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GERALDTON EMBAYMENTS COASTAL SEDIMENT BUDGET STUDY

Final Project Report

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Coastal Vulnerability & Risk Assessment Program - Project 2 - Stage 2

Sediment Mapping for Identification of Sediment Sources, Transport Pathways and Sinks for Components of the Batavia Coast, With Special Consideration of the Inshore Waters and Coast Between the Greenough River and Buller River

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EXECUTIVE SUMMARY

A sediment budget study was carried out in the coastal zone off Geraldton, adjacent to an expanding urban and industrial complex which serves an important port facility for the state of Western Australia (WA). The coastal change that is impacting the town beaches led to the need for a broader understanding of the Geraldton coastal system in terms of geomorphic settings, sediments and habitat distribution and their linkage to sediment production, transport and storage.

Coastal Geraldton has two west-facing embayments which are separated by a prominent tombolo at Point Moore, which is also the site of the Geraldton port and its associated infrastructure, including a ~14 m deep dredged channel. A shallow (~10 m) coastal platform with discontinuous, north-south trending limestone ridges borders a sandy shoreline and coastal plain with only minor small rivers and low relief. This near shore platform has a shallow (~1 m thick) sediment cover as demonstrated by the analysis of seismic data.

The Geraldton coastal environment has natural and artificial sources and sinks for sediment which were identified using geomorphological and sedimentological indicators. The primary input of littoral and shallow water sediment was found to be seagrass derived, with secondary riverine quartz sediment input and dune related carbonate sediment input.

Benthic habitats and underwater morphology were mapped through acoustic and ground truth data and our results reveal that at Geraldton, seabed morphology, substrate mobility and habitat distribution are closely related and need to be examined together to better understand coastal sediment dynamics and relate dynamics to coastal stability and assets.

Seismic and sediment surveys, swath mapping and benthic community transects were applied in an integrated analysis of the coastal sedimentary system, which has determined in detail the sediment pathways and qualitative sediment budget at Geraldton. Whilst the two littoral embayments are actively exchanging sediment, the main sediment sinks were identified in the northern embayment where beach erosion is more significant. Natural and artificial features were identified as sediment sinks indicating that coastal infrastructure modifies the local sediment dynamics.

This research project was undertaken for the Department of Transport (DoT) and provides coastal information to assist management agencies in determining long term management of the Geraldton coastline and to facilitate the development of planning and adaptation measures. The environmental data used for this study of sediment dynamics provide a strong basis for future quantitative studies of sediment transport, which will fit into a highly detailed sediment budget model. Some of the key findings from the report are summarised below.

COASTAL ENVIRONMENT

The Geraldton marine environment is a wave dominated domain and the local circulation is driven by wind and tidal forces. Swell height at the coast is attenuated by coastal limestone ridges; however wave heights and periods are sufficient to initiate bottom sediment particle movement over the entire Geraldton inshore platform. There is an overall south to north transport pattern driven by south-westerly swell waves and strong sea breeze wave fields, however the Cardno (2012a and 2012b) data indicates that eddies are established near Point Moore and particularly to its south. Temporary reversals to transport pathways are expected during winter NW oriented storm conditions.

The littoral sediment dynamics under these processes were investigated in this study and are described in the chapters 9 and 10 of the main body of the report. A summary of the main results is presented below and includes the onshore and offshore geomorphic features most relevant in terms of sediment budget, together with the main habitats and sediments types characterising the coast.

Coastal sand dunes

Carbonate sand dunes are common along the Geraldton coastline and are important as they interact with the coastal sediment budget. The Southgate dune system is a significant mobile dune sheet to the south of the city of Geraldton, just north of the Greenough River. Since 1942 it has been progressively migrating northward, most particularly along the western edge. This mobile dune system supplies sediment to the nearshore for northward littoral transport, resulting from the prevailing SSW wind direction.

Rivers

The study area comprises three river channels, which are, from south to north: the Greenough, Chapman and Buller Rivers. Only the Chapman River was demonstrated to supply significant sediment to the coastal system, with the Greenough and Buller Rivers mainly consisting of inactive coastal estuaries or dry steams.

