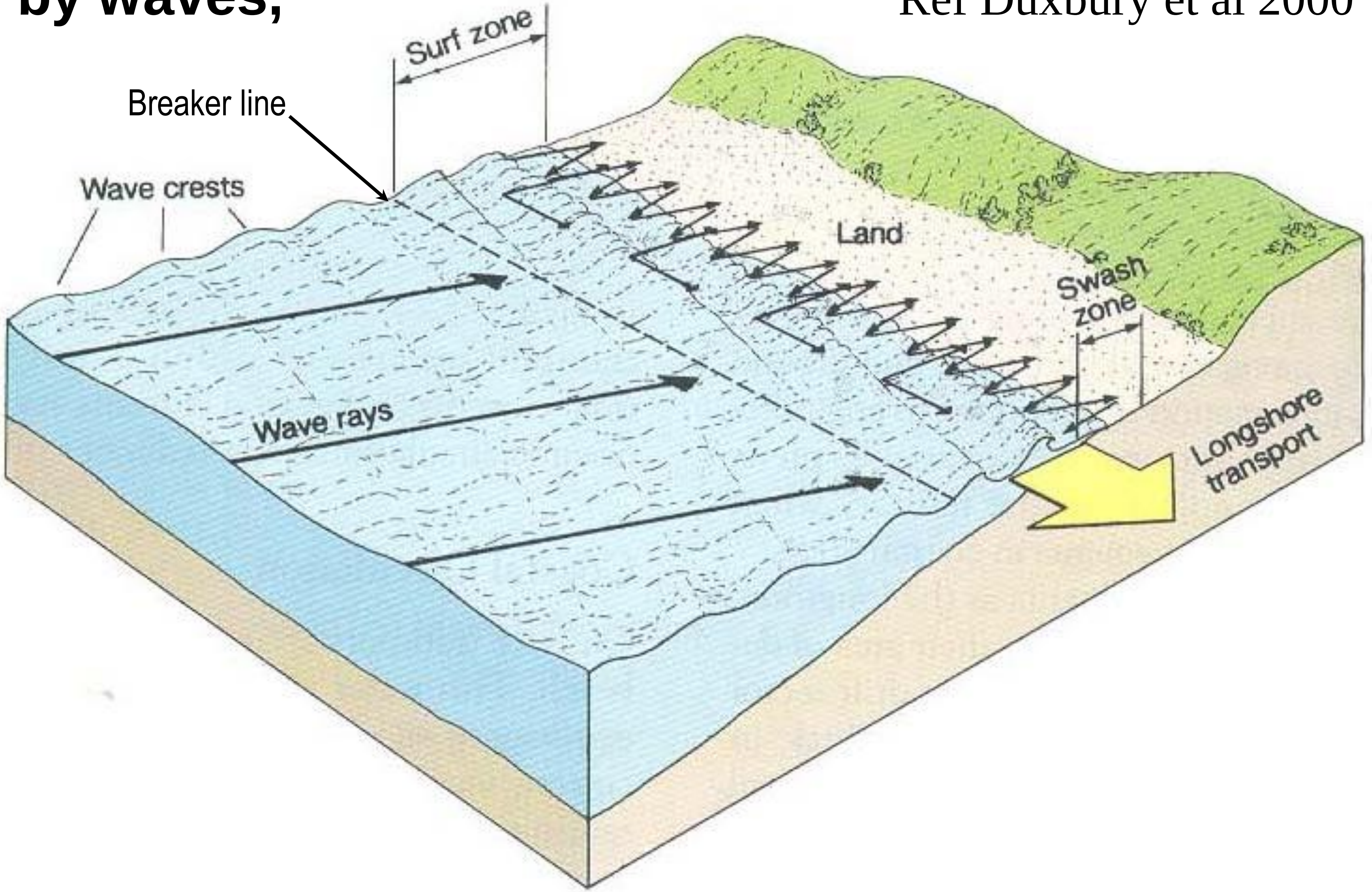


3.2 Sediment transport:

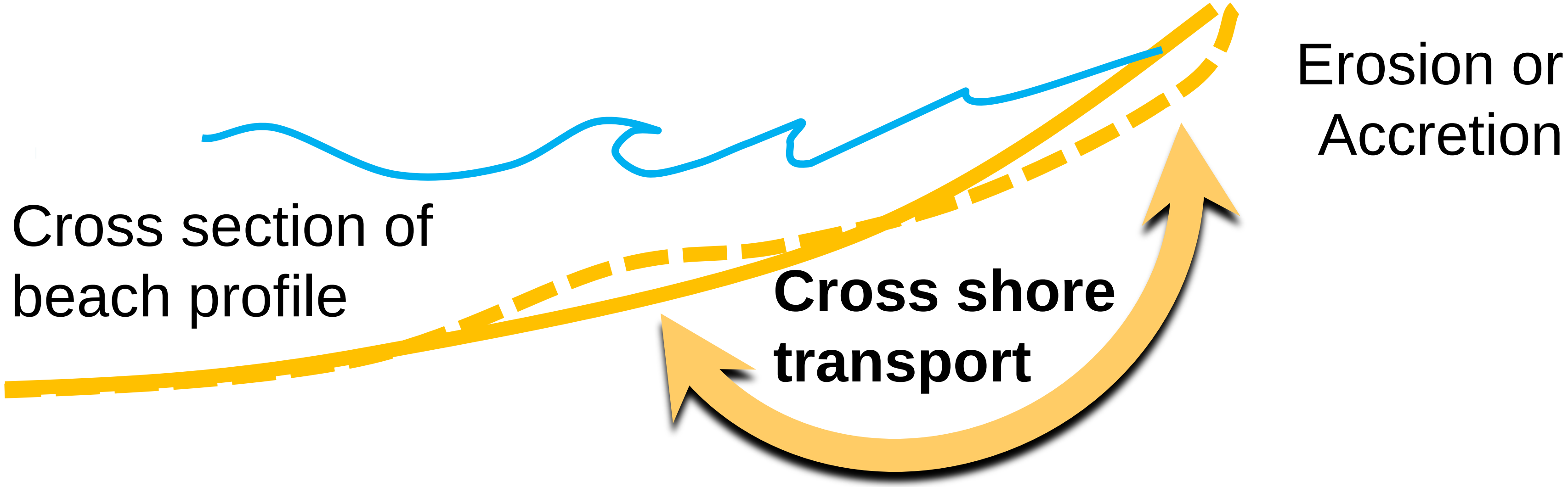
Photograph: Clark Little

Longshore transport of water and beach sand by waves,

Ref Duxbury et al 2000




Cross-shore transport
[Dwarsvervoer]


Erosion or
Accretion
Cross section of
beach profile
Cross shore
transport

Wind-blown sand transport ⇨ problems…

Typical Coastal Problems / Failures - Small Stormwater Outlets


(Photo: A Theron)

Sand accretion at & blockage of outlets


Aeolian accretion of sand at the outlet
(Photo: Lindford, 2015)


(Photo: A Theron)

