CAWTHRON

Potential Effects of High Sediment Loads on the Marine Environment of the East Coast of the North Island, East Cape - Hawke Bay: A Review of Existing Information

Cawthron Report No. 1389

November 2007

Potential Effects of High Sediment Loads on the Marine Environment of the East Coast of the North Island, East Cape - Hawke Bay: A Review of Existing Information

Paul Gillespie

Prepared for

Gisborne District Council

Cawthron Institute
98 Halifax Street East, Private Bag 2
Nelson, New Zealand
Ph. +64 3 548 2319
Fax. + 64 3 546 9464
www.cawthron.org.nz

Reviewed by: Paul Barter

Approved for release by: Rowan Strickland

Recommended citation:
Gillespie P 2007. Potential Effects of High Sediment Loads on the Marine Environment of the East Coast of the North Island, East Cape - Hawke Bay: A Review of Existing Information. Prepared for Gisborne District Council. Cawthron Report No. 1389. 9 p.

TABLE OF CONTENTS

LIST OF FIGURES

1. SCOPE

Envirolink 334-GSDC45 advice inquiry requests a literature survey, informal verbal consultation and collation of research material concerning the effects of high sediment loads from soft rock erosion-prone hill country on the east coast North Island marine environment between East Cape and Hawke Bay. The present report summarises the information gathered. The references cited were selected to cover representative examples and do not constitute an exhaustive list.

2. GENERAL HABITATS POTENTIALLY AT RISK

The topic covers a large area of coastline including numerous regions considered to be of significant conservation value (Gisborne District Council Proposed Regional Coastal Environment Plan). These regions encompass a seaward continuum of terrestrial → intertidal → shallow subtidal → offshore continental shelf seabed habitats and all are essential components of a healthy coastal ecosystem. The significant regions identified include (among others) numerous high-value estuarine wetland systems, marine terraces with extensive intertidal and subtidal reefs, a large open water hard rock reef system, some rare species assemblages and extensive soft sediment habitats. Of particular note is the 2,452 ha Te Tapuwae o Rongokako Marine Reserve located 16 km north of Gisborne. The larger ecosystem comprising these habitats supports commercial and recreational fish and shellfish stocks and marine mammal and seabird populations. The plant and animal assemblages associated with all of these habitats are potentially sensitive to episodic or chronic sedimentation effects.

3. SEABED BIOLOGICAL COMMUNITIES

Although subtidal seabed physical habitats have been broadly described (Gisborne District Council Proposed Regional Coastal Environment Plan Appendix 3, Foster & Carter 1997), the plant and animal communities within them are in general poorly characterised. With some exceptions, very little biological information is available describing the subtidal rocky reef habitat that is likely to be particularly sensitive to sedimentation effects. Exceptions include reef fish monitoring within Te Tapuwae o Rongokako Marine Reserve (Freeman 2005) and seabed habitat mapping and monitoring of reef flora and fauna of the Te Mahia Peninsula (Miller & Ormond 2007). Historical information is available describing soft sediment biotic communities of a large number of sites within the region (McKnight 1969). Data describing physical, chemical and biological characteristics of reef and soft sediment seabed habitats in Poverty Bay have been collected by Gisborne District Council (GDC) as part of a wastewater discharge consent monitoring programme (Keeley *et al*. 2002). The sites covered by these studies are summarised in Figures 1 and 2.

