PORT OF **WEIPA**

REPORT

Nearshore environment change mapping and high-level rehabilitation potential

Nearshore environment change mapping and high-level rehabilitation potential, Weipa Port

North Queensland Bulk Ports

13/12/2019

2rog

DOCUMENT CONTROL

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ABBREVIATIONS

Abbreviation	Description
ha	Hectare/s
NDVI	Normalised Difference Vegetation Index
NIR	Near Infrared

EXECUTIVE SUMMARY

Application of dredge material sourced from local dredging of navigable harbours and channels provides an opportunity for North Queensland Bulk Ports to undertake long term restoration of nearshore vegetation communities and to provide for targeted beach nourishment. To assess opportunities for habitat restoration in the Port of Weipa region of northern Queensland (Port Musgrave to Aurukun), a regional assessment of vegetation cover change (mangroves and saltmarsh) was undertaken within nearshore environments using change detection of Landsat satellite imagery (1988 to 2019). The mapped extent of beach environments was also identified using spatial data provided by GeoScience Australia.

Any areas of identified cover change in nearshore environments and/or areas of mapped beach environment were then prioritised according to dredge accessibility to pump ashore including:

- Minimum water depth of 6 m
- Within 1.5 km of the 6 m depth line for standard pumping
- Within 2.5 km of the 6 m depth line for boosted pumping

A total of 11 sites of potential nearshore environment vegetation cover change were identified via the image analysis process. These areas showed varying patterns of loss and recovery in vegetative cover. Extensive areas of beach environment are also mapped within the study area, with 5,539 ha of mapped beach environment occurring within the potential target zone.

INTRODUCTION AND PROJECT SCOPE

Scope

2rog Consulting was contracted by North Qld Bulk Ports to undertake a regional study to locate potential nearshore environment rehabilitation and beach nourishment sites 100 km to the north and south of the Port of Weipa, Queensland (Figure 1). Specifically, the study involved:

- Regional assessment of changes to the vegetated nearshore environment (mangroves and saltmarsh) extent using change detection of Landsat satellite imagery. Areas were to be greater than 10 hectares (ha) and to show substantial change through degradation.
- Locating beach environments via existing mapping sources.
- Target site prioritisation though GIS-based assessment of selected nearshore environments and all mapped beach environments to determine locations within 1.5 km and 2.5 km from the 6 m water depth line.

Background literature

Two recent Australian studies have assessed regional changes in mangrove and other nearshore environments using a variety of remotely sensed data. Jupiter et al (2007) used historical aerial photography and Landsat TM imagery from 1990 and 2000 to assess changes in mangrove communities around Mackay. The images were processed into Normalised Difference Vegetation Indices (NDVI) and then subtracted to create a change image that was used to map changes in mangrove environments at a regional scale. Historical aerial photography was also used to quantify change over smaller target areas. An overall decline in mangrove extent over time was observed, although mangrove extent tended to fluctuate through the study period. The main cause of mangrove loss was infilling to expand urban or agricultural land use, with concomitant changes in the hydrological regime of some areas leading to further mangrove losses.

Duke et al (2017) also used historical Landsat imagery, both TM and the older MSS, in combination with targeted assessment of higher resolution aerial photography, to quantify mangrove losses associated with a known dieback event in the Gulf of Carpentaria. Like Jupiter et al (2007) they processed the Landsat TM imagery into NDVI images and undertook image change detection through image subtraction and subsequent change image thresholding. Over 7,400 ha of mangrove dieback was mapped, the cause of which remains unverified. The authors noted that the period leading up to the dieback event was characterised by higher than normal temperatures and low levels of precipitation in the region. They also noted that mangrove dieback was related to elevation and hence hydrological regime. Dieback was more prominent at the margins of the zones between different mangrove species (Figure 2).

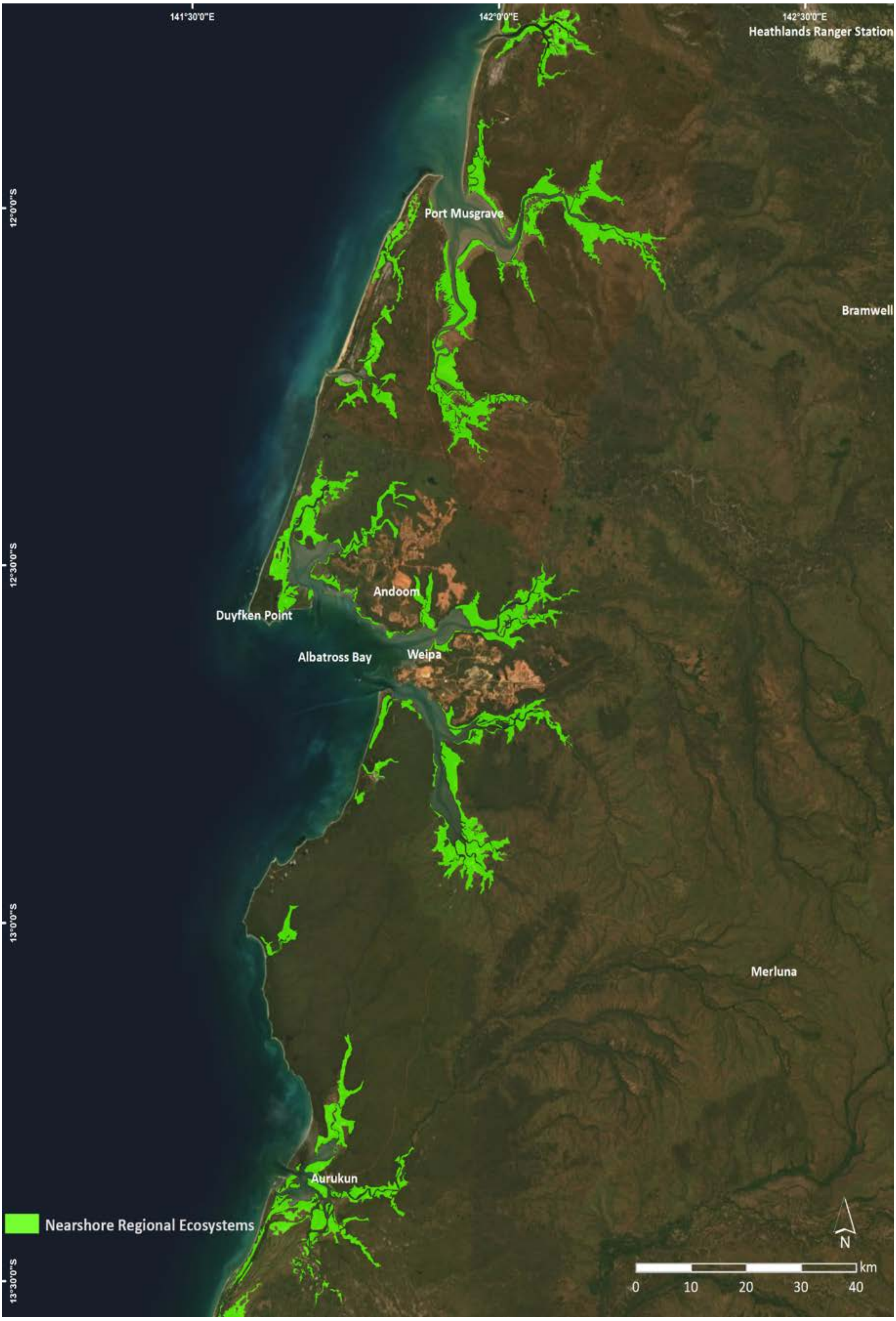

Figure 1 Study Area: Nearshore (mangrove and saltmarsh) shown in green.

