Datasets Guidance 1: *Shoreline Explorer* Present-day coastal sensitivity to flooding and erosion

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Introduction

There are three datasets in Shoreline Explorer:

- Sediment compartments (Section 1 in this document). This summarises the available information on physical (i.e., ocean currents, geomorphology etc.) coastal risks for each coastal compartment in Australia.
- Smartline (Section 2). This comes in a basic version and an advanced version. It is by far the most complex of the datasets in CoastAdapt, so you may wish to try the basic version first. It provides information on erodibility of the coastline based on geology.
- Water Observations from Space (Section 3). This provides information on present-day flood risk using satellite data.

Local government boundaries are also provided. You can look at more than one dataset at once. Each dataset has a horizontal slider bar below its name – this controls the transparency and opacity of the dataset. Sliding it to the left makes the data more transparent, and to the right more opaque.

All datasets in Shoreline Explorer are accessed from the same starting point, as follows:

1. From the home page of CoastAdapt click on Shoreline Explorer. This will take you to a page that provides short descriptions of available datasets in Shoreline Explorer.
2. Clicking on one of the Shoreline Explorer links from this page will take you to an interactive map of Australia. You can choose (top left-hand corner) to show this map as a satellite image, or as a national colour base map. We use two base maps because, although using the satellite base map is more visually appealing, features are not marked. The national colour base map show place names and roads, making it easier to pinpoint precise locations.
3. On the left-hand side of the screen, the available datasets are listed. You just have to tick the box(es) for the one(s) you want.

The first time you try to use Shoreline Explorer it may seem difficult, but with a little practice it will become a straightforward process.

1. Coastal sediment compartments

1.1 What is a sediment compartment?

It is possible to divide the coastline into discrete units within which there are broadly homogeneous features that may include geology, landform types, near-shore currents and sediment availability and movement. This can be done at different scales, and scientists have divided the Australian coastline into primary, secondary and tertiary compartments.

There are 359 secondary compartments (see Figure 1). A compartment might be, for example, a bay lying between two headlands. The scale of the secondary compartments makes them convenient units at which to consider present-day exposure and vulnerability to erosion from, for example, wave action and storm surge. Present-day exposure and vulnerability are, of course, good guides to where problems are likely to arise as a result of future sea-level rise and therefore where adaptation efforts may need to be concentrated.

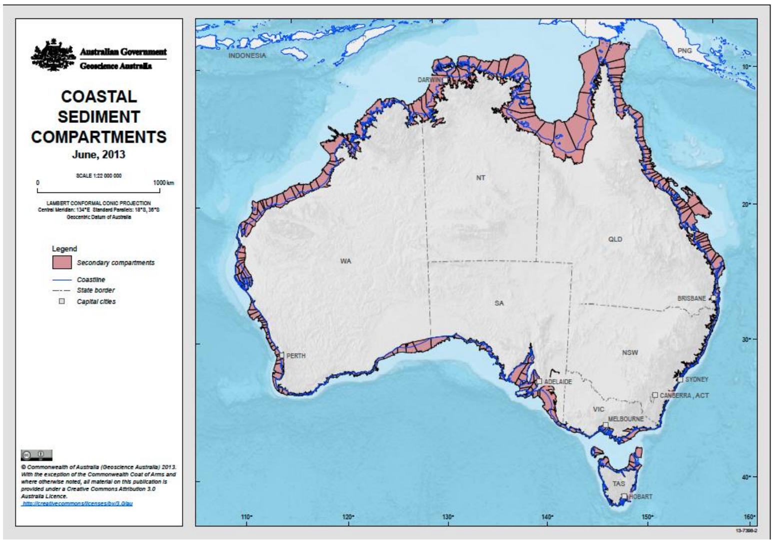

Figure 1: Australian coastal secondary sediment compartments. Source: Geoscience Australia http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_76502, accessed 29 June 2016.

Geomorphic data are available for primary and secondary compartments (http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_76502, accessed 29 June 2016). A project was carried out to build on what was known about each compartment, and to gather together the available information on coastal risk for each coastal compartment in Australia. Further information on the project is provided in Section 1.5. This information has been compiled into a dataset which is available through CoastAdapt.

1.2 How to access sediment compartment information

Once you have clicked the box in the Shoreline Explorer for the dataset you want (see the beginning of this document), proceed as follows:

1. You can find your area of interest either by typing the name of the place in the search box (top right hand corner of the map), or by zooming in using your mouse or the zoom slider.
2. Blue lines indicate the boundary of each compartment.
3. Click on the compartment of interest and an attribute table will appear in a pop-up box. The pop-up box contains a summary of the attributes for that sediment compartment. An example is shown in Table 1.
4. In the third row of each attribute table there is a link to a document. Select this link and a pdf with additional detail and information about the sediment compartment appears. An example of a pdf for the Tweed sediment compartment in New South Wales is provided in Appendix 1.

Table 1: Attribute table for the Tweed sediment compartment.

Sediment compartment name	Tweed
Included area	From Point Danger to Cape Byron
Further information	http://docs.coastadapt.com.au/sediment_compartments/NSW01.01.01.pdf
Geomorphology	Isolated rock headlands, zeta-form bays[1], sandy beaches, dunes and active blowouts (mixed Pleistocene-Holocene bay barriers infilling embayments), Tweed River mouth and estuary.
Sensitivity	Sensitivity rating is generally a 4, with several sections already 5. The southern end of several of these beaches is sensitive and undergoing periodic erosion and overwash

You will see in row 4 of the table that the compartment has been given a sensitivity rating. For the purposes of assessing future shoreline behaviour a sensitivity scale (1 to 5) was developed that could be applied in each of the 359 secondary compartments. The scale is as follows.

1. Shorelines that are presently accreting and are likely to continue or accelerate their accretion as sea-level rise continues (as a result of increased supply of sand from an alongshore source or from river/tidal channel sources).
2. Shorelines that are currently stable but are likely to start accreting as sea-level rise continues (includes shorelines that periodically grow seaward but may be subject to episodes of erosion).
3. Relatively stable shorelines which may be subject to periodic erosion followed by recovery (accretion), but no long-term recession expected in the next few decades since the sediment budget remains sufficiently balanced over time from offshore, alongshore or terrestrial sources.
4. Shorelines that currently do not show evidence of long-term recession but are likely to begin receding with continuing sea-level rise (based on sediment availability onshore and offshore).
5. Shoreline recession is occurring now (typically documented by historical shifts in shoreline position) and the shoreline is likely to continue to recede as sea level rises (possibly at a faster rate depending on local conditions).

Thus, in the case of the Tweed, the shoreline is expected to recede under sea-level rise (rating 4), with some sections already showing evidence of recession (rating 5). Action is likely to be necessary in the near future to address these risks.

Sometime the sediment compartment information provides a confidence rating, to provide users with an indication of the confidence of the experts in the sensitivity ranking they have provided (see Table 2).

[1] A zetaform bay *has a shoreline that in plan view is asymmetrical, with a decreasing radius of curvature toward one end.*

Table 2: Three categories of confidence were used to infer the sensitivity ranking.

Low	Limited or no information describing landforms or coastal landform change over the historical period is available.
Medium	Some information is available on changes to landforms, from multiple sources, which may include recent landform change from site descriptions and irregular aerial photographs over the past decade.
High	Detailed information is available identifying changes to coastal landforms spanning the historical period and includes regular remotely sensed information over the past 30 years or more.

