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**Shoreline Ecological Assessment
Aerial and Ground Surveys
7-19 November 2009**

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Title

Shoreline Ecological Assessment Aerial and Ground Surveys 7-19 November 2009



(Images from left to right: Mangroves and saltmarsh in King Sound, Western Australia; Survey helicopter flying in to land on the research vessel; Rocky shore, Western Australia).

As part of the Scientific Monitoring Study of the Montara Monitoring Plan

A report commissioned by PTTEP Australasia (Ashmore Cartier) PL for the Department of the Environment, Water, Heritage and the Arts (DEWHA).

Declaration

This report/proposal has been prepared in accordance with UniQuest's Quality Management System, which is compliant with AS/NZS ISO 9000:2000.

Signed for and on behalf of UniQuest Pty Limited

A handwritten signature in black ink, appearing to read 'G Heyden'.

.....
Gary Heyden – General Manager
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EXECUTIVE SUMMARY

- On the 29 October 2009, Dr Norm Duke of the University of Queensland was commissioned by PTTEPAA in consultation with DEWHA to lead shoreline ecological aerial and ground surveys in the Montara oil spill region of coastal NW Australia.
- The survey, conducted from the vessel *Flamingo Bay*, began in Darwin NT on the 9th November, 2009 and ended on the 18th November in Broome WA.
- This report provides a detailed compilation of coastal shoreline habitats, excluding islands, present within the Montara oil release region.
- No identifiable oil slicks or oil contamination were observed during the survey. However, there were notable flotsam and bloom-like debris in many places. These were observed and sampled during the survey. Preliminary findings suggest these were biotic in makeup, or the result of agitated tidal flows.
- Aerial surveys employed high definition digital video and still cameras from a helicopter at 500 feet altitude to capture detailed imagery of 5102 km of shoreline in the region. Video footage, covering the entire coastline, was used to categorize the shoreline with 16 subregions into representative classes of type and condition. An archive of 6000 high definition still imagery provides a further resource and baseline record.
- Tidal wetlands are common across the survey region, with mangroves occurring along 3214 km of shoreline. OzCoasts database includes 9441 km² of tidal wetland (mangrove plus saltmarsh) as occurring along the surveyed coastline, with an average of 1.85 km² of tidal wetland for every kilometer of shoreline within the Montara well release region (Darwin to Broome). This measure quantifies coastal shorelines at greatest risk, varying between 0.04 and 10.88 km² of tidal wetland/km of shoreline. Three coastal areas are at greatest risk in having disproportionately vast tidal wetland areas, including: Joseph Bonaparte Gulf (subregion #5), Cambridge Gulf (subregion #6) and King Sound (subregion #14).
- Vulnerability is associated also with the biodiversity of mangrove species progressively limited to the west. Species endpoint occurrences are recognized as limits of existence where such species are at high risk from further disturbance, like an oil spill. Respective coastal areas at greatest risk in having species limits west, include: the area west of Darwin (subregions #1 & #2), and the area around King Sound (subregions #14 & #15).
- Significant diversity and numbers of marine megafauna were observed. The type of megafauna recorded included: dolphins, dugong, whales, turtles, crocodiles, sharks and rays. All sightings were marked with location coordinates. Greatest concentrations of megafauna (~60% observed) were recorded from Cape Londonderry to Admiralty Gulf (subregions #8 & #9). The majority (67%) of sightings were of turtles. Additional

observations of beaches with recent turtle tracks were also recorded – as a potentially valuable contribution to our knowledge of turtle nesting activity along this coastline. In the latter case, shoreline imagery taken can be assessed for enhanced quantification. There were signs of greater nesting activity shown with turtle tracks in York Sound (subregion #11).

- A number of estuary mouths and inlets were observed, recorded on film and compared with those previously given in regional and national databases. Imagery showing each estuary was available for use in estuarine databases (like OzCoasts.org.au). Our findings show a number of estuaries were poorly known or described for this country.
- Sea and land based sampling of water and marine sediments were taken at 24 sampling stations, with samples being provided to Eleanor Stoney of PTTEPAA for further analysis. Many of these were made in the intertidal zone. Analysis of these samples is not part of this assessment.
- Land based surveys identified the presence of mangrove species in two locations to compare with species available for the region.
- Video and photographic data captured during the survey provides a permanent baseline record of shoreline habitats and their condition in the Montara oil release region from which impacts associated with future large-scale disturbances can be gauged.

Report submitted to PTTEPAA includes:

Written report with associated:

- Shoreline maps
- Appendices

Shoreline electronic database (66GB) consisting of:

- Excel spreadsheet “Darwin – Broome Shoreline Ecological Surveys”
- Digital image library of photographs and frames from video footage



Figure 1. Mangroves and saltmarsh, King Sound Western Australia.

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1. BACKGROUND

On Friday 21st August 2009, an oil release was observed from the West Atlas drilling rig at Montara oil field in the Timor Sea, off the northern coast of Western Australia. Oil continued leaking until November 3, 2009 when mud was pumped into the well and stopped the flow. The West Atlas rig is owned and operated by Seadrill. The Montara oilfield is operated by PTTEP Australasia, a subsidiary of PTT Exploration and Production (PTTEP) a subsidiary of PTT, the Thai state-owned oil and gas company. The leaking rig was located off the Kimberley coast, 250 km (160 mi) north of Truscott airbase, and 690 km (430 mi) west of Darwin. The oil loss rate was variously estimated to be between 400 and 2000 barrels/day by the Australian Department of Resources, Energy and Tourism, and PTTEP Australasia. Oil from the Montara Well is a light crude oil with an 11% wax content.

As shoreline impact, and subsequent harm, was anticipated, it was considered useful to obtain baseline information relating to the fitness of coastal species and habitats prior to impact. This information would assist in determining whether any damage observed after impact might be due to the oil, cleanup or it was pre-existing. This was important also for habitats such as mangroves where seasonal dieback is known to occur, or for species where carcasses on shorelines are not uncommon.

The Project

On the 29 October 2009, Dr Norm Duke of the University of Queensland was commissioned by PTTEP Australasia (Ashmore Cartier) PL (PTTEPAA) in consultation with the Australian Government Department of Environment, Water, Heritage and the Arts (DEWHA) to lead shoreline ecological aerial and ground surveys in the Montara oil spill region of coastal north western Australia. This included a rapid survey of marine megafauna (defined as cetaceans and marine reptiles) plus water and sediment sampling. Dr Duke working with postgraduate student colleagues (Jock Mackenzie, Alex Haller, Apanie Wood plus four others), also from University of Queensland assisted with these surveys.

The survey, conducted from the vessel *Flamingo Bay*, began in Darwin Northern Territory NT on the 9th November, 2009 and ended on the 18th November in Broome Western Australia WA.



Figure 2. 'RV Flamingo Bay', the support vessel used in aerial surveys.

The project specifically addressed two of the West Atlas Monitoring Programme tasks:

- Shoreline Ecological Assessment Aerial Surveys (Study S2). In this, the project targeted the aerial survey of mainland shoreline in the first instance.
- Shoreline Ecological Ground Surveys (Study S6). As with Study S2, this was designed to quantify any effects on coastal fauna or flora.

This was considered primarily a baseline survey to ascertain prior condition of habitats threatened by the oil leak offshore. The major component of the shoreline aerial survey was undertaken using a helicopter. This allowed flexibility, so if in the eventuality there were signs of associated impacts, these locations could be identified immediately, and preliminary ground surveys undertaken as needed. This was considered crucial to provision of unequivocal confirmation of the source of any potential impact. The shoreline aerial surveys were conducted at the earliest possible date. The shoreline survey is designed to capture the current and prior condition of the shoreline from Darwin in the Northern Territory to Broome in Western Australia. Primary information was recorded as digital imagery. Recorded data included both high definition (HD) video and still images along with coordinate location information and date of acquisition. Using these digital data, interpretation observations were scored and combined with observations recorded from logbooks kept during aerial surveys. Our interpretations identify types of shoreline habitats, their condition, and to some extent, their vulnerability to oil damage.

This report presents the findings of these aerial and ground surveys in fulfilment of our part in the Scientific Monitoring Study S2 “Shoreline Ecological Assessment Aerial Surveys” and Study S6 “Shoreline Ecological Ground Surveys” as set out in the Montara Monitoring Plan. This work included the option to take samples of sediment, waters and biota on behalf of Operational Monitoring Study O2 “Monitoring of Oil Character Fates and Effects”. In all these, the scope of work accounts for baseline studies only and does not include Ashmore or Cartier reefs.

Specific objectives of surveys

The objectives of our survey were based listed in the Montara Monitoring Plan, specifically described as:

- To quantify the presence of megafauna (like dugongs) in the subject area pre-impact in order to determine the level of potential exposure to oil
- To quantify the presence and extent of communities or habitats (mangroves, other tidal wetlands, and other shoreline types) in the subject area before impact by oil in order to determine the level of potential exposure to oil
- To record pre-existing (i.e. pre-impact) condition of communities or habitats (e.g. dieback, bare areas) in the subject area
- To determine any exposure of waters, sediments, fauna or flora to oil and if detected, to quantify the level of exposure
- To quantify actual area or extent of any observed effects of oil impact on habitats or communities in the subject area in order to determine the level of potential exposure.

Later (non baseline) surveys included the following objectives:

- To determine any residual exposure of waters, sediments, fauna or flora to oil and if detected, to quantify the level of exposure
- To quantify area or extent of recovery from any harmful effect of oil impact on habitat or communities in the subject area.

2. METHODOLOGY

Survey Logistics and Operations

Aerial surveys were conducted from a mobile base, 'RV Flamingo Bay' – owned and operated by Flamingo Bay Research, registered in Queensland with USL 2B survey and fitted for receiving and deploying a helicopter that meets AMSA and CASA standards. The vessel and crew have extensive Australian and overseas project experience and marine survey work.

The aircraft used was a Robinson R44 helicopter (Fig. 2), owned and operated by Cape York Helicopters. The helicopter, equipped with pop out flotation devices for overwater activity, was flown from the mobile base. Both pilot and aircraft have conducted regular marine and seagrass surveys for Queensland Fisheries Service over many years and have covered the coastline from Darwin around the Gulf of Carpentaria to Thursday Island in Torres Strait, as well as the area between Cairns and Townsville.



Figure 3. Robinson R44 helicopter with crew conducting aerial ecological surveys.

This combination of operational logistics proved essential for the expeditious, effective and efficient conduct of aerial surveys for this project. The vessel provided not only a platform for the helicopter, but also a base for its fuel, as well as providing all accommodation, transport and office work space for our survey crew. Each of these elements contributed to the ultimate successful conduct and completion of the aerial survey - on schedule, as planned.

Survey Shoreline Ecological Assessment Team

Project Director, Dr Norm Duke (MSc, PhD), with the University of Queensland, is a mangrove and tidal wetlands ecologist of more than 30 years standing, specialising in mangrove floristics, biogeography, genetics, climate change ecology, vegetation mapping, plant-animal relationships, pollution and habitat health assessments. Norm gained his earlier experience at James Cook University, Australian Institute of Marine Science, and Smithsonian Tropical Research Institute in Panama. He currently leads an active research and teaching group on marine tidal wetlands at the University of Queensland School of Biological Sciences. With his detailed knowledge and understanding of tidal wetland processes he regularly advises on effective management and mitigation of disturbed, damaged and polluted ecosystems. He has published more than 170 peer-reviewed articles and technical reports, including 'Australia's mangroves'. Fifty of his publications include assessments of the impacts of large oil spills on mangrove forests around Australia, Panama and Micronesia.

Mr Jock Mackenzie has worked with Dr Duke for the past 8 years developing mangrove survey methods to assess estuary and mangrove ecosystem health. He is currently undertaking a PhD assessing mangroves as indicators of estuarine health. This includes surveys of tidal wetlands in the Burnett-Mary region as part of the State of the Estuary reporting, assessment of Kien Giang coastline condition, Vietnam and development of Mangrove Watch methodology for community group assessment of mangrove condition.

Mr Alex Haller began working under the supervision of Dr Duke at the University of Queensland's Centre for Marine Study in May of 2008. Since then he has been involved in several coastal/estuarine survey projects including: the development of horizontal mangrove profiles in the Burnett-Mary region and mangrove health assessment maps throughout the Moreton Bay area. Alex has experience working with and interpreting satellite imagery, using mapping software such as ArcGIS, as well as recent aerial and ground surveys using helicopters and small vessels.

Survey Shoreline Ecological Assessment Methods

The major component of the shoreline ecological assessment was the aerial surveys. As noted, surveys were conducted using helicopter aircraft. Assessments were based on observer records in combination with two high definition video cameras and three Digital still cameras all synchronised by time and with GPS units recording both track and waypoints.

On-going assessments and data compilation were undertaken on the vessel to carefully download each flight record, with labelling, archival, and recording of operational observations.

This was undertaken using on-board computers and appropriate monitors and data storage capacity.

2.1 Shoreline Video Surveys

The Shoreline Video Assessment Method (SVAM) relies on qualitative assessments of shoreline habitat, physical condition and human influence determined from continuous video recordings of the shoreline and intertidal zone of a coastline. The video is analysed for a number of features that relate to the 'condition' of the coast. For the current project, this method was used to quantify coastal and shoreline habitats present within the Montara well release region. Video surveys were completed between Darwin (Northern Territory) and Broome (Western Australia) between the 9-18th November 2009. Simultaneous GPS data acquisition enabled features to be mapped to give accurate spatial representation of shoreline habitats.

2.1.1. Video Recording

A video of the shoreline was taken using High Definition Sony Handycam cameras (HDR-XR200E) from a helicopter flying parallel to the coastline mostly at 500 ft altitude. Two Garmin GPS devices (Garmin GPS60) were used to record latitude and longitude every 2 seconds. Four digital cameras (one Nikon DSLR D90, two Olympus Tough cameras M770 SW, one Sony Cybershot), were used to photograph the shoreline to supplement video footage with higher resolution imagery. Digital still cameras, GPS units and Handycam video cameras were set to the same time for aerial and ground surveys.



Figure 4. Two HD video cameras were used during aerial surveys – one hand held, and the other mounted.

2.1.2. Video Assessment

The video was assessed as a continuous point intercept transect of the coast.

Video of the coastline was reduced to 1 second frame .jpg files.

The time of the video and GPS was used to match each frame to a specific GPS location. Each frame that matched a GPS position was used as a point on the transect. Observer based assessments of frames (.jpg images) were used to classify the SVAM into the following parameters.

Physical characteristics – Rocky, Beach, Flat, Dune, Other Wetland.

Vegetated habitat type – Mangrove, Saltmarsh, Fringing Coral Reefs, Seagrass Verge, Coastal Woodland

State of erosion and deposition– Eroded, Stable, Depositional.

Tidal wetlands – Mangrove, Saltmarsh, Mud Flats, Salt Flats, Sand Flats.

Other – Human Modified, Water Reach.

The classification *Water Reach* was defined as any water body the survey crossed, including channels and large estuary mouths.

For examples of the remaining above categories see Appendix 7.2

2.1.3. Mapping methods

- I. For each video clip taken on each survey day, coordinates were matched to every frame number in Excel, based on synchronised time of GPS and video camera (i.e. start and end time of each clip). Coordinates were then identified for each section of analysed video data contained in data file using LOOKUP equation in Excel – i.e. coordinates were identified for each location where the coastline was assessed to change according to one or more assigned categories. Occasional coordinates where the GPS track had skipped a section, e.g. due to poor reception, were approximated in ArcMap using nearest track points. For each survey day, all analysed video clip data matched with coordinates (2-10 clips per day) was collated in one Excel worksheet and prepared for import into ArcGIS. Each data point was assigned a number ID in the order in which the data was collected.
- II. The surveyed coastline was digitised from Google Earth images.
- III. All data points were shifted perpendicularly from their original position along the helicopter track to a position along the coastline, to reflect their approximate location when viewed from helicopter. This was initially undertaken using a VBA macro ("Snap

and split program” developed by Dussault and Brochu (2009), available from ESRI ArcScripts website), and then checked manually and points further shifted as necessary. Manual shifting was necessary where the automatic shift was not perpendicular to helicopter track (since the macro shifted points to nearest position along coastline). Data points analysed as “Water” were used as approximate checkpoints against creeks/rivers identifiable in the underlying satellite images (from Google Earth). These points were used to estimate positional accuracy. As a conservative estimate, positional accuracy is ± 500 m.

- IV. The coastline was split at all data point locations using VBA macro (“Split lines at points” developed by Lundeen (2008), available from ESRI ArcScripts website, and then checked to ensure splits had occurred at all points. A number ID was assigned to each line segment, and checked to ensure all line segments were numbered in the order in which data was collected and corresponded to the ID number of the shifted data point.
- V. Line segments were joined to attributes using “Join” tool based on line segment ID and corresponding data point ID, and then exported as a new shapefile/dataset.
- VI. The nine shapefiles containing mapped video analysis data for each survey day were checked for consistency, and then appended into one shapefile/data table (File name: “ALL_coast_data”).
- VII. Lengths of each segment/assessed category were calculated in ArcMap, after splitting the data based on UTM grid zone (zones 51 and 52) and projecting the data for each zone separately. A table from each file was exported to Excel, appended, and used for calculating distances surveyed and lengths of each assessed category. Note these distances have been calculated from a simplified representation of the coastline, therefore are approximate, and may be more appropriately regarded as percentages of distance surveyed.
- VIII. The surveyed coastline was split into 16 coast sections. Maps were created of each region at scales ranging from 1:200 000 to 1:500 000, showing physical characteristics, vegetated habitat type, tidal wetlands, state of erosion and deposition, and observations of estuary mouths and marine megafauna.

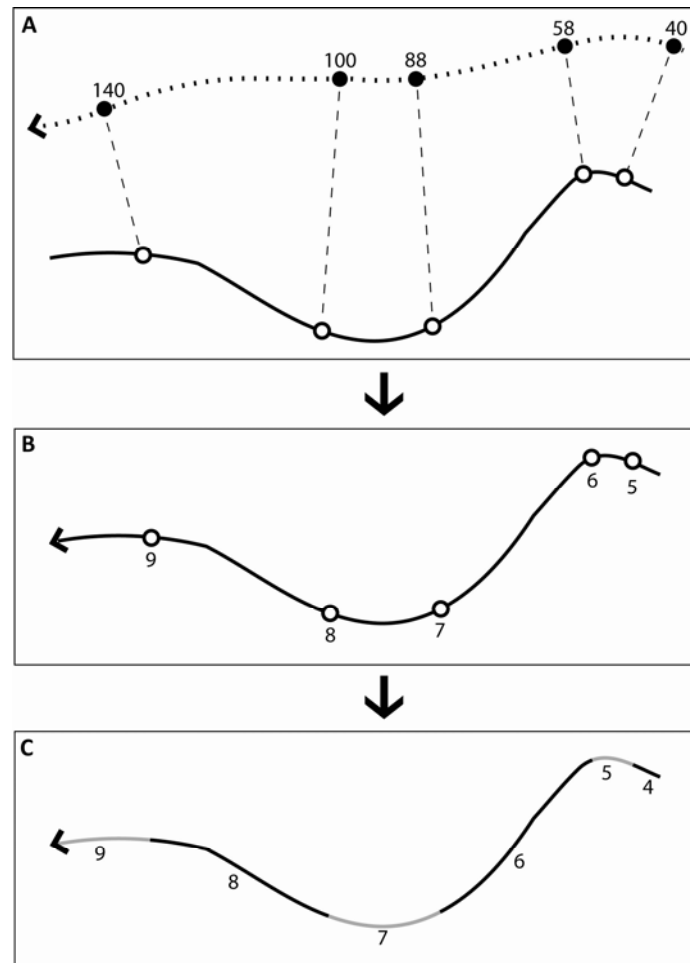


Figure 5: Methods used in mapping analysed coastline video data. (A) shows the helicopter track recorded by GPS (dotted line) with video clip frame number (solid black dots) where the coastline changed according to one or more assessment criteria (i.e. a different category was assigned to the frame). The coordinates for these points were shifted perpendicularly to the coastline to reflect the approximate location when viewed from the helicopter (hollow dots). Positional error was conservatively estimated at ± 500 m. (B) shows the ID number for each shifted data point (which is linked to analysed video data). (C) shows the line split by points, and each segment given the same ID number as its corresponding data point, which was then used to join attributes to line segments.