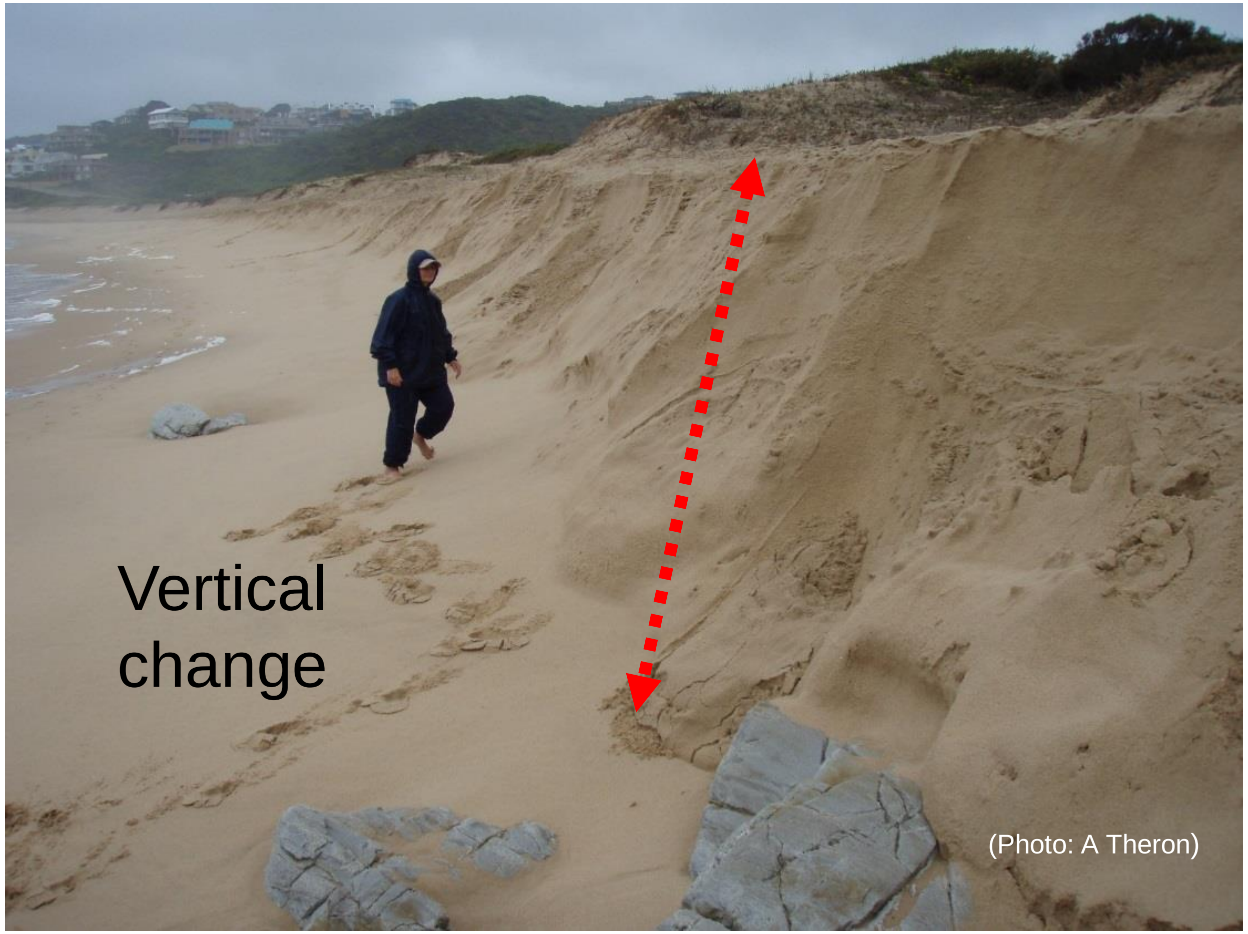

Blocking of an outlet resulting from vegetation growth and sand inundation

Southern Cape
(Photo: A Theron)

3.2 Sediment transport:

➢ **Coastal erosion:**

horizontal & vertical changes!



Beach erosion and/or scour - Waves

La Lucia March 2007 R Kasserchun

Under-scouring of an outlet located within reach of storm wave run-up

Coastal erosion: Rokeby & Roches beaches (AU)

Typical Coastal Problems / Failures of Small Stormwater Outlets

Beach erosion and/or scour
- Stormwater

(Photo: A Theron)

Beach erosion and lowering of the beach elevation seaward of an outlet due to stormwater outflows

(Photo: A Theron -KZN)

Typical Coastal Problems / Failures of Small Stormwater Outlets

Beach erosion and/or scour - Stormwater

Undercutting of outlet structures by stormwater runoff outflow from the pipe end
(left: Mossel Bay, between Bay View and Hartenbos at Nooitgedacht parking, Vela VKE, 2011);
(right: Mossel Bay - Tergniet, MVD, 2011)

Beach erosion and/or scour - Stormwater


(Photo: A Theron, Southern Cape).

Scour around the sides of a structure due to surface water runoff from higher ground behind the outlet


(Photo: A Theron)

Stormwater pipes *south of Strandfontein beach wall:*

<u>Undermined</u>

Brickwork in dynamic coastal zone ☹!

PDNA
PD NAIDOO & ASSOCIATES

Photos: Pieter Nieuwoudt

This is better, but generally brickwork not suitable in dynamic coastal zone !