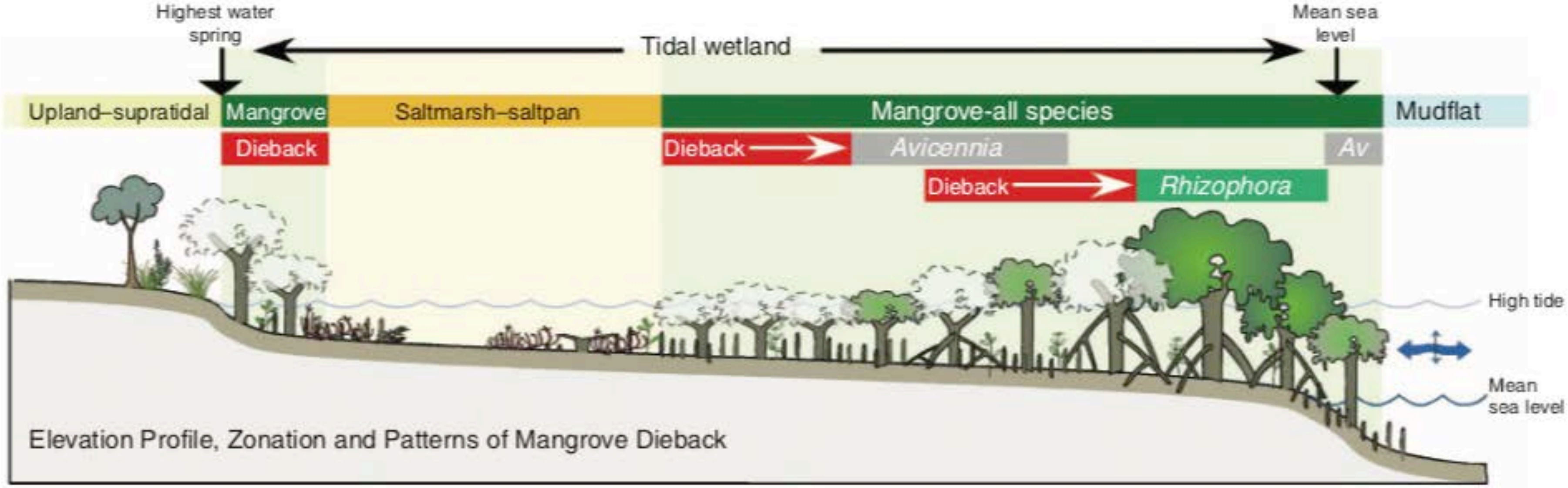

Figure 2 Cross-section of mangrove zonation linked to elevation, showing the pattern of dieback to be more prevalent in the zone (ecotone) between communities (Duke et al 2017).

METHODS

Overview

Remote sensing based change detection was used to assess changes in nearshore environments (primarily mangroves and saltmarshes) from north of Port Musgrave to south of Aurukun in northern Queensland (Figure 1). The assessment used a sequence of Landsat TM images from the late 1980s to 2019 to detect changes over time. Given the size of the study area and the resolution of the imagery a minimum mapping area of 10 ha was chosen.

Datasets

Landsat imagery for the study area (Figure 3) was sourced via the EarthExplorer website (earthexplorer.usgs.gov). Two Landsat scene areas (path/rows 99-68 and 99-69) covered the study area. Images were chosen during the dry season from May to September to reduce the likelihood of cloud cover affecting image quality. Four images for each scene were selected, commencing in 1988 with subsequent images selected at approximate decade intervals (Table 1). The 2019 images were captured by Landsat 8, whereas earlier images were captured from Landsat 4 or 5. All images comprised both near infrared (NIR) and red bands with a pixel resolution of approximately 30 m (about 111 pixels per 10 ha area).

Other spatial data used in the processing included:

- Major Vegetation Groups mapping from National Vegetation Information System (NVIS) Version 5.1 (MVG number 22 (Chenopod Shrublands, Samphire Shrublands and Forblands) and 23 (Mangroves)) to capture nearshore environments (Figure 1);
- Beach data sourced from Geoscience Australia GEODATA TOPO series (**Error! Reference source not found.**);
- Bathymetry model data from Australian Bathymetry and Topography Grid (2009); and
- Esri aerial imagery composites (Table 1).

Table 1 Study datasets and sources

Data Layer	Source
Landsat Imagery	USGS – EarthExplorer (earthexplorer.usgs.gov) Path/Row 99-68 and 99-69 Image dates 99-68: 17/09/2019, 30/09/2009, 31/08/1998, 16/06/1988 99-69: 17/09/2019, 30/09/2009, 31/08/1998, 16/06/1988
Saltmarsh and Mangroves	(NVIS 2018) National Vegetation Information System (NVIS) Major Vegetation Groups – Extant Vegetation-version 5.1 https://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system/data-products#mvsg51. Downloaded 28/10/2019
Bathymetry	Australian Bathymetry and Topography Grid, June 2009 - 250 m https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/67703. Downloaded on 28/10/2019
Beaches/Sand	(Geoscience Australia GEODATA TOPO series 2009) https://data.gov.au/data/dataset/310c5d07-5a56-4cf7-a5c8-63bdb001cd1a Downloaded on 28/10/2019
Esri Imagery	Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community (2014 and 2016 composites depending on location)

Nearshore environment change detection

To highlight variation in vegetation density and vigour across the landscape, an NDVI was created with each Landsat image (**Error! Reference source not found.**) using the following algorithm:

NDVI = (NIR-Red) / (NIR+Red)

Landsat 4 and 5 – red is band 3 and NIR is band 4; Landsat 8 – red is band 4 and NIR is band 5.

Change detection was undertaken by subtracting NDVI images from each other to highlight areas of vegetation loss or gain between the compared image dates. Image comparisons were: 1988-2019 (earliest versus latest images); 1988-1998; 1998-2009; and 2009-2019. Change images were enhanced to highlight areas of positive and negative change.

To map areas of significant change (>10 ha) in the nearshore environment, each change image was displayed along-side the comparison Landsat images, Esri aerial imagery and relevant vegetation mapping data. The change image was then zoomed to a scale of approximately 1:24,000 and systematically assessed to identify areas of significant cover change within nearshore areas. Any areas identified were tagged and then compared to individual image data, vegetation mapping and aerial imagery to confirm the environment and nature of the change identified.

This systematic process was undertaken initially using the 1988-2019 change image and then repeated with the 1988-1998, 1998-2009 and 2009-2019 images. The process was then repeated with the 1988-2019 image to ensure mapping consistency.

Beach environment mapping

Beach/Sand environment mapping (Figure 4) was obtained from Geoscience Australia topographic datasets (2009). This mapping layer was displayed over the image data to confirm spatial rectification and undertake a rapid visual inspection to confirm the likely nature of the target environments.

Target site prioritisation

The bathymetry dataset was used to create a set off buffers to help identify nearshore environment and beach environment sites within operating parameters required for the trailing suction hopper dredger (TSHD) Brisbane. These parameters include:

- Ocean depth of 6 m and greater
- Target within 1.5 km or 2.5 km of the 6 m bathymetry line

The 6 m water depth line was determined using the bathymetry layer. Two buffer lines were then created, one at 1.5 km and another at 2.5 km, inland from the 6 m water depth line (**Error! Reference source not found.**). These buffers were intersected with the target nearshore areas and beach environments to determine the location of points that may be accessible for the delivery of dredge material.

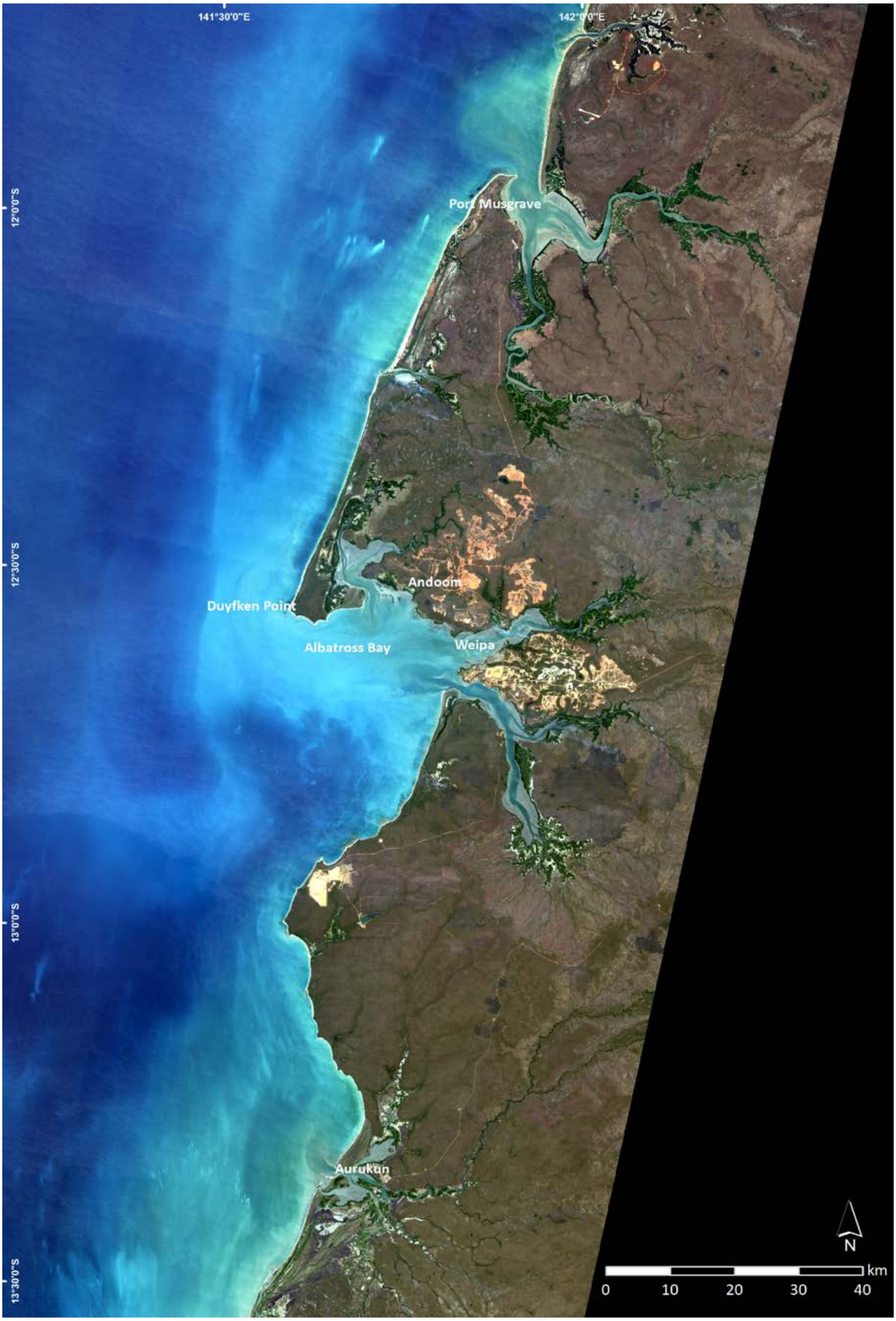

Figure 3 2019 Landsat images of the study area.