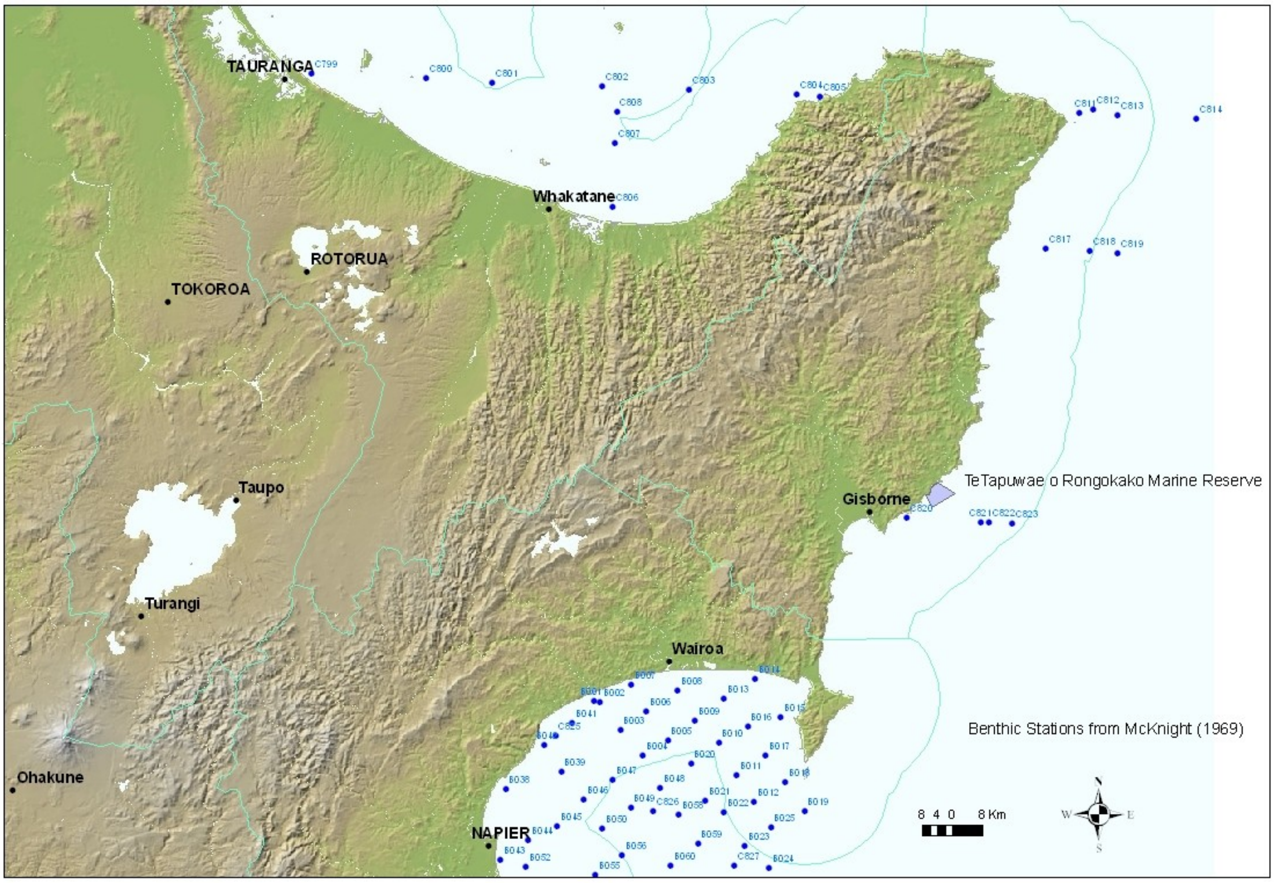

Figure 1. Benthic stations described by McKnight (1969).