1.3 How to use sediment compartment information in coastal management and adaptation

We suggest the following steps to use sediment compartments in coastal management and adaptation.

1. Start by looking at the sediment compartment information in CoastAdapt and identify the level of sensitivity for the compartments that relate to your local government area or location of interest. This is on a scale of 1 to 5, with higher numbers indicating a greater sensitivity to erosion, and lower numbers indicating a greater sensitivity to accretion. Generally, it is good practice to avoid locating infrastructure that could disrupt coastal processes in highly sensitive compartments.

2. If the sensitivity to change is medium to high, for example 4 or 5, it is important to get expert advice on the cause of the erosion risk to understand whether it is, for example, caused by high volumes of longshore sediment transport, or a deficient offshore sand supply. Limited offshore sources of sand are often revealed in beaches where recovery from storm erosion is slow or incomplete. A high level of sensitivity suggests that adjacent compartments may also need to be considered in coastal planning, thus helping to determine appropriate scales of action and whether collaboration and partnerships are required.

3. Consider the scale of planned development in the coastal compartments. If a large or high-value development is planned, for example a port or sewer facility, it is useful to consider the implications of that development at finer (tertiary, see Figure 2) compartment scales. Detailed impact modelling using local data will be needed for large developments or for critical infrastructure. For many smaller scale decisions, consideration of implications up to secondary compartments will be appropriate although local assessments at tertiary scale may also be needed.

4. If a planned development is near a compartment boundary, it is also important to consider the adjacent compartment in planning, assessment and decision-making.

Other sources of information will also be required for effective coastal planning and management, particularly where the compartment sensitivity rating is high. For example, understanding of the local sources and behaviour of sediments is needed to design effective coastal protection measures. In sediment deficient compartments, there may be few local sources of sand that can replenish eroding beaches. As a result, engineering solutions that depend on sediment accumulation may not work.

Guidance for consultants. In many cases, consultants do not collect new data and use whatever information is available. The information provided through this project can assist consultants to obtain relevant information, but can also help them to identify gaps and determine when new data are required. Similarly, users can use the information to help develop briefs for consultants.

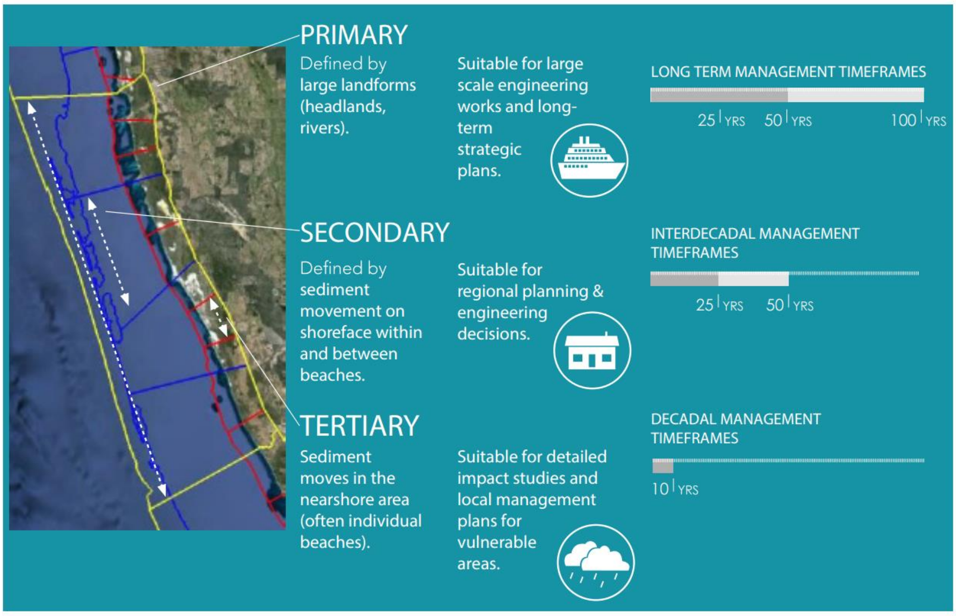

Figure 2: Coastal compartment scales, use and timeframes. (Source: Thom, B. Coastal Compartments Project Summary for Policy Makers, http://www.environment.gov.au/system/files/resources/4f288459-423f-43bb-8c20-87f91adc3e8e/files/coastal-compartments-project.pdf, accessed 12 April 2017.

1.4 Some thoughts on the sediment compartment database

Users of the information contained in the attribute tables (example in Table 1) and their pdf links (example in the Appendix) should note that no set climate change assumptions have been made other than those provided by CSIRO projections for sea-level rise, as described in Sea-level rise and you. For example, while tropical cyclones may increase in intensity, no assumption is made as to this, or to change in frequency or shift in location. Similarly, we have not assumed any changes to East Coast Lows in future decades, or any major changes in sediment outputs from rivers or tidal channels.

A major advantage of having information on secondary compartments is that it helps users to recognise that different compartments can, and most likely will, respond in different ways to climate change. The key is the link between landform type and sediment availability as expressed in the dynamics of the sediment budget within each secondary, and more locally tertiary, compartment. The project offers a basis for more informed consideration of sediment type, sources, pathways and sinks. It points to the need to go offshore and map sediment types and bottom conditions and to not make simple assumptions about directions and rate of shoreline movement over the time scales appropriate for coastal planning and management, and risk assessment.

1.5 The Coastal Sediment Compartments project in CoastAdapt

1.5.1 Overview

Aim

The aim of the sediment compartments project is to improve coastal risk assessments under conditions of climate change at regional scales. The compartment approach provides a spatial framework which integrates driving forces with landform type and sediment availability that best assists decision-makers involved in coastal land use planning and asset management (Thom 2015). This dataset is developed by Bruce Thom, Ian Eliot, Matt Eliot, Nick Harvey, Jo Mummery, David Rissik, Chris Sharples, Andrew Short and Colin Woodroffe.

Background

The approach involves the division of the Australian coast into discrete units based on sections where there are identifiable features that reflect sediment availability and fluxes, landform types or associations (see Information Manual 8: Coastal sediments for more details), and a potential ability to determine sediment (mostly sand) budgets. In the initial phase of the project, the coast was first divided into regions, which defined overall climatic and oceanographic process regimes (Figure 3). Regions can then be divided into primary, secondary and tertiary compartments or cells (Figure 2). It was agreed that the secondary compartments were most practical for regional planning and management decisions. The project involved descriptions of the characteristics of the 359 secondary compartments on a state-by-state basis.