Figure 4 Location of mapped beach environments (Geodata Topo Series 2009)

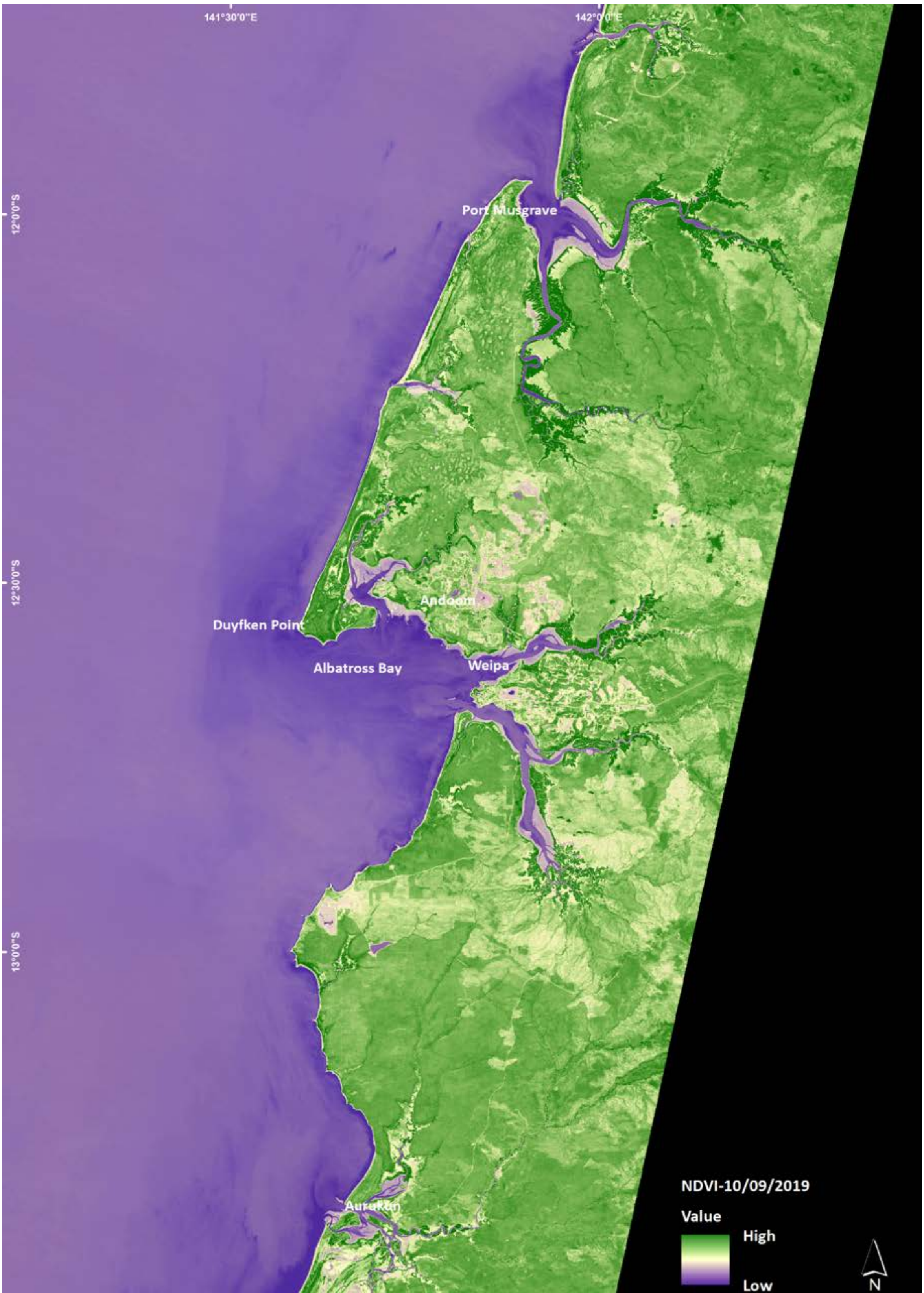

Figure 5 NDVI for the study area (2019), darker green indicates denser vegetation.

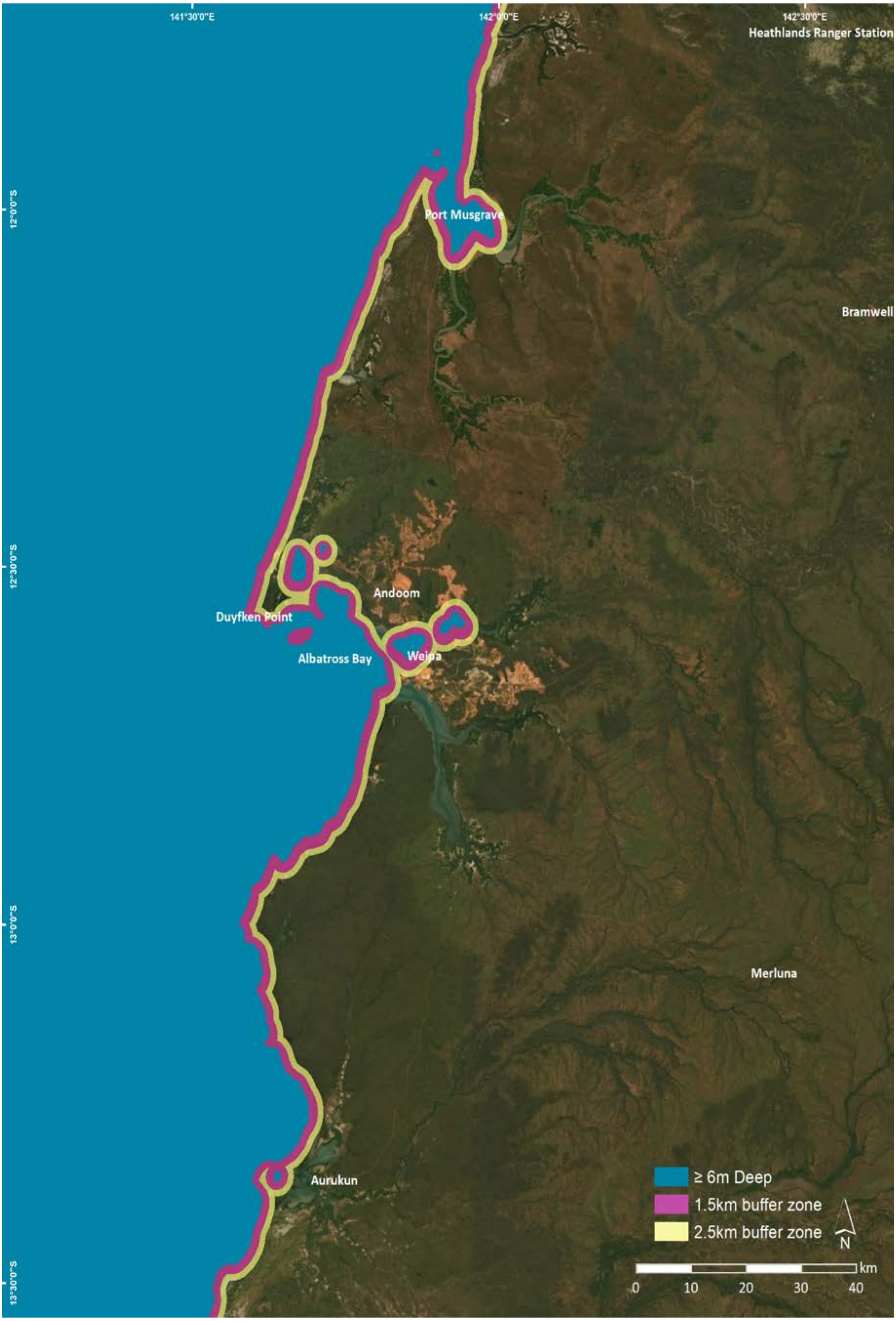

Figure 6 Prioritisation assessment approach using buffering of the 6 m depth bathymetry line.