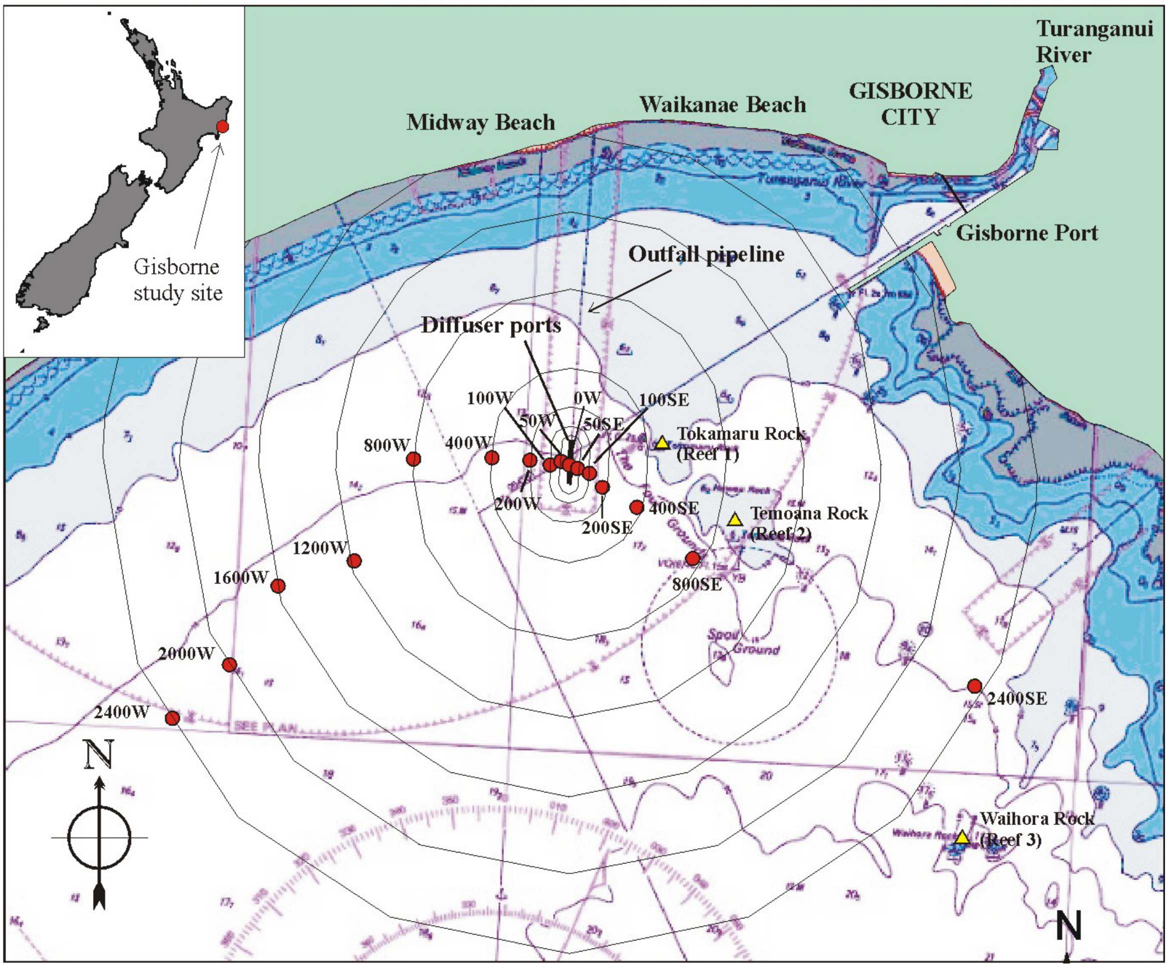

Figure 2. Sampling locations along south-west and south-east transects (red circles) and rocky reef sampling sites (yellow triangles) within Poverty Bay (from Keeley *et al*. 2002).

4. SEDIMENT OUTWELLING PLUMES

The stretch of North Island (NI) coastline from East Cape to Hawke Bay is potentially affected by numerous freshwater outwelling plumes that carry catchment-sourced materials (*e.g.* nutrients, suspended sediments and chemical and microbiological contaminants) into the coastal environment. Some of the more significant plume-generating rivers include (from north to south) the Awatere, Waiapu, Uawa, Waiomoko, Pouawa, Turanganui and Waipaoa. During heavy rainfall events these rivers discharge varying amounts of fine-grained suspended sediments (along with any contaminants they may contain) into the coastal receiving environment. Particularly high suspended sediment loads are known to be associated with both the Waiapu and Waipaoa rivers (GDC State of the Environment Report, 2003-4). The dispersion and deposition of these materials are discussed by Foster & Carter (1997). Aspects of circulation patterns and plume behaviour in Poverty Bay are described by Scott Stephens and Robert Bell (NIWA 2003) and Paul Barter (Cawthron 2006) in evidence presented to the Environment Court with regard to the GDC wastewater outfall consent application.

The major source of the suspended sediments is known to be the highly erodible rock formations that are characteristic of the region, including coastal cliffs that are in places exposed to tidal and wave activity (Kennedy & Dickson 2007). Erosion of the soft rock formations generates a high proportion of fine particulate muddy sediments.

A GIS dataset generated by NIWA and Landcare Research (Hicks *et al.* 2003), permits estimation of the mean annual yield of river/stream suspended sediment output for any defined catchment boundary in New Zealand.