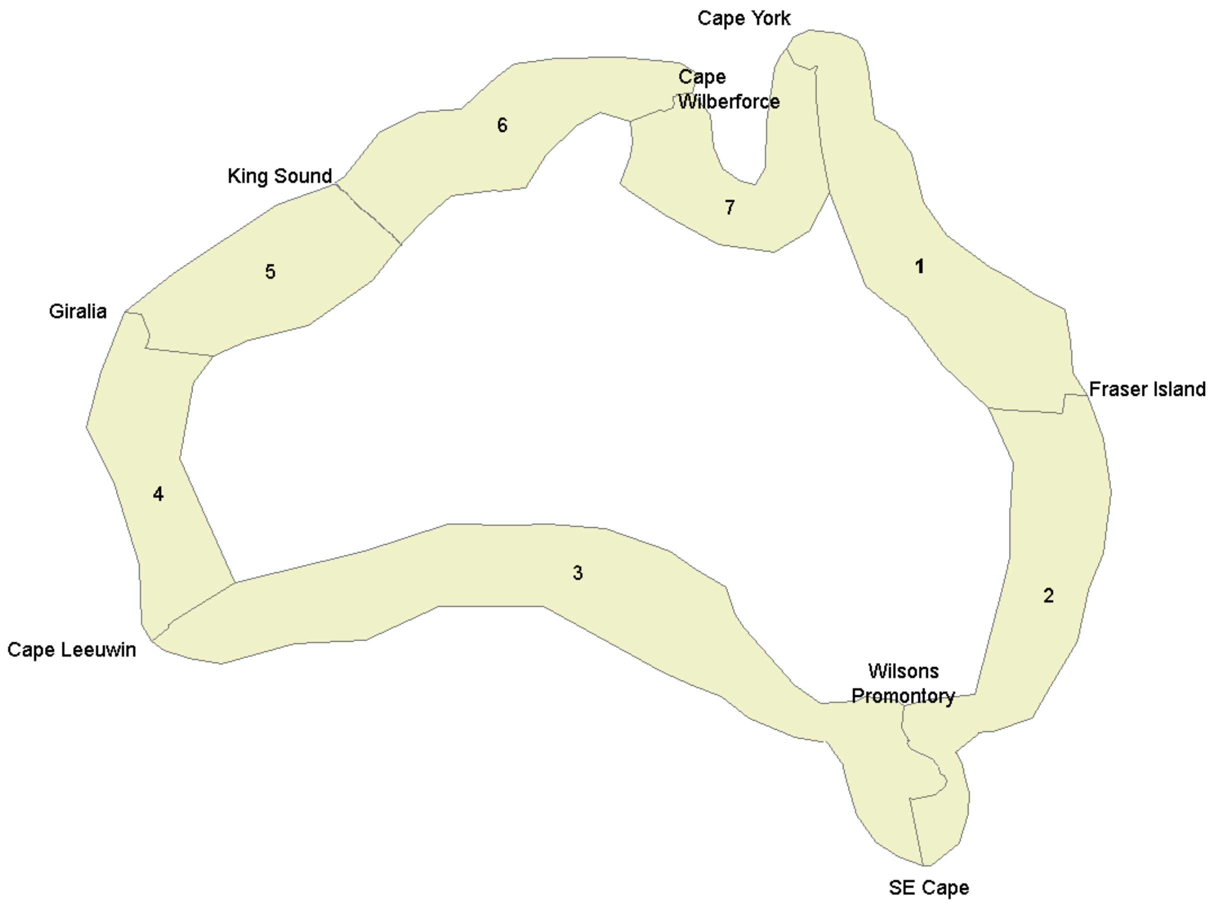

Figure 3: Regions which defined overall climatic and oceanographic process regimes.

Changes in shoreline condition within coastal compartments at the secondary scale can involve transport of sand in both cross-shore and alongshore directions, into and out of river and estuary entrances, and into dune fields. These transfers of sand can operate within these natural units regardless of administrative boundaries such as those of local government. It is then appropriate to highlight the way in which coastal processes and shoreline change should be investigated across such boundaries. The approach offers a consistent methodology determined by an understanding of the distinctive geomorphological characteristics of each compartment. This will include knowledge of existing sediment conditions; an interpretation of both recent geologic and historic trends in shoreline position; and, based on what is known about sediment budgets and shoreline behaviour of each compartment, an attempt to project the nature and degree of change into the future under the new climate era.

From a geomorphic perspective, shoreline behaviour in the future will depend on how sediment budgets will respond to the driving forces. For instance, we cannot simply assume a linear shift in shoreline position with sea-level rise if the sediment budget is in surplus or in deficit. Even in so-called equilibrium condition, we cannot assume that all sand will be permanently lost from the beachface to the shoreface as some component may be transported. It may move into an adjoining compartment to be captured by a control point such as a headland or rocky outcrop, or be lost into an estuary mouth that will then change the form and processes (morphodynamics) of estuaries (e.g. impact on tidal regime of the estuary or coastal lake). Understanding landform type and offshore sediment/rock condition can provide indications of which compartments are likely to respond earlier (fast responders) or later (slow responders) to sea-level rise and/or changes in wave climate. It is possible that the dynamics of sediment exchange and availability within a given compartment will allow shorelines within a compartment to remain stable for decades before any noticeable long term change is identified (resilient behaviour). Even within a secondary compartment it is possible for tertiary compartments or cells to differ in sensitivity to change compared to the overall condition at a larger scale; local investigations are required to determine these differences.

1.5.2 Assessing future shoreline behaviour

The process of assessment of shoreline behaviour now and into the future was based on expert judgement using an array of national, state, regional and local sources. Seven experts were assigned states and territories (Table 3). Of national importance were the original Geoscience Australia coastal maps, Smartline mapping undertaken for the former Department of Climate Change led by Chris Sharples, the national survey of beach types and sediments by Andy Short, sea-level projections by CSIRO, and various tools used to project inundation on Digital Elevation Models (DEMs) and Google Earth. At the state and regional scale, the experts used various published sources plus their own understanding of stretches of the Australian coast where they have undertaken fieldwork. In addition, they accessed many unpublished reports by academics and consultants and state and local agencies. Descriptions were standardised at a two day meeting attended by the team.

Table 3. Experts involved in the project and the areas they described.

Geographic Region	Expert
Far North Queensland	Nick Harvey/ Colin Woodroffe
North to South Queensland	Andy Short
New South Wales	Colin Woodroffe and Bruce Thom
Victoria	Chris Sharples
Tasmania	Chris Sharples
South Australia	Nick Harvey
West Australia	Ian Eliot and Matt Eliot
Northern Territory	Colin Woodroffe

References

Thom, B., 2015: Coastal Compartments Project Summary for Policy Makers. Accessed 29 June 2016. [Available online at www.environment.gov.au/system/files/resources/4f288459-423f-43bb-8c20-87f91adc3e8e/files/coastal-compartments-project.pdf].

2. Smartline

2.1 Overview

Aim

Smartline was developed to provide a single, consistent map of coastal landforms for the entire Australian coast. The aim is to provide information to help underpin coastal zone management, risk assessment prioritisation, and decision making. The project to develop Smartline was led by Chris Sharples.

What is Smartline?

The Smartline map divides the coastline into numerous distinct segments. Within each segment, multiple attributes describe the subtidal, intertidal and backshore coastal landforms and geology that dominate a coastal zone. The description extends (nominally) 500 m landward and seaward of the High Water Mark line. Each segment begins and ends where there is a significant change in any of the landform characteristics along the coastline, such as the beginning or end of a sandy beach (see Figures 4 and 5).

Background

The Smartline coastal geomorphic (landform) map of Australia was created during 2007 – 2009 in response to a need for a single detailed and consistently-classified map of coastal landforms for the entire Australian coast. Preparation of the map did not involve original mapping, but rather the extraction, reclassification and combining of relevant details from over 200 pre-existing, but differently purposed, scaled and classified coastal map datasets into a single nationally-consistent map. The format of representing detailed descriptive coastal landform information as multiple attributes within a simple digital (GIS) line map was chosen over the more traditional two-dimensional or polygon map format. The reason being, firstly, this provided a practical method of compiling a new national dataset within a limited time frame and, secondly, the essentially linear nature of coastlines makes the GIS line map a particularly efficient format in which to capture, represent and extract many types of useful coastal information. Although some types of coastal information do require polygon maps and digital elevation models, the ease with which a simple line map can efficiently capture and display many types of useful coastal information has led to it being referred to as the 'Smartline' format.