Brickwork structure
(Photo: A Theron, KZN)

3.3 Environmental issues

It's about:

1. Identifying, understanding, quantifying & designing for the impacts of the environment (e.g. design loads) on proposed infrastructure/amenities;

2. being able to understand, plan, design, build, operate & manage the impact of development & infrastructure on the natural coastal environment.

NB

Avoidance or minimization of adverse effects to critical areas and habitats need not be viewed as an impediment to coastal engineering projects. Rather, these issues can be viewed as opportunities to apply innovative technology to environmental problem-solving in the coastal zone.

3.3 Environmental issues

NEMA (National Environmental Management) - Integrated Coastal Management Act – Purpose:

''… to promote the **conservation of the coastal environment**, and **maintain the natural attributes of coastal landscapes and seascapes**, and to **ensure that development** and the use of natural resources within the coastal zone **is socially and economically justifiable** and **ecologically sustainable**; …
to **control dumping** at sea, **pollution** in the coastal zone, **inappropriate development** of the coastal environment and other adverse effects on the coastal environment; …''

Coastal environment - managing anthropogenic ("human") impacts, by:

identify and confirm the preferred site, through a detailed site selection process, which includes an impact and risk assessment process inclusive of cumulative impacts and a ranking process of all the identified alternatives focusing on the geographical, physical, biological, social, economic, and cultural aspects of the environment;

identify suitable measures to avoid, reverse, mitigate or manage identified impacts and to determine the extent of the residual risks that need to be managed and monitored.

3.3 Environmental Issues To Be Considered for All Projects

Consider: Potential environmental constraints & opportunities

- Coastal & marine nearshore habitat changes & impacts
- Be aware of potential environmental & ecological impacts (engs. are *not* experts)
- Development/infrastructure located near NB conservation/protected areas
- Water quality/pollution & contamination issues near NB conservation/protected areas
- Aesthetics or "sense-of-place" of the coastal zone
- Etc, etc…

The primary objective of managing an ecosystem is to maintain its integrity of function, diversity, and structure.

Engineers & managers must enable cost-effective integration of engineering & environmental science into sustainable coastal growth & development (within SA context).

3.3 Environmental issues

E.g.: avoid/mitigate aesthetic impacts & pollution

Dirty stormwater running over the beach to the sea
(left: Maputo; right False Bay; photos: A Theron)

