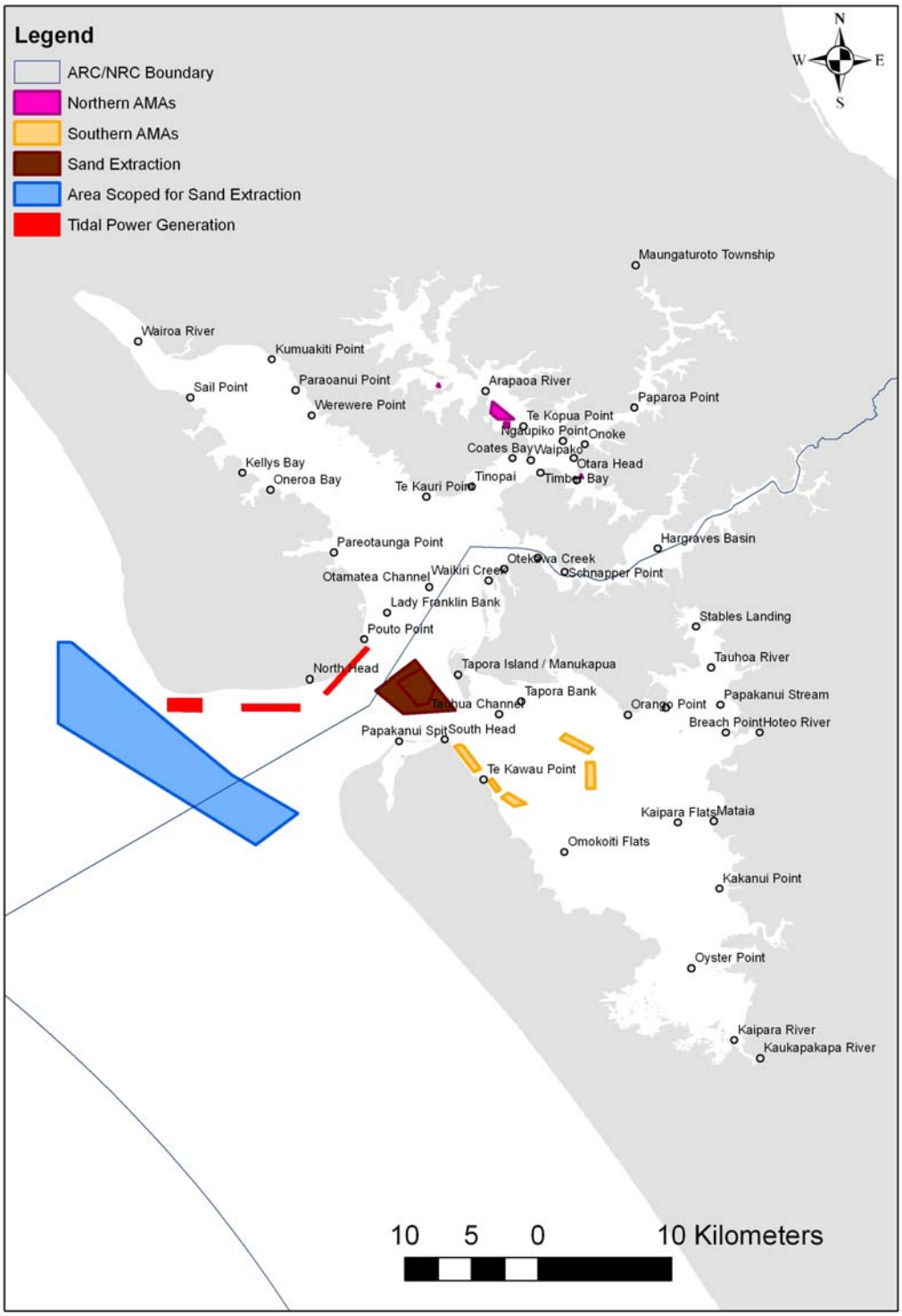
Figure 63 Activities that may cause cross-boundary effects in the Kaipara Harbour. Note the largest impact that may cause cross-boundary effects (landuse activities) incorporates the entire Kaipara catchment area.



Sand mining

Sand mining currently undertaken by Mt Rex Ltd and Winstone Aggregates Ltd on the Tapora Bank and Fitzgerald Bank regions occurs adjacent to the NRC/ARC boundary (Figure 65) and has the potential to cause several cross-boundary effects. Ultimately, environmental issues associated with sand extraction are related to the frequency of dredging, the volume of sand being extracted, and the physical characteristics (substratum and water column) of the dredged area.