Beaches

The coastline of the study area has an abundance of Quaternary carbonate-rich barriers and backing dunes, paralleled by largely submerged Pleistocene calcarenite barriers, which form near continuous limestone reefs in the nearshore. The beaches in the study region are classed as wave-dominated beaches, as the wave action along the microtidal coastline and interaction with limestone topographic barriers are major factors contributing to coastal dynamics. The overall pattern is that beaches are wide and stable in the south where natural processes dominate, and show higher instability in the north where development has been more significant and nourishment activities are needed to preserve the coastline position.

Geomorphology and habitats

The inshore platform is ~4 km wide and is rather flat, colonised by patchily distributed seagrass meadows, sandy substrates and mixed sandy, seagrass and macroalgae substrates. The macroalgae found here are small and do not form dense communities. Seagrass meadows are common to ~ 10 m depth and are dominated by *Posidonia* sp. between Pages Beach and the dredged channel, whilst *Amphibolis griffithii* and *Amphibolis antarctica* dominate off Tarcoola Beach, off the Northern Beaches and at Drummond Cove. These locations (Figures 69 to 72) are considered to be areas where modern sediment particles are currently being produced, mainly composed of microscopic shells of seagrass-associated organisms.

In terms of sediment budget the most important natural geomorphic features are shallow limestone reefs and sand bar and sheet systems, which indicate areas of sediment accumulation (Figures 64, 65 and 66). Sand bars and sheets are constituted by significantly thick sandy substrates found off Southgate dune and the Chapman River, but also in between the Point Moore reef system. Rippled sand flats occur at all mapped depths throughout the study area indicating that wave action influences the entire coastal platform which is ~ 10 m deep. Underwater sand dunes show a prevalent sediment transport direction toward the shore to the east of Separation Point. Shallow limestone reefs are

commonly developed at ~10 m depth along the edge of the coastal platform and are well developed off Point Moore but are also present in close proximity to the beaches at Separation Point, along the Northern Beaches and at Drummond Cove. Sediment accumulation around these reefs is common. Macroalgal communities with dense vegetation colonise the reef systems and these areas are contributing to sediment production by facilitating the development of mollusc associations.

Sediments

Fine modern bioclastic sand, medium-coarse modern and relict bioclastic sand and river derived sand are the most common marine and coastal sediment types at Geraldton (Figure 62). Coarse reworked sand is only representative of the offshore sediments (> 20 m depth).

Fine modern skeletal sand was mapped on the most protected coastal areas close to shore (up to 10 m depth) and is redistributed along the shore by the littoral currents. Fine carbonate sand was also found along the beaches, where sand nourishment activities have not been undertaken recently.

Medium-coarse modern and relict bioclastic sand was found in higher energy areas (~10 m depth), surrounding the limestone ridge systems colonised by dense macroalgal communities.

Modern grains comprise ~60% of the fine modern skeletal sand and ~40% of the medium-coarse modern and relict skeletal sand, with the remaining consisting of reworked grains. Modern grains are associated with in situ sediment production connected to marine vegetated areas i.e. seagrass meadows and macroalgal communities. Hence, the protection of the living marine communities contributing to sediment production should be considered a high priority, as a significant amount of sediment production and supply is dependent upon their existence.

River derived sediment mostly “sinks” in the central part of Champion Bay and is composed of ~45% river supplied sand (i.e. quartz), with the remaining consisting of modern and reworked grains which are derived from older sediments and rocks. This sediment occupies sparsely vegetated areas and is partly transported northwards particularly off Glenfield.

SEDIMENT SOURCE AND SINK AREAS

The near shore platform at Geraldton (< 10 m water depth) has thin (< 2 m) sediment cover over limestone, and is composed of a significant proportion of relict sediment (section 9.2). Local biological production of sediment provides most of the sediment input in the study area (section 9.9.1). This production is limited to the shallower sectors < 10 m deep, mainly associated with the sparse seagrass meadows found throughout Champion Bay, and the dense macroalgal communities colonising shallow limestone reef systems located along the seaward edge of the coastal platform at ~10 m depth and surrounding the Point Moore area.