The dataset consists of 100 m grids with each grid cell representing the suspended sediment (SS) yield in tonnes/km^2/year. Therefore, by overlaying individual catchments and taking the sum of all grid units within each catchment, the total suspended sediment load from each catchment (in kt/catchment/year) can be calculated. A map of the estimated sediment yield for the Waiapu catchment is presented in Figure 3.

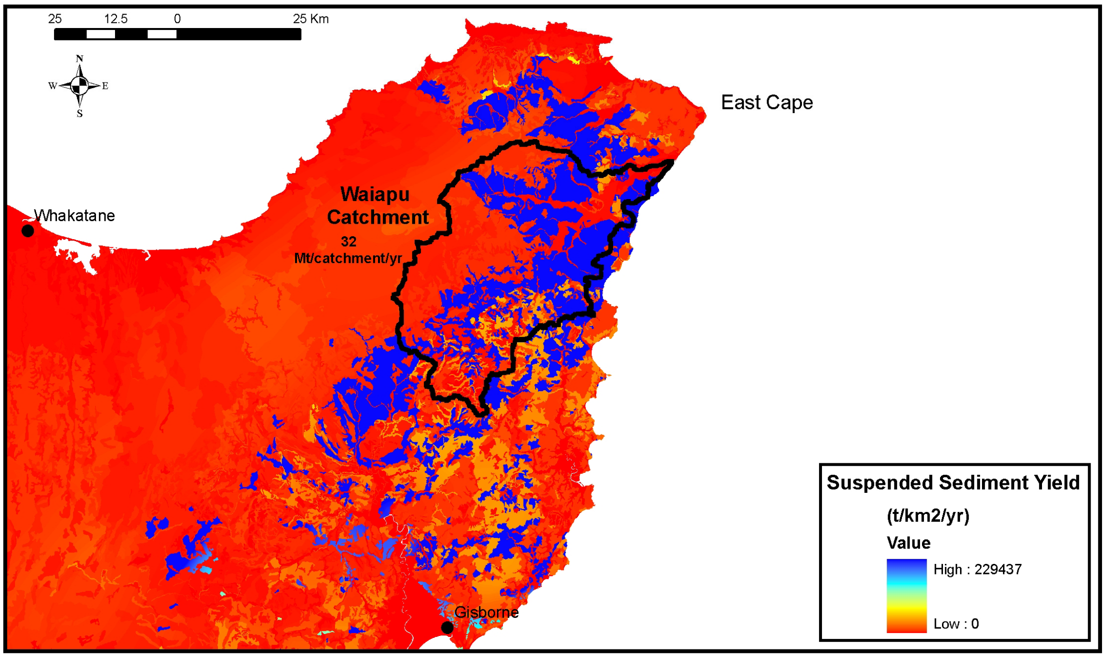

Figure 3. Estimated annual suspended sediment yields in kt/catchment/year for the Waiapu catchment near East Cape.

This figure is an example of how the sediment yield tool can be used to estimate annual loads from any catchment in New Zealand. It estimates an annual SS discharge of 32 Mt/year for the Waiapu catchment. This estimate is the sum of all the individual 100 m^2 grid values that fall within the catchment shown in the base map as a graduated colour. While only the

Waiapu catchment has been evaluated here, the tool could be used to estimate the annual load of SS entering the regions coastal environment from any defined catchment(s).

5. ESTUARINE EFFECTS

Coarse-grained gravels and sandy materials are generally deposited close to the river mouths where they may form estuaries or deltas or be transported along shore to nourish beaches. McLay (1976) identifies 15 estuarine areas, East Cape to Napier. These include the Karakatuwhero*, Awatere, Waiapu*, Uaua*, Pakarae, Turanganui and Waipaoa river mouth estuaries and the Wherowhero Lagoon* (* = those listed in the GDC Proposed Regional Coastal Environment Plan, Appendix 3, as having significant conservation value). Because terrigenous sediment input has been reported to be a major factor affecting estuarine habitats (*e.g.* Thrush *et al.* 2004), the values associated with many of the listed wetland sites may be at risk.