RESULTS

Changes in nearshore environments

Remote sensing based change detection was used to assess changes in nearshore environments (primarily mangroves and saltmarshes) from Port Musgrave to Aurukun. The assessment used a sequence of Landsat TM images from the late 1980s to present to detect changes over time. A total of 30 mapped features were identified for further detailed investigation using the remote sensing based change detection approach (Table 2, **Error! Reference source not found.**).

A total of 22 sites exhibited a net loss or retraction in mangrove/saltmarsh cover over the study period. A further 7 sites showed a loss in cover that then recovered by 2019 with no net change. One site that was unvegetated in the 1988 and 1998 images gained vegetation cover visible on the 2009 and 2019 images.

Combining the target prioritisation layer with the identified nearshore environment target layer identified 11 points of interest (A to K) for further consideration (Table 2, Figure 8). Each of these points was examined in detail using the image sequence and the high-resolution aerial imagery. While this assessment is informative, it was conducted at a regional level and we recommend that further assessment of each of these areas is undertaken considering local knowledge, high resolution image sequences and potential field investigation.

Figure 9 shows potential target sites A and B. The image sequence shows vegetation cover was present on the 2009 image, likely a salt marsh community. The subsequent images show that the vegetation cover at these sites was reduced on all subsequent images.

Figure 10 shows potential target sites C and D. The image sequence shows vegetation cover was absent on the 1988 and 1998 images. The image sequence then shows a recovery on the 2009 and 2019 images (likely recovery to saltmarsh), indicating a dynamic environment through the study period.

Figure 10 and Figure 12 show potential target sites E and F. The image sequence shows a loss/gain/loss pattern indicating a highly dynamic environment through the study period. The vegetative cover is likely to be a combination of salt marsh and mangrove communities.

Figure 13 shows potential target site G. The image sequence shows vegetation cover was present on all images except 2019, when vegetation cover was clearly absent. The former vegetative cover was likely to be mangrove communities.

Figure 14 shows potential target sites H and I. The image sequence shows vegetation cover has recovered over the study period, likely as a result of local clearing being rehabilitated.

Figure 15 shows potential target site J. The image sequence shows a loss/gain/loss pattern indicating a highly dynamic environment through the study period. The vegetative cover is likely to be a salt marsh community.

Figure 16 shows potential target site K. The image sequence shows a location within a channel network, with apparent loss shown on the 2009 image. However, this site is likely influenced by variation in tidal water levels, with vegetative cover (probably saltmarsh) remaining constant.

Table 2 Points of interest identified in the change detection assessment.

Feature Number	1988 - 1998	1999 - 2009	2009 - 2019	1988 - 2019	Within Target Zones	ID of point of further interest	Recovered by 2019
1	X		X	X			
2	X	X	X	X	Yes	K	
3	X			X			
4	X	X	X	X	Yes	J	
5	X		X	X	Yes	H	
6			X	X			
7	X			X			
8	X	X			Yes	D	
9	X			X	Yes	B	
10	X			X	Yes	A	
11	X	X			Yes	E	
12	X	X			Yes	C	
13	X	X	X	X	Yes	F	
14	X						
15	X	X					
16			X	X	Yes	G	
17	X			X	Yes	I	
18	X	X	X	X			
19			X	X			
20	X						
21	X	X	X	X			
22	X		X	X			
23	X			X			
24			X	X			
25			X	X			
26	X	X	X	X			
27	X	X	X	X			
28	X		X	X			
29			X	X			
30	X						

X denotes change detected; 'yes' denotes points of interest; green indicates feature has potentially recovered

Figure 7 Change detection points of interest within nearshore environments.

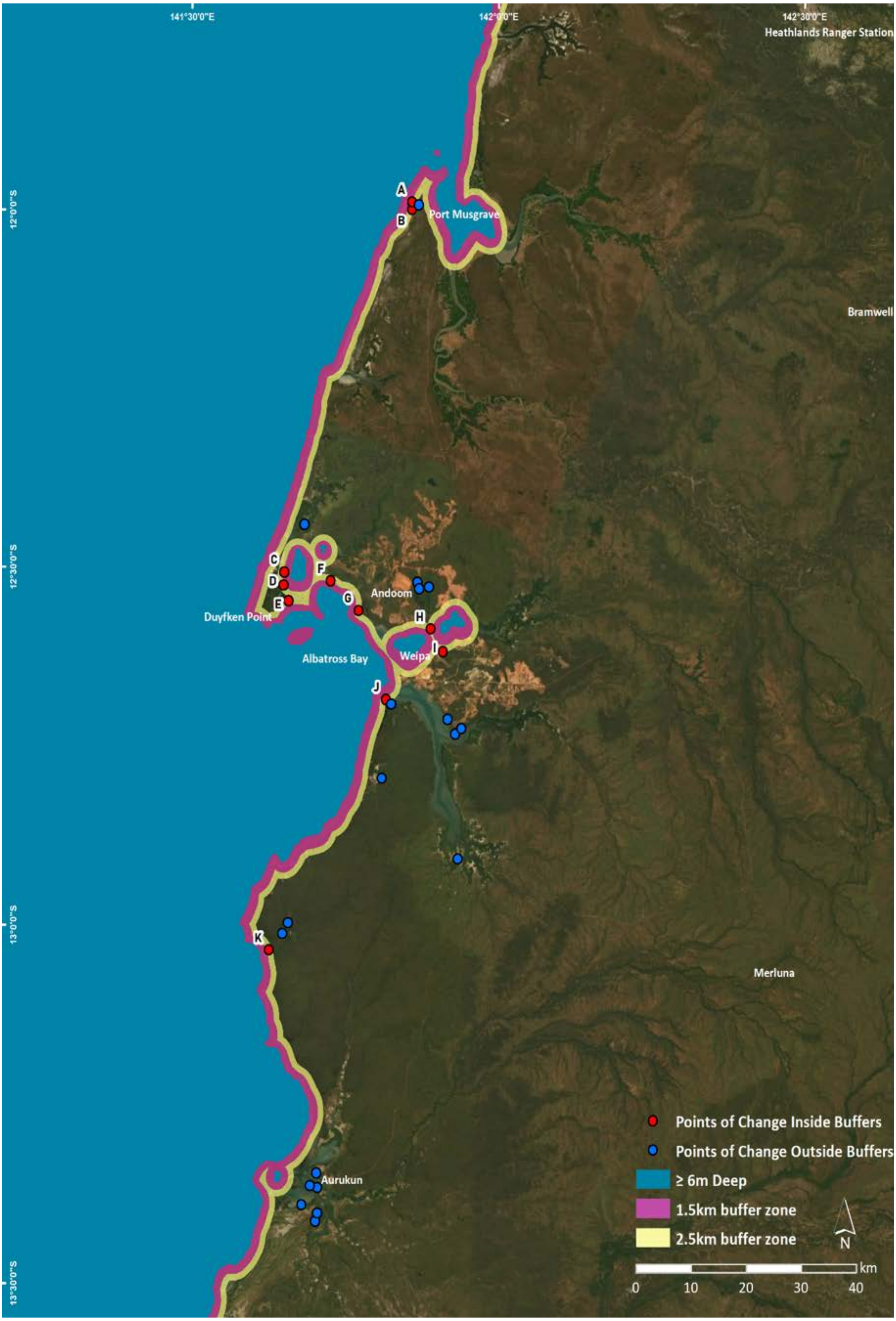

Figure 8 Potential target nearshore environment areas.