Dredging may affect the physical environment by altering bathymetry and changing the current velocities and wave conditions (Jensen and Mogensen 2000) which, in turn, affect sedimentary processes leading to erosion. Previous sand extraction adjacent to Pouto Point was abandoned due to possible effects of the sand extraction on shoreline erosion (NRC 2002). With regard to the existing sand extraction activities, there is uncertainty about the volume of sand arriving into the Tapora area relative to the amount extracted. This is viewed as a critical knowledge gap, since this area (the flood delta or shield) has a great influence on the flow of water into both the northern and southern arms of the Kaipara Harbour. Changes associated with this part of the harbour, resulting from sand extraction, may consequently impact both the southern and northern areas of the harbour (e.g. disruptions in the physical processes in an area which may have implications for the dominant ecological communities within the harbour).

Another significant environmental issue arising from sand extraction is the disturbance to benthic communities and dominant species within the dredged area, particularly tuatua with their distribution restricted to the harbour entrance. At present, it is unknown how the various tuatua populations are connected within the harbour, and whether the tuatua beds located in and around the extraction area (which may be impacted by sand mining) are an important brood-stock for maintaining other tuatua populations in the harbour entrance, such as those found adjacent to North Head.

Temporary decreases in water clarity, increased concentrations of suspended matter, and increased rates of sedimentation are additional environmental issues associated with sand extraction within the harbour that have the potential to cross the ARC/NRC boundary during periods of calm weather and reduced wave action. However, due to the physical nature (high wave energy) of the dredged area, these type of environmental issues are unlikely to be great.

At present, McCallum Brothers Ltd is scoping the feasibility of sand extraction in area of seabed immediately adjacent to the Kiapara Heads, the ebb tidal delta. The proposed area is approximately 20,000 ha in extent with a proposed annual extraction of up to 300,000 m^3. While estimates of sand arriving at the entrance to the harbour are uncertain, as are the sediment transport volumes and pathways into the Kaipara Harbour proper, both the size and volume of sand have the potential to create significant cross-boundary effects related to coastal processes. These include alterations to the North and South Head

coastlines and impacts on sediment transport into the harbour (as for tidal power generation, discussed below). Furthermore, as the sand extraction area encompasses almost the entire harbour entrance, issues associated with fish and mammal disturbance between the open coast and harbour could have significant cross boundary implications within the harbour.

Fishing

Unsustainable fishing within the Kaipara Harbour has the potential to result in environmental effects that cross the various planning boundaries of the harbour. However, management of these effects are removed from council responsibilities by the exemptions of Section 12(1)(c) and (e) of the Resource Management Act (1991), with fishing-related impacts being managed by the Ministry of Fisheries.

Fishing-related issues that may potentially result in cross-boundary effects within the harbour include:

- Changes in the abundance, population characteristics, and reproductive output of target species.
- Changes in the abundance, population characteristics, and reproductive output of by-catch species.
- Risks associated with the incidental capture of threatened species such as Maui's dolphin.
- Damage to the seabed and associated habitats (which may include breeding, spawning, and nursery habitats).
- Flow-on effects of harvesting target species to other parts of the food web (e.g. trophic cascades).

Ecosystem-level impacts may not be restricted only to the harbour, as many of the species move outside it.

Destruction or deterioration, by fishing, of habitats that are important spawning and nursery areas or that aggregate fish due to their structure (e.g. sponges) also has the potential to greatly alter species abundance and distribution, resulting in cross-boundary effects. The main fishing methods associated with direct habitat destruction are trawling and dredging; with dredging applying only to the scallop, tuatua, and mussel fisheries within the Kaipara. The latter two species are presently not fished commercially within the harbour and the recent ban on scallop harvesting suggests that dredging impacts are unlikely to be a major issue within the harbour at present. This situation could change when the ban on scallop harvesting is lifted.

Historical declines in fisheries (such as the mussel dredge fishery in the early 1990s) coupled with a general lack of understanding on trophic interactions within the harbour,

suggests that many fishing-related impacts that have ecosystem-level and cross-boundary impacts may have gone undetected.