The landform and geological information provided in the Smartline dataset is as accurate as the base datasets from which it has been compiled. However owing to the varied nature and detail of these, there are known to be some data gaps and generalisations present within the Smartline; particularly in regions for which less detailed existing geomorphic mapping was available such as parts of the Northern Territory and Gulf of Carpentaria. It is hoped that future work will enable the level of detail of the Smartline data for areas such as these to be improved.

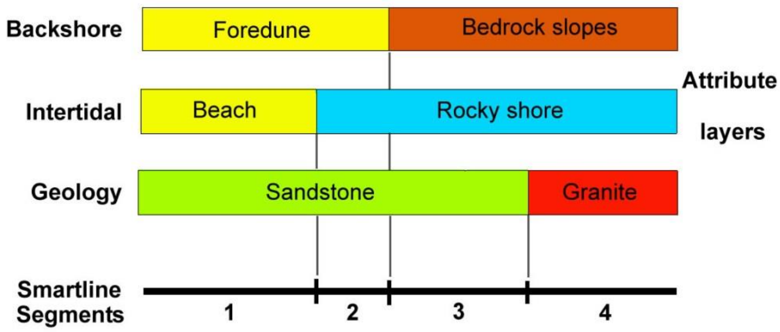

Figure 4: Illustration of how multiple layers of information about the coastal zone can be attributed to a single digital line map representing the coastline, with the correct alongshore extent of each attribute being preserved by segmenting the line wherever any one of the attributes change.

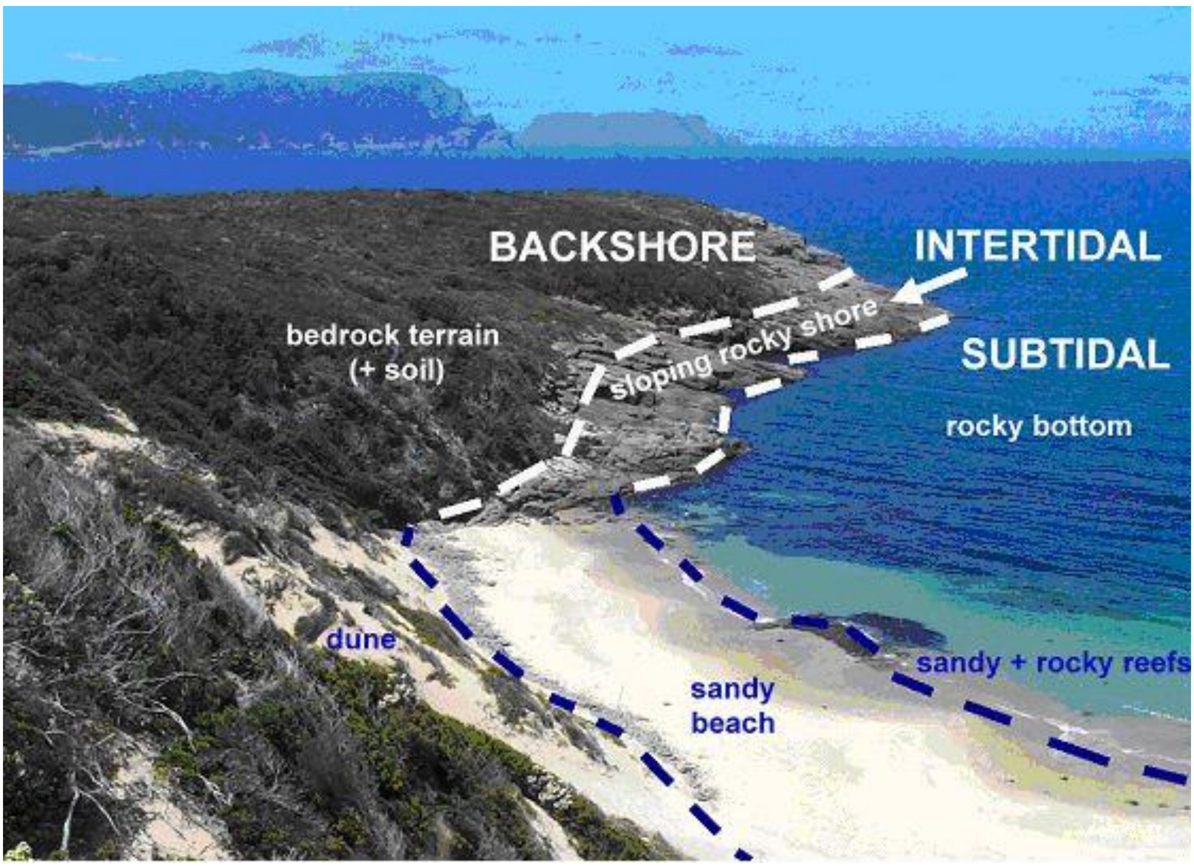

Figure 5: In its more detailed attributes, Smartline describes the landforms of the coastal zone in terms of three shore-parallel tidally-defined zones as indicated in this figure. Landforms within each of these zones are described using two descriptive attribute fields plus another field describing the overall zone profile or slope. The two simpler levels of detail provided in Shoreline Explorer within the CoastAdapt tool do not display these attributes separately, but rather amalgamate them into simpler characterisations of the coastal zone. For example, the two main coastal segments in this figure would be characterised as ‘Sloping hard rock shore backed by bedrock’ and ‘Sandy beach backed by dunes over bedrock’.

The Smartline format permits very detailed information about coastal landforms (or other coastal attributes) to be recorded in multiple attributes, however it also allows this information to be 'distilled' down into simpler, broader landform categories represented by just a few or even just a single map attribute or layer. Two such simpler layers are provided in the Coast Adapt Tool: Smartline Basic and Smartline Advanced.

2.2 Smartline within CoastAdapt

Shoreline Explorer provides two Smartline layers with different levels of detail.

- At the simplest level, a single map layer called 'Smartline Basic' can be used to display the coast classified into just four landform categories based on very broad differences in the composition and erodibility of coastal landforms.
- At the second level of detail, called 'Smartline Advanced', separate layers can be displayed showing the location and extent of more differentiated but still quite broadly-defined coastal landform types or groups, such as hard rocky shores (of several types e.g. cliffed and sloping), sandy beaches (e.g. backed by bedrock or by soft sediment terrain), soft-rock shores of several types, and others.

2.3 How can I use Smartline information?

The value of Smartline lies first and foremost in its provision of a single detailed nationally-consistent map identifying the location and distribution of a wide variety of coastal landform types around the entire Australian coast. At present, no other coast of comparable length anywhere in the world has been consistently mapped and classified to the level of landform mapping detail provided by Smartline.

This information has been used to map the regional and national distribution of shores having broadly different levels or modes of sensitivity to sea-level rise and coastal erosion or recession at the two levels of detail (basic and advanced) provided within CoastAdapt. The advanced level of detail provided allows differentiation between broadly defined categories such as erodible sandy beaches exposed to or sheltered from swell-wave action, resilient sloping hard rock shores, slump-prone 'soft-rock' shores, and other susceptibilities. Note however that Smartline cannot provide estimates of likely rates or magnitudes of shoreline responses (such as recession or slumping) to sea-level rise at specific locations, as this requires additional modelling of coastal processes.