A sand bar and sheet system has developed in between limestone reefs of the N-S trending Point Moore ridge system which captures and obstructs the sediment supply from south and west to the Town Beaches. This feature is partly developed within the port infrastructure. The dredged shipping approach channel for the port basin cuts across the Point Moore ridge system and continues southward to the port basin. The data analysed in this study have supported the identification of sediment deposition within the channel basin (section 9.9.2), indicating that the channel acts as a sediment trap for northward and eastward directed sediment transport.

The Chapman River is supplying quartz sand into Champion Bay (section 9.9.1). This is only a minor component of the sediment currently being provided to the overall study area, but it constitutes ~45% of the sediment deposited in the middle of Champion Bay, with the remaining consisting of modern and reworked particles. This sediment is not interacting with the littoral transport system but it accumulates and "sinks" in the centre of Champion Bay.

Southgate dune is supplying sediment to the Geraldton southern embayment and thereby participating in beach stability. Development on Southgate dune has the potential to reduce the sediment supply to the near shore and consequently influence coastal change at Tarcoola Beach.

SEDIMENT TRANSPORT PATHWAYS AND SEDIMENT BUDGET

The littoral sediment dynamics are separate to the offshore sediment mobility (>10 m deep), as fine carbonate sand was not found offshore indicating a clear separation between littoral and offshore transport systems. On the other hand, fine carbonate sands were mapped along the beaches indicating that the sediment produced by the seagrass communities is transported onshore by the wave action. There is an overall south to north transport pattern, however temporary reversals to transport pathways are expected during NW oriented storm conditions, which are considered responsible for occasional southwards oriented sediment transport including redistribution of quartzose sand supplied by the Chapman River to the south.

Southgate dune supplies sediment to the coastal system which deposits offshore and is distributed to the north by the littoral currents. This sediment, together with the local sediment production, accumulates to the east and west of the Separation Point limestone ridge where it is generating a significant coastal sediment wedge and contributes in the beach stability of the Geraldton southern embayment. However a significant sediment volume is transported north of Point Moore but is not accumulating at Grey's Beach, where the erosion phenomenon appears to be naturally driven.

The sediment transported north of Point Moore is "sinking" in the deposition areas found in between the limestone ridge systems and in the dredged channel and port basins. Together these elements appear to interrupt the sediment exchange from the south to the east. The sediment exchange from the southern to the northern embayment is a natural transport pathway under the prevailing hydrodynamic conditions of the Champion Bay area, and regularly supplies Point Moore and Pages Beach.

The overall relative sediment "starvation" of the Geraldton inshore platform is contributing to the low sediment supply to the town beaches, which are stabilised by periodic nourishment activities. However, the sediment artificially supplied to the Northern Beaches and Town Beach is lost offshore and transported northwards by the dominant littoral current, indicating a need for ongoing sediment bypassing in the area. The coastal sediment wedge off Town Beach and the sand deposition off the Batavia Coast Marina might indicate the areas where the sediment supplied by the nourishment activities at Town Beach is eventually depositing.

The sediment supplied by the Chapman River is accumulating in the middle of Champion Bay and is being partly redistributed to the north, contributing to sand accumulation at Glenfield Beach. A small amount of sediment is expected to filter through the shallow reef system at Drummond Cove and is transported to the north.

The sediment budget model described above for the Geraldton embayments (Figure 87) reflects the sediment transport, exchange and deposition of five self-contained sediment cells, with one additional cell starting at Drummond cove and extending further north (section 9.11). Whilst previous work

undertaken in the area has identified a northern and southern coastal compartments bounded by Point Moore, this study has demonstrated that there is sediment leakage around this Point with susequent northwards sediment transport as shown by a greater complexity of data. The level of detail provided by this study of sediment dynamics is not usually available regionally, and it is intended to provide an improved foundation on which to base future scientific analysis, planning and management which will be required as the Geraldton region continues to grow.