2.2 Rapid Water Quality & Benthic Sediment Assessment

Samples of sediments, water and biota were collected during this survey. These were shipped to PTTEPAA for further analysis. It was proposed that these are handled and analysed as per Monitoring Study S7, Study O2 or other methods as determined by PTTEPAA.

Duration of sampling: November 10-19, 2009

Locations of sampling: Darwin to Broome at various sites selected based on conservation and cultural significance as outlined by NT/WA government, logistical feasibility, and areas identified as possibly suspect for release byproducts (e.g. suspicious foam or particles in water).

At the sample sites water samples were obtained either from the vessel (boat) or during touch downs of the helicopter survey (beach). When possible, sediment samples were taken, all "beach" samples included sediment, however due to varying substrates (e.g. bedrock) and depths on "boat" samplings, sediment was often unobtainable. Tissue samples were collected at locations where bivalve specimens were able to be collected without impairing the progress of the rest of the survey.

At each sample site a unique identification number (S1-S24) the time and date, lat and long, and general conditions were recoded. When logistics allowed, the ambient water conditions (pH, DO, Salinity or conductivity, temperature) were also noted. Generally, samples taken from the vessel (location title included "boat" in parentheses) included these ambient water conditions, samples from "beaches" did not. This information is provided in a table in Appendix 7.4.

Water sampling for the following were taken:

- Seawater: Just below the surface, depth of 1m, and, when sampling from the vessel, at approximately 10m. PVC Niskin bottle was used to obtain sampled from the vessel, from the beach sampled were collected directly into bottles
- When obtainable, a sediment grab sample of 0.5L
- When obtainable, bivalves for tissue analysis wrapped in solvent cleaned aluminum foil.

Handling and storage

- Water samples were stored at approximately 0 °C (not frozen due to salinity content) in solvent-rinsed, amber 1L bottles for water storage were obtained from QHSS

- Sediment and tissue samples frozen and stored in glass jars acid washed, rinsed in demonized water, mentholated spirits, and acetone.

2.3 Marine Megafauna Surveys

During aerial surveys, all marine megafauna observed were recorded and identified to the lowest taxonomic level possible. Helicopter height remained between 500 ft, allowing a large area of ocean to be monitored. Observations were made by all helicopter crew (4 observers per survey), and waypoints taken using a GPS (Garmin GPS 60). Sea turtle tracks and nests were also recorded. The help of Carole Palmer, a marine megafauna specialist from the Northern Territory Department of Natural Resources, Environment and The Arts, was solicited during the first 5 days of survey. Carole's presence allowed training of the crew, who then completed the final 5 survey days. Visibility was affected by both sun position and weather, in particular sea swell and wind level. As water turbidity and general visibility varied, detailed abundance estimates should not be made from these observations. Our sightings are usefully considered an indication of available marine megafauna present. Locations of megafauna observations are mapped for each of the 16 coastline sections.

2.4 Mangrove species

A list of mangrove species with ranges within the survey region was compiled from the literature and presented for each of the sixteen coastal regions. This data was supplemented with actual recorded sightings in each estuary, as listed in various publications and compiled in a database by Dr Duke. Listings of mangrove species present and respective source information is provided for each of the 16 subregions for this survey. Source references for mangroves list are designated in the tables for each subregion and are as follows;

NCD = Duke (1985)

GW81 = Wells (1981)

GW82 = Wells (1982)

GW85 = Wells (1985)

GW86 = Wells (1986)

SKW = Semeniuk *et al* (1978)



Figure 6. Selected landings enabled sampling and verification of ground conditions.

3. RESULTS

Around 5102 km of shoreline was surveyed, analysed and mapped to provide spatial and quantitative characterisation of vulnerable coastal ecological features between Darwin (NT) and Broome (WA). Mangroves, the most vulnerable coastal habitat present, grow along 63% of the surveyed shoreline, covering over 3200 km (Table 1). Saltmarsh occurs on more than 1200 km of coastline or 23.8% survey region and the coastline is rocky for 2763 km of shoreline (Table 1).

For the total shoreline surveyed, 9441 km² of tidal wetland were observed (Table 4; OzCoasts 2009). This is calculated as 1.85 km² of tidal wetland for every kilometer of shoreline within the Montara well release region (Darwin to Broome).

Assessment of oil spill impacts

No visual evidence of oil or wax residue was identified during this shoreline survey of the Montara well release region.

Observations of marine megafauna

Marine megafauna sightings were common in all survey regions except Port Darwin, with a wide range of taxonomic groups being represented including marine reptiles, cetaceans, sharks, rays and dugongs as outlined in Table 2.

Ground ecological assessment sampling

Twenty-four water and sediment samples were collected during the survey at destinations highlighted in Figure 8. Sediment samples were collected during the survey in November 2009.

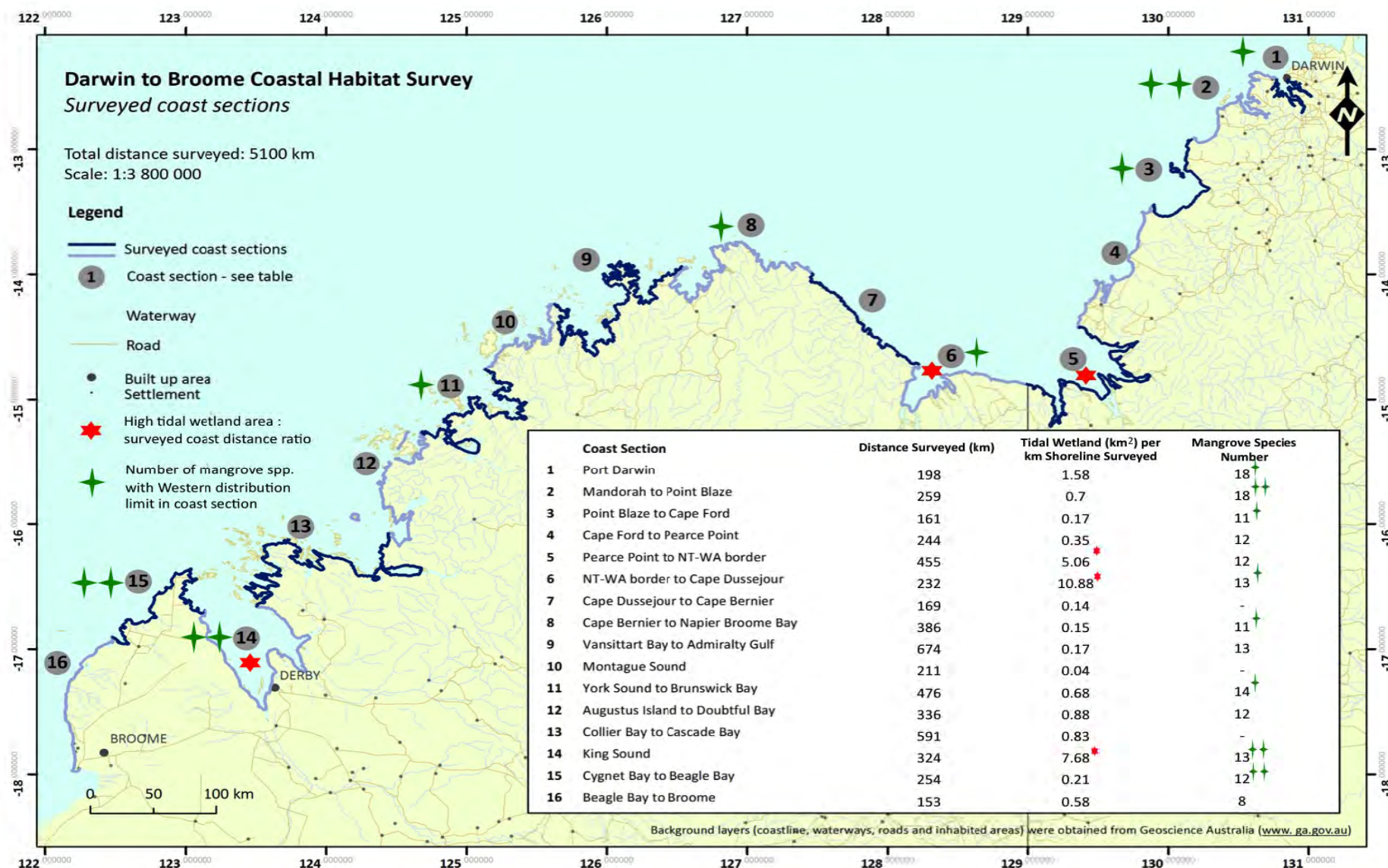


Figure 7: Surveyed coast sections, Darwin – Broome.

Table 1: Summary of coastal characteristics from Darwin (NT) to Broome (WA). Category percentages do not add to 100 as categories overlap in some locations.

		km	% of shoreline
<u>Physical characteristics</u>	Rocky	2762.8	54.2
	Beach	1663.7	32.6
	Flat	2185.5	42.8
	Dune	1536.9	30.1
	Other wetland	15.9	0.3
<u>Vegetated habitat type</u>	Mangrove	3214.1	63.0
	Saltmarsh	1215.4	23.8
	Fringing coral	350.9	6.9
	Seagrass verge	11.5	0.2
	Coastal Woodland	3886.6	76.2
<u>State of erosion and deposition</u>	Deposition	548.8	10.8
	Erosion	544.7	10.7
	Stable	3576.7	70.1
<u>Tidal wetlands</u>	Mangrove	3214.1	63.0
	Saltmarsh	1215.4	23.8
	Sand and mud flats	1379.2	27.0
	Salt flat	1396.8	27.4
<u>Other</u>	Human modified	169.5	3.3
	Water reach	514.2	10.1

Table 2: Summary of marine megafauna observed during aerial ecological assessment surveys by subregions, and in total.

Marine Megafauna - NT-WA shoreline survey																
Ordered West to East – Broome (WA) to Darwin (NT)																
Species / Subregion #	WA	WA	WA	WA	WA	WA	WA	WA	WA	WA	WA	NT	NT	NT	NT	Total
Dolphins – Family Delphinidae	2	3	0	12	5	8	2	25	17	20	7	0	0	0	1	102
Dugongs – <i>Dugong dugong</i>	0	0	0	0	3	2	0	12	18	10	2	0	0	2	1	50
Whales – <i>Cetacea</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Turtles – <i>Chelonia</i> or <i>Caretta</i> spp	20	36	6	71	32	8	10	135	283	29	4	0	1	2	3	640
Sea turtle tracks – <i>Chelonia</i> or <i>Caretta</i> spp	0	0	0	0	1	18	6	7	4	1	0	0	0	0	0	37
Saltwater crocodiles - <i>Crocodylus porosus</i>	0	0	0	7	0	2	0	3	1	1	0	0	0	0	0	14
Rays – Superorder Batoidea	0	10	1	5	1	3	1	52	5	11	0	0	0	0	4	93
Sharks – Superorder: Selachimorph	0	2	0	1	4	0	1	7	6	2	0	0	0	0	0	23
TOTAL observed	22	52	7	96	46	41	20	241	334	74	13	0	1	4	9	960

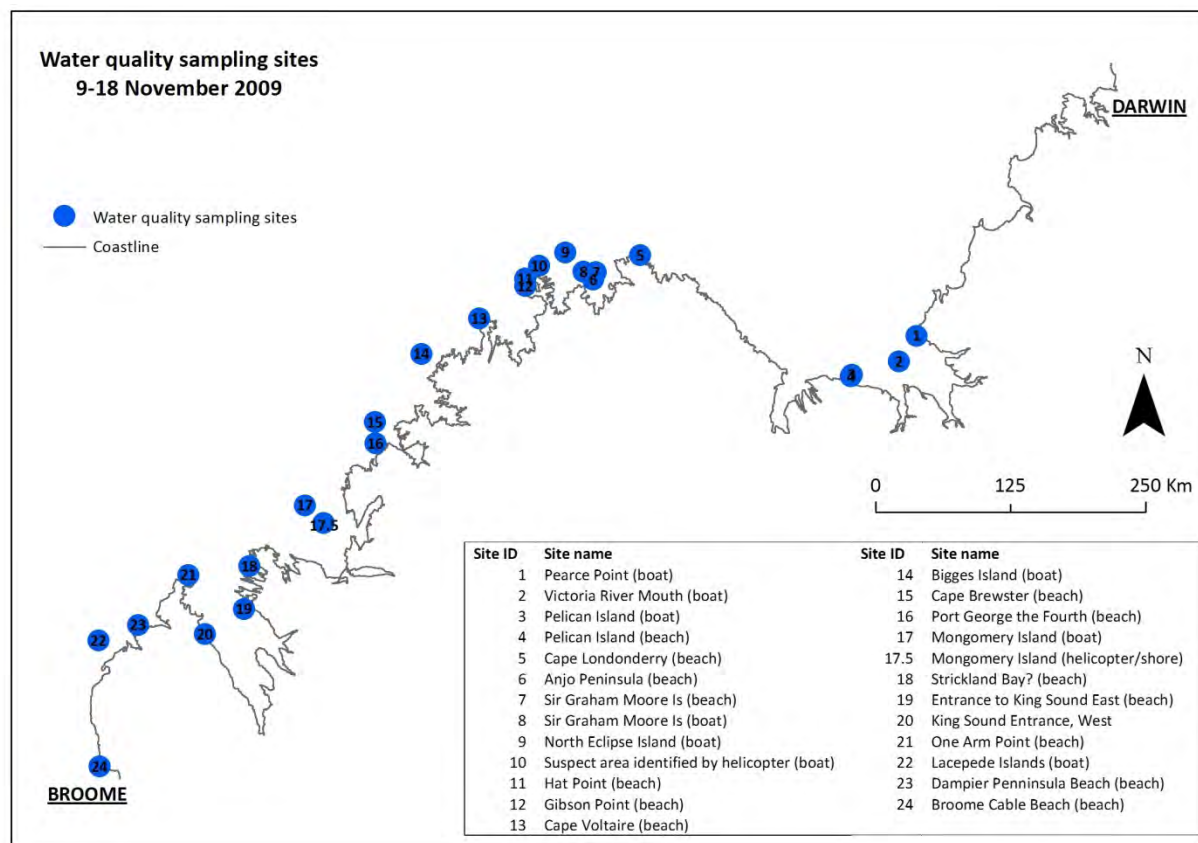


Figure 8: Location of water and sediment sampling sites for the 24 samples collected and dispatched to PTTEPAA for analysis.

Survey region and sub region background data

Table 3: Coastline data for the complete survey region. Source OzCoasts 2009

Total NT-WA Survey – Darwin (NT) to Broome (WA)		
Features	Total	Relevance to Australia
Annual Rainfall –range & mean (mm)	600-1688 (1190)	Dry & hot
Number of estuaries listed	114	~7 estuar./subregion
Total Catchment Area (km ²)	599,885	
Average Catchment Area (km ²)	5262	Large catchments
Total Estuary Length (km)	2041	
Average Estuary Length (km)	17.9	Large estuaries
Tidal Range (in m)	6.10	High
Condition Status	Near Pristine to Modified	Very low disturbance by humans
Area of Mangrove (km ²)	2827.47	~1/3 of national total
Area of Salt Marsh (km ²)	6613.15	
WCI% from Region Total	30.0	
Total Tidal Wetland (km ²)	9440.63	
BOM 1998 Climatic Area	Dry hot steppe - Summer drought to Tropical Savannah - Wet Autumn	
Mangrove species number	22	43 in Australia
Mangrove species limit west	11	

Table 4: Coastline data for the Northern Territory region of surveyed coast (Darwin (NT) to the NT/WA border. Source OzCoasts 2009.

NT-WA Survey – Northern Territory (NT) section.		
Features	NT	Relevance to survey region
Annual Rainfall –range & mean (mm)	1134-1688 (1515)	Moderate overall
Number of estuaries listed	23	~5 estuar./subregion
Total Catchment Area (km ²)	167232	27.9%
Average Catchment Area (km ²)	7271	Smaller in WA
Total Estuary Length (km)	619	30.3%
Average Estuary Length (km)	26.9	Shorter in WA
Tidal Range (in m)	5.42	High
Condition Status	Near Pristine to Modified	Low disturbance by humans
Area of Mangrove (km ²)	920.65	67.4%
Area of Salt Marsh (km ²)	2046.59	69.1%
WCI% from Region Total	31.0	Large saltpan areas
Total Tidal Wetland (km ²)	2967.23	31.4%
BOM 1998 Climatic Area	Mostly tropical savannah - wet autumn - uniform temp	
Mangrove species number	20	32 in NT
Mangrove species limit west	4	

Table 5: Coastline data for the Western Australia region of surveyed coast (NT/WA border to Broome WA). Source OzCoasts 2009.

NT-WA Survey – Western Australia (WA) section.		
Features	WA	Relevance to survey region
Annual Rainfall –range & mean (mm)	600-1400 (1042)	Semi-arid overall
Number of estuaries listed	91	~8 estuary/subregion
Total Catchment Area (km ²)	432,653	72.1%
Average Catchment Area (km ²)	4754	Larger in NT
Total Estuary Length (km)	1422	69.7%
Average Estuary Length (km)	15.6	Longer in NT
Tidal Range (in m)	6.42	Highest
Condition Status	Near Pristine to Largely Unmodified	Very low disturbance by humans
Area of Mangrove (km ²)	1906.83	67.4%
Area of Salt Marsh (km ²)	4566.57	69.1%
WCI% from Region Total	29.5	Large saltpan areas
Total Tidal Wetland (km ²)	6473.39	68.4%
BOM 1998 Climatic Area	Mostly dry hot steppe - summer drought	
Mangrove species number	17	18 in WA
Mangrove species limit west	6	

Table 6: Mangrove species present in the Northern Territory and Western Australia. Green highlights species with ranges within each shoreline region (source: Duke 1985). Crosses identify recorded species occurrence in the shoreline region.