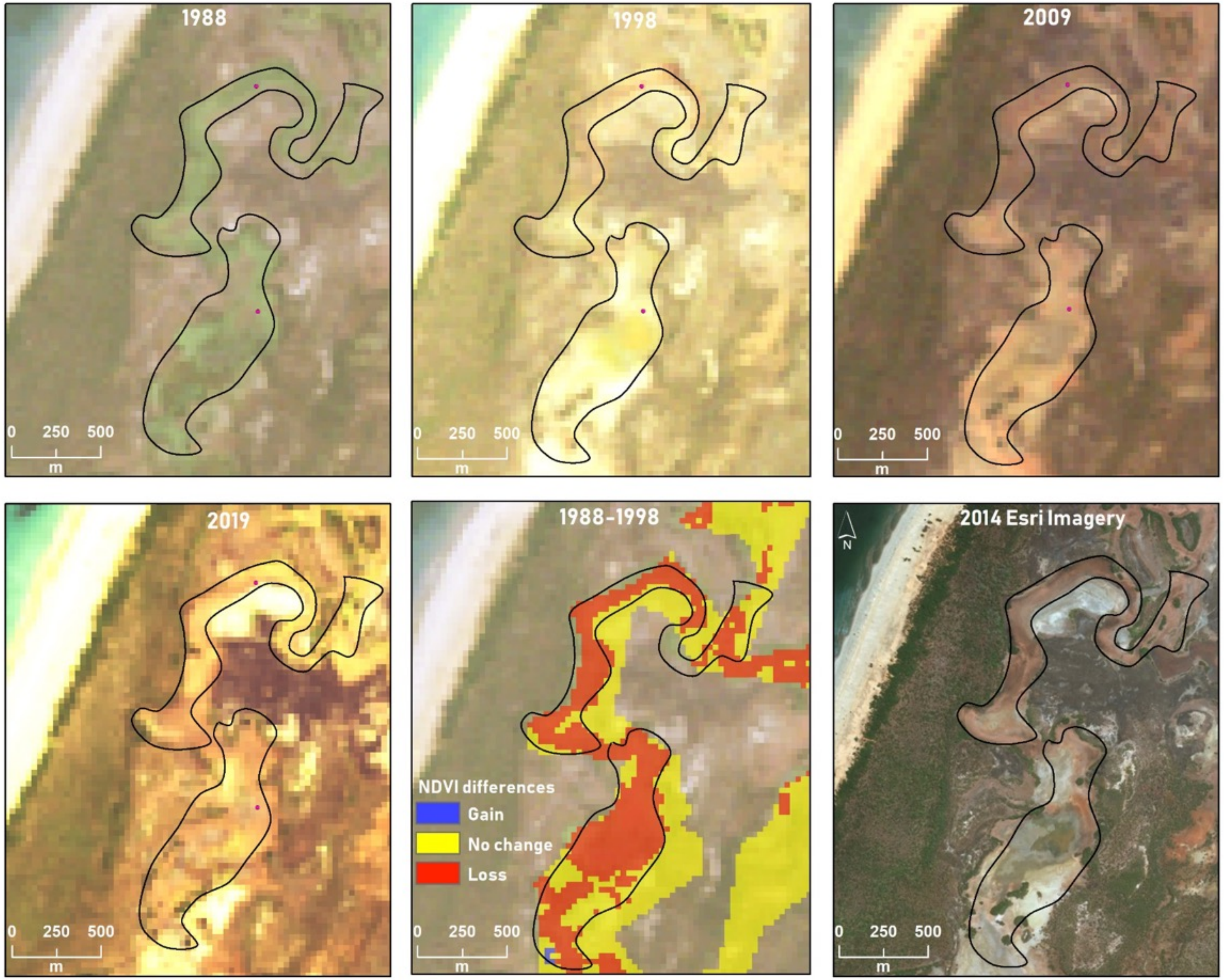

Figure 9 Nearshore environment points of interest A and B with image and change detection sequence.

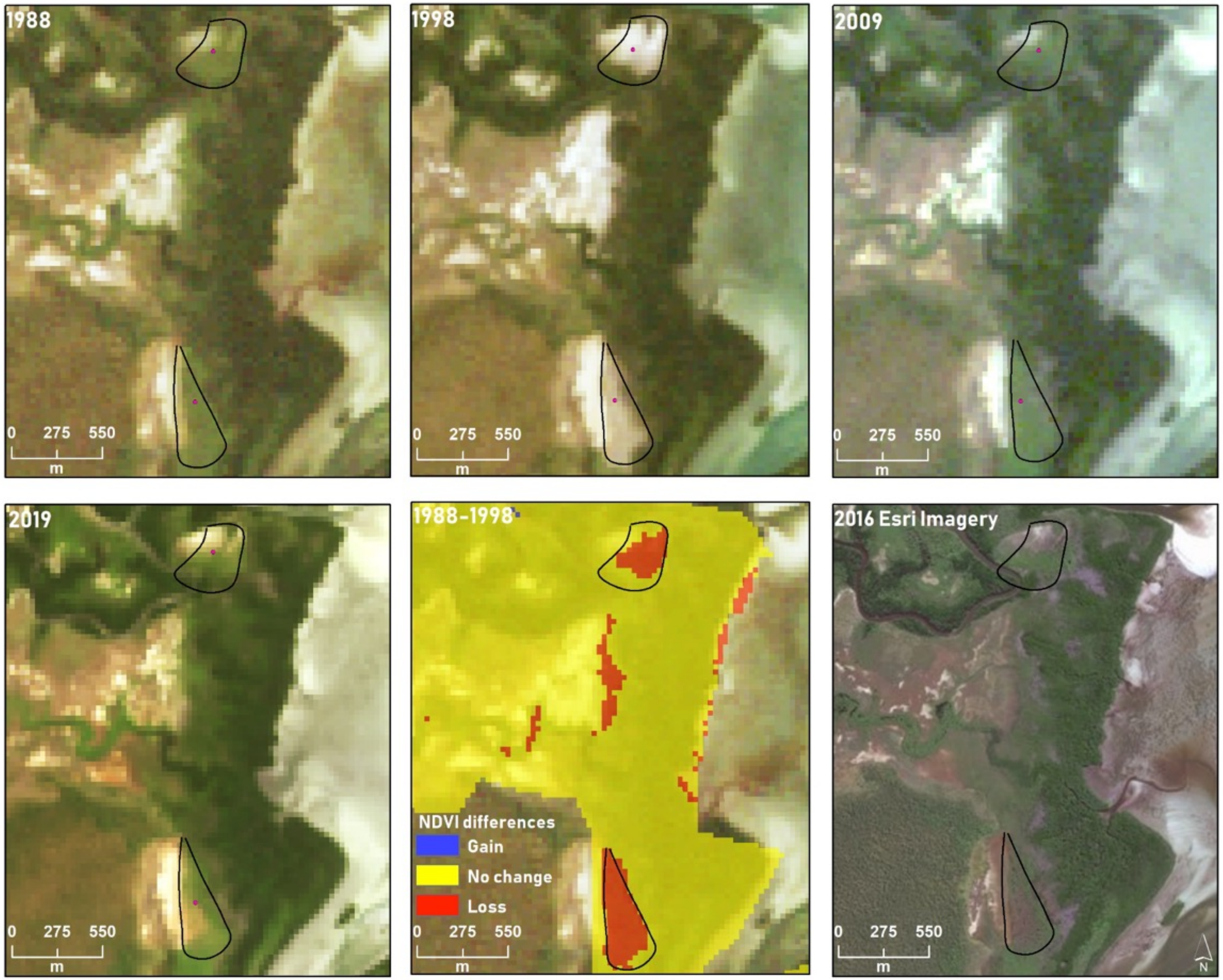

Figure 10 Nearshore environment points of interest C and D with image and change detection sequence.

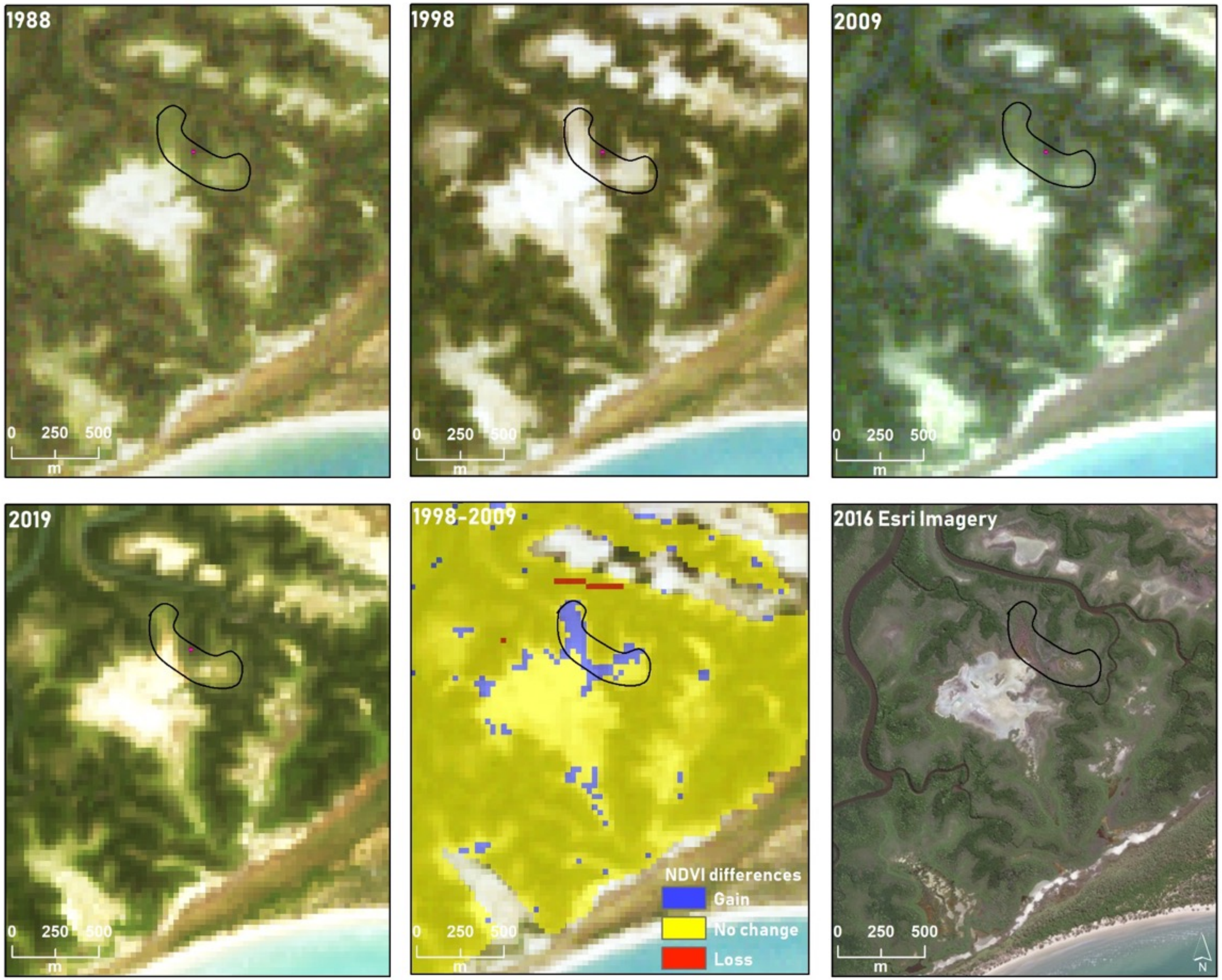

Figure 11 Nearshore environment point of interest E with image and change detection sequence.