Aquaculture

Cross-boundary issues associated with aquaculture include landscape, natural character, and biosecurity. The small oyster farms within the Hargreaves Basin (Oruawharo) River (total 200 ha) potentially have visual effects and small-scale ecological impacts due to sedimentation and biodeposition but are unlikely to cause large-scale, cross-boundary effects. However, the effects of large-scale aquaculture may extend across planning boundaries and the potential effects on functionally important habitats are of particular concern. Ideally, aquaculture planning should be integrated across the harbour and involve more detailed assessments of the associated and cumulative risk.

Invasive species

In conjunction with habitat deterioration and fragmentation, the spread of invasive species within the coastal marine area is a significant environmental issue with the potential to cross jurisdictional boundaries. Currently, invasive species such as *Musculista senhousia* and *Theora lubrica* occur throughout the northern and southern arms of the harbour. The initial incursion periods of these species is difficult to determine. Due to the number of activities (e.g. fishing, aquaculture, dredging, construction), structures (marine farms, wharfs), and habitats within the harbour, the potential for introducing new invasive species is relatively high. The spread of invasive species is also influenced by the hydrodynamics, the availability of suitable substratum, and the life-history characteristics of the species. Accordingly, it is not simple to predict where incursions are likely to occur; although popular fishing spots, structures such as wharfs, and marine farms are likely to be high risk areas.

Tidal power generation

Tidal power generation planned for the northern Kaipara has associated environmental issues with the potential to cause significant cross-boundary effects. Although the proposed location of the tidal generator arrays is within the Northland Region, the removal of tidal energy (potentially 5% of total tidal energy) from the tidal stream is an issue that could impact on both the southern and northern areas of the harbour. At present, the effect(s) of tidal dampening are not known with respect to coastal processes and sediment transport within the harbour. Of particular concern are the potential impacts of reduced sediment deposition on the flood tide delta, which essentially governs the hydrodynamics and thus the presence of physical features (sand banks, tidal channels) and biological communities within both arms of the harbour. Additional far-reaching impacts on tidal current velocities and water levels (i.e. impeding the tidal current may reduce or increase water levels inside the harbour) may also affect the whole harbour. Due to a lack of current information about the effect of tidal generators on the tidal stream, the various

impacts associated with a loss of tidal power across planning boundaries are generally unknown.

8 Identification of knowledge gaps that are critical barriers to integrated management

Management of the Kaipara Harbour resources is undertaken by a range of regulatory bodies, notably the regional councils, district councils, Department of Conservation, Ministry of Fisheries, and MAF-Biosecurity New Zealand. Knowledge about the current environmental quality of the Kaipara Harbour as a whole is extremely fragmented, due in part to its size, but also to the different objectives amongst the various regulatory bodies, and the availability of resources for addressing management issues in the harbour (Peart 2007). Consequently, there are a variety of environmental knowledge gaps that act as barriers to successful and integrated management of the Kaipara Harbour. These are identified and discussed below.

8.1 Landuse and development

The enclosed nature of the Kaipara Harbour makes it particularly vulnerable to activities carried out in the adjoining catchments. However, information on landuse impacts is largely anecdotal or inferred from studies that were not specifically designed to examine these impacts. Key information gaps include:

- Long-term plans for catchment development and its associated effects on the harbour.
- Changing patterns of landuse.
- The effectiveness of current plans, policies, and non-statutory tools designed to maintain the quality of the harbour appears to be largely unknown.
- Ecological changes that would provide feedback on policy effectiveness (ecological monitoring is not carried out routinely in the Kaipara Harbour).
- The current scale and magnitude of sediment-related effects.
- The long-term cumulative impacts of sediment and contaminant runoff (individually and in combination with other stressors).

Tools are available which allow the effects of different landuse scenarios to be modelled (e.g. as applied to Whitford, the Upper Waitemata Harbour, Central Waitemata Harbour and south-east Manukau Harbour) and could be used to assess the long-term cumulative impacts of various landuse scenarios on the entire harbour. They would also allow 'problem' sub-catchments, where special landuse controls may be required to prevent erosion or contaminant generation, to be identified. Information generated from these models would provide a strong foundation for policy and plan provisions, or non-statutory methods, which would seek to ensure the long-term sustainability of the harbour.

8.1.1 Water quality

Available evidence suggests that water quality in some parts of the harbour is relatively poor (Elmetri et. al. 2006), but assessment of harbour-wide water quality and tracking changes over time is hampered by the poor spatial resolution of the sampling and/or interrupted time-series data.