Mangrove Species - NT-WA shoreline survey																
Ordered West to East – Broome (WA) to Darwin (NT)																
Species / Subregion #	WA 16	WA 15	WA 14	WA 13	WA 12	WA 11	WA 10	WA 9	WA 8	WA 7	WA 6	NT 5	NT 4	NT 3	NT 2	NT 1
<i>Acanthus ebracteatus</i>											X			X	X	
<i>Acanthus ilicifolius</i>														X	X	X
<i>Acrostichum speciosum</i>																X
<i>Aegialitis annulata</i>	X	X	X		X	X		X	X		X	X	X	X	X	X
<i>Aegiceras corniculatum</i>	X	X	X		X	X		X	X		X	X	X	X	X	X
<i>Avicennia integra</i>																
<i>Avicennia marina</i>	X	X	X		X	X		X	X		X	X	X	X	X	X
<i>Bruguiera exaristata</i>	X	X	X		X	X		X	X		X	X		X	X	X
<i>Bruguiera gymnorhiza</i>																X
<i>Bruguiera parviflora</i>			X		X	X		X					X		X	X
<i>Bruguiera sexangula</i>																
<i>Camptostemon schultzei</i>		X	X		X	X		X			X	X	X	X	X	X
<i>Ceriops australis</i>	X	X	X		X	X		X	X		X	X	X		X	X
<i>Ceriops decandra</i>															X	X
<i>Ceriops tagal</i>																
<i>Cynometra iripa</i>																
<i>Diospyros littorea</i>																
<i>Excoecaria agallocha</i>	X	X	X		X	X		X			X	X	X	X	X	X
<i>Lumnitzera littorea</i>															X	
<i>Lumnitzera racemosa</i>		X	X			X		X	X		X	X	X	X	X	X
<i>Nypa fruticans</i>																
<i>Osbornia octodonta</i>	X	X	X		X	X		X	X		X	X	X		X	X
<i>Pemphis acidula</i>		X							X							
<i>Rhizophora apiculata</i>																
<i>Rhizophora X lamarckii</i>																
<i>Rhizophora stylosa</i>	X	X	X		X	X		X	X		X	X	X	X	X	X
<i>Scyphiphora hydrophyllacea</i>									X						X	X
<i>Sonneratia alba</i>		X	X		X	X		X	X		X	X	X		X	X

Mangrove Species - NT-WA shoreline survey (continued)																
Ordered West to East – Broome (WA) to Darwin (NT)																
	WA	WA	WA	WA	WA	WA	WA	WA	WA	WA	WA	NT	NT	NT	NT	NT
Species / Subregion #	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<i>Sonneratia lanceolata</i>																
<i>Sonneratia X urama</i>																
<i>Xylocarpus granatum</i>						X										
<i>Xylocarpus moluccensis</i>			X		X	X		X	X		X	X	X	X	X	X
TOTAL recorded species	8	12	13	0	12	14	0	13	11	0	13	12	12	11	18	18
TOTAL species with range in the vicinity	11	13	15	15	15	16	16	16	17	17	18	18	18	19	21	22

3.1 Port Darwin (NT)

Coast section start: Lat: -12.47445,
 Long: 130.84674

Coast section end: Lat: -12.44232
 Long: 130.77077

Region includes Stokes Hill Wharf to Mandorah

- 198 km coast surveyed, making 4% of the total 5102 km.
- 90.8% of the shoreline region is mangrove.
- 312.70 km² of mangrove habitat occurs within the region (OzCoasts 2009), calculated as 1.58 km² mangrove habitat per kilometer of coastline surveyed in the region.
- 32.2 km of coast has been modified by human activity (16.4% of the region).
- Estuaries in this region include Darwin Harbour, Woods Inlet, West Arm, Middle Arm, East Arm and Reichardt Creek.
- No marine megafauna were sighted in the Port Darwin region.

Table 7: Summary of coastal characteristics in Port Darwin region.

		km	% of region
<u>Physical characteristics</u>	Rocky	23.7	12.0
	Beach	10.5	5.3
	Flat	170.4	86.2
	Dune	14.7	7.4
	Other wetland	0.3	0.1
<u>Vegetated habitat type</u>	Mangrove	179.5	90.8
	Saltmarsh	61.8	31.2
	Fringing coral	0.0	0.0
	Seagrass verge	0.0	0.0
	Coastal Woodland	156.3	79.0
<u>State of erosion and deposition</u>	Deposition	0.3	0.2
	Erosion	15.6	7.9
	Stable	174.3	88.2
<u>Tidal wetlands</u>	Mangrove	179.5	90.8
	Saltmarsh	61.8	31.2
	Sand and mud flats	149.0	75.4
	Salt flat	88.5	44.8
<u>Other</u>	Human modified	32.4	16.4
	Water reach	16.5	8.3

Port Darwin (NT):

Figure 9: Representative coastline imagery from the Port Darwin region. Image numbers are unique within the electronic database

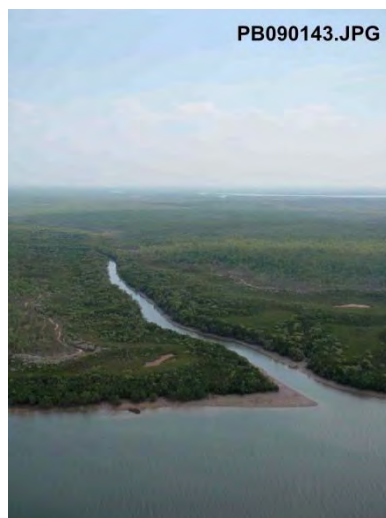


Table 8: Coastline data for the Port Darwin region. Source OzCoasts 2009.

NT-WA Survey – 1. Port Darwin, NT		
Features	#1	Relevance to survey region
Annual Rainfall –range & mean (mm)	1609-1684 (1646)	Above average
Number of estuaries listed	6	Below average
Total Catchment Area (km2)	3821	Below average size
Total Estuary Length (km)	93.4	Below average size
Tidal Range (in m)	5.45	
Condition Status	Near Pristine to Modified	Low disturbance by humans
Area of Mangrove (km2)	312.70	
Area of Salt Marsh (km2)	59.74	
WCI% from Region Total	84.0	
Total Tidal Wetland (km2)	372.44	
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn - Uniform temp	
Mangrove species number	18	22 in vicinity
Mangrove species limit west	1	

Table 9: Estuary data for notable estuaries within the Port Darwin (NT) shoreline region. Source NLWRA; 1998.

NT-WA Survey 1. Port Darwin, NT				
Feature / Location	Darwin Harbour	Woods Inlet	East Arm	Reichardt Creek
NLWRA Estuary Reference#	98	99	102	103
Latitude S	12.421	12.480	12.495	12.467
Longitude E	130.802	130.760	130.888	130.890
Annual Rainfall – mean (mm)	1684	1673	1618	1609
Catchment Area (km2)	1990	80	498	47
Estuary Length (km)	20.15	7.72	21.21	3.52
Tidal Range (in m)	5.5	5.4	5.5	5.5
Condition Status	LU	P	MOD	MOD
Area of Mangrove (km2)	171.85	10.92	32.25	8.28
Area of Salt Marsh (km2)	34.97	0.63	11.63	0.96
Wetland Cover Index (WCI %)	83.1	94.5	73.5	89.6
Total Tidal Wetland (km2)	206.82	11.55	43.88	9.24
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn - Uniform temp	Tropical Savannah - Wet Autumn - Uniform temp	Tropical Savannah - Wet Autumn - Uniform temp	Tropical Savannah - Wet Autumn - Uniform temp
Mangrove species number	16 (22)			7 (22)
Source of mangrove data:	GW85, NCD			NCD

Table 10: Mangrove species present in the Northern Territory and Western Australia. Green highlights species with ranges within the Port Darwin region (source: Duke 2006). Crosses identify recorded species occurrence in the listed estuary. Yellow denotes western limit of species range.

1. Port Darwin		
Species/ Locations	Darwin Harbour #98	Rapid Creek #103
<i>Acanthus ebracteatus</i> subsp. <i>ebarbatus</i>		
<i>Acanthus ilicifolius</i>		X
<i>Acrostichum speciosum</i>		X
<i>Aegialitis annulata</i>	X	
<i>Aegiceras corniculatum</i>	X	
<i>Avicennia integra</i>		
<i>Avicennia marina</i>	X	X
<i>Bruguiera exaristata</i>	X	X
<i>Bruguiera gymnorhiza</i>	X->	
<i>Bruguiera parviflora</i>	X	
<i>Bruguiera sexangula</i>		
<i>Campostemon schultzei</i>	X	
<i>Ceriops australis</i>	X	
<i>Ceriops decandra</i>	X	
<i>Ceriops tagal</i>		
<i>Cynometra iripa</i>		
<i>Diospyros littorea</i>		
<i>Excoecaria agallocha</i>	X	X
<i>Lumnitzera littorea</i>		
<i>Lumnitzera racemosa</i>	X	X
<i>Nypa fruticans</i>		
<i>Osbornia octodonta</i>	X	
<i>Pemphis acidula</i>		
<i>Rhizophora apiculata</i>		
<i>Rhizophora X lamarckii</i>		
<i>Rhizophora stylosa</i>	X	X
<i>Scyphiphora hydrophyllacea</i>	X	
<i>Sonneratia alba</i>	X	
<i>Sonneratia lanceolata</i>		
<i>Sonneratia X urama</i>		
<i>Xylocarpus granatum</i>		
<i>Xylocarpus moluccensis</i>	X	
TOTAL recorded	16	7
TOTAL in vicinity	22	22
Sources:	GW85, NCD	NCD