Smartline information can be used in conjunction with sediment compartment descriptions (see Section 1) to extend assessment of sensitivity of beaches to short, medium and long-term change and help to prioritise action.

Smartline information can be used as a basis for undertaking foreshore related climate adaptation planning and as a useful starting point for research projects on foreshore stability.

Together with other datasets relating to the shoreline, Smartline can help understanding of coastal and estuarine foreshore processes.

In addition, the Smartline provides a useful format to which a wide variety of other coastal data can be attached as new attribute layers become available. This functionality is not available through CoastAdapt, but requires importing the Smartline base data into the users' GIS environment.

2.4 How to access Smartline

A. Smartline Advanced

Once you have clicked the box in the Shoreline Explorer for the dataset you want (in this case, Smartline Advanced, see the beginning of this document), proceed as follows:

Step 1: In the drop-down box, select one of the ten geomorphic types you are interested in (Figure 6). For each geomorphic type you select, a key will appear below showing the colour scheme for various geomorphic attributes. An example of the legend for a sandy classification is shown in Figure 7.

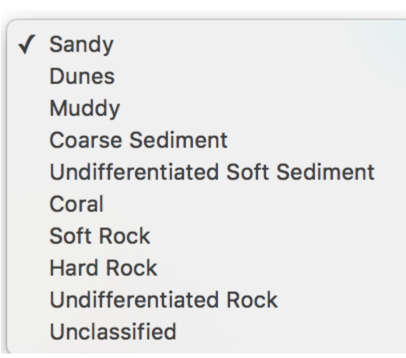

Figure 6: Geomorphic types in SmartLine.

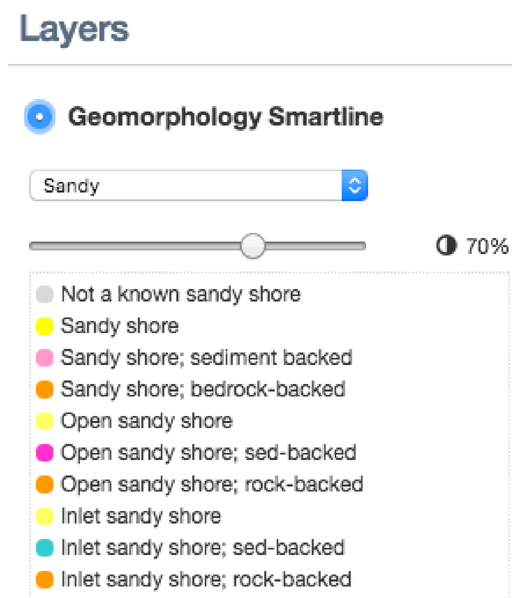

Figure 7: Legends for sandy classification.

Step 2: Find your area of interest either by typing the name of the place in the search box (top right hand corner of the map), or by zooming in using your mouse or the zoom slider. A coloured line will appear showing the extent of the geomorphic characteristic selected.

Step 3: If you are interested in any particular place or point, you can click directly on the coloured line at that place of interest. This will bring up an attribute table that will show information about the ten geomorphic attributes (Figure 8).

Muddy	Not identified as a muddy shore
Sandy	Sandy shore backed by soft sediment deposits to below sea-level
Dunes	Dune-field undiff exposed to wave attack at seaward side
Coarse Sediment	Not identified as a coarse sediment shore
Undifferentiated Soft Sediment	Not identified as an undifferentiated soft sediment shore
Soft Rock	Not identified as a soft rock shore
Hard Rock	Not identified as a hard rock shore
Undifferentiated Rock	Not identified as an undifferentiated rock shore
Coral	Not identified as a coral coast
Unclassified	Shoreline stability classified

Figure 8: Example attribute table for SmartLine.

B. Smartline Basic

Step 1: Once you have clicked the box in the Shoreline Explorer for the dataset you want (in this case, Smartline Basic, see the beginning of this document), a legend will appear below showing six categories of erodibility (Figure 9).

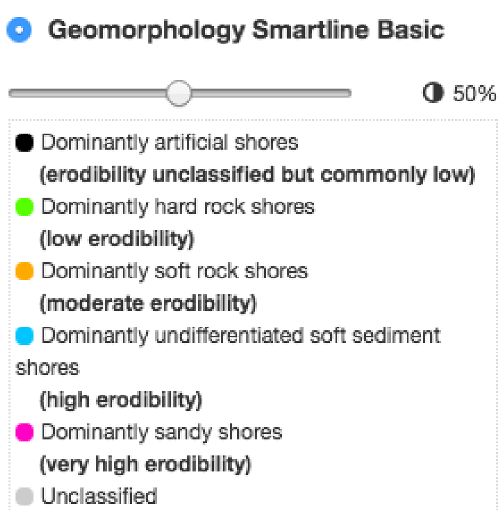

Figure 9: Smartline Basic key.

Step 2: Find your area of interest either by typing the name of the place in the search box (top right hand corner of the map), or by zooming in using your mouse or the zoom slider. A coloured line will appear showing the extent of the erodibility characteristic selected.

Step 3: If you are interested in any particular place or point, you can click directly on the coloured line at that place of interest. This will bring up an attribute table that will indicate the erodibility at that point (Figure 10).

Erodibility	Dominantly sandy shores (very high erodibility)

Figure 10: Example attribute table of Smartline Basic.

2.5 Further information

Smartline can also be used at an even more detailed level than the two described above, using further attributes that classify coastal landform attributes in greater detail. To use Smartline effectively at this higher level of detail it is necessary to have some experience using the dataset and to be familiar with both GIS techniques generally and the Smartline Data Model specifically. Further information on Smartline and its potential uses can be found at the OzCoasts website http://www.ozcoasts.gov.au/coastal/index.jsp; this allows users to interact online with Smartline data, and provides a useful extended introduction to the structure and use of Smartline (at http://www.ozcoasts.gov.au/coastal/introduction.jsp). In addition, a detailed 'Smartline Manual and Data Dictionary' providing full technical details can be downloaded from the same OzCoasts website.

smartline
coastal data segmentation

3. Water Observations from Space (WOfS)

3.1 Introduction

Water Observations from Space (WOfS) is a dataset developed by Geoscience Australia (GA). The project was commissioned by the Australian Government following extreme flooding in eastern Australia in 2011. It aims to map the extent of surface water across Australia using the multi-decadal archive of Landsat satellite imagery. WOfS provides information on historical surface water observations derived from satellite imagery for all of Australia for the period 1987 to 2014. Close to 200 000 images from 27 years of observations from Landsat 5 and Landsat 7 were analysed using a water detection algorithm to show where surface water was usually observed, occasionally observed and rarely observed by satellite.

Water detection methods are based on the absorption of longer wavelengths of light in water. Using an automated water detection algorithm, the number of times that water was detected in a location is compared to the number of clear observations of that location (i.e. observations not affected by cloud, shadow or other quality issues). Each location is a cell in a 25 m by 25 m grid across Australia. The resulting information indicates how often water was observed at each location. The approach enables identification of areas with episodic inundation such as flooding (lower calculated values) and those with water bodies such as lakes and dams (higher calculated values).