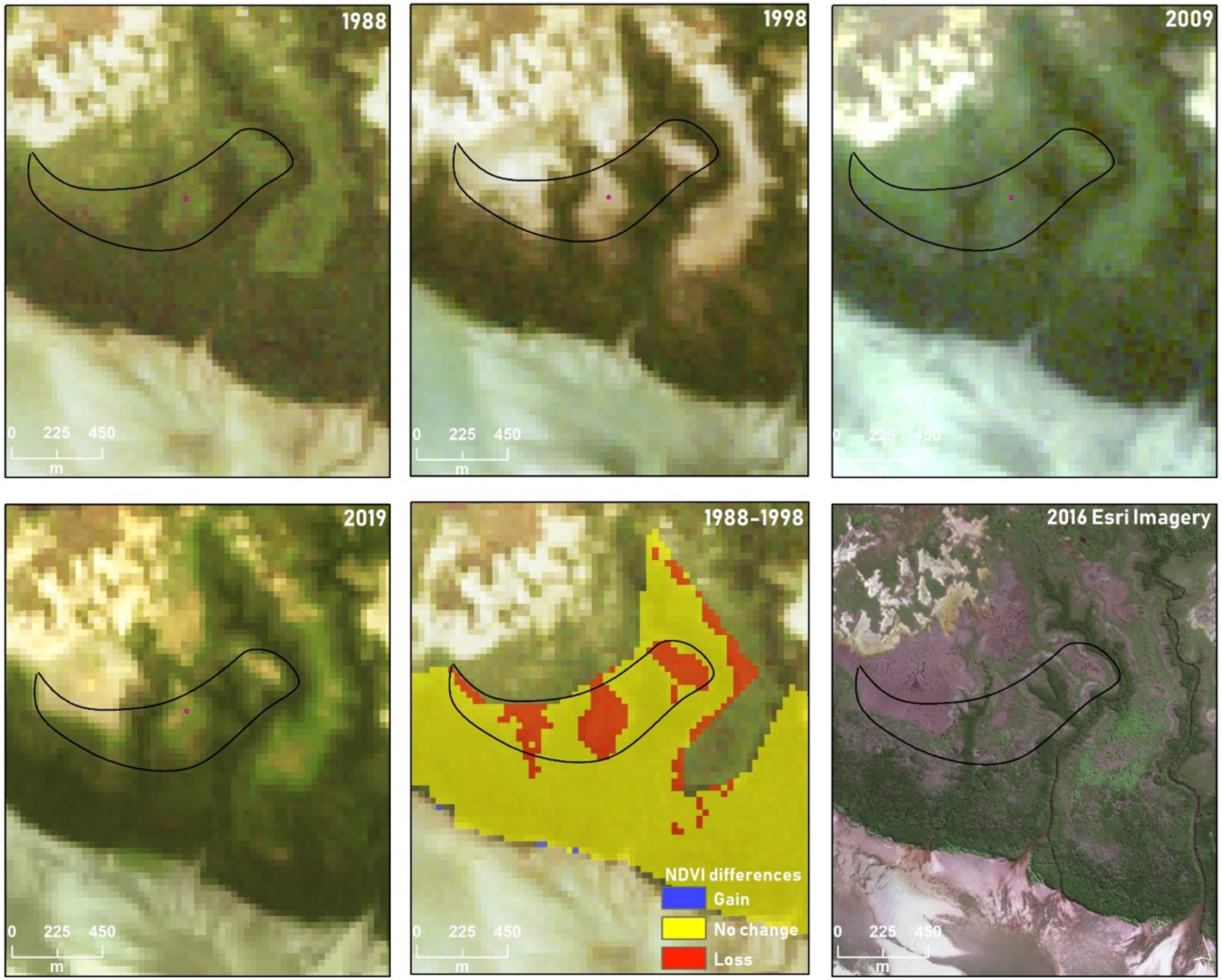

Figure 12 Nearshore environment point of interest F with image and change detection sequence.

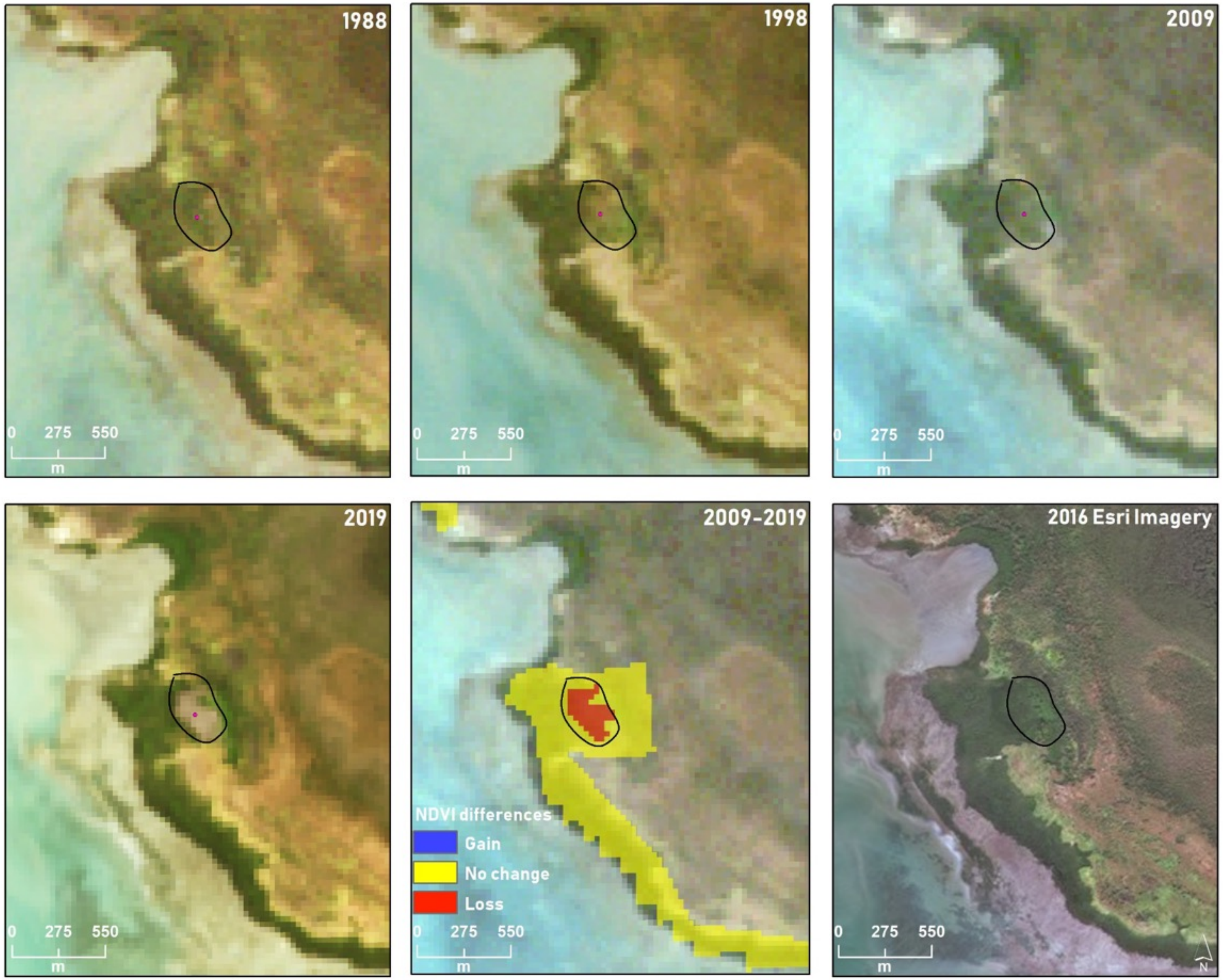

Figure 13 Nearshore environment point of interest G with image and change detection sequence.

