



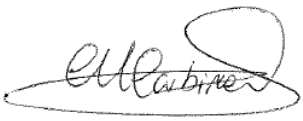

Inventory of Spatial Information for Manukau Harbour and Auckland West Coast

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Inventory of Spatial Information for Manukau Harbour and Auckland West Coast

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Prepared for
Auckland Council

National Institute of Water & Atmospheric Research Ltd

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June 2012
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Executive Summary

The management of the marine environment and resources can be facilitated by maps and geo-referenced information that identify where and how coastal resources are being used. This report provides an initial collation and preliminary assessment of available spatial information for the Manukau Harbour and West Coast region. This includes spatial information on fauna, flora, coastal habitat types, and biological, physical and geological resources of the region. The report focuses on the marine environment but includes some information pertaining to terrestrial and coastal areas. Literature was reviewed under a number of criteria including the direct inclusion of mapped information, the date of the study, the location and extent of information, the methods used to collect the information and the applicability of the information to future mapping initiatives.

The reviewed literature provides insight into the gaps in spatial coverage and where specific science disciplines are lacking. The majority of physical studies exist at broader spatial scales than most of the other scientific fields, facilitated by modeling approaches. Geological/sedimentological information also has broad coverage although there is concern with some of these approaches due to the level of extrapolation and consequent effect on accuracy. Biological information spans a wide variety of information types; ranging from specific habitat mapping, long-term monitoring of a few sentinel locations, to manipulative ecological experiments which are often conducted in a few select locations.

Examining by geographic region, it is clear that there is much of the West Coast that has an absence of detailed ecological information with the data that does exist originating from locations close to human settlements (Piha, Muriwai). For the Manukau Harbour, available information also focuses in the north-west of the harbour closest to the population centres, with the south and west much less studied.

The review of literature indicated that many studies contained mapped variables, but that not all of this was useful due to the age, resolution and reliability of information. Conversely, other studies did not actively 'map', but contained geo-referenced information which may be useful in marine spatial planning. This highlighted a need for careful assessment of literature to avoid overlooking useful information.

1.0 Introduction

Auckland Council is committed to the protection of coastal resources by ensuring integrated and sustainable management (<http://theplan.theaucklandplan.govt.nz/>). This can be achieved through Marine Spatial Planning (MSP), bringing together multiple users of marine resources and facilitating informed and coordinated decision-making. This ultimately upholds the principles of 'Ecosystem Based Management' (McLeod et al. 2005, McLeod and Leslie 2009). A key part of MSP is to use maps and geo-referenced information to identify where and how coastal resources are being used.

To assist with the development of the Unitary plan and to facilitate any future spatial planning in the Manukau Harbour and the West Coast region (from Waikaretu in the south to Waionui inlet at the Mouth of the Kaipara Harbour, Figure 1), Auckland Council (AC) contracted the National Institute of Water and Atmospheric Research (NIWA) to begin collating and summarising available spatial information. Information summarised included, but was not limited to:

- Type of information.
- Age of the data.
- Methods of collection.
- Reliability/uncertainty.
- Spatial extent (areas of coverage).
- Availability (source/permission).

In this report we provide a portfolio of the information ascertained from a comprehensive review of available studies. This includes spatial information on fauna, flora, coastal habitat types, and biological