An integrated, harbour-wide, monitoring programme that established a robust water quality dataset would greatly improve the usefulness of the information collected. The programme should:

- Increase the number of water quality monitoring sites within the harbour, to cover key environmental compartments.
- Maintain a regular sampling frequency (preferably monthly).
- Measure the temperature, pH, salinity, chlorophyll *a*, dissolved oxygen, turbidity, total suspended solids (TSS), nitrate, ammonium, phosphate, total reactive phosphate, enteroccoci and faecal coliforms,

Sample collection by helicopter would be efficient, consistent, and cost-effective.

8.1.2 Fisheries

The Kaipara Harbour is particularly important for local fishers and the broader West Coast fishery. A number of species that are harvested for commercial, recreational, and cultural purposes have sustainability concerns but, in many cases, information which would assist management decisions is lacking. Key information gaps are the:

- General lack of biological information on the life histories, distribution, and habitat utilisation of fishery species within the harbour.
- Effects of non-fishing activities on fish (e.g. sand mining, tidal power generation).
- Effects of habitat loss or degradation, particularly on juvenile fish.
- Effect that changes in fishing methods have had on the calculation of maximum sustainable yields (Paulin and Paul 2006).
- Extent and nature of fishery interactions between the West Coast and the Kaipara Harbour.
- Connectivity between marine receiving environment health and freshwater fish populations.
- Effects of removing target fishery species on the broader harbour ecosystem.
- Efficacy of bans on scallop harvesting.

Studies funded by the Foundation for Research, Science and Technology, and the Ministry of Fisheries are addressing some of these knowledge gaps. Preliminary data indicates that structurally complex biogenic habitats such as seagrass and horse mussel beds are particularly important to the juvenile stages of many fish species (e.g. snapper). Habitat forming species such as horse mussels are known to be sensitive to sediment (Gibbs and Hewitt 2004). Therefore, the implication for resource managers is that sediment-generating landuse activities could have an indirect effect on the early stages of commercial and non-commercial fish species, through biogenic habitat destruction. This is particularly important for the Kaipara Harbour, as it is estimated to provide around three-quarters of West Coast snapper recruits.

8.1.3 Sustainable aquaculture

Pressure for the expansion of aquaculture in the Kaipara Harbour is likely to continue into the future and there is a risk of slow, long-term aquaculture 'creep' if clear guidance is not provided in planning documents. The effects of aquaculture will be specific to the location, type, and scale of the marine farms and information requirements will vary accordingly. A reasonable level of information is available for the southern Kaipara, which can underpin a broad assessment of the areas that may be suitable for aquaculture. More detailed studies are likely to be required to assess the specific impacts of particular aquaculture proposals (note that ecological concerns may not be the key driver for aquaculture planning). A number of key information gaps remain for the northern Kaipara. These include:

- A lack of detailed information on the habitats and communities present.
- Information on the ecological habitats, communities, and species that are likely to be most vulnerable to the effects of aquaculture.
- Constraints due to spatial conflicts with other values and activities.
- Information on nutrient budgets, primary production, and the aquaculture carrying-capacity.

In addition, it would be useful to have a better understanding of the cumulative impacts of aquaculture in combination with other activities. Ideally, planning for aquaculture should be done on a harbour-wide basis, with consideration of the cumulative effects and consistency in the standard of assessment.

8.1.4 Spread of invasive species

Due to a general lack of long-term ecological monitoring within the harbour, it is impossible to determine any changes that may have occurred due to invasive species. This is problematic for management, as evidence is emerging from other harbours (where historical data is available) of the negative effects of invasive species on the distribution and abundance of native species (e.g. Waitemata Harbour, as documented by Hayward et

al. 1997, 1999). Knowledge gaps that pose difficulties for successful integrated management in relation to invasive species include:

- Biological (particularly reproductive) characteristics of invasive species.
- Impacts of invasive species on native community structure and on specific native species. i.e. knowledge of the stressors (invasive species), receptors (communities and habitats affected), and the various linkages between them (see Arenas et al. 2006). For example, the loss of *Pomatoceros caeruleus* from Meola Reef in the Waitemata Harbour due to an increased abundance of Pacific oysters (Hayward et al. 1999, Ford et al. 2006).
- Effect of invasive species on food chains and, in particular, the effects on higher order predators (e.g. birds, fishes, marine mammals) and on trophic linkages among dominant species.
- Identification of invasive species and knowledge of the invasion history.
- Appropriate tools to eradicate invasive species.
- Identifying main vectors and activities responsible for introducing invasive species.