6. NEAR SHORE AND OFFSHORE EFFECTS

During periods of major flooding, sediment-laden plumes can extend over large areas of coastline. Very fine-grained sediments from even moderate sized rivers can be carried tens of kilometres, or much further, off shore and transported along the coast by wave action and tidal currents (Foster & Carter 1997; Lohrer *et al.* 2006; Tuckey *et al*. 2006). For example, investigations carried out through the Motueka Integrated Catchment Management (ICM) research programme (http://icm.landcareresearch.co.nz/) revealed an approximately 50 km^2 area of metals-contaminated sediments within the Motueka river plume in western Tasman Bay (Forrest *et al*. 2007; Forrest 2007). High sediment nickel and chromium concentrations, traced to a natural upper catchment mineral belt (Gillespie, unpublished), greatly exceeded guideline threshold levels for biological effects. The spatial extent of the plume, as shown by metals concentrations, can be seen in Figure 4.

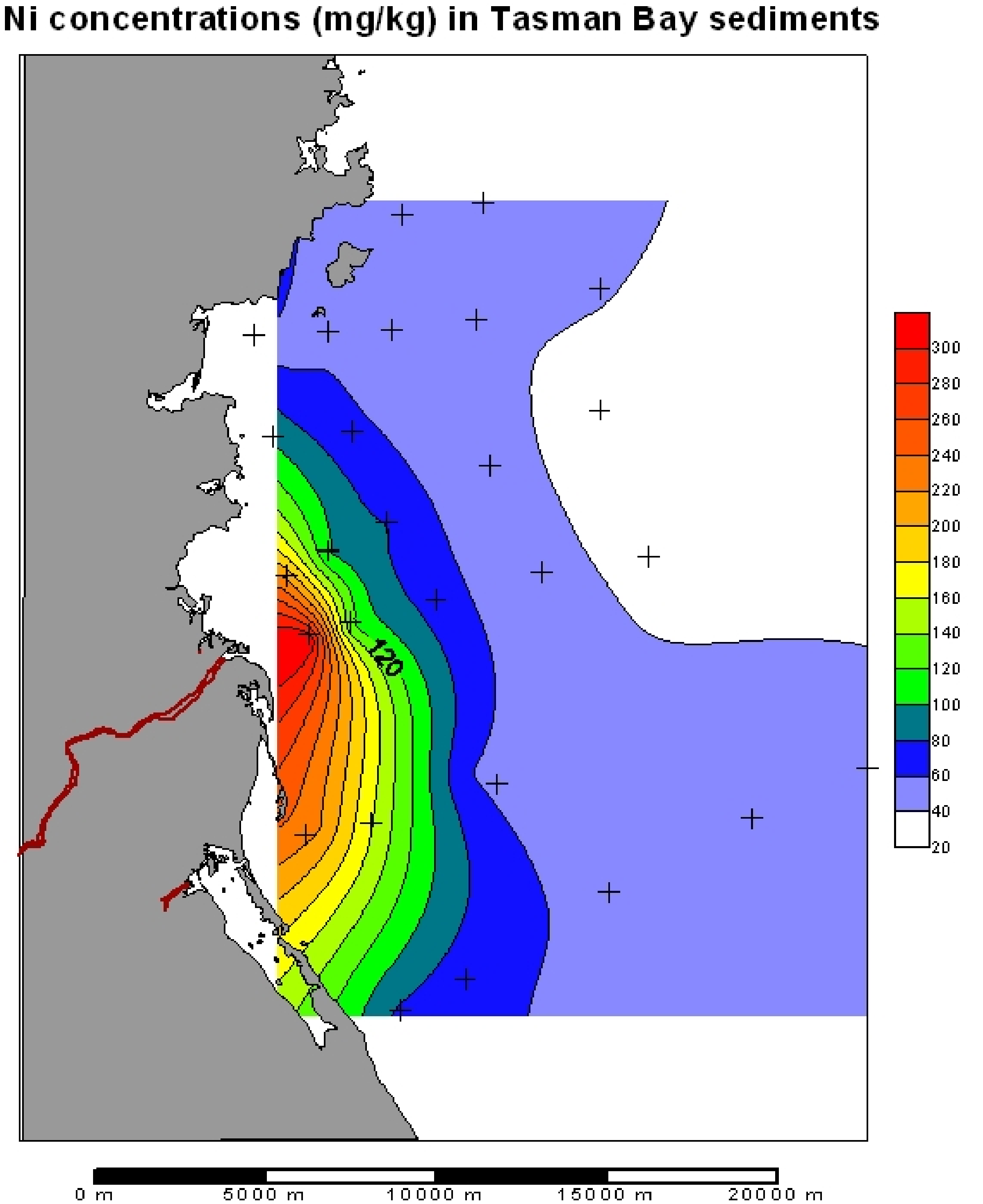

Figure 4. Nickel concentrations (mg/kg) in Tasman Bay sediments (Forrest & Gillespie, in prep.).