3.3 Environmental issues

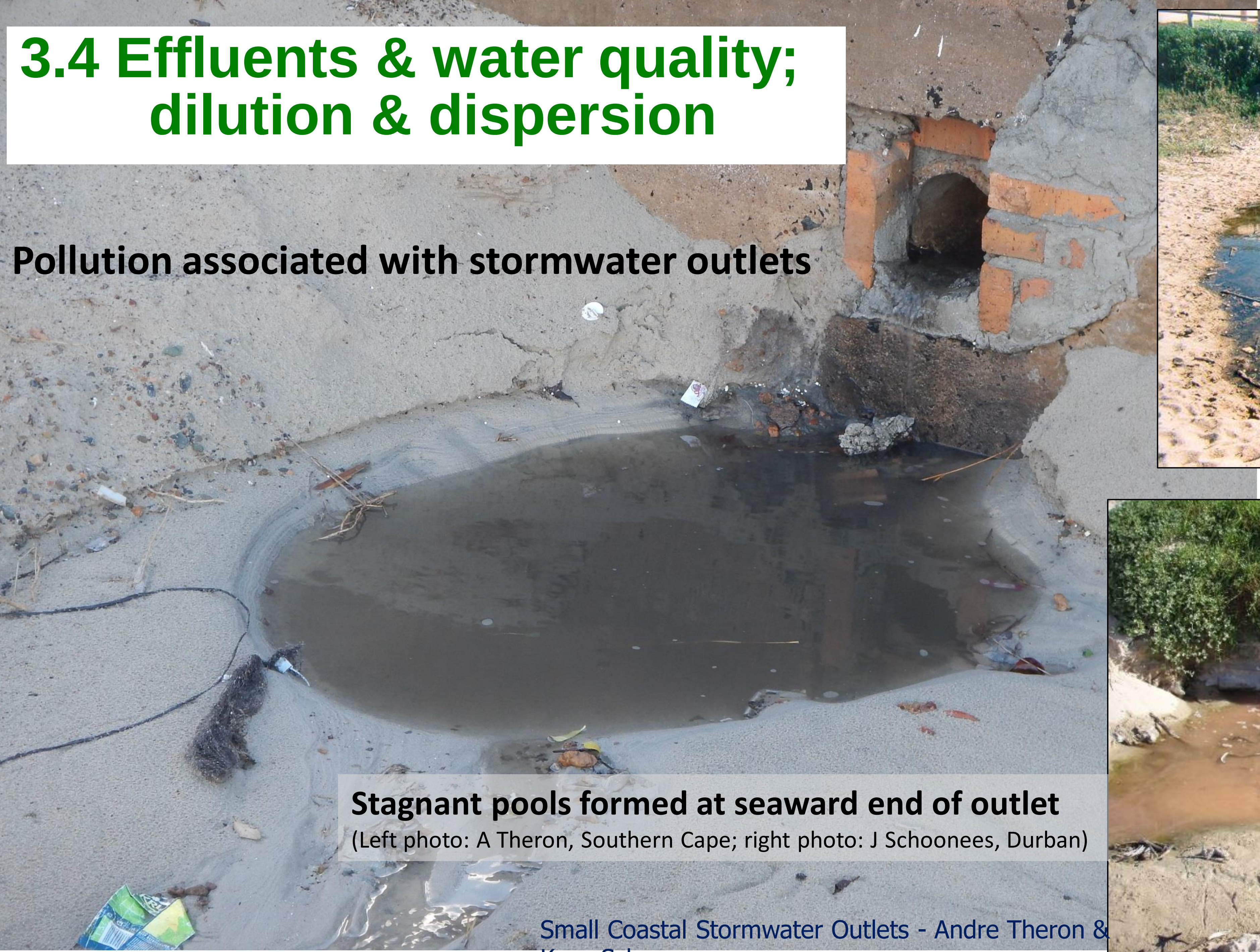
Social issues, e.g.: Heritage

Historical fish traps near Stilbaai are of cultural heritage importance ⟹ **avoid such areas**