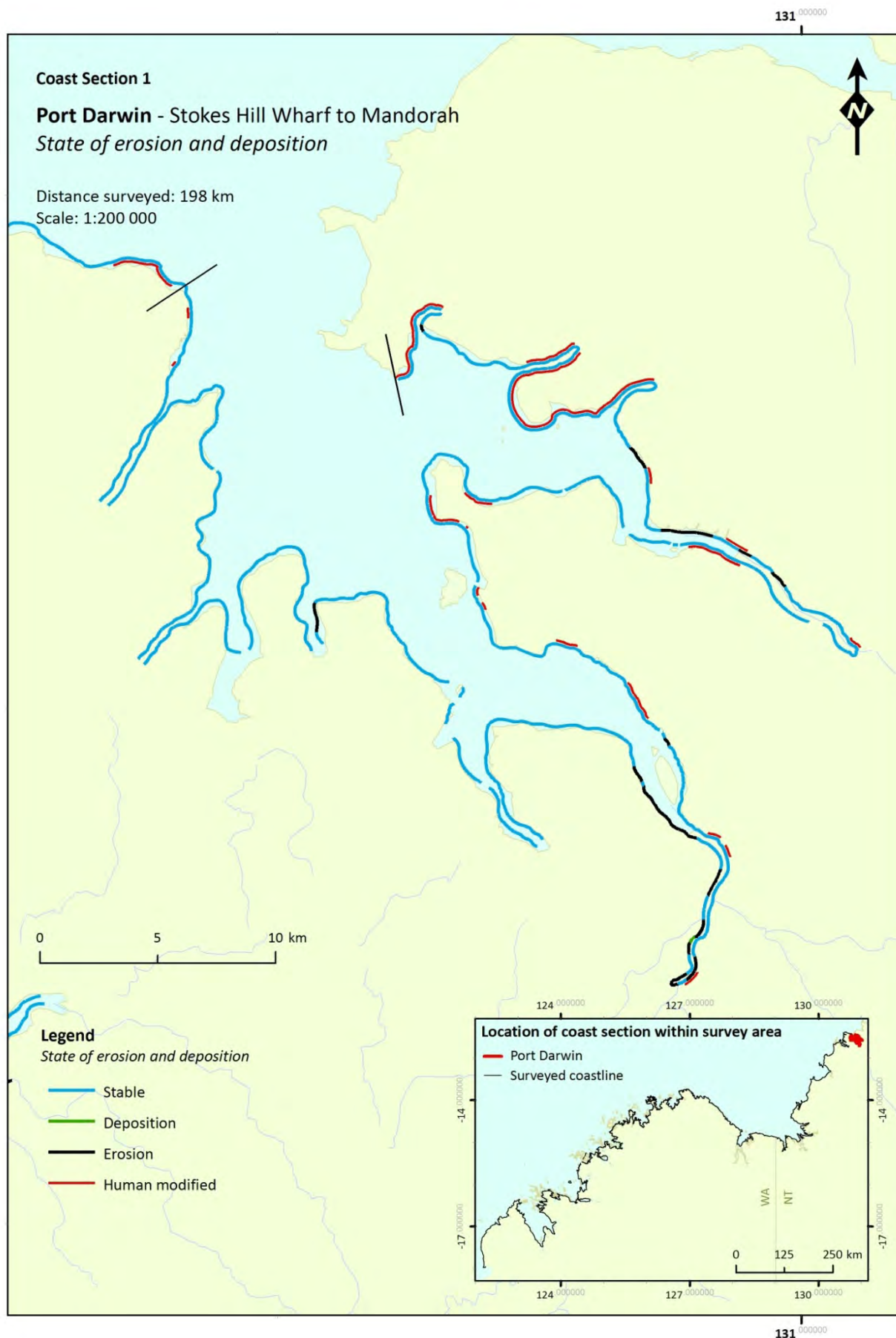


Figure 10: Shoreline stability in the Port Darwin survey region

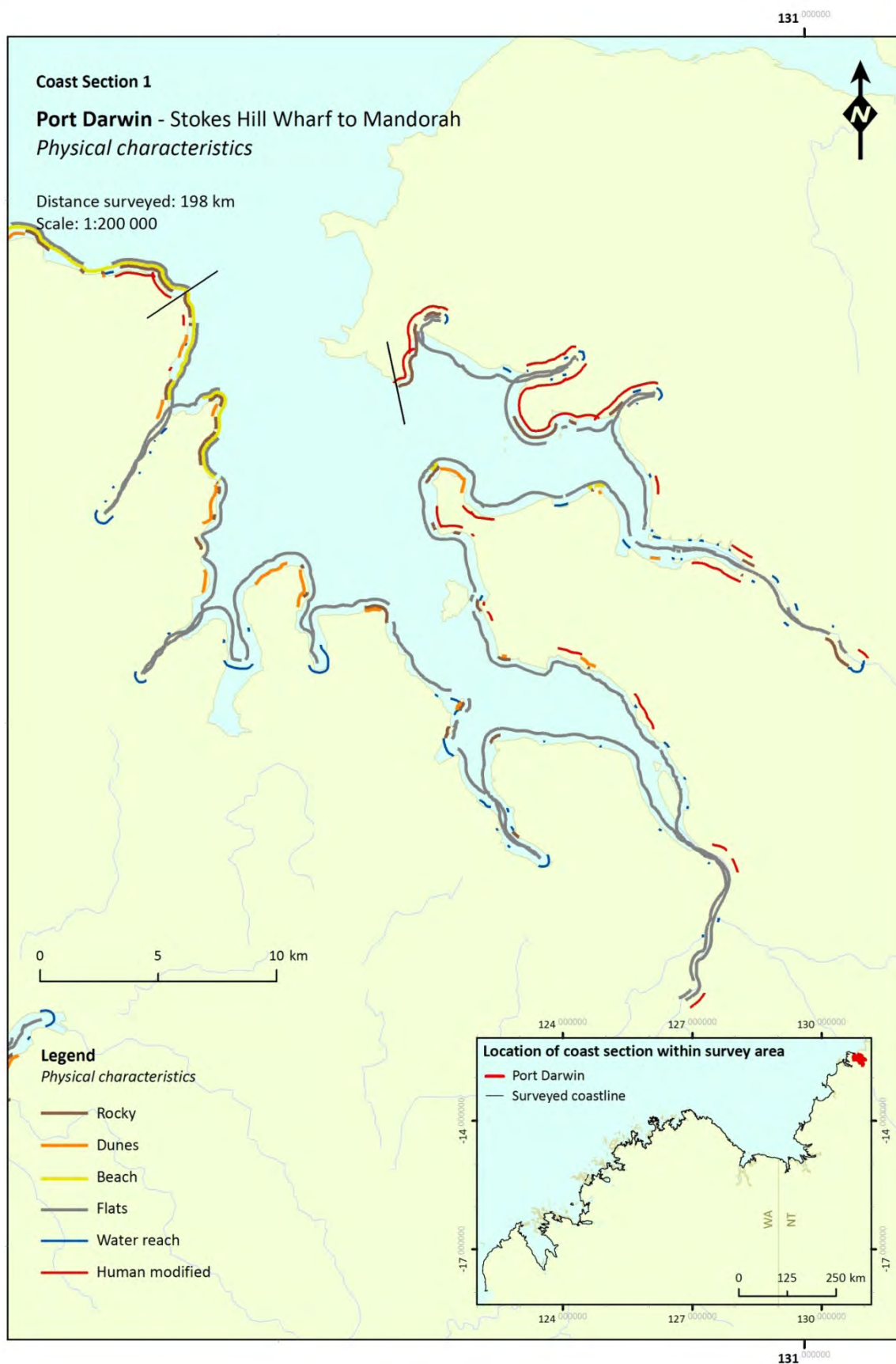


Figure 11: Physical characteristics of the Port Darwin survey region

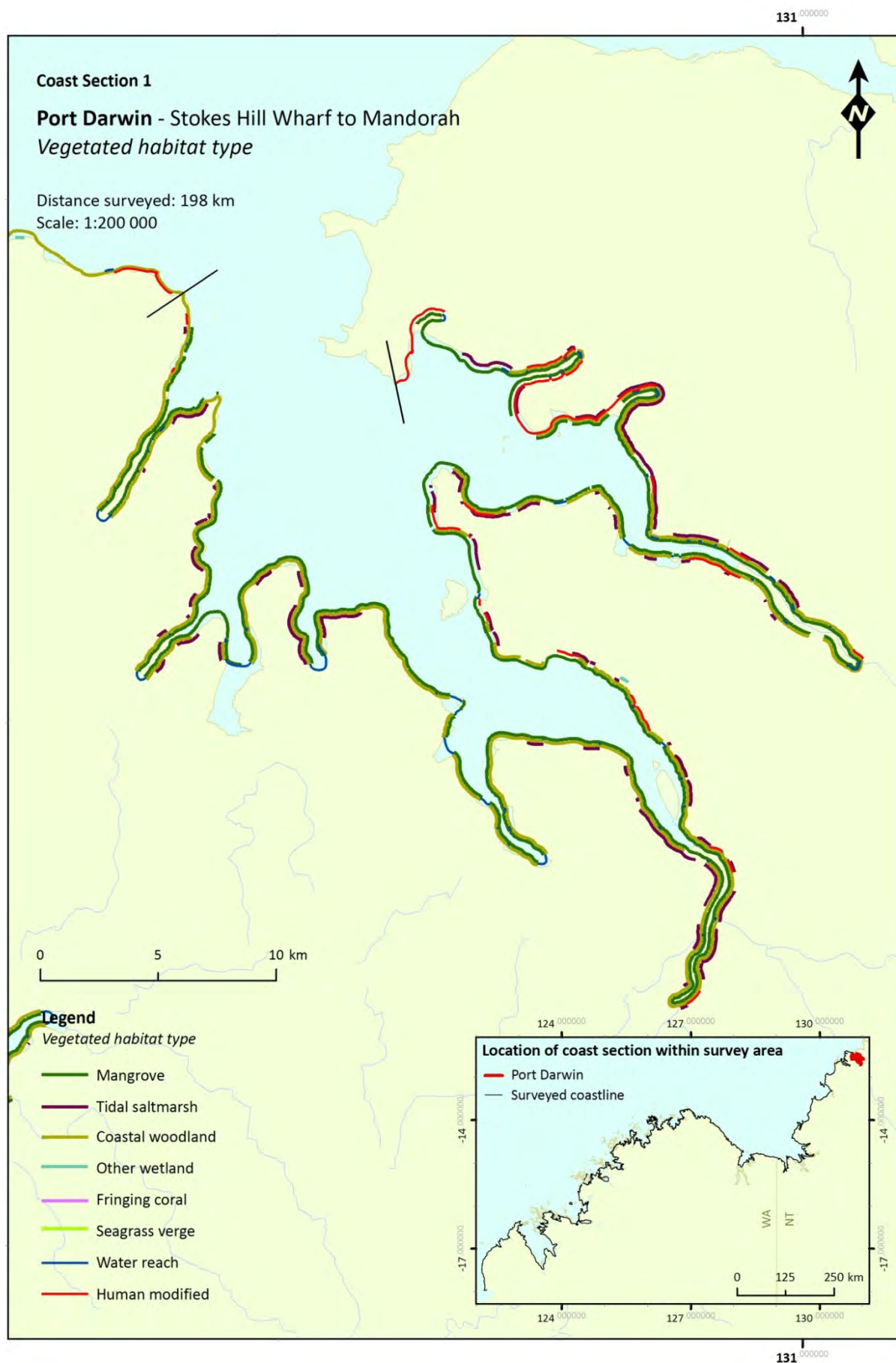


Figure 12: Vegetated habitat types within the Port Darwin survey region

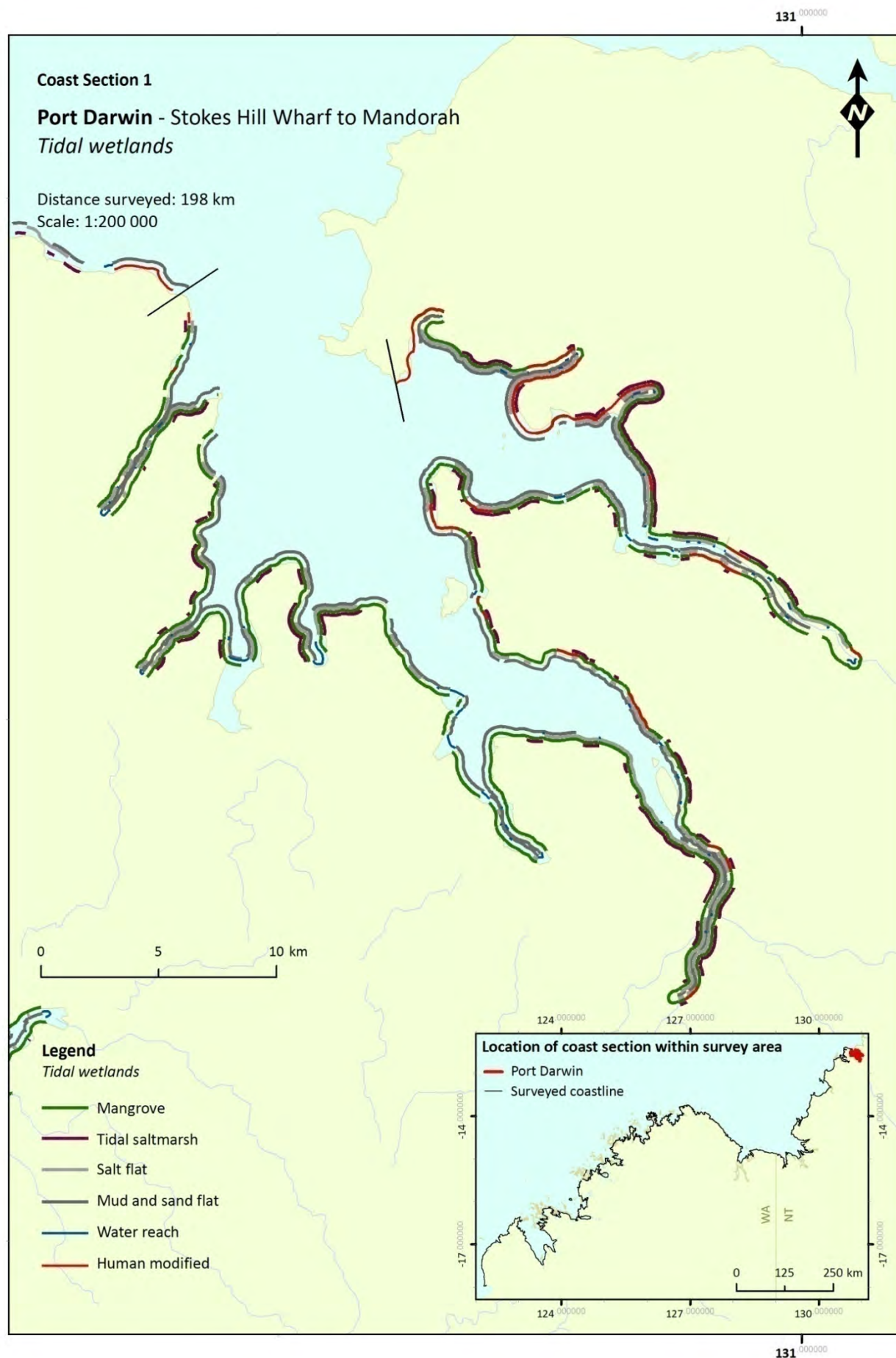


Figure 13: Tidal wetlands in the Port Darwin region

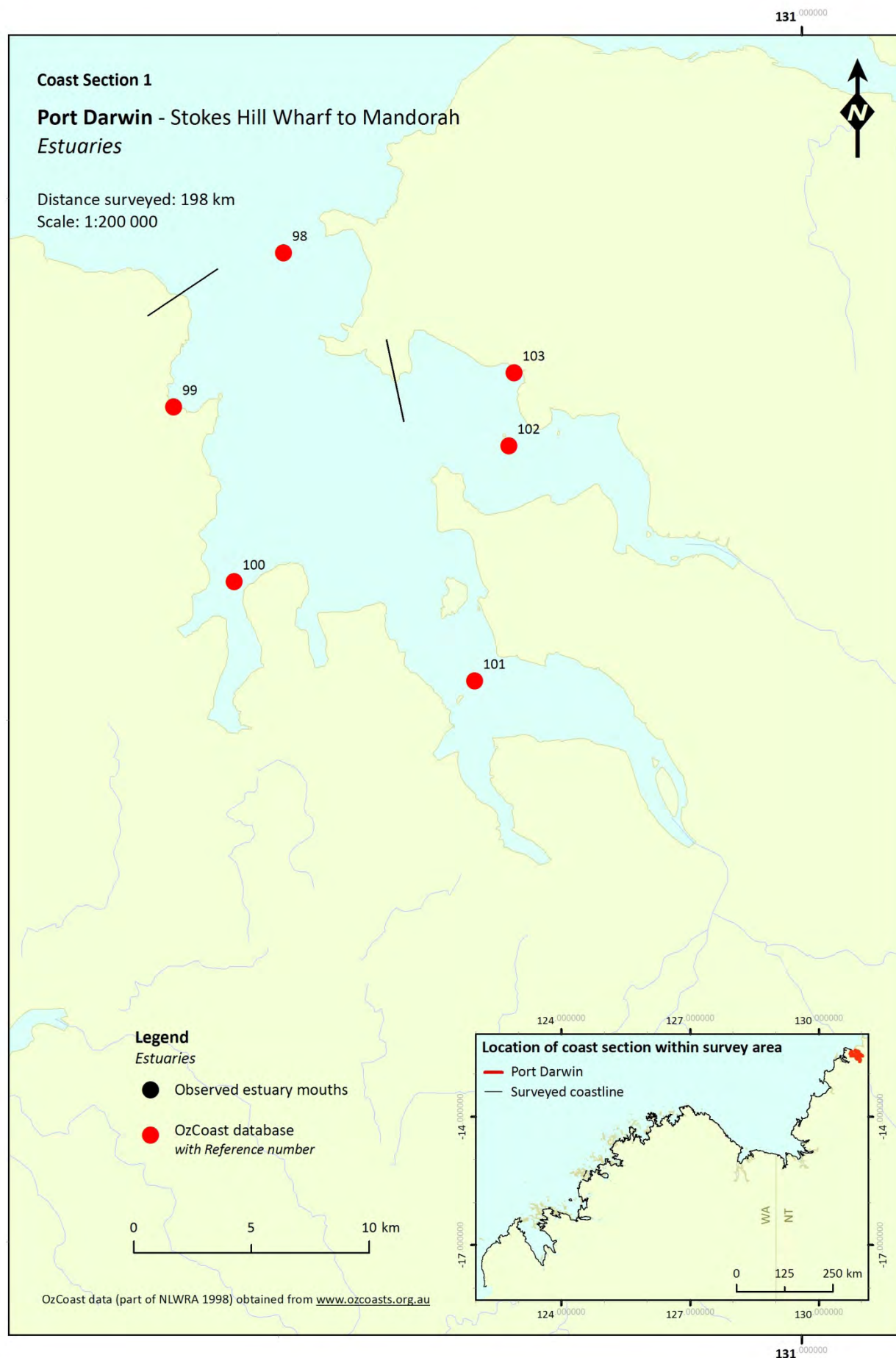


Figure 14: Estuaries in the Port Darwin region

3.2 Mandorah to Point Blaze (NT):

Coast section start: Lat: -12.43312
 Long: 130.76673
 Coast section end: Lat: -12.90963
 Long: 130.17198

Region includes Bynoe Harbour and Fog Bay

- 259 km coast surveyed, making 5% of the total 5102 km.
- 73% of the region is mangrove. Flats (sand, mud and salt) are found on 72.8% of the region. Total area of tidal wetland in the region is 180.55 km² (OzCoasts 2009), calculated as 0.7 km² tidal wetland per kilometer of coastline surveyed in the region.
- Human modification of the coast is lower than in the Darwin Port region, with 11% of the coast having been impacted by human activity (28.6 km).
- Coastal woodland is found on 211.7 km (76.5%) of coast above the intertidal region.
- Estuaries in this region include Finnis River, Bynoe Harbour & Corrawara Creek.
- Dugong, rays, one snubfin dolphin and three sea turtles were sighted during aerial surveys in the region.

Table 12: Summary of coastal characteristics in the Mandorah to Point Blaze region.

		km	% of region
<u>Physical characteristics</u>	Rocky	77.7	30.0
	Beach	74.0	28.6
	Flat	188.5	72.8
	Dune	82.3	31.8
	Other wetland	2.9	1.1
<u>Vegetated habitat type</u>	Mangrove	189.1	73.0
	Saltmarsh	69.0	26.7
	Fringing coral	1.9	0.7
	Seagrass verge	1.2	0.4
	Coastal Woodland	211.7	81.7
<u>State of erosion and deposition</u>	Deposition	11.5	4.4
	Erosion	25.8	9.9
	Stable	198.0	76.5
<u>Tidal wetlands</u>	Mangrove	189.1	73.0
	Saltmarsh	69.0	26.7
	Sand and mud flats	172.6	66.6
	Salt flat	75.3	29.1
<u>Other</u>	Human modified	28.6	11.0
	Water reach	22.3	8.6

Mandorah to Point Blaze (NT):

Figure 15: Representative coastline imagery from the Mandorah to Pt Blaze region. Image numbers are unique within the electronic database



Table 13: Summary of marine megafauna observed during aerial surveys of Mandorah to Point Blaze (NT).

Common name	Genus/Species	Total observed
Australian snubfin dolphin	<i>Orcaella heinsohni</i>	1
Indo-Pacific bottlenose	<i>Tursiops aduncas</i>	0
Unidentified dolphin species	Family Delphinidae	0
Sea turtle	<i>Chelonia</i> or <i>Caretta</i> spp	3
Sea turtle track	<i>Chelonia</i> or <i>Caretta</i> spp	0
Dugong	<i>Dugong dugong</i>	1
Whale	Order Cetacea	0
Manta ray	<i>Manta birostris</i>	0
Ray species	Superorder Batoidea	4
Saltwater crocodile	<i>Crocodylus porosus</i>	0
Unidentified shark species	Superorder: Selachimorph	0

Table 14: Coastline data for the Mandorah to Point Blaze region (NT). Source OzCoasts 2009.

NT-WA Survey – 2. Mandorah to Point Blaze, NT		
Features	#2	Relevance to survey region
Annual Rainfall –range & mean (mm)	1600-1688 (1649)	Above average
Number of estuaries listed	4	Below average
Total Catchment Area (km2)	4303	Below average size
Total Estuary Length (km)	78.1	Below average size
Tidal Range (in m)	5.20	
Condition Status	Near Pristine to Largely Unmodified	Low disturbance by humans
Area of Mangrove (km2)	165.96	
Area of Salt Marsh (km2)	14.59	
WCI% from Region Total	91.9	
Total Tidal Wetland (km2)	180.55	
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn	
Mangrove species number	18	21 in vicinity
Mangrove species limit west	2	

Table 15: Estuary data for notable estuaries within the Mandorah to Point Blaze region (NT) .
 Source NLWRA; 1998.

NT-WA Survey 2. Mandorah to Point Blaze, NT				
Feature / Location	Finnis River	Port Paterson, NT014	Bynoe Harbour	Corrawarra Creek
NLWRA Estuary Reference#	94	95	96	97
Latitude S	12.890	12.671	12.560	12.449
Longitude E	130.335	130.386	130.543	130.618
Annual Rainfall – mean (mm)	1600	1642	1666	1688
Catchment Area (km2)	2823	275	1014	191
Estuary Length (km)	16.48	13.64	40.64	7.38
Tidal Range (in m)	5.2	5.2	5.2	5.2
Condition Status	LU	P	P	P
Area of Mangrove (km2)	6.79	13.50	139.94	5.73
Area of Salt Marsh (km2)	7.33	2.86	4.00	0.40
Wetland Cover Index (WCI %)	48.1	82.5	97.2	93.5
Total Tidal Wetland (km2)	14.12	16.36	143.94	6.13
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn	Tropical Savannah - Wet Autumn	Tropical Savannah - Wet Autumn	Tropical Savannah - Wet Autumn
Mangrove species number		14 (20)	17 (21)	
Source of mangrove data:		GW85	GW85	

Table 16: Mangrove species present in the Northern Territory and Western Australia. Green highlights species with ranges within the Mandorah to Point Blaze region (NT) (source: Duke 2006). Crosses identify recorded species occurrence in the listed estuary. Yellow denotes western limit of species range.

2. Mandorah to Point Blaze		
Species/ Locations	Port Paterson NT014 #95	Bynoe Harbour #96
<i>Acanthus ebracteatus</i> subsp. <i>ebarbatus</i>		X
<i>Acanthus ilicifolius</i>		X
<i>Acrostichum speciosum</i>		
<i>Aegialitis annulata</i>	X	X
<i>Aegiceras corniculatum</i>	X	X
<i>Avicennia integra</i>		
<i>Avicennia marina</i>	X	X
<i>Bruguiera exaristata</i>	X	X
<i>Bruguiera gymnorhiza</i>		
<i>Bruguiera parviflora</i>	X	X
<i>Bruguiera sexangula</i>		
<i>Camptostemon schultzei</i>	X	X
<i>Ceriops australis</i>	X	X
<i>Ceriops decandra</i>		X->
<i>Ceriops tagal</i>		
<i>Cynometra iripa</i>		
<i>Diospyros littorea</i>		
<i>Excoecaria agallocha</i>	X	X
<i>Lumnitzera littorea</i>	X->	
<i>Lumnitzera racemosa</i>	X	X
<i>Nypa fruticans</i>		
<i>Osbornia octodonta</i>	X	X
<i>Pemphis acidula</i>		
<i>Rhizophora apiculata</i>		
<i>Rhizophora X lamarckii</i>		
<i>Rhizophora stylosa</i>	X	X
<i>Scyphiphora hydrophyllacea</i>		X
<i>Sonneratia alba</i>	X	X
<i>Sonneratia lanceolata</i>		
<i>Sonneratia X urama</i>		
<i>Xylocarpus granatum</i>		
<i>Xylocarpus moluccensis</i>	X	X
TOTAL recorded	14	17
TOTAL in vicinity	20	21
Sources:	GW85	GW85