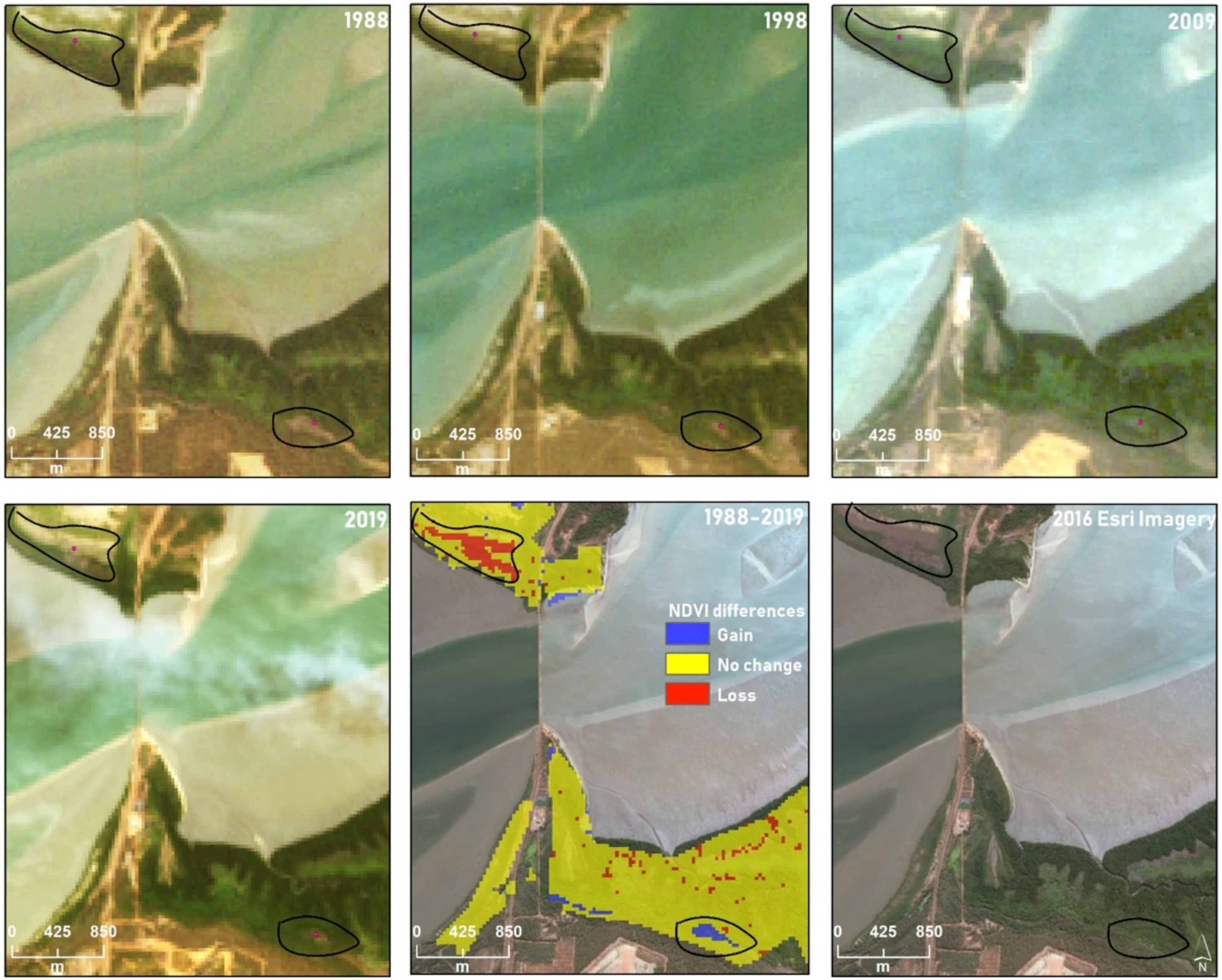

Figure 14 Nearshore environment points of interest H and I with image and change detection sequence.

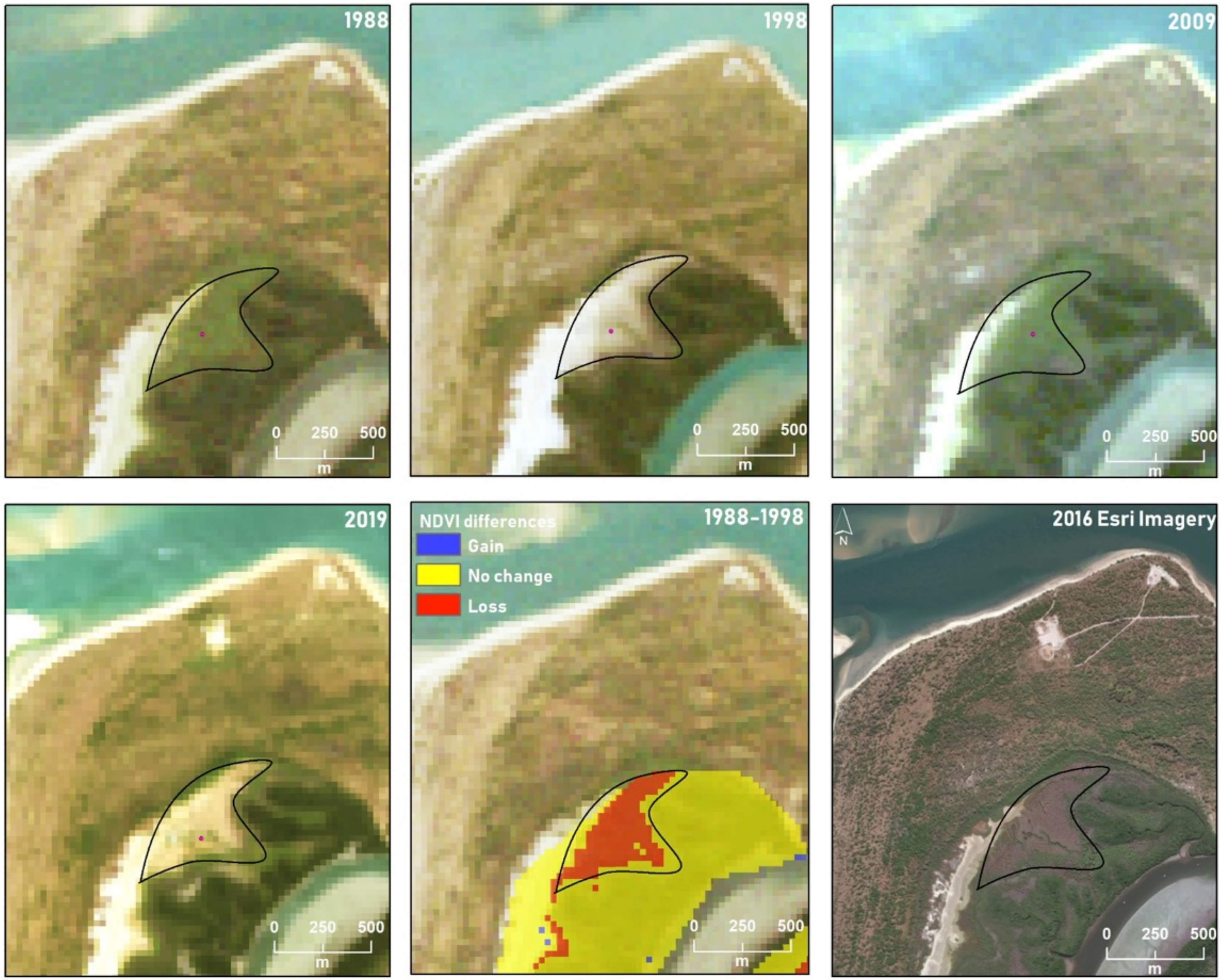

Figure 15 Nearshore environment point of interest J with image and change detection sequence.