Along the open and relatively exposed NI East Coast, the majority of fine sediments are likely to be rapidly flushed away from potentially sensitive near-shore rocky reef habitat and eventually deposited in soft mud/sand habitats in deeper waters or semi-protected embayments. Nevertheless increased near-shore sedimentation rates can still occur resulting in adverse impacts to reef biota (Schiel *et al.* 2006). Complex interaction of the prevailing easterly to southerly wave climate (Pickrill & Mitchell 1979) and inshore and offshore components of the East Cape Current (Heath 1985) is likely to dictate river plume behaviour and resulting sediment dispersion/depositional patterns in a predictable way. The species composition and biodiversity of plant and animal communities within depositional zones can be severely affected by episodic sedimentation events. During major flood events (*e.g.* cyclone Bola, March 1988) sediment plumes can result in the creation of near-bottom high turbidity (fluid mud) layers that extend out over the majority of the continental shelf (Foster & Carter 1997). Such events can have catastrophic smothering effects on benthic communities and recovery rates could be in terms of years (Battershill 1993).

Although soft-bottom animal communities are generally less sensitive to sedimentation effects than reef communities, high rates of deposition can restrict species diversity and abundance. These habitats cover by far the largest area of New Zealand's coastal zone and they comprise important feeding and/or spawning grounds for a variety of commercially important fish species (*e.g.* snapper). Fine sediments on the relatively flat seabed surface can be readily resuspended by tidal and wave-generated currents to the extent that they interfere with the growth/survival of suspension feeding shellfish (Gillespie & Rhodes 2006; Lohrer *et al.* 2006). These effects can be exacerbated by dredging and trawling disturbances of the sediment/water boundary layer. Thus river outwelling plumes of the east coast NI region are likely to affect seabed plant and animal communities to various degrees. Outwelling plumes may also have positive and/or negative implications for any aquaculture developments considered for the region (Gillespie 2007). The extent and shape of the plume-affected zones and the magnitude of sedimentation effects will depend on (1) the quantity and quality of the river outflow, (2) the hydrodynamic characteristics that control plume behaviour (*e.g.* Tuckey *et al.*2006) and (3) the physical and biological makeup of the seabed habitat.

7. RECOMMENDATIONS

A standardised GIS mapping protocol for assessing changes in the aerial coverage of intertidal habitats has been developed by Robertson *et al.* (2002) and implemented in more than 20 estuaries throughout New Zealand (*e.g.* Clark *et al*. 2006). Implementation of an estuary monitoring strategy, incorporating such techniques (if not already in existence) and prediction of the approximate extent of the coastal sedimentation footprint for rivers with particularly high suspended sediment loads (*e.g.* the Waiapu and Waipaoa rivers) would be likely important steps towards identifying general impact regions. Prioritisation of catchments with respect to predicted suspended sediment loads would be possible using the GIS data set described in Section 4.

These initiatives could be linked with broad-scale GIS mapping of subtidal coastal habitat features, including high-value and/or potentially sensitive biological communities (*e.g.* fish spawning grounds, rocky reef, *etc*.) and any proposed aquaculture management areas.

Implementation of such initiatives along the NI East Coast would support corresponding development of an integrated catchment-scale focus for management of sedimentation impacts.

8. REFERENCES CITED

Battershill CN 1993. What we do to the land we do to the sea: Effects of sediments on coastal marine ecosystems. Abstract in Marine Conservation and Wildlife Protection Conference, Wellington, 1992.

Clark K, Stevens L, Gillespie P 2006. Broad Scale habitat mapping of Moutere Inlet. Cawthron Report No. 1037. Prepared for Tasman District Council. 20 p.