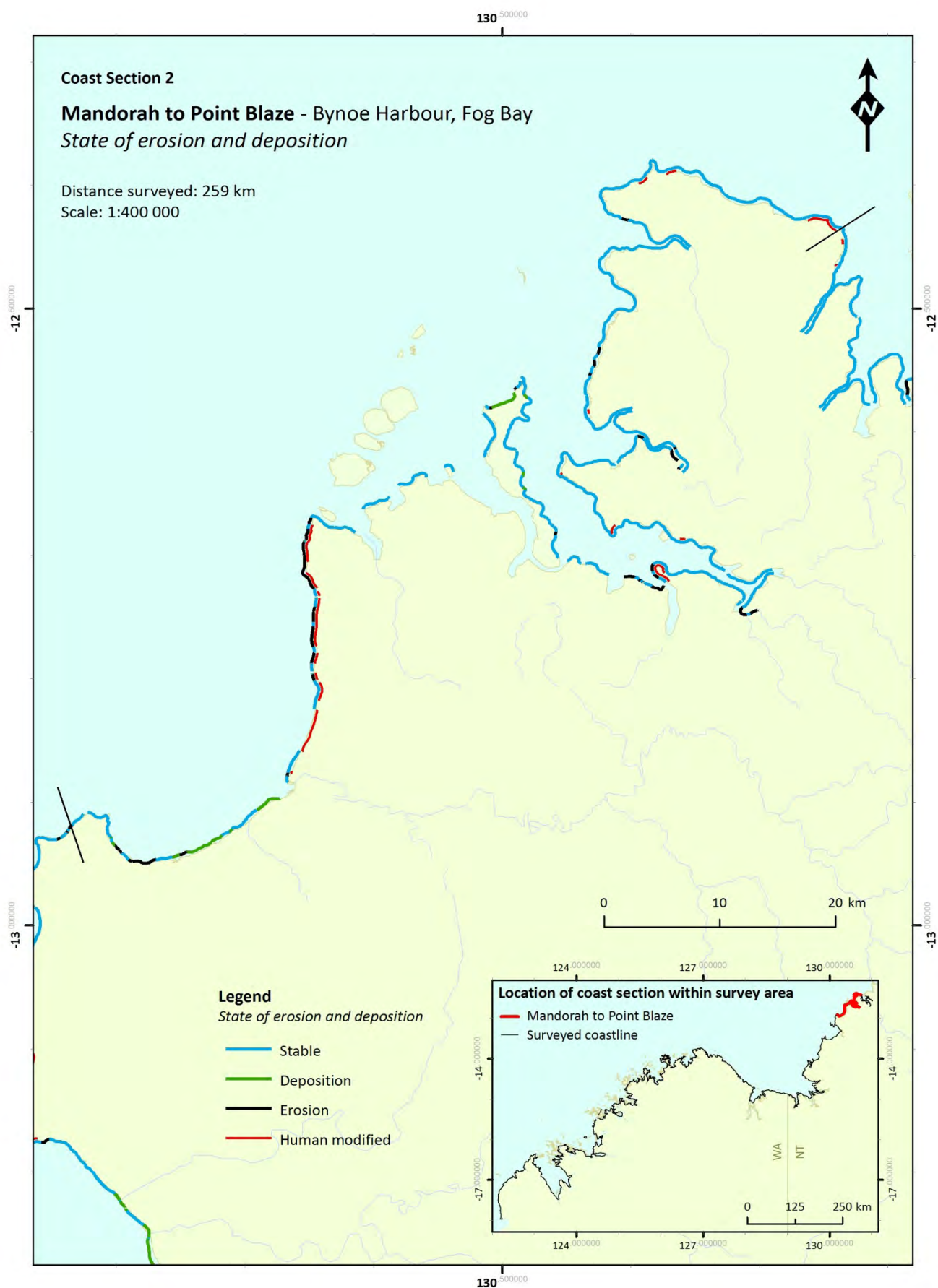


Figure 16: Bank stability within the Mandorah to Pt Blaze region

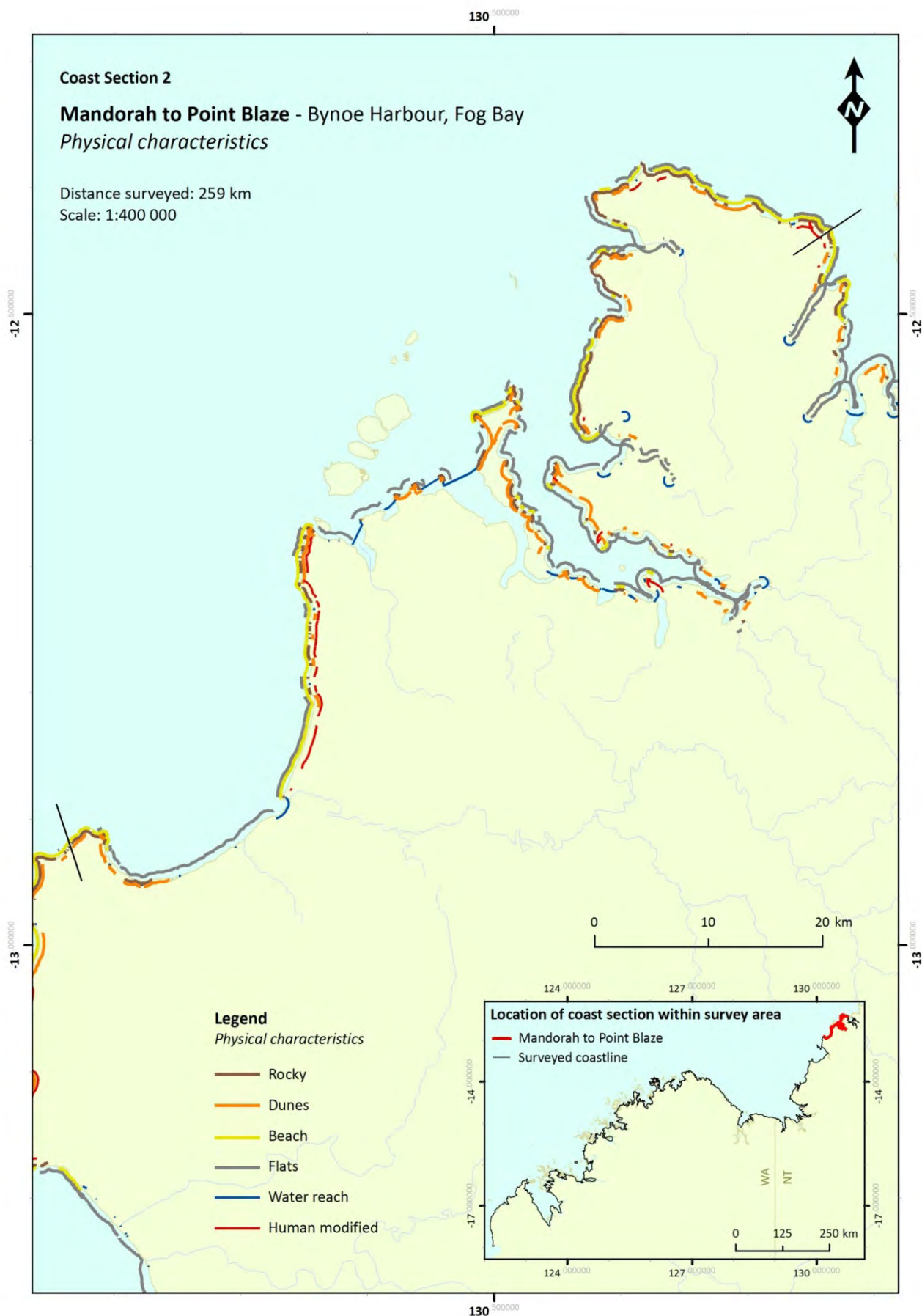


Figure 17: Shoreline physical characteristics in the Mandorah to Pt Blaze region

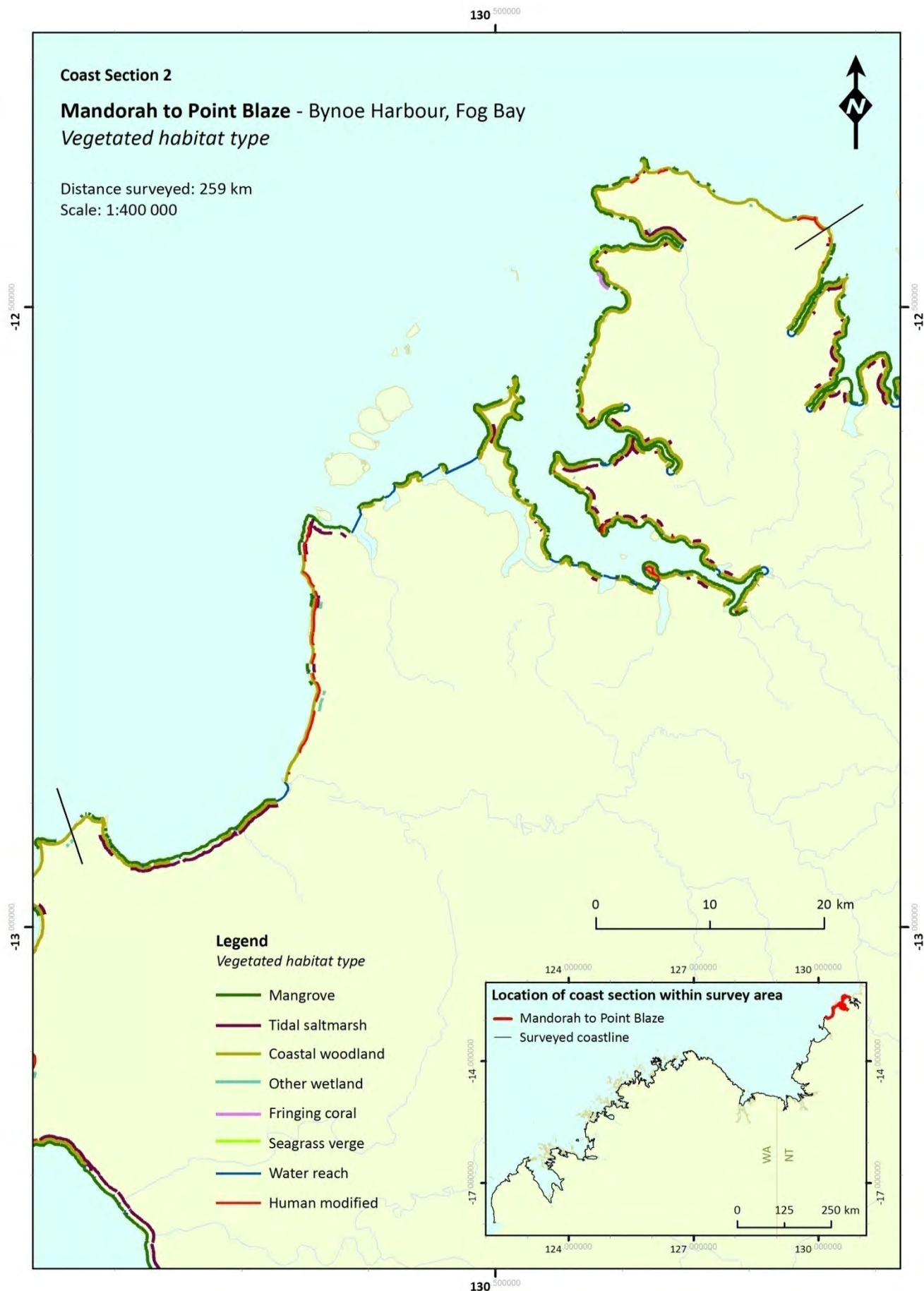


Figure 18: Vegetated habitat types within the Mandorah to Pt Blaze region

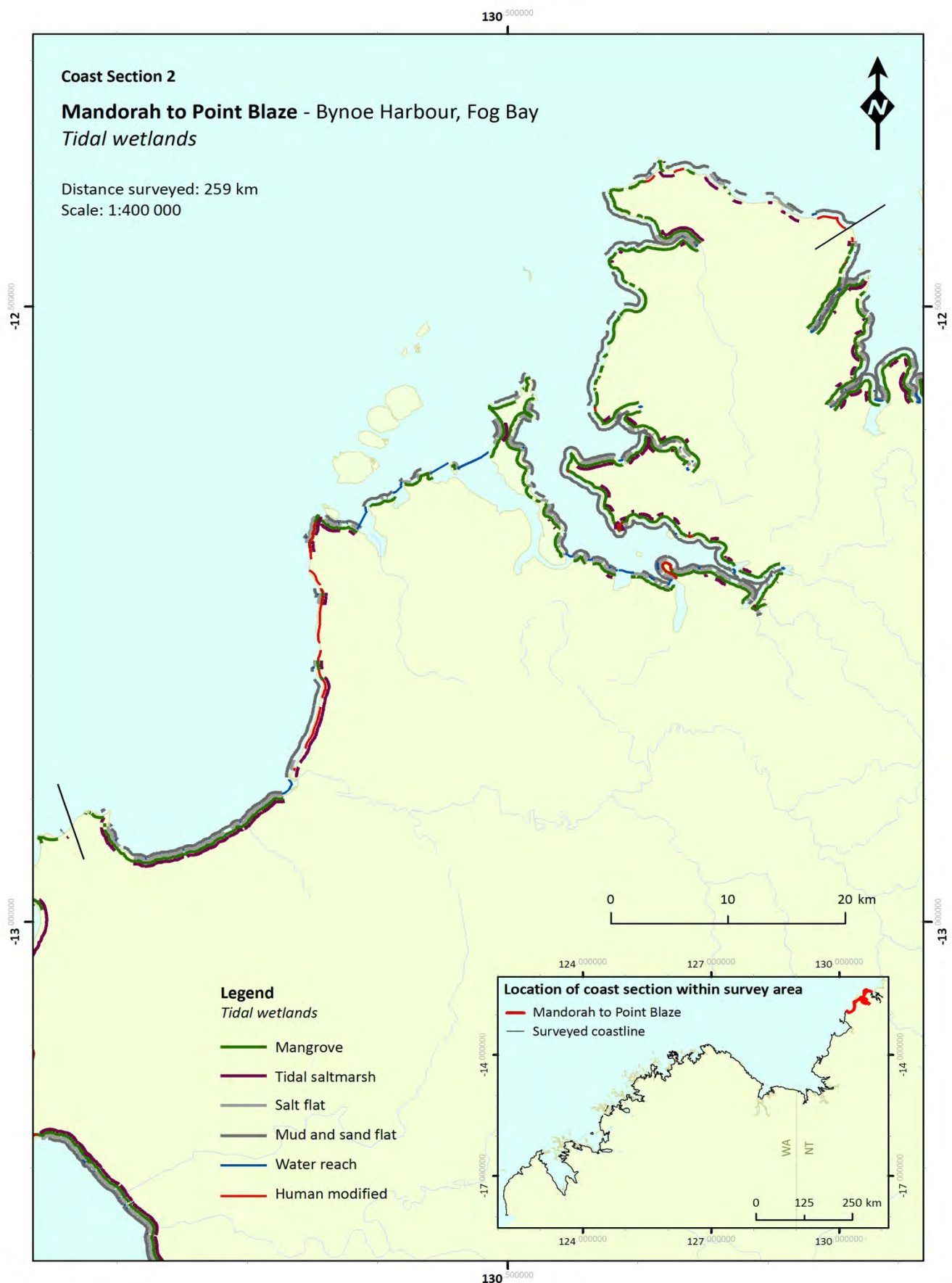


Figure 19: Tidal wetlands within the Mandorah to Pt Blaze region

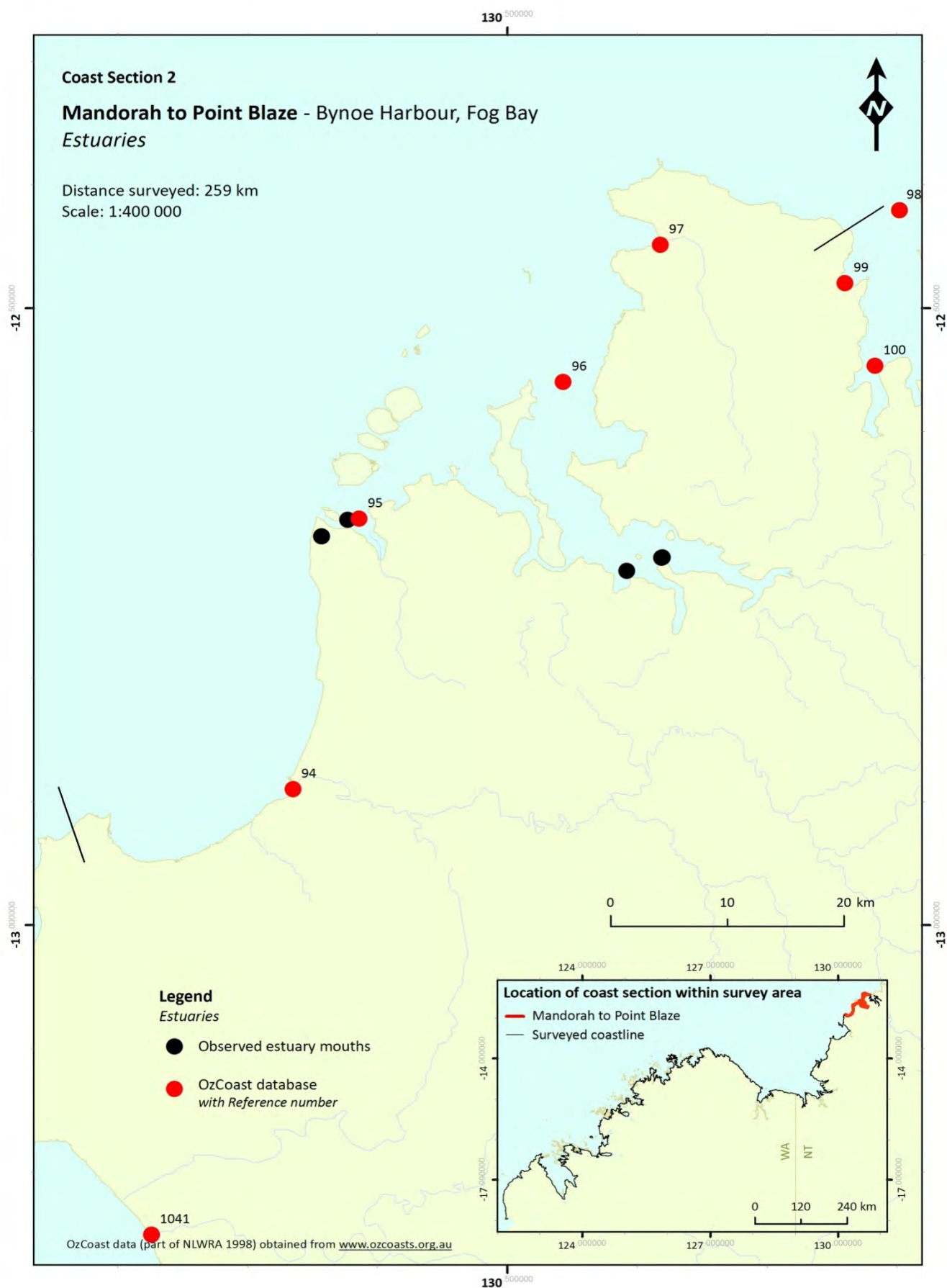


Figure 20: Estuaries within the Mandorah to Pt Blaze region

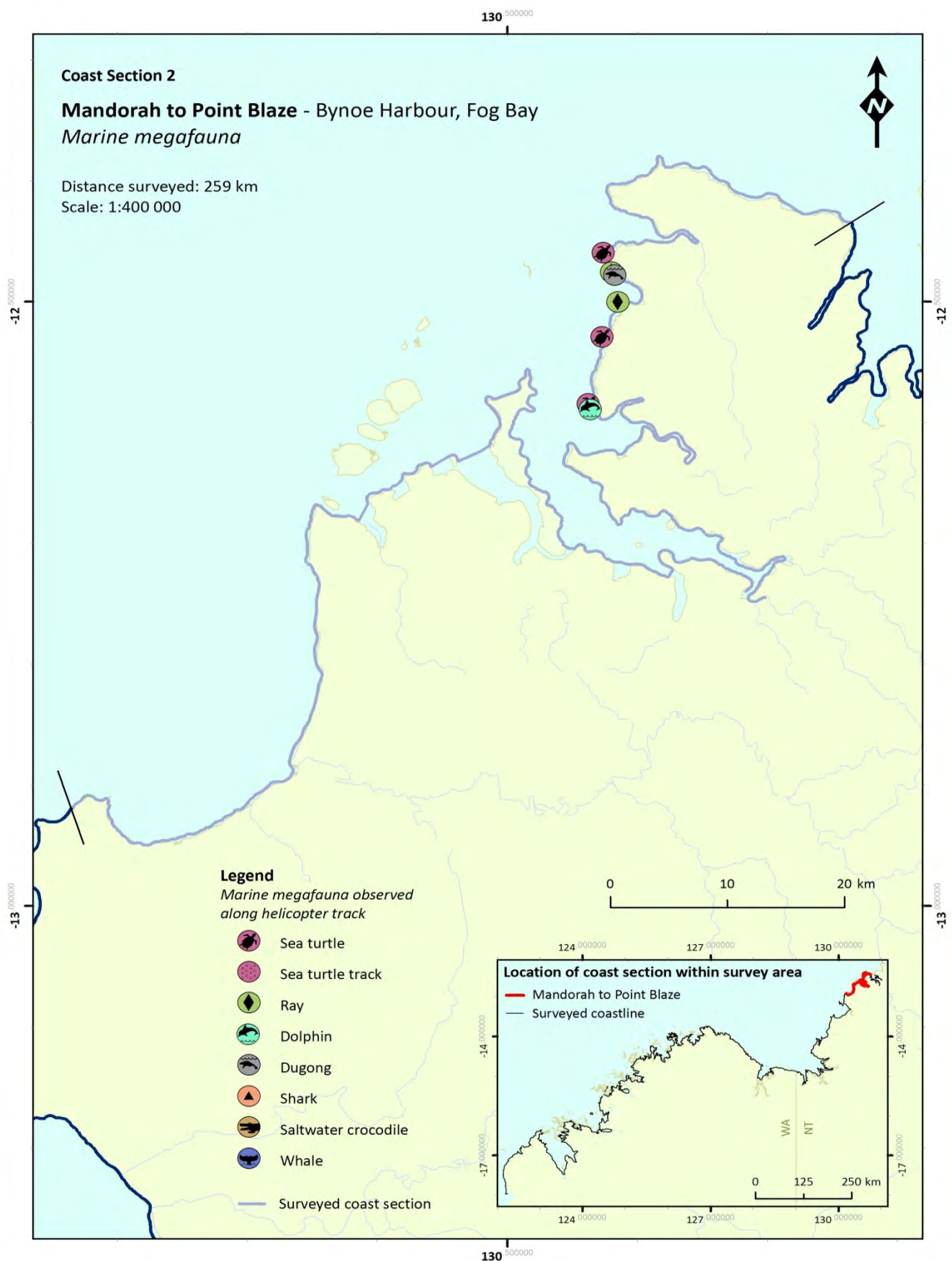


Figure 21: Marine megafauna observed in the Mandorah to Pt Blaze region

3.3 Point Blaze to Cape Ford (NT)

Coast section start: Lat: -12.91714
 Long: 130.16413

Coast section end: Lat: -13.43934
 Long: 129.90061

Region includes Daly River, North and South Peron Islands and Anson Bay

- 161 km coast surveyed, making 3% of the total 5102 km.
- Mangroves grow along 91.4 km of coast in this region, 56.9%. Total area of tidal wetland in the region is 26.68 km² (OzCoasts 2009), calculated as 0.17 km² tidal wetland per kilometer of coastline surveyed in the region.
- Beaches dominate in this region, spanning 119.2 km of coastline (74.3%).
- Human modification of the coast is low in this region (14.6 km, 9.1%).
- Estuaries in this region include the mouths of the Daly River and Reynolds River.
- Marine megafauna in this region included sea turtles and Dugong.