3.2 The information

For each grid cell in the map, WOfS in CoastAdapt contains two datasets:

- Dataset 1 Water summary (filtered): the percentage of clear (no cloud, shadowing etc.) observations in which water was detected from 1987 to 2014 (i.e. the number of occasions water was detected divided by the number of clear satellite observations).
- Dataset 2 Confidence: the confidence (or probability) that the percentage value displayed in Dataset 1 is correct at a location. This is expressed as a percentage, based on a number of factors including the slope of the land and the existence of other corroborative evidence.

Dataset 1 is labelled as filtered because information is only shown where the confidence is at least 1%.

3.3 How to access WOfS

Once you have clicked the box in the Shoreline Explorer for WOfS (see the beginning of this document), proceed as follows:

1. If you want to see where the local government boundaries are, click on this dataset also.
2. You can find your area of interest either by typing the name of the place in the search box (top right hand corner of the map), or by zooming in using your mouse or the zoom slider.
3. Immediately below the tick box for WOfS, you have to choose between two datasets: the actual data (‘water summary filtered’) and the confidence in that data (‘confidence’). You will want to look at the water summary before you look at the confidence.

4. Use the horizontal slidebar to set your transparency/opacity for the displayed data.

In the context of climate change, information from WOfS can be used to understand existing flood and inundation risk at a location. Specifically, when conducting a risk assessment, it is useful to identify any existing risk of flooding or inundation in the coastal area. In the absence of any local studies, WOfS can give a broad understanding of the previous flood and inundation history.

Dataset 1 Water summary (filtered)

When you select this dataset, you will see a coloured map in which different colours show the percentage of clear observations when water was detected. The key on the left shows the interpretation of colours (Figure 11). As an example, red colour at a location indicates that only 1% of the observations identified water at that location. This means the location does not have a regular presence of water but may have flooded in the past (1%, if all observations are clear, is 3-4 days per year). On the other hand, blue colour suggests 80% of observations identified water at that location, indicating that the location is a semi-permanent water body.

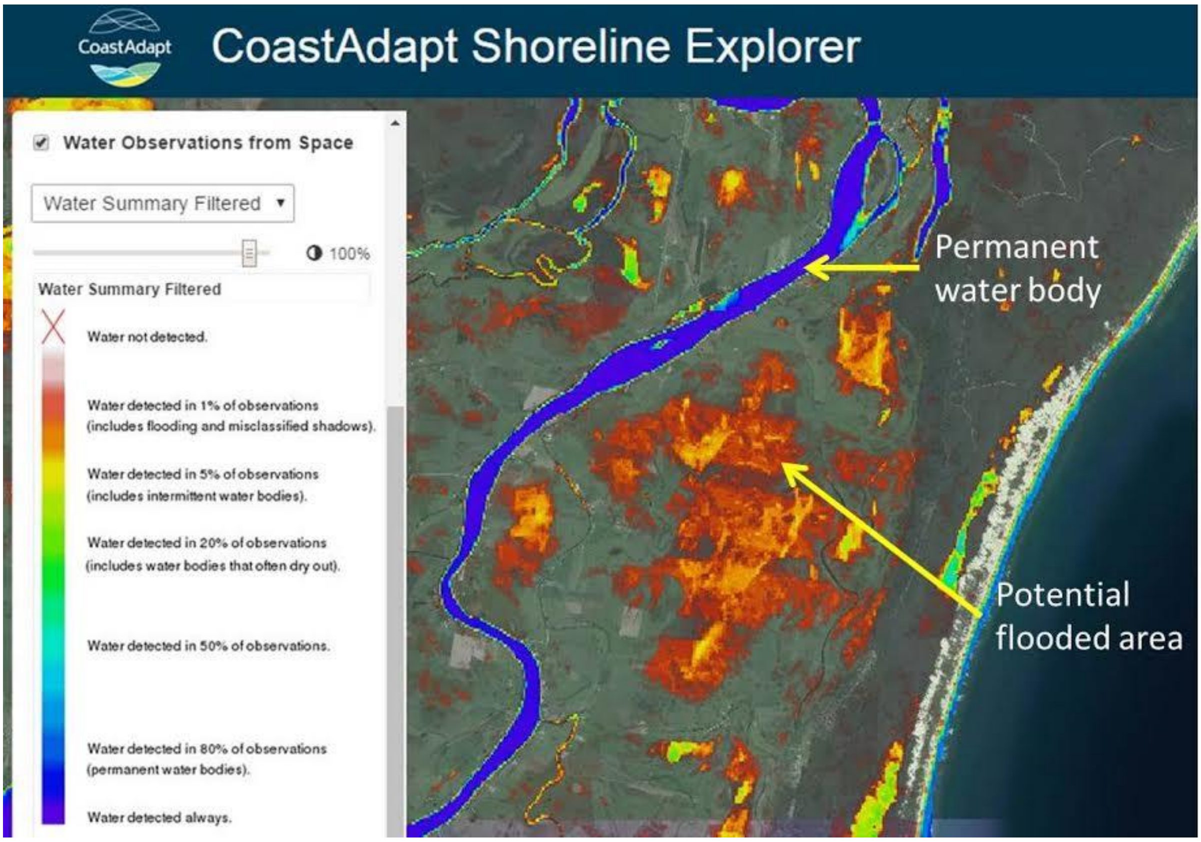

Figure 11: Example of Dataset 1 Water summary filtered in CoastAdapt WOfS.

Some of the limitations of WOfS are (Geoscience Australia 2015a):

- The Landsat satellites, which provide data for WOfS, view a 185 km-wide strip of Australia once every 16 days, and the observations show only what was visible on the day of the satellite pass. Therefore not all historical floods will have been observed.
- Although the water detection algorithm has an overall accuracy of 97%, it is designed to detect large areas of water and may miss small water bodies.
- Errors occur along rivers, small waterbodies and swamps where the presence of both water and vegetation within the pixel leads to a failure to detect water. This leads to an underestimation of the extent of water in locations with mixed water and vegetation pixels.
- Some densely urbanised or steep areas are sometimes misclassified as water.

Dataset 2 Confidence

To account for the limitations mentioned above, WOfS provides a second dataset showing the confidence in the water summary information at each location. Red indicates low confidence (less than 2%) and green suggest high (75%) to very high (100%) confidence in the information (Figure 12).

These two datasets can build understanding of past flooding extent at a location. As an example, if a location shows red in the Water summary dataset, and green in the Confidence dataset, you can be confident that this indicates a past history of flooding.