(Photo A Theron)

3.4 Effluents & water quality; dilution & dispersion

Pollution associated with stormwater outlets



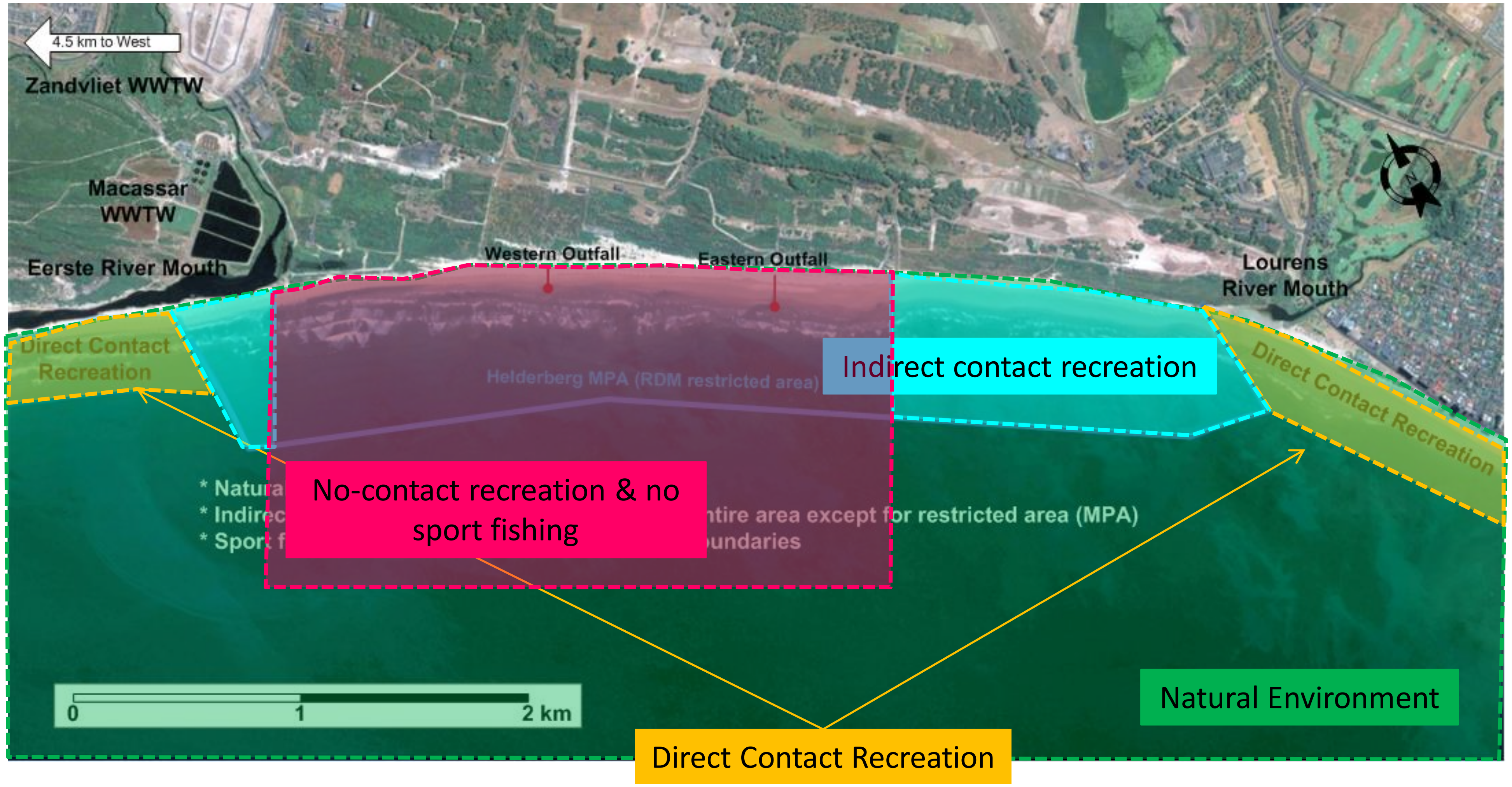
Stagnant pools formed at seaward end of outlet