Table 17: Summary of coastal characteristics in Point Blaze to Cape Ford region.

		km	% of region
<u>Physical characteristics</u>	Rocky	43.6	27.2
	Beach	119.2	74.3
	Flat	114.5	71.3
	Dune	77.8	48.4
	Other wetland	1.4	0.8
<u>Vegetated habitat type</u>	Mangrove	91.4	56.9
	Saltmarsh	60.7	37.8
	Fringing coral	0.0	0.0
	Seagrass verge	0.0	0.0
	Coastal Woodland	117.4	73.1
<u>State of erosion and deposition</u>	Deposition	11.9	7.4
	Erosion	19.6	12.2
	Stable	125.2	78.0
<u>Tidal wetlands</u>	Mangrove	91.4	56.9
	Saltmarsh	60.7	37.8
	Sand and mud flats	111.3	69.3
	Salt flat	44.5	27.7
<u>Other</u>	Human modified	14.6	9.1
	Water reach	6.5	4.1

Point Blaze to Cape Ford (NT)

Figure 22: Representative coastline imagery from the Pt Blaze to Cape Ford region. Image numbers are unique within the electronic database



Table 18: Summary of marine megafauna observed during aerial surveys of Point Blaze to Cape Ford (NT).

Common name	Genus/Species	Total observed
Australian snubfin dolphin	<i>Orcaella heinsohni</i>	0
Indo-Pacific bottlenose	<i>Tursiops aduncas</i>	0
Unidentified dolphin species	Family Delphinidae	0
Sea turtle	<i>Chelonia</i> or <i>Caretta</i> spp	2
Sea turtle track	<i>Chelonia</i> or <i>Caretta</i> spp	0
Dugong	<i>Dugong dugong</i>	2
Whale	Order Cetacea	0
Manta ray	<i>Manta birostris</i>	0
Ray species	Superorder Batoidea	0
Saltwater crocodile	<i>Crocodylus porosus</i>	0

Table 19: Coastline data for the Point Blaze to Cape Ford, NT region. Source OzCoasts 2009.

NT-WA Survey – 3. Point Blaze to Cape Ford, NT		
Features	#3	Relevance to survey region
Annual Rainfall –range & mean (mm)	1500-1520 (1510)	Above average
Number of estuaries listed	2	Far below average
Total Catchment Area (km2)	53776	Above average size
Total Estuary Length (km)	65.8	Below average
Tidal Range (in m)	5.60	
Condition Status	Near Pristine	Virtually no disturbance by humans
Area of Mangrove (km2)	3.22	
Area of Salt Marsh (km2)	23.46	
WCI% from Region Total	12.1	
Total Tidal Wetland (km2)	26.68	
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn	
Mangrove species number	11	19 in vicinity
Mangrove species limit west	1	

Table 20: Estuary data for notable estuaries within the Point Blaze to Cape Ford (NT) shoreline region. Source NLWRA; 1998.

NT-WA Survey 3. Point Blaze to Cape Ford, NT		
Feature / Location	Daly River	Reynolds River
NLWRA Estuary Reference#	93	1041
Latitude S	13.312	13.251
Longitude E	130.232	130.226
Annual Rainfall – mean (mm)	1500	1520
Catchment Area (km2)	53776	
Estuary Length (km)	65.76	
Tidal Range (in m)	5.6	
Condition Status	P	
Area of Mangrove (km2)	3.22	
Area of Salt Marsh (km2)	23.46	
Wetland Cover Index (WCI %)	12.1	
Total Tidal Wetland (km2)	26.68	
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn	
Mangrove species number	11 (19)	
Source of mangrove data:	GW85	

Table 21: Mangrove species present in the Point Blaze to Cape Ford, NT region. Green highlights species with ranges within the Port Darwin region (source: Duke 2006). Crosses identify recorded species occurrence in the listed estuary. Yellow denotes western limit of species range.

3. Point Blaze to Cape Ford	
Species/ Locations	Daly River #93
<i>Acanthus ebracteatus</i> subsp. <i>ebarbatus</i>	X
<i>Acanthus ilicifolius</i>	X->
<i>Acrostichum speciosum</i>	
<i>Aegialitis annulata</i>	X
<i>Aegiceras corniculatum</i>	X
<i>Avicennia integra</i>	
<i>Avicennia marina</i>	X
<i>Bruguiera exaristata</i>	X
<i>Bruguiera gymnorhiza</i>	
<i>Bruguiera parviflora</i>	
<i>Bruguiera sexangula</i>	
<i>Campostemon schultzii</i>	X
<i>Ceriops australis</i>	
<i>Ceriops decandra</i>	
<i>Ceriops tagal</i>	
<i>Cynometra iripa</i>	
<i>Diospyros littorea</i>	
<i>Excoecaria agallocha</i>	X
<i>Lumnitzera littorea</i>	
<i>Lumnitzera racemosa</i>	X
<i>Nypa fruticans</i>	
<i>Osbornia octodonta</i>	
<i>Pemphis acidula</i>	
<i>Rhizophora apiculata</i>	
<i>Rhizophora</i> X <i>lamarckii</i>	
<i>Rhizophora stylosa</i>	X
<i>Scyphiphora hydrophyllacea</i>	
<i>Sonneratia alba</i>	
<i>Sonneratia lanceolata</i>	
<i>Sonneratia</i> X <i>urama</i>	
<i>Xylocarpus granatum</i>	
<i>Xylocarpus moluccensis</i>	X
TOTAL recorded	11
TOTAL in vicinity	19
Sources:	GW85

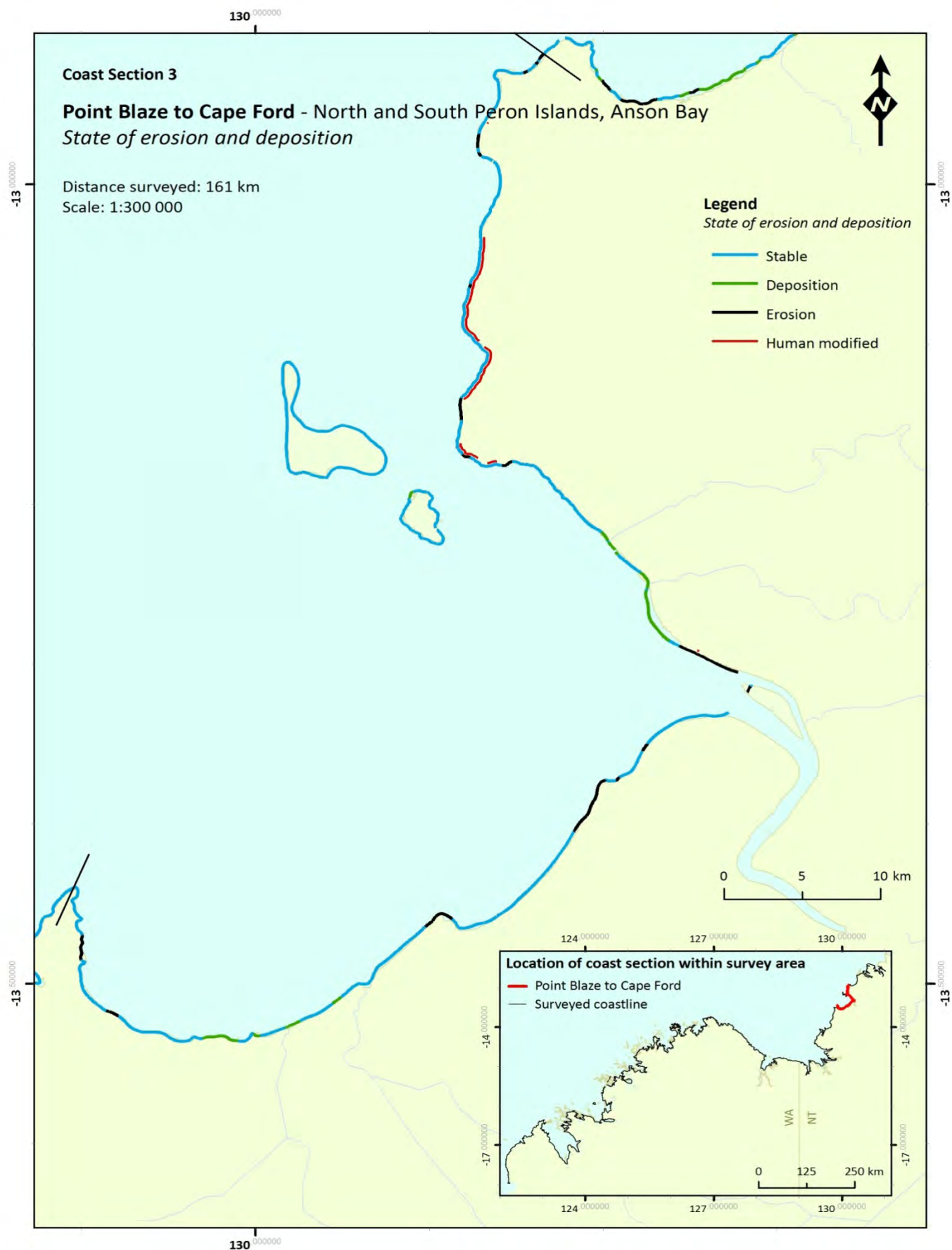


Figure 23: Bank stability within the Pt Blaze to Cape Ford region

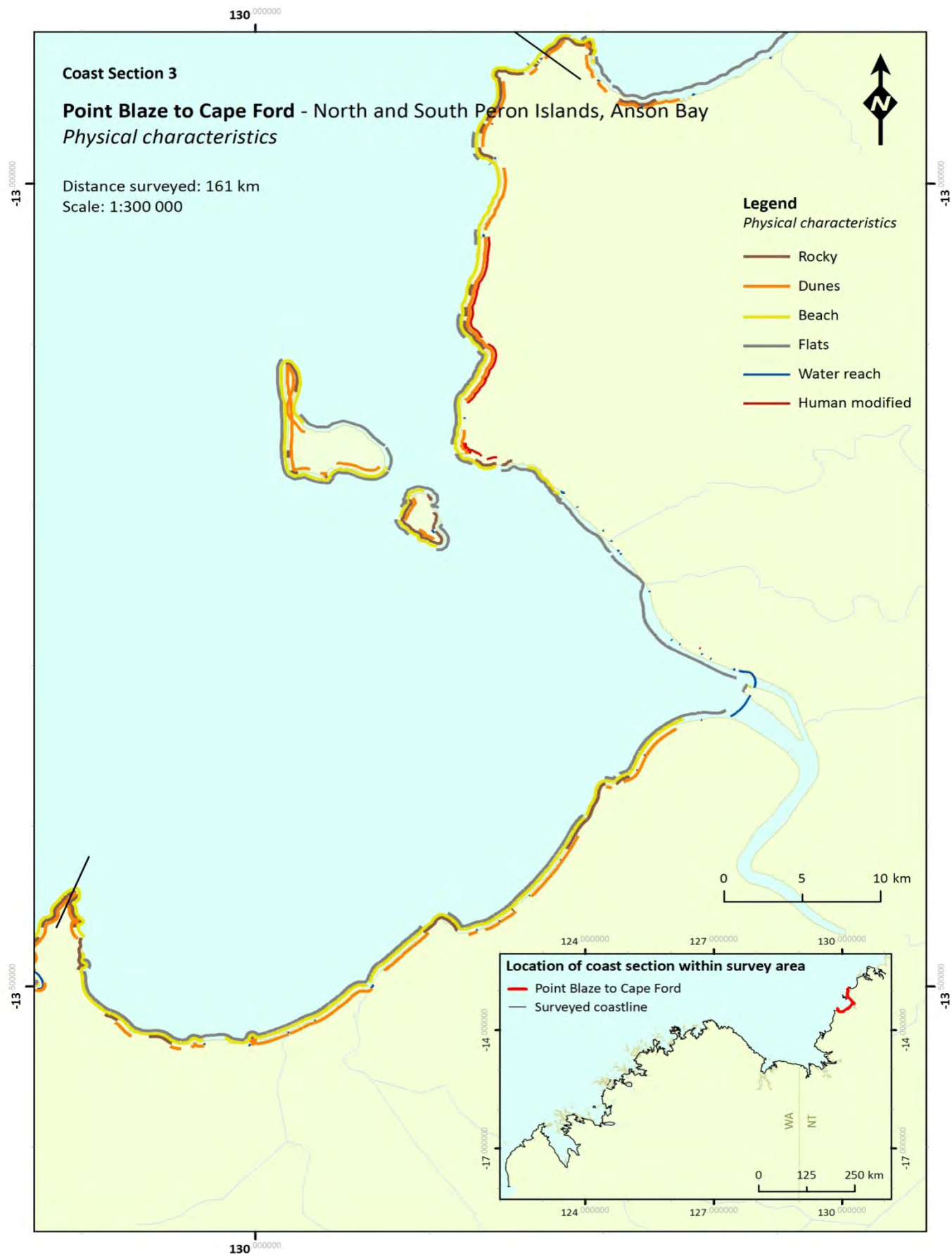


Figure 24: Shoreline physical characteristics in the Pt Blaze to Cape Ford region