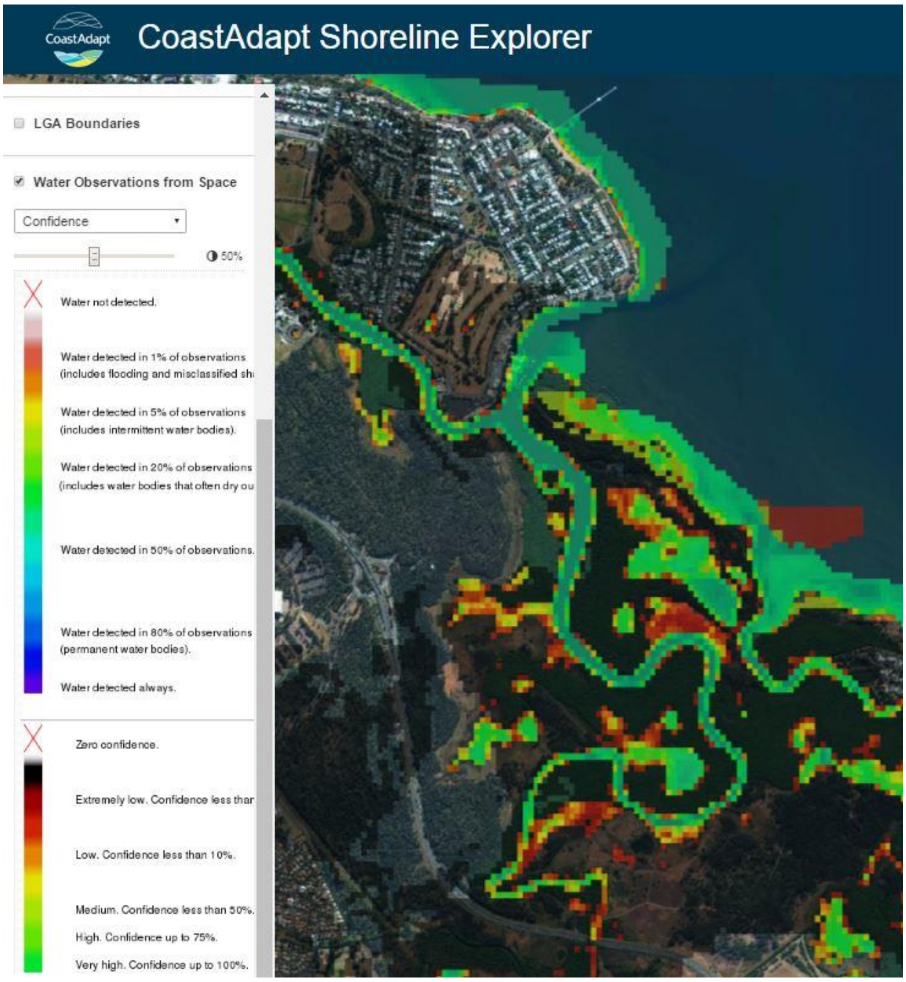

Figure 12: Example of Dataset 2 Confidence in CoastAdapt WOfS.

3.4 Things to keep in mind (Geoscience Australia 2015a)

1. The absence of water observations in WOfS at a particular location does not provide certainty that flooding will never occur in the future.
2. The probability of surface water appearing at a particular location may vary over time due to anthropogenic changes, for example dam building. WOfS in CoastAdapt cannot reflect these changing probabilities. Where such changes have occurred, Dataset 1 may no longer give a true picture of the probability of surface water being observed.

Further details on WOfS are available in the product description.

References and further information

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Appendix

Example of pages from sediment compartment data (see https://coastadapt.com.au/sites/default/files/docs/sediment_compartments/NSW01.01.01.pdf).

Tweed NSW01.01.01

Regional Setting

The dominant regional processes influencing coastal geomorphology in this region are the humid warm to cool temperate climate, micro-tides, south-easterly Tasman Sea swells, easterly seas, dominantly quartz (terrigenous) sediments with northerly longshore transport in the northern part, and the El Nino Southern Oscillation (driving beach erosion/accretion cycles, cyclone frequency).

Regional hazards or processes driving large scale rapid coastal changes include: East Coast Lows (extra-tropical cyclones), mid-latitude cyclones (depressions), and storm surges (<1 m).

This compartment extends from Point Danger to Cape Byron.

Justification of sensitivity

Overall sensitivity rating is a 4. Within the compartment, several sections are already rated as 5, although if onshore sand supply is maintained for some sections, the sensitivity rating could be 3 for extended periods. The southern ends of several of these beaches are sensitive and undergoing erosion as a result of differential rates of littoral drift on adjacent beaches. Overwash from cyclonic storms has occurred in places where foredunes are low and narrow.

Other comments

This compartment comprises several tertiary compartments, characterised by northwards longshore drift, influenced by both tropical cyclones and East Coast lows (PWD, 1978; Helman, 2007).

It terminates to the north at the training walls of the Tweed River on Letitia Spit. Sand accumulation on the southern side of this training wall, following extension 1962-1965, deprived Gold Coast beaches to the north of sand. It also led to the installation of the Tweed River bypassing project, which pumps ~500,000 m^3 of sand a year (552,682 m^3 in 2015) from NSW to nourish Kirra and other beaches on the Gold Coast. See http://www.tweedsandbypass.nsw.gov.au/.

Patterson (2013) indicates that there is only a modest gradient in the longshore sand transport, increasing from about 200,000 m^3/yr at Ten Mile Beach, Iluka, to about 550,000 m^3/yr at northern Stradbroke Island (Patterson, 2013, p. 82; see also Patterson et al., 2011).

The supply of river sand to the coast is limited on the section of coast to the south, and the source of sand to sustain northwards drift is inferred to be from onshore transport from the shelf (Boyd et al., 2008, Mariani et al., 2013). If maintained as sea level rises, it is possible that the shoreline position for long stretches of beaches facing generally east could be maintained as sea level rises (sensitivity 3) until an unknown threshold is reached (Cowell et al., 2000). However, there is likely to be some degree of short-term recession in the tertiary embayments during periods when sand feed from the south is restrained.

Sand moves around headlands, such as the basaltic Fingal Head, and Norries Head, as a slug (see example at Cudgen in Short, 1999, p244). Here, the training walls along Cudgen Creek create a permanent but variable sand shoal in the northern lee of Cudgen Headland, with associated erosion problems for Kingscliff. Tweed Council is developing a long-term strategy to manage the erosion threat at Kingscliff (see Coghlan et al., 2011, WRL report).

The southern ends of several of these beaches are undergoing periodic erosion as a result of differential rates of littoral drift on adjacent beaches. Cabarita Beach is experiencing ongoing shoreline recession due to by littoral drift imbalance (Mariani et al., 2013). Headlands at Norries and Cudgen both act like groynes protruding through the active surf zone. Sand tends to build up on their south (updrift) sides until bypassing occurs when the updrift areas are filled to capacity. During times of elevated wave action a pulse or slug of sediment can be moved around the headland (Figures 1 and 2), often partially depleting the updrift area, which has to re-fill before bypassing is again fully established (Short, 2007; Mariana et al., 2013). Cabarita

Beach appears to undergo an recession of 1 m/year, when explained as a result of the differential of 110,000 m^3/y, as a consequence of the loss around Cudgen Head of 350,000 m^3/yr compared with a gain around Norries of only 240,000 m^3/yr. Unless this imbalance is offset by onshore drift as shown in Figures 3 and 4, the shoreline in this tertiary compartment will recede under climate change and cut into the foredune buffer built after mining operations ceased in the 1980s.

Cape Byron provides an obstacle at the southern end and only a limited quantity of sand makes it around the headland to contribute to the southern end of this compartment (PWD, 1978). A consequent drift differential can result in periodic erosion of the foreshore on the beaches north of Cape Byron. Some sand at Cape Byron can be lost to an offshore sand lobe (PWD, 1978; Patterson & Britton Partners, 2006) while there may be a component of cross embayment sand transport (Patterson, 2013, Figure 7-38). Various consulting reports prepared for Byron Shire Council, involving modelling of Byron Bay coastal erosion processes and hazards, have highlighted the vulnerability of this section of the coast, especially Belongil Spit, (for example BMT WBM , 2010). Hopley (1967, and PWD, 1978) also noted the impacts of overwash accompanying storm surges at the southern end of the compartment.