Forrest R. 2006. Trace metals in the sediments and biota of the Motueka River plume, Tasman Bay. MSc Thesis, University of Otago. 140 p.

Forrest BM, Gillespie PA, Cornelisen CD, Rogers KM 2007. Multiple indicators reveal river plume influence on sediments and benthos in a New Zealand coastal embayment. New Zealand Journal of Marine & Freshwater Research. 41: 13-24.

Foster G, Carter L 1997. Mud sedimentation on the continental shelf at an accretionary margin-Poverty Bay, New Zealand. New Zealand Journal of Geology and Geophysics 40: 157-173.

Freeman D 2005. Reef fish monitoring Te Tapuwae o Rongokako Marine Reserve. Department of Conservation, East Coast Hawkes Bay Conservency, Gisborne. 26 p.

Gillespie P 2007. River outwelling plumes: good or bad places to farm mussels? New Zealand Marine Farming Association Newsletter, June Issue.

Gillespie P, Rhodes L 2006. The quantity and quality of suspended particulate material of near-bottom waters in the Motueka River outwelling plume, Tasman Bay. Prepared for Stakeholders of the Motueka Integrated Catchment Management Programme. Cawthron Report No.1114. 27 p.

Gisborne District Council. Proposed Regional Coastal Environment Plan. Appendices 1-3.

Gisborne District Council. The State of Our Environment – Gisborne 2003-2004. www.gdc.govt.nz/Environment/StateoftheEnvironment2003-4.htm

Heath R 1985. A review of the physical oceanography of the seas around New Zealand – 1982. New Zealand Journal of Marine & Freshwater Research 19: 79-94.

Hicks M, Shankar U, McKerchar A 2003. Sediment yield estimates: a GIS tool. National Institute of Water & Atmospheric Research Ltd. Water & Atmosphere 11(4).

Keeley N, Barter P, Robertson B 2002. Assessment of ecological effects on the seabed surrounding the Gisborne wastewater outfall: winter 2002. Cawthron Report No. 735. Prepared for Gisborne District Council. 40 p. + Appendices.

Kennedy DM, Dickson ME. 2007. Cliffed coasts in New Zealand: perspectives and future directions. Journal of the Royal Society of New Zealand 37: 41-57.

Lohrer AM, Hewett JE, Thrush SF 2006. Assessing far-field effects of terrigenous sediment loading in the coastal marine environment. Marine Ecology Progress Series 315: 13-16.

McKnight DG 1969. Infaunal benthic communities of the New Zealand continental shelf. New Zealand Journal of Marine & Freshwater Research 3: 409-444.

McLay CL. 1976. An inventory of the status and origin of New Zealand estuarine systems. Proceedings of the New Zealand Ecological Society 23: 8-26.

Miller S, Ormond G 2007. Managing Kaimoana Resources at Te Mahia. Poster presentation to New Zealand Marine Sciences Society Conference, Hamilton, 29-31 August.

Pickrill RA, Mitchell JS 1979. Ocean wave characteristics around New Zealand. New Zealand Journal of Marine & Freshwater Research 13: 501-520.

Robertson BM, Gillespie PA, Asher RA, Frisk S, Keeley NB, Hopkins GA, Thompson SJ, Tuckey BJ 2002. Estuarine Environmental Assessment and Monitoring: A National Protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93 p. Part B. 159 p. Part C. 40 p. plus field sheets.

Schiel DR, Wood SA, Dunmore RA, Taylor DI 2006. Sediment on rocky intertidal reefs: Effects on early post-settlement stages of habitat-forming seaweeds. Journal of Experimental Marine Biology and Ecology 331: 158-172.

Thrush SF, Hewett JE, Cummings VJ, Ellis JI, Hatton C, Lohrer A, Norkko A 2004. Muddy waters: elevating sediment input to coastal and estuarine habitats. Frontiers in Ecology and the Environment 2: 299-306.

Tuckey BJ, Gibbs MT, Knight BR, Gillespie PA 2006. Tidal circulation in Tasman and Golden Bays: implications for river plume behaviour. New Zealand Journal of Marine & Freshwater Research 40: 305-324.