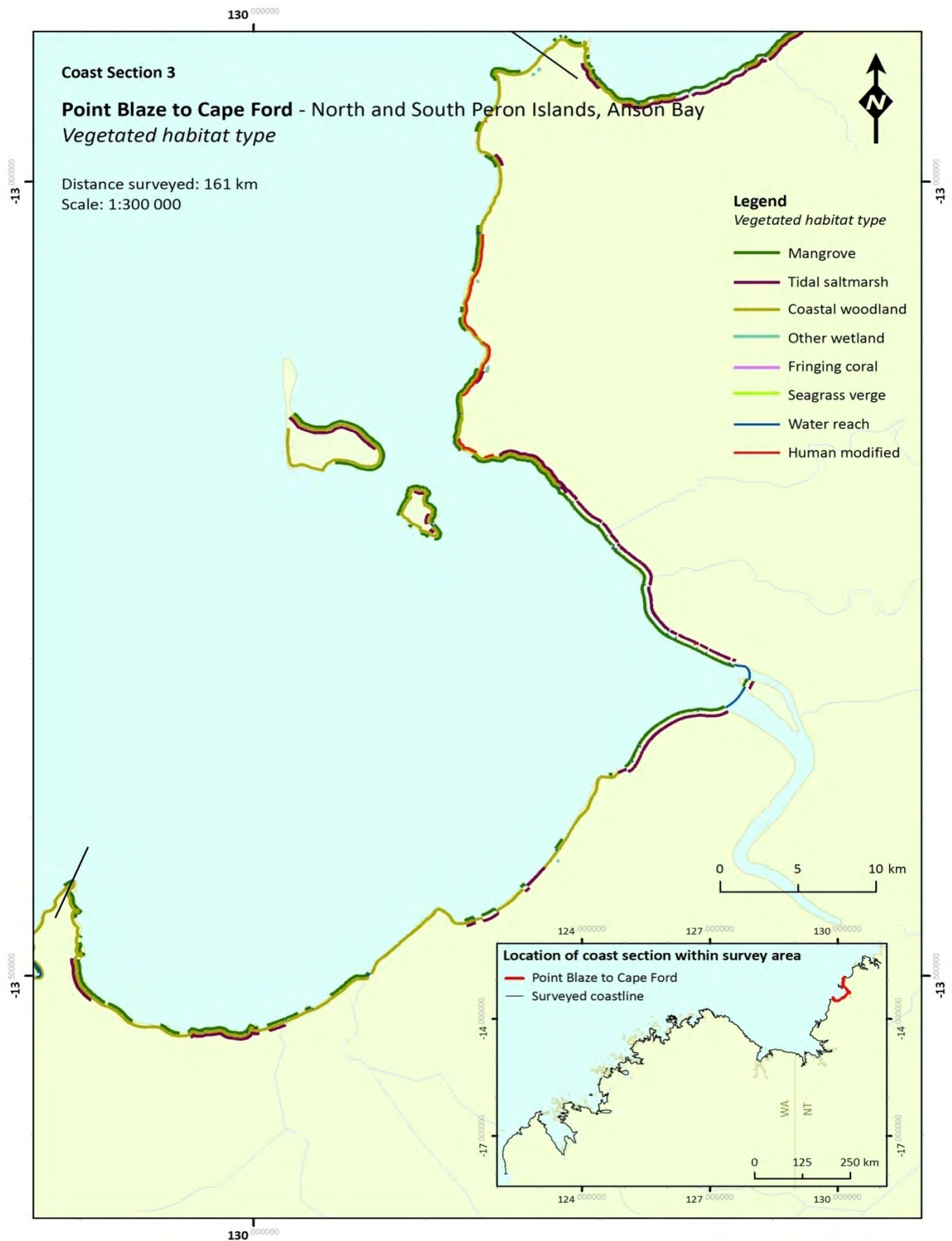


Figure 25: Vegetated habitat types in the Pt Blaze to Cape Ford region

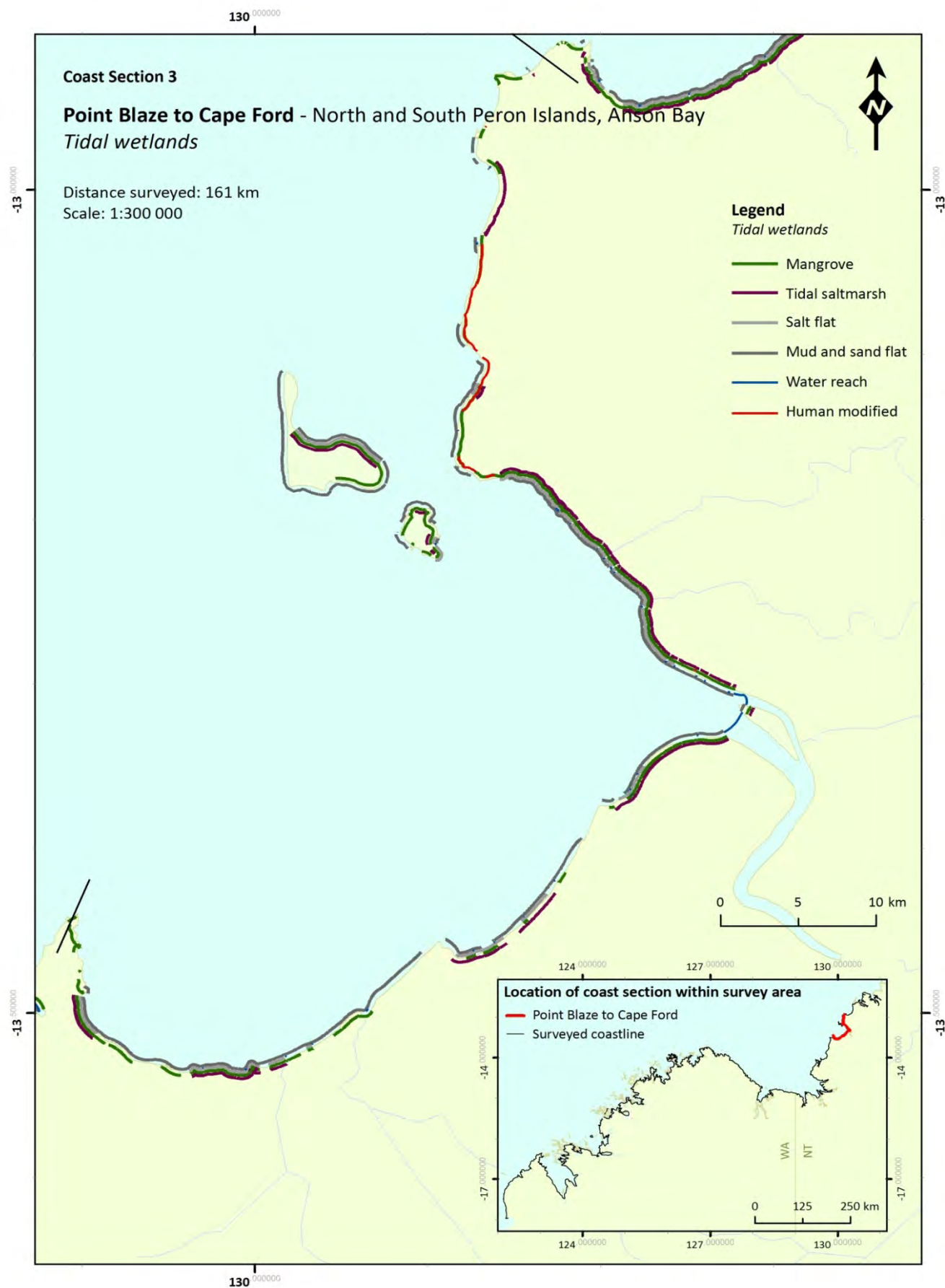


Figure 26: Tidal wetlands in the Pt Blaze to Cape Ford region

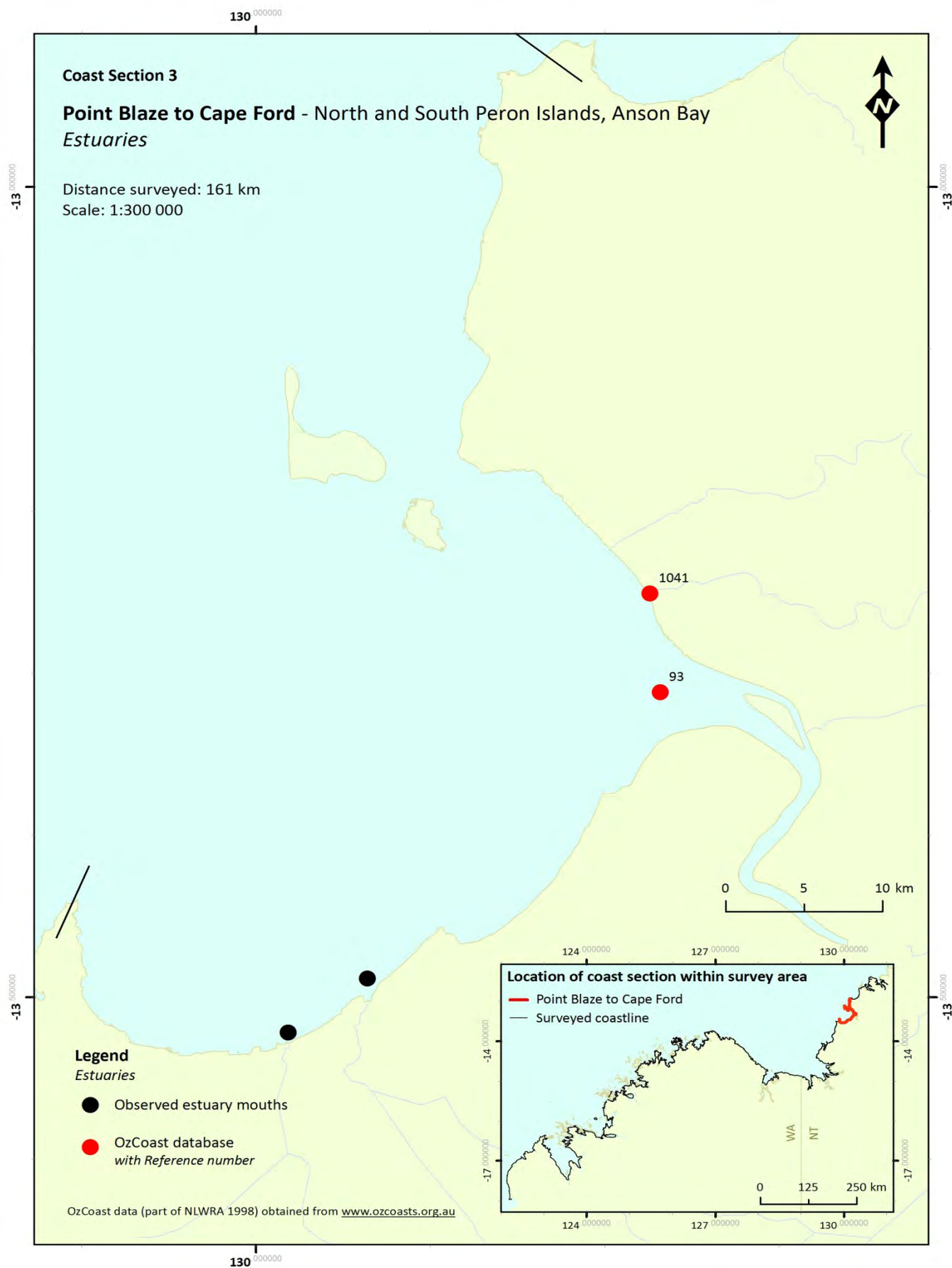


Figure 27: Estuaries within the Pt Blaze to Cape Ford region

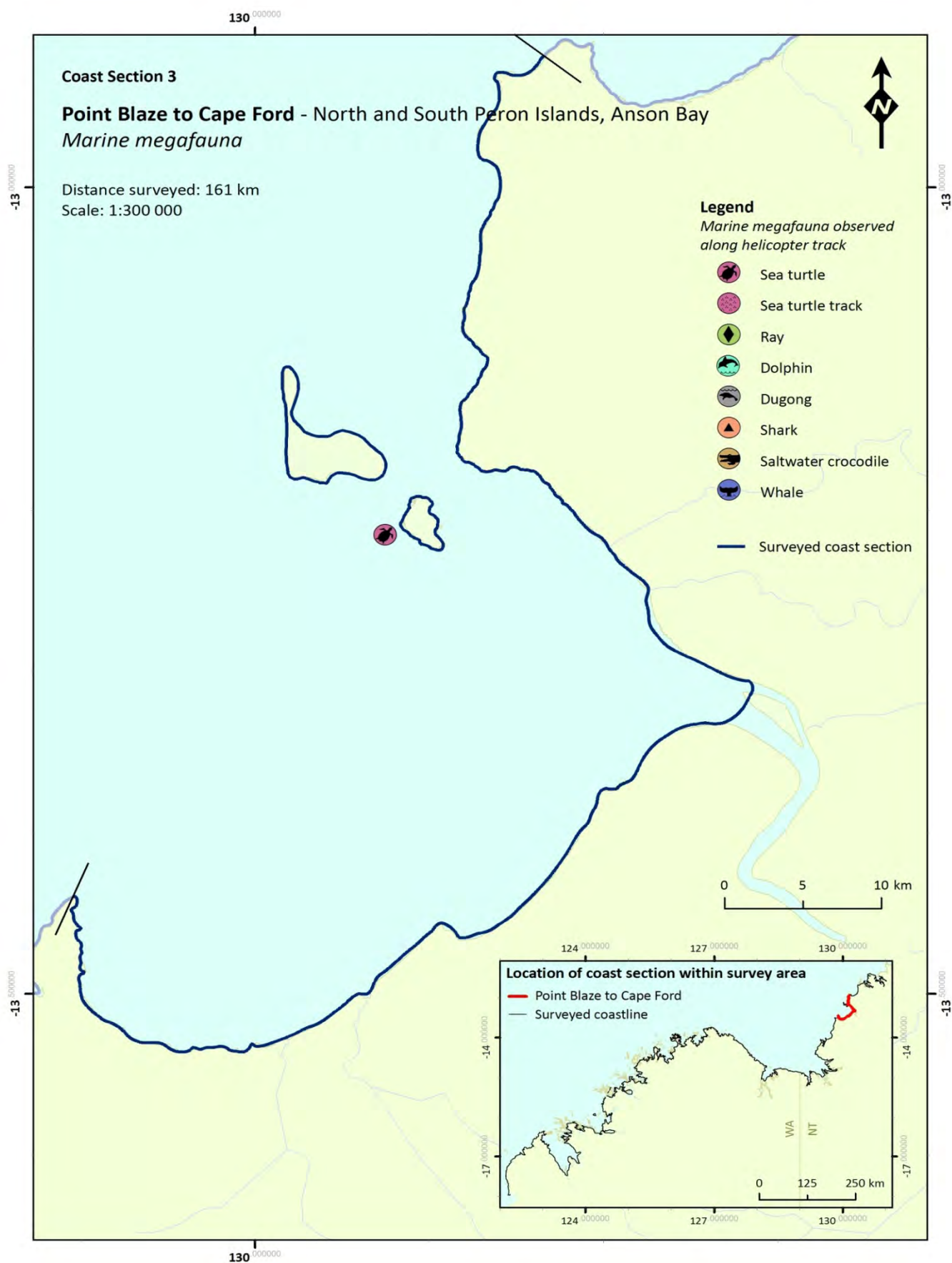


Figure 28: Marine megafauna observed in the Pt Blaze to Cape Ford region

3.4 Cape Ford to Pearce Point (NT)

Coast region start: Lat: -13.43925
 Long: 129.89579
 Coast region end: Lat: -14.42518
 Long: 129.35248

Region includes Moyle River and Port Keats

- 244 km coast surveyed, making 4% of the total 5102 km.
- Mangroves are found on 51.5% of the region, 115.2 km. Total area of tidal wetland in the region is 86.33 km² (OzCoasts 2009), calculated as 0.35 km² tidal wetland per kilometer of coastline surveyed in the region.
- Beaches dominate in this region, spanning 160.7 km of coastline (71.8% of the region).
- Human activities impact 5 km of coastline, 2.2% of the region.
- Estuaries include Port Keats, Moyle River and Little Moyle Inlet.
- Marine megafauna in this region was limited to one sea turtle sighting (*Caretta* or *Chelonia* spp.).

Table 22: Summary of coastal characteristics in Cape Ford to Pearce Point region.

		km	% of region
<u>Physical characteristics</u>	Rocky	75.4	33.7
	Beach	160.7	71.8
	Flat	132.5	59.3
	Dune	125.3	56.0
	Other wetland	3.7	1.7
<u>Vegetated habitat type</u>	Mangrove	115.2	51.5
	Saltmarsh	78.0	34.9
	Fringing coral	0.0	0.0
	Seagrass verge	0.0	0.0
	Coastal Woodland	180.1	80.5
<u>State of erosion and deposition</u>	Deposition	7.0	3.1
	Erosion	39.9	17.8
	Stable	174.5	78.0
<u>Tidal wetlands</u>	Mangrove	115.2	51.5
	Saltmarsh	78.0	34.9
	Sand and mud flats	86.1	38.5
	Salt flat	70.4	31.5
<u>Other</u>	Human modified	5.0	2.2
	Water reach	17.4	7.8

Cape Ford to Pearce Point (NT)

Figure 29: Representative coastline imagery from the Cape Ford to Pearce Point region.
Image numbers are unique within the electronic database



Table 23: Coastline data for the Cape Ford to Pearce Point region (NT). Source OzCoasts 2009.

NT-WA Survey – 4. Cape Ford to Pearce Point, NT		
Features	#4	Relevance to survey region
Annual Rainfall –range & mean (mm)	1522-1563 (1542)	Above average
Number of estuaries listed	4	Below average
Total Catchment Area (km2)	5832	Below average size
Total Estuary Length (km)	52.9	Below average size
Tidal Range (in m)	5.43	
Condition Status	Near Pristine	Virtually no disturbance by humans
Area of Mangrove (km2)	44.14	
Area of Salt Marsh (km2)	42.19	
WCI% from Region Total	51.1	
Total Tidal Wetland (km2)	86.33	
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn	
Mangrove species number	12	18 in vicinity
Mangrove species limit west	0	

Table 24: Estuary data for notable estuaries within the Cape Ford to Pearce Point region (NT). Source NLWRA; 1998.

NT-WA Survey 4. Cape Ford to Pearce Point, NT				
Feature / Location	Port Keats	NT009	Moyle River	Little Moyle Inlet
NLWRA Estuary Reference#	89	90	91	92
Latitude S	14.085	14.085	13.975	13.782
Longitude E	129.551	129.586	129.745	129.784
Annual Rainfall – mean (mm)	1563	1559	1522	1522
Catchment Area (km2)	322	373	3835	1302
Estuary Length (km)	18.32	13.45	9.69	11.4
Tidal Range (in m)	5.5	5.5	5.4	5.3
Condition Status	P	P	P	P
Area of Mangrove (km2)	21.78	6.11	2.80	13.45
Area of Salt Marsh (km2)	19.50	15.30	3.95	3.44
Wetland Cover Index (WCI %)	52.8	28.5	41.5	79.6
Total Tidal Wetland (km2)	41.28	21.41	6.75	16.89
BOM 1998 Climatic Area	Tropical Savannah - Wet Autumn	Tropical Savannah - Wet Autumn	Tropical Savannah - Wet Autumn	Tropical Savannah - Wet Autumn
Mangrove species number	11 (18)		6 (18)	
Source of mangrove data:	GW85		GW85	

Table 25: Mangrove species present in the Northern Territory and Western Australia. Green highlights species with ranges within the Cape Ford to Pearce Point region (NT) (source: Duke 2006). Crosses identify recorded species occurrence in the listed estuary. Yellow denotes western limit of species range.

4. Cape Ford to Pearce Point		
Species/ Locations	Port Keats #89	Moyle River #91
<i>Acanthus ebracteatus</i> subsp. <i>ebarbatus</i>		
<i>Acanthus ilicifolius</i>		
<i>Acrostichum speciosum</i>		
<i>Aegialitis annulata</i>	X	X
<i>Aegiceras corniculatum</i>	X	
<i>Avicennia integra</i>		
<i>Avicennia marina</i>	X	X
<i>Bruguiera exaristata</i>		
<i>Bruguiera gymnorhiza</i>		
<i>Bruguiera parviflora</i>	X	
<i>Bruguiera sexangula</i>		
<i>Camptostemon schultzei</i>	X	X
<i>Ceriops australis</i>	X	X
<i>Ceriops decandra</i>		
<i>Ceriops tagal</i>		
<i>Cynometra iripa</i>		
<i>Diospyros littorea</i>		
<i>Excoecaria agallocha</i>		X
<i>Lumnitzera littorea</i>		
<i>Lumnitzera racemosa</i>	X	
<i>Nypa fruticans</i>		
<i>Osbornia octodonta</i>	X	
<i>Pemphis acidula</i>		
<i>Rhizophora apiculata</i>		
<i>Rhizophora X lamarckii</i>		
<i>Rhizophora stylosa</i>	X	X
<i>Scyphiphora hydrophyllacea</i>		
<i>Sonneratia alba</i>	X	
<i>Sonneratia lanceolata</i>		
<i>Sonneratia X urama</i>		
<i>Xylocarpus granatum</i>		
<i>Xylocarpus moluccensis</i>	X	
TOTAL recorded	11	6
TOTAL in vicinity	18	18
Sources:	GW85	GW85