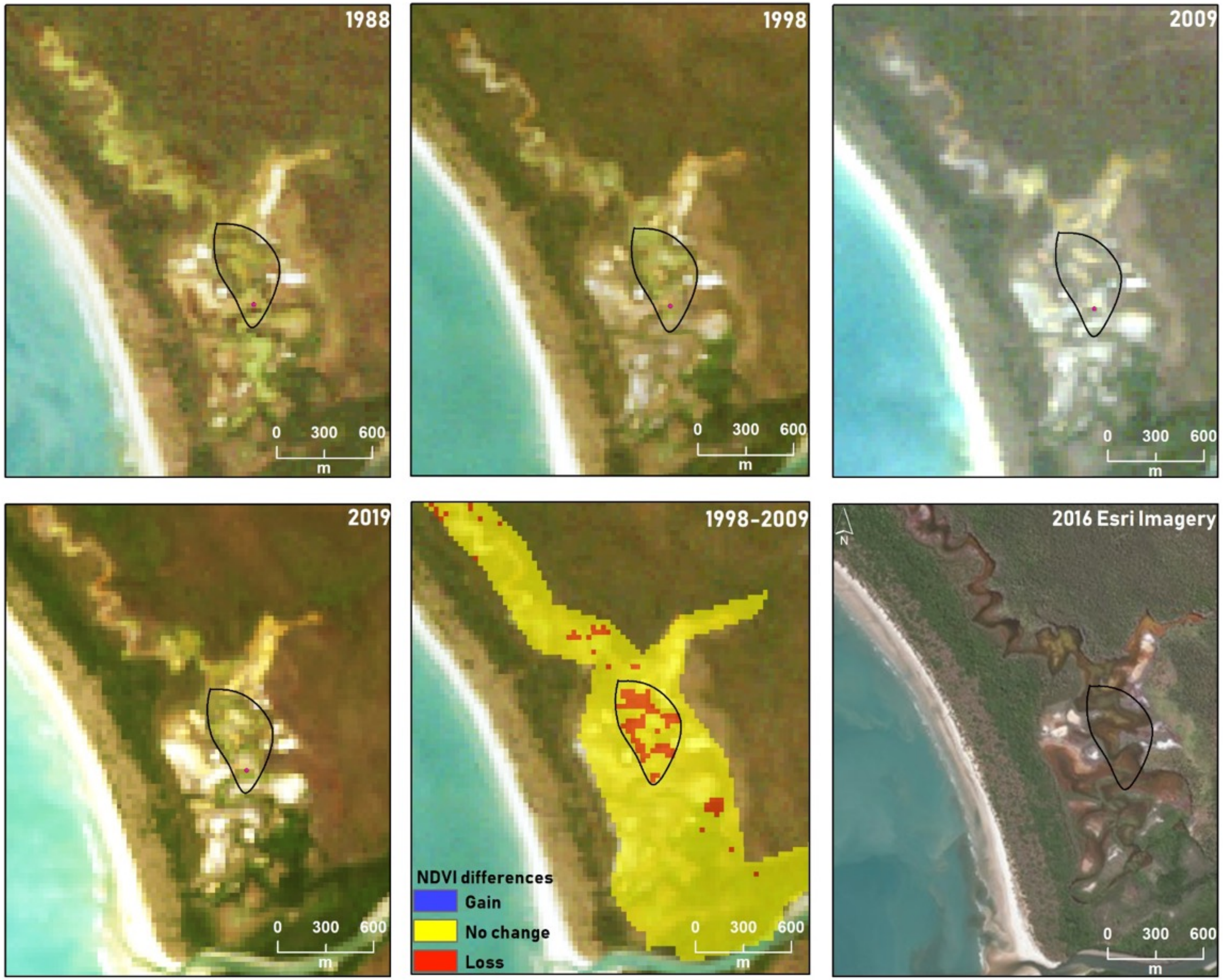

Figure 16 Nearshore environment point of interest K with image and change detection sequence.

Beach Environments

The combined mapping of beach and sand environments (Geoscience Australia 2009) showed extensive areas of beach environment present within the study area - a total area of 5,607 ha of beach was mapped within the study area (Figure 17). When the total extent of beaches was intersected with the target prioritisation layer (i.e. within the 2.5 km zone), a total of 5,539 ha of the beach environment (99%) was found within the target prioritisation layer while only 68 ha (~1%) was found outside the target area. Thus 99% of all beaches in the region are potentially available for beach nourishment via dredge and pump operations.

The study did not find any areas of beach that had lost noticeable amounts of sediment. However, given the relatively coarse resolution of the Landsat imagery, the very large tidal range in Gulf and the investigation of 4 image dates (times) only it is unlikely that all but the largest area of beach erosion would be discernible. Further investigation of target regions using higher resolution imagery and more image dates may assist to better understand where any areas of beach erosion exist if any are present.

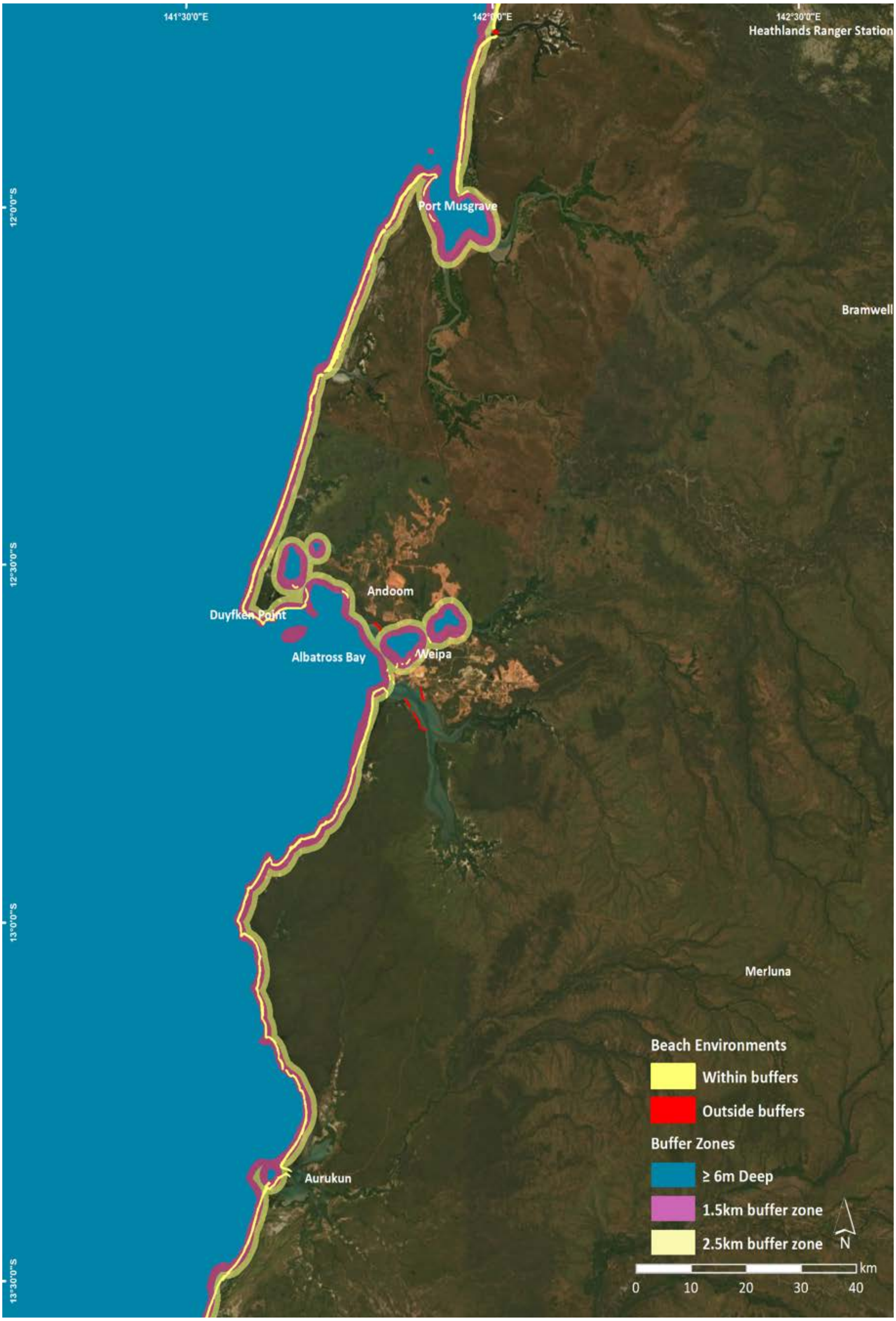

Figure 17 Beach environments within target zones.

CONCLUSIONS AND RECOMMENDATIONS

A regional assessment of nearshore and beach environments from Port Musgrave to Aurukun was undertaken as a preliminary investigation of potential areas that might benefit from placement of dredge material. Landsat image analysis through image change detection was undertaken to assess changes in mangrove and saltmarsh community extent (nearshore environments) from 1988 to 2019. This assessment identified 30 areas of change in nearshore environment extent.

Following assessment of potential nearshore and beach target areas a further assessment was undertaken to assess if these areas were readily accessible via a dredge and pump. All areas that were located within 1.5 km (standard pump) or 2.5 km (boosted pump) of the 6 m depth line were highlighted as regions for further investigation. This assessment identified 11 nearshore environments within the target zones. In addition, 99% of the mapped beach environment was identified within dredge accessible zones.

It should be noted that no areas of broad-scale mangrove or saltmarsh dieback were found. Many areas that were observed to have changed throughout the image sequence were found to show patterns of degradation and recovery. Also the resolution of the Landsat imagery prevents assessment at the individual tree crown level and patchy areas of vegetation loss or recovery may have been overlooked. We recommend that further investigation of the identified target sites is undertaken using a combination of local knowledge, higher resolution photography or imagery, and field survey to verify changes in the identified target areas.

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