The findings of a baseline study currently being undertaken for Biosecurity New Zealand will provide an important inventory (including abundance and distribution) of invasive species within the harbour. Additional studies also being commissioned by Biosecurity New Zealand include conceptual modelling of stressor-response relationships to explore the flow-on effects of invasions in the Waitemata, and the development of methods for eradication. The results of these studies will be applicable to the Kaipara.

When information from the baseline study is available, with additional information from other studies, an invasive species detection and response programme could be developed for the Kaipara Harbour. This should include routine surveillance of 'at-risk' areas within the harbour which would be the responsibility of Biosecurity New Zealand.

Management of established invasive species is very difficult. Consequently, the best approach is to prevent the introduction of invasive species through the identification and management of vectors and high-risk activities. Key vectors and high-risk activities that require biosecurity control by regional councils include: aquaculture (movement of stock, vessels, and equipment), marine construction (movement of vessels and equipment), and ports and marinas (vessel movements). The ability of regional councils to restrict vessel movements is fairly limited. However, a number of questions should be considered when consenting to biosecurity high-risk activities. These include:

a. Are the biosecurity risks adequately understood in terms of their likelihood of occurrence and potential consequences?

b. Is the regional council confident that the biosecurity risks of the activity can be controlled, and are the proposed control mechanisms adequate?

c. Should the consent be granted if the biosecurity risk is deemed to be significant?

8.1.5 Protection of critical habitats and taxa

The Kaipara Harbour contains a number of habitats, communities, and taxa that are rare or endangered and likely to provide critical ecological functions and services for the harbour and broader West Coast. Their identification and protection is hampered by: the lack of information on their distribution; the ecological processes involved in the provision of functions and services; threats, and protection measures.

The classification of coastal bird habitats and coastal bird taxa is well established and provides a basis for the development of protection strategies related to birds. Similarly, coastal vegetation has been mapped in the southern Kaipara and a variety of controls are available to protect, or preferably, expand its range. In contrast, much less is known about important marine habitats, communities, and taxa, and methods of protection. Key knowledge gaps for important marine habitats, communities, and taxa therefore include:

- Distribution (although reasonable information is available for the southern Kaipara, little is known about the northern Kaipara).
- Spatial and temporal changes in distribution and abundance.
- The ecological functions and services they provide.
- Individual and cumulative threats.
- Methods for protection.

8.1.6 Protection of marine mammals

Currently there is little detailed information on marine mammal distribution, abundance within the Kaipara Harbour or information on how marine mammals utilise the Kaipara Harbour. Most of the information comes from stranding records and casual sightings (Fisher 2005).

9 Conclusions

This report summarises the available environmental information on the Kaipara Harbour coastal environment, with a primary focus on the coastal marine area (CMA). The Kaipara Harbour is an extremely important ecological system that contains many high value species, communities, and habitats which provide local, regional, and international functions and services. However, the environmental values of the Kaipara have been, and continue to be, degraded. More detailed information tends to be available for the marine ecological communities and birds in southern parts of the harbour (compared to the northern Kaipara) but information on fish and marine mammal distributions is fairly limited for the entire harbour. Available information on habitat quality is variable in coverage, quality, and temporal integrity.

Threats to environmental values

The environmental quality and values of the harbour are potentially under threat from a variety of activities managed under the Resource Management Act (1991), Fisheries Act (1996), and Biosecurity Act (1993).

Landuse activities that generate sediment appear to be particularly problematic. The scale and magnitude of these impacts is likely to increase if sediment (and in some areas, contaminant) discharges are not managed appropriately. It is recommended that sediment accumulation models be developed for the Kaipara Harbour to allow the long-term effects of various landuse options to be predicted. These models would provide a strong foundation for policy and plan provisions, or non-statutory methods, which seek to ensure the long-term sustainability of the harbour.

The spread of invasive species (biosecurity) is a harbour-wide issue, with a number of well-established species already occurring in many areas. The transfer of vessels, stock (aquaculture), and equipment between infested areas elsewhere and the Kaipara exposes the harbour to a substantial risk of further infestation by new species.

The effects of fishing are also significant and recent reviews and fisheries assessments indicate that grey mullet, school shark, rig, and scallop fisheries all have sustainability issues within the Kaipara. Fishing down populations of target species can have marked effects on other parts of the marine food chain. The indirect effects of fishing are poorly understood but, given the status of local fish stocks, they could be quite significant in the Kaipara Harbour.