Several locations, such as Brunswick Heads, are sensitive where training walls have been built, with erosion becoming apparent downdrift after the storms in the 1970s. The Brunswick River is neither a source nor sink for sand (PWD, 1978). The settlement of Sheltering Palms to the north of the Brunswick River was severely eroded in the early 1970s and houses were abandoned and lost by 1977.

The area has been extensively explored and subjected to sand mining for heavy minerals (Gardner, 1955; Roy, 1999).

Figure 1: Erosion in front of surf club at Kingscliff (photo A. Short).

Figure 2: Sand slug moving around at Kingscliff (photo A. Short).

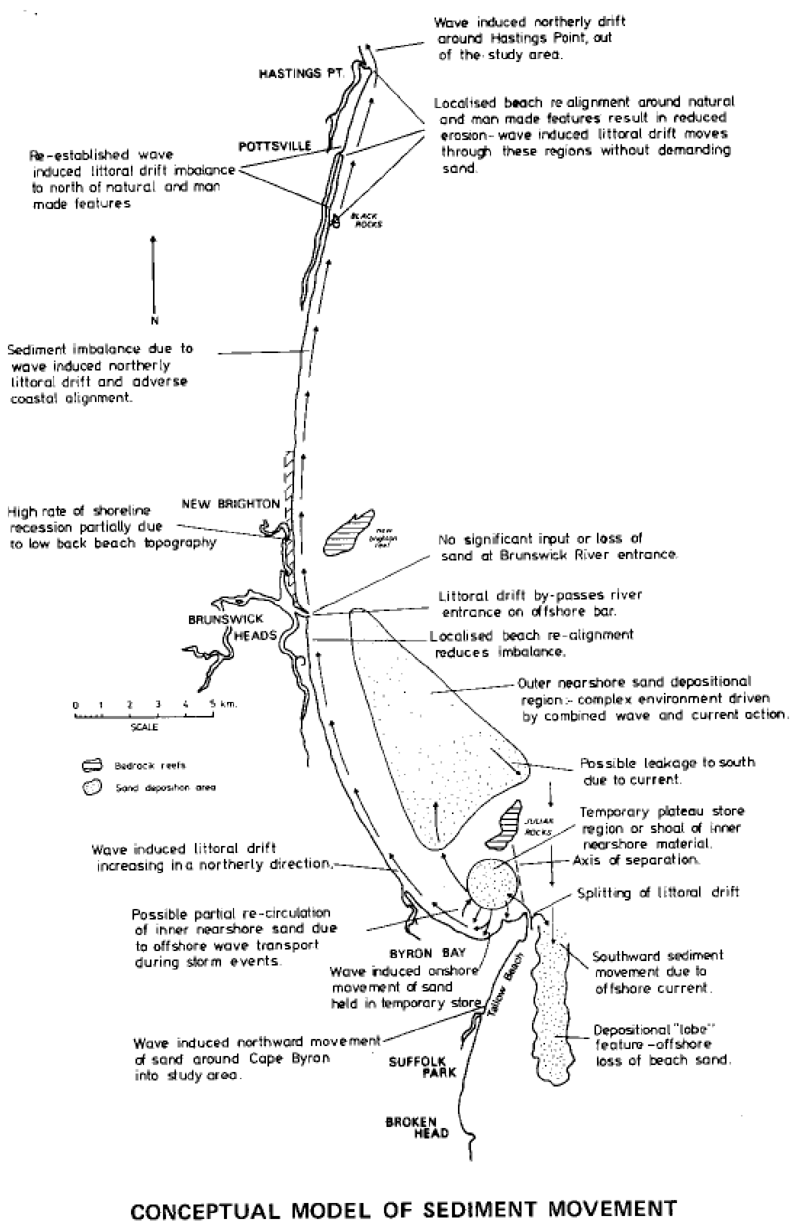

Figure 3: Conceptual model of Cape Byron (PWD, 1978)

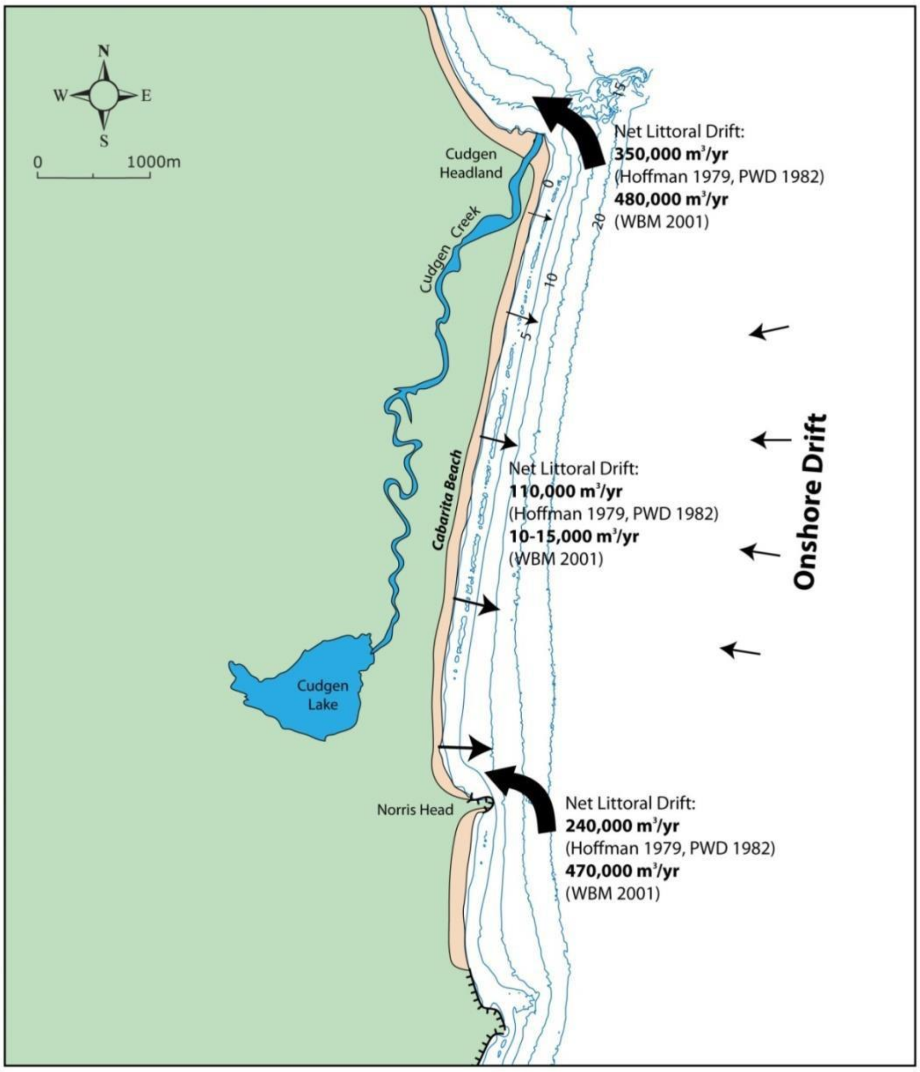

Figure 4: Conceptual sediment budget model (Fig 2.10 from Mariani et al., 2013)

Confidence in sources

High confidence: Longshore drift along the northern NSW coast has been the subject of numerous detailed studies, including several focused on erosion at Tweed Heads, Kingscliff, Cudgen and Byron Bay, especially Belongil Spit.

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