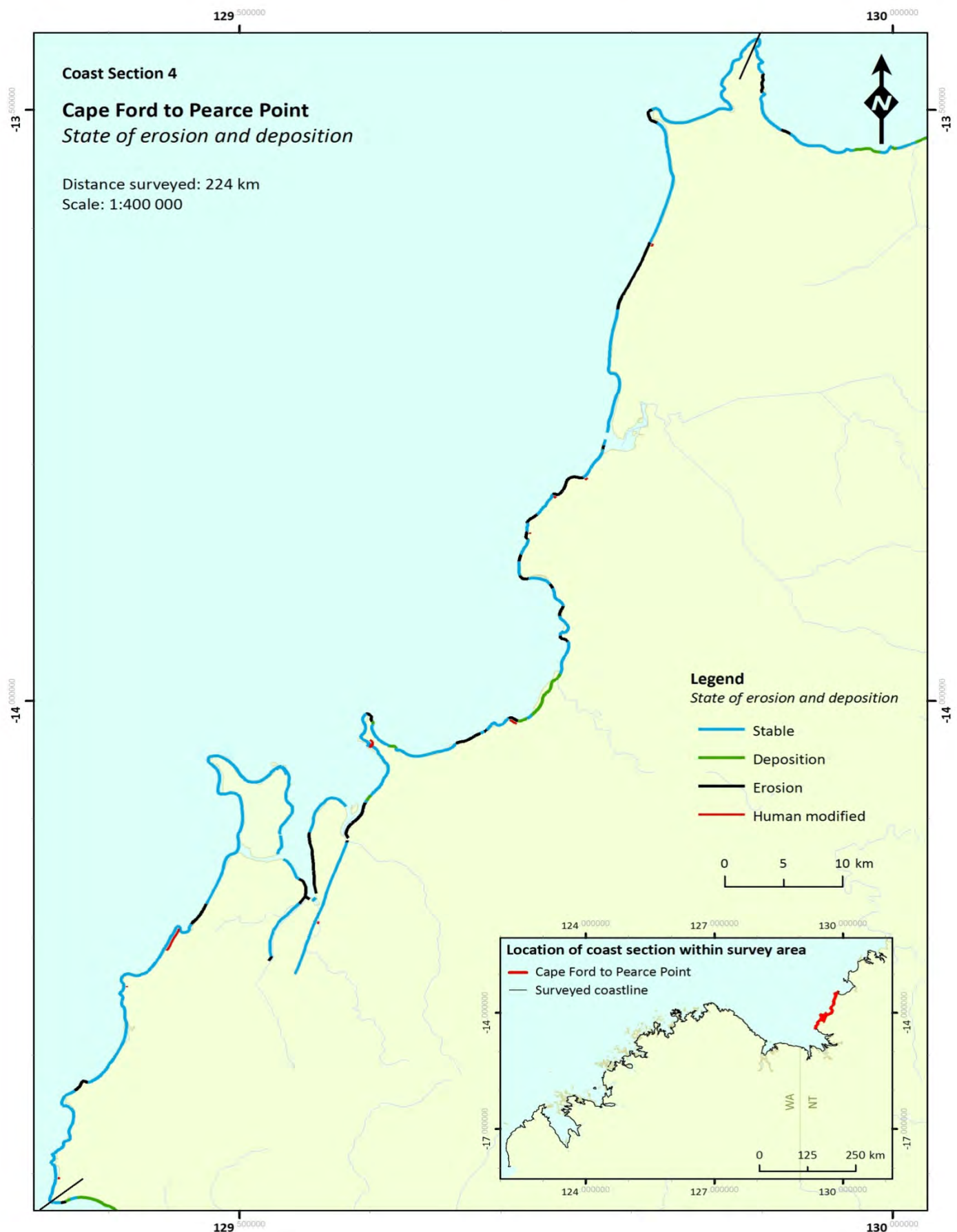


Figure 30: Bank stability in the Cape Ford to Pearce Pt region

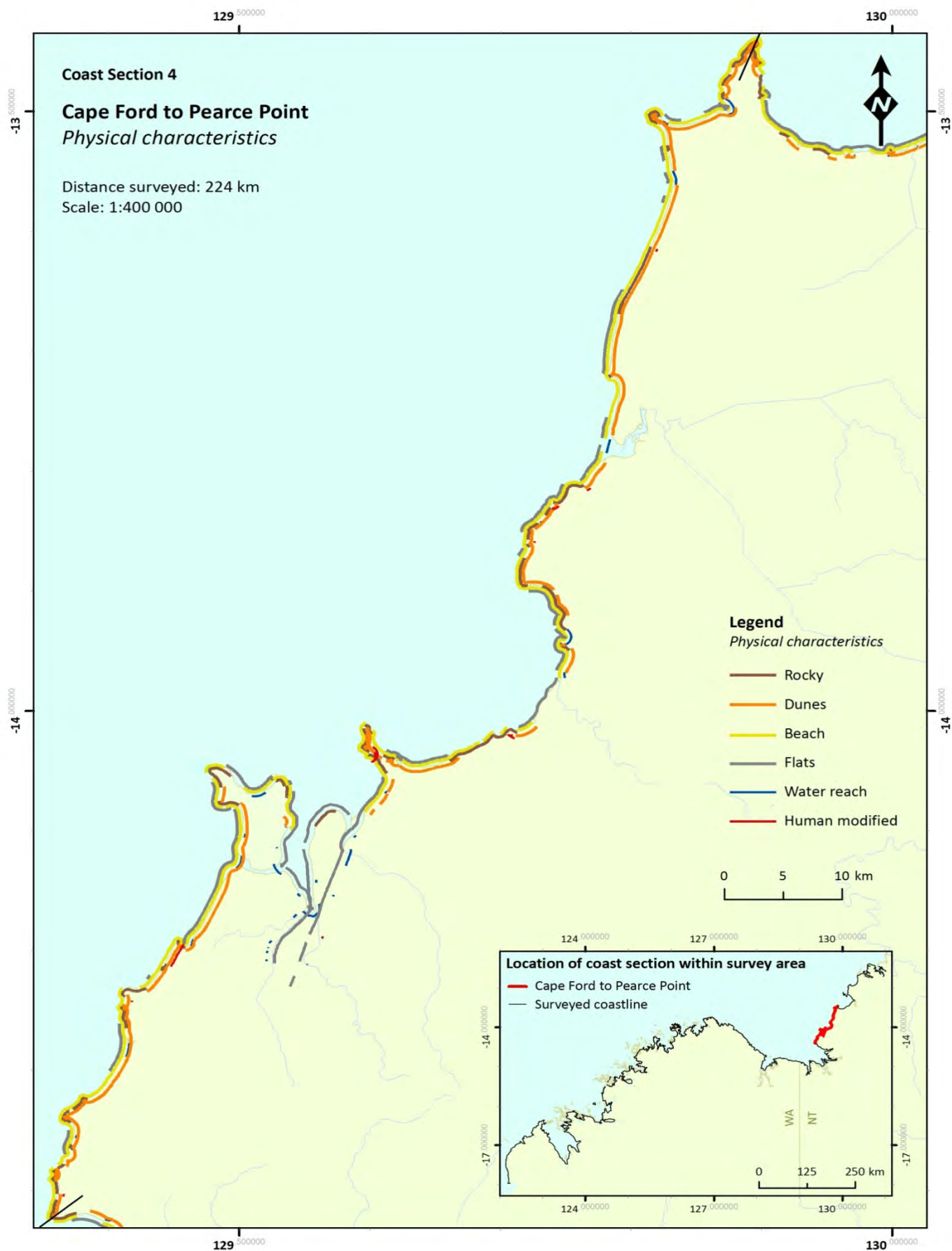


Figure 31: Physical characteristics in the Cape Ford to Pearce Pt region

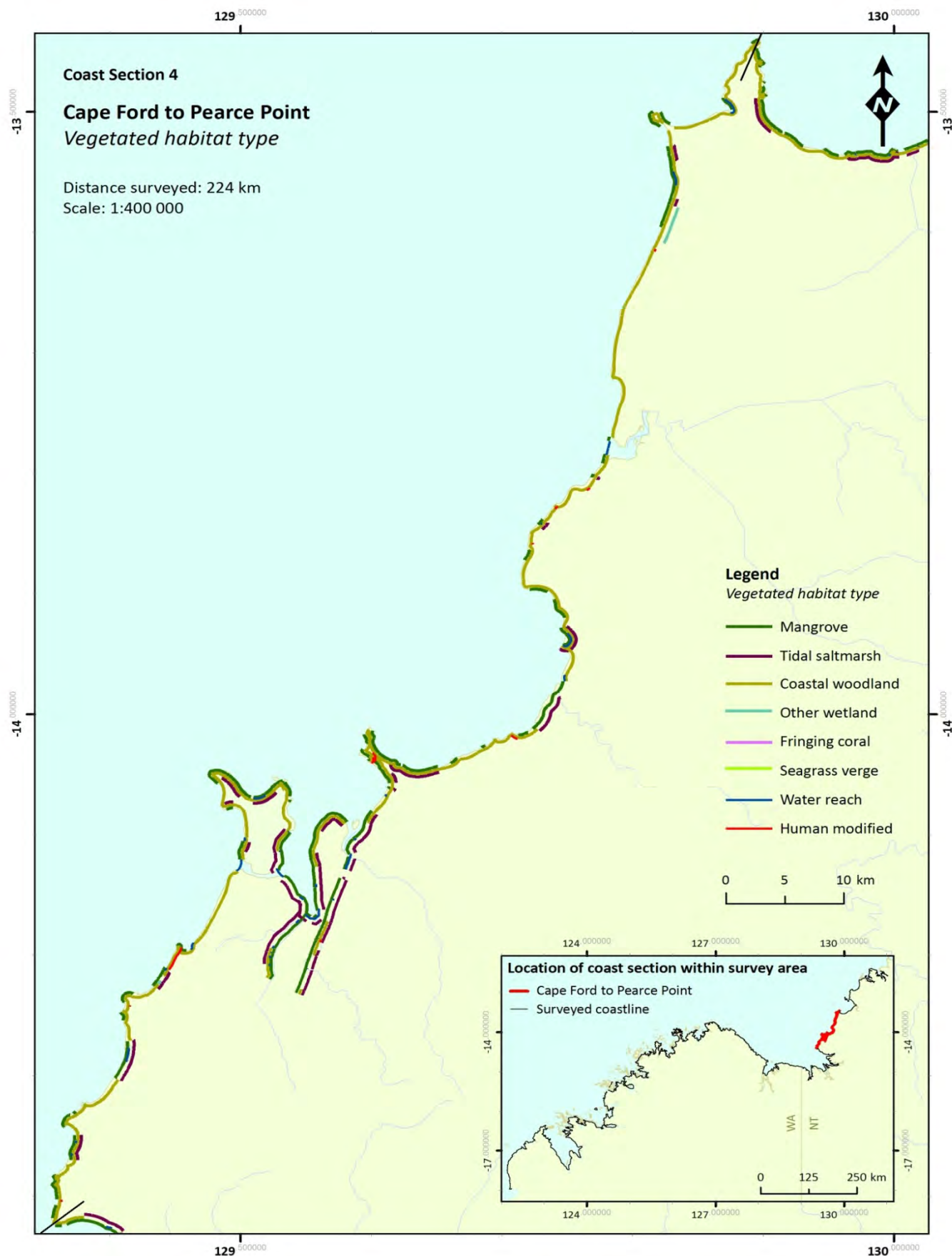


Figure 32: Vegetated habitat types in the Cape Ford to Pearce Pt region

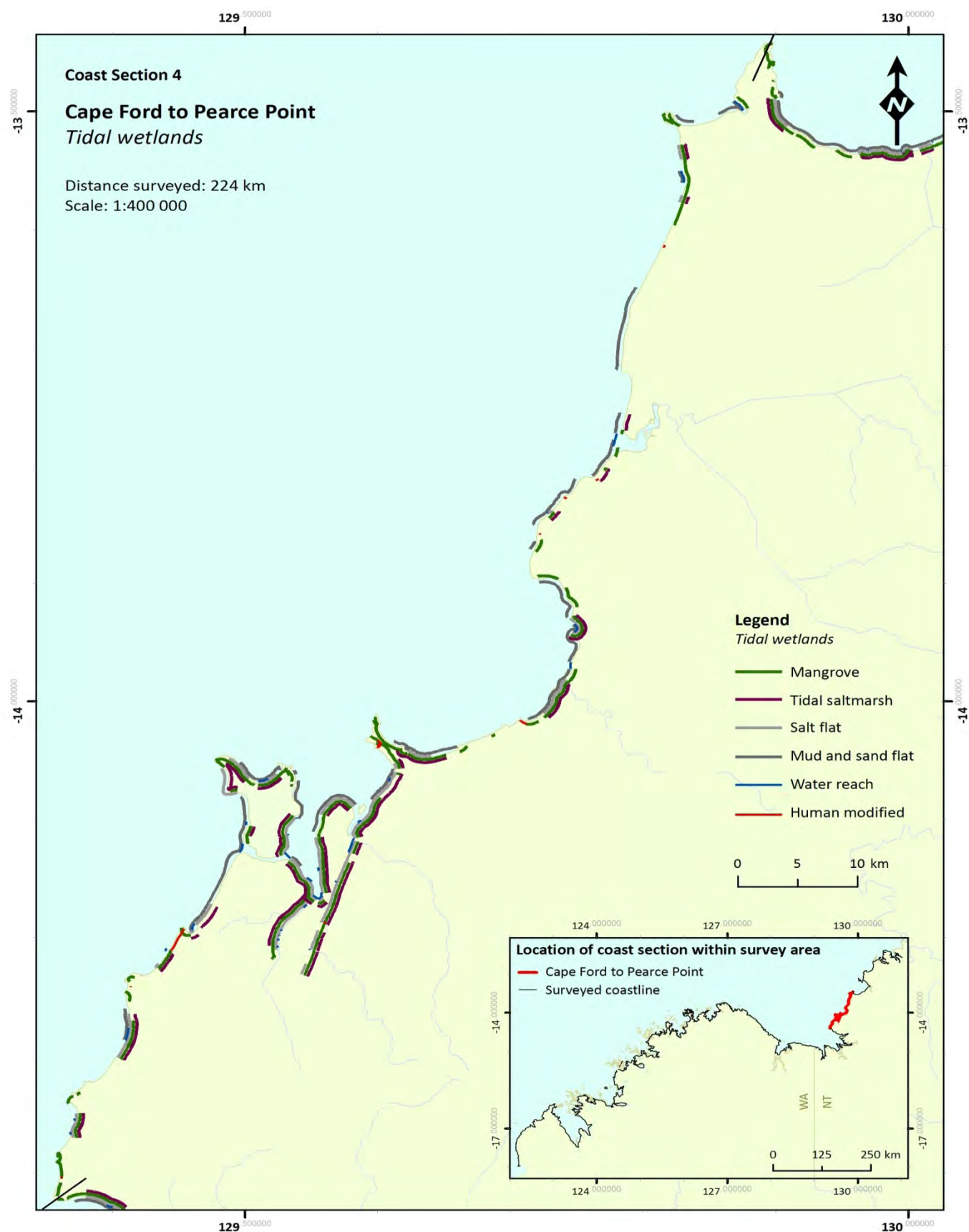


Figure 33: Tidal wetlands in the Cape Ford to Pearce Pt region

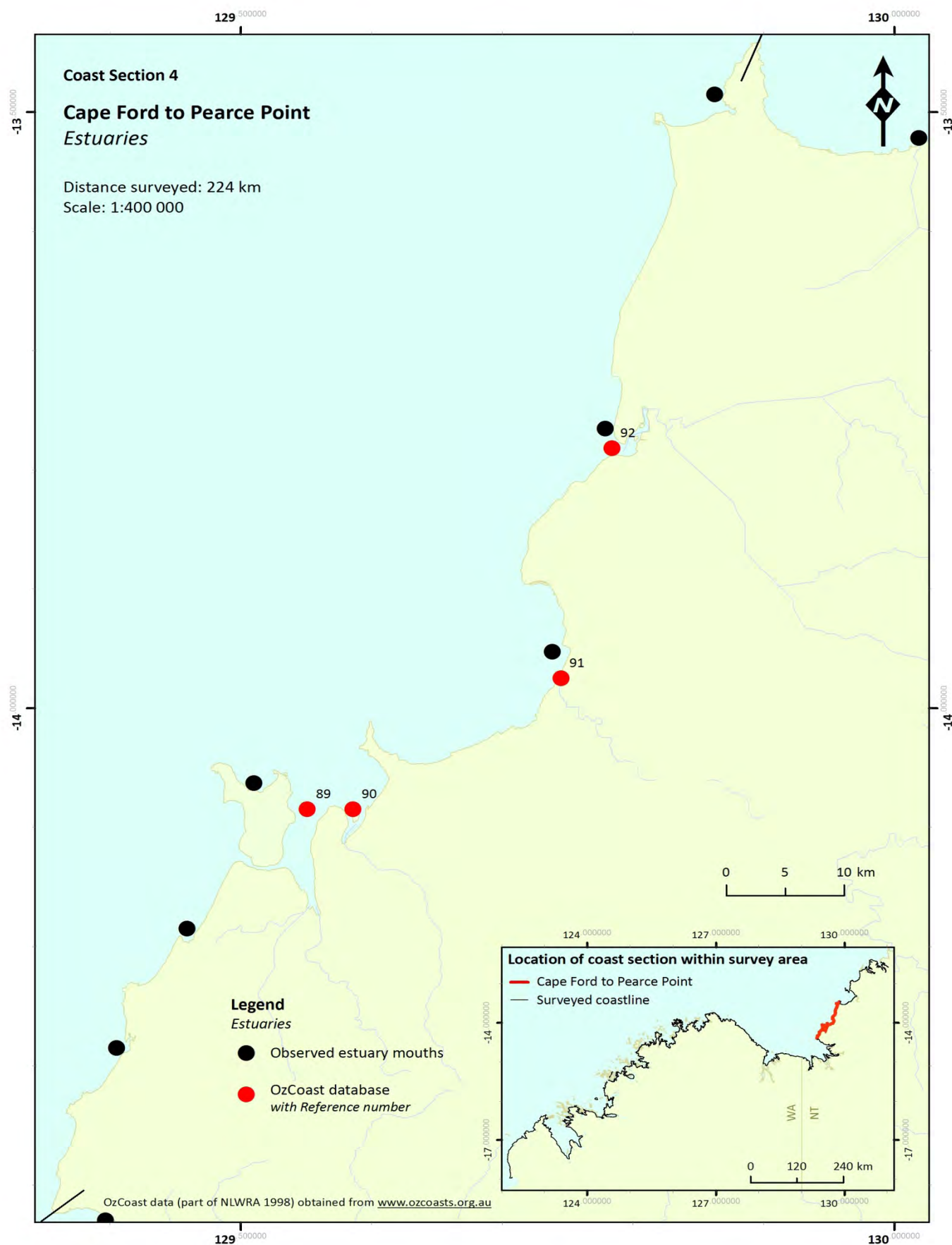


Figure 34: Estuaries in the Cape Ford to Pearce Pt region

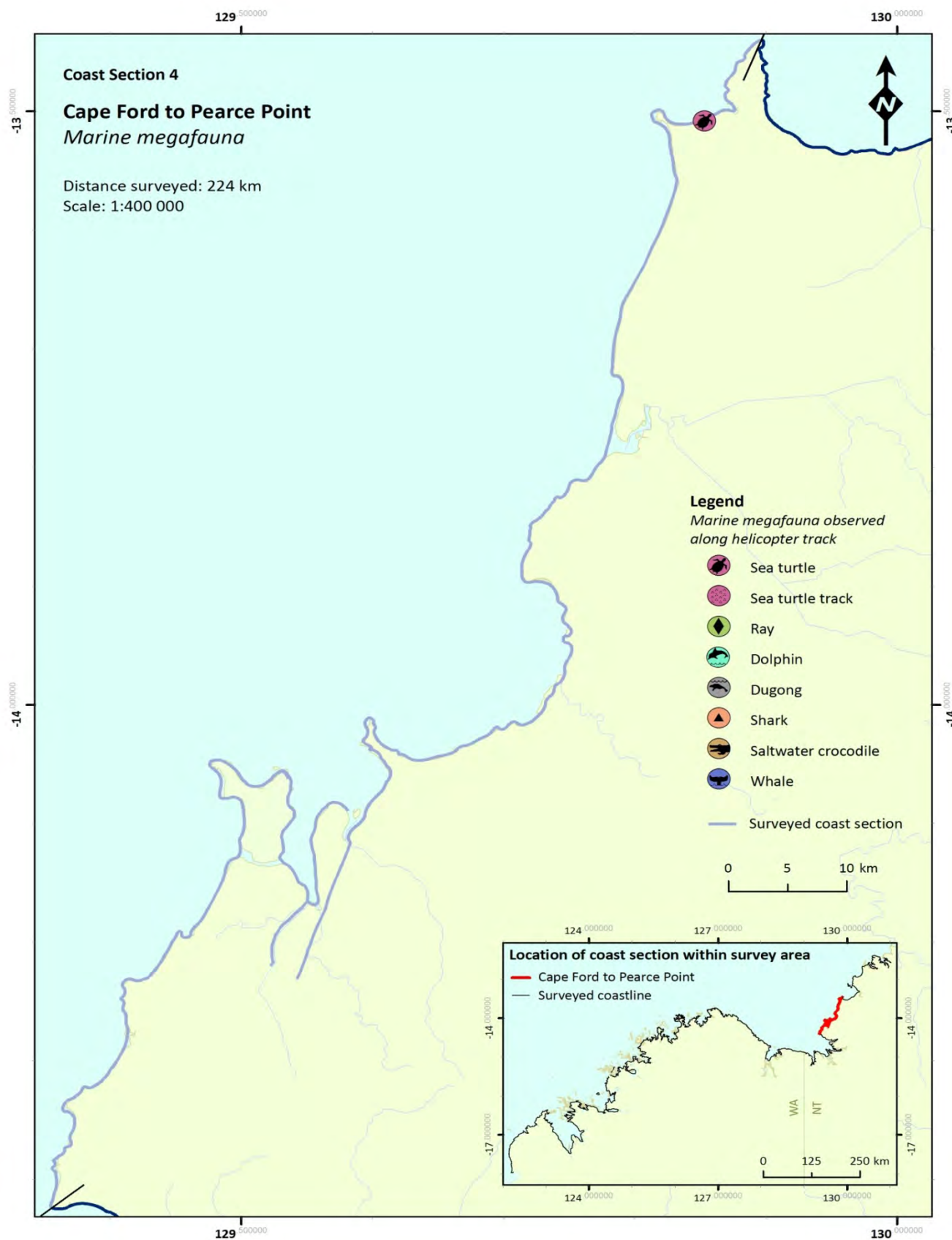


Figure 35: Marine megafauna observed in the Cape Ford to Pearce Pt region