The potential effects of aquaculture, sand extraction, and tidal energy generation on the environmental quality and values of the harbour are also poorly understood. These activities could have a direct affect on the harbour but the scale and magnitude of their individual effects is difficult to isolate and quantify with the information available. It is therefore not possible to reliably quantify the cumulative effects of multiple activities,

although many activities (both proposed and existing) have the potential to cause large-scale cumulative impacts that cross planning boundaries, both individually (e.g. land-use) or in combination with other activites (e.g. sand-mining and tidal energy extraction). Further work on assessing the cumulative impacts of multiple activities is needed.

Monitoring

Time-series monitoring is undertaken in the Kaipara Harbour for: State of the Environment assessments of general water quality (including bulk water quality, bathing water quality, and shellfish monitoring) and benthic communities; fisheries assessments; and as a condition of resource consents.

Water quality monitoring in the Southern Kaipara is temporally intensive but intentionally lacks spatial coverage, whereas water quality monitoring in the Northern Kaipara includes a number of sites but is temporally episodic. The available data suggests that water quality is relatively poor in many areas but the limited nature of monitoring makes it is difficult to assess whether broad-scale environmental changes have occurred or what the magnitude of change has been. Integrating and improving both the spatial and temporal coverage of the water quality monitoring programmes carried out by the ARC and the NRC would provide a more robust and useful dataset, which would assist in the harbour-wide management of water quality.

A broad-scale State of the Environment survey has been carried out in the southern Kaipara. A similar survey of the northern Kaipara would give a harbour-wide overview of benthic ecology and provide an extremely valuable foundation for resource management decisions. More frequent ecological monitoring of a few high-risk sites should also be considered to provide an early warning of undesirable trends in ecological health. Results from the broad-scale State of the Environment survey should assist in the selection of high-risk sites.

Fisheries monitoring in the harbour is specific to target species and tends to be fairly limited in scope. Information on habitats important to fishery species is also limited (e.g. nursery habitats) and the extent and quality of key habitats is not systematically monitored. This is a significant concern, given the importance of the Kaipara Harbour to the West Coast snapper and, possibly, other fisheries.

Resource consent monitoring provides data relevant to the specific activities but is not particularly useful for assessing cumulative impacts in the Kaipara Harbour. A standardised toolbox of sampling methods for resource consent monitoring would enable data from individual activities to be amalgamated, and assist in the evaluation of broad-scale cumulative effects.

Knowledge gaps for effective integrated management:

The general lack of environmental information on the Kaipara coastal environment serves as a significant barrier to the integrated management of the Kaipara Harbour system.

There are many critical knowledge gaps which impede effective resource management. These include, but are not limited to:

a. A lack of consistent, spatially extensive, and regularly collected water quality data.

b. Detailed information on long-term plans for catchment development and its associated effects on the harbour.

c. Ecological maps for the northern Kaipara (similar to those produced by Tier II SoE monitoring of the Southern Kaipara).

d. Fundamental information on sedimentation patterns and mangrove expansion.

e. Utilisation of Kaipara Harbour by Maui's dolphins (when and where).

f. Biosecurity risks of consented activities, particularly construction and aquaculture.

g. Aquaculture carrying-capacity of the harbour.

h. Identification of fish nursery areas and an understanding of their susceptibility to Resource Management Act activities.

i. Extent and nature of fishery interactions between the West Coast and the Kaipara Harbour.

j. Effects of removing target fishery species on the broader harbour ecosystem.

k. Uncertainty about the volume of sand arriving into the Tapora area, relative to the amount extracted.

l. The effects of sand extraction on sediment transport processes operating in the entrance of the Kaipara Harbour.

m. Linkages between tuatua populations at the harbour entrance and the impacts of sand extraction on commercial harvesting.

n. The cumulative impacts of Resource Management Act activities, both individually and in combination with fishing and biosecurity threats.

o. The effects of large-scale energy harvesting (i.e. tidal power generation).

p. The scale and magnitude of sediment impacts on the Kaipara Harbour (both direct and indirect).

q. Areas that require protection for a range of species (birds, fishes, critical habitat).

Investigations currently being carried out on: invasive species, the productivity of seagrass beds, fish habitat utilisation; the efficacy of scallop protection measures, and marine mammal use of the harbour (particularly Maui's dolphin) will help fill some of these knowledge gaps. However, a range of additional work is required to provide the information base needed for effective management of Kaipara Harbour.

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