(Left photo: A Theron, Southern Cape; right photo: J Schoonees, Durban)

3.5 Conflicting beach usages : OUTFALL LOCATION – AREA?

Beneficial Uses: i.e. direct contact, indirect contact recreational activities, collection of filter feeders,

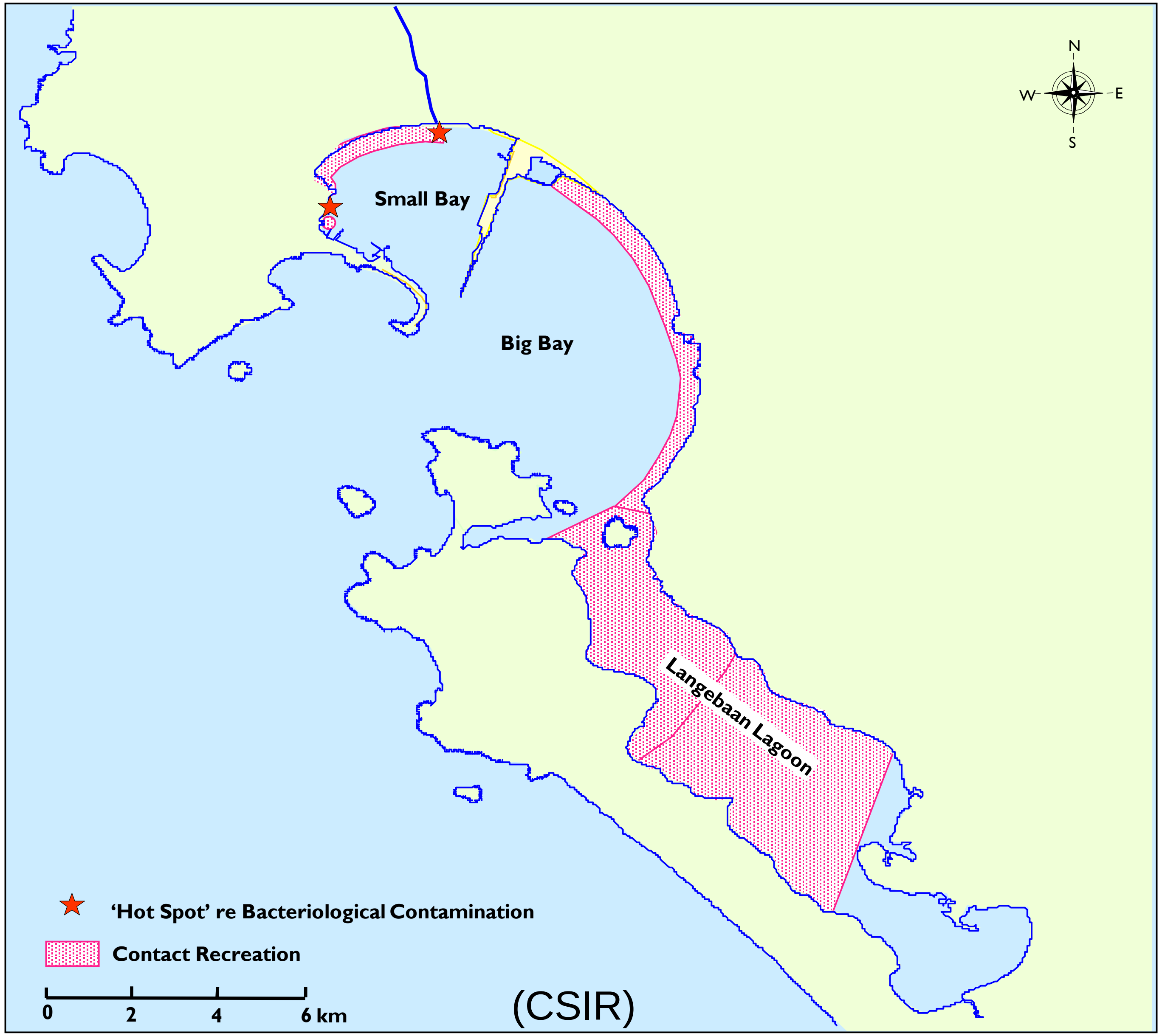
MPAs, Industrial, mariculture, natural environment



3.5 Conflicting beach usages

OUTFALL LOCATION – AREA?

E.g.: Saldanha Bay water quality/pollution & contamination issues in/near important conservation, protected & national park areas, contact recreation areas, etc.



3.5 Conflicting site issues at a beach, e.g.:

Some Site Selection Criteria for a *Brine* Outfall

Technical Criteria	Environmental Risk Criteria
•Access to Roads	•Impacts on Terrestrial Biodiversity
•Proximity to the Reservoir	•Brine Dispersion and Marine Ecology
•Geotechnical aspects	•Impacts on Heritage Resources
•Land Zoning, Ownership etc.	•Proximity to Protected Areas
•Exposure to Ocean Energy	•Landscape and Natural Scenery
•Hydraulic design factors	• Access to good quality feedwater

Adapted from slide by
Patrick Morant &
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3. Processes to consider & information required:

Data/information requirements:

- coastal topography,
- bathymetry,
- sediment, geomorphology,
- waves, wind regime
- historic shoreline changes,
- etc….

Some sources of information/data:

- Aerial photographs, orthophotos, stereo imagery
- Topo. surveys
- Remote sensing, LiDAR, satellites
- Geophysical GIS data
- etc…..

Minimum data standards and specifications:

- coastal topography (vertical: 20-50 cm, hors. coverage, …)
- bathymetry (SAN data & charts or better)
- etc….

3. Processes to consider & information required:

Web sites that might be useful :
Web ruimtes wat nuttig kan wees :

Google Earth (& Earth Engine; Pro) https://www.google.com › earth

http://mapservice.environment.gov.za/coastal%20viewer/

https://webapp.navionics.com/#boating

http://www.sanbi.org

http://www.agis.agric.za/agisweb/agis.html

http://gis.elsenburg.com/apps/cfm/

https://www.gebco.net

Good Luck !

✓ 3. Processes to consider & information required

⟹ Need some practices to mitigate typical problems:

- **Erosion, scour and structural damage**
- **Sand inundation**
- **Backshore flooding**
- **Impacts on beach usage & aesthetics, and pollution**

⇨ 4. Design Guidelines (to mitigate such problems)

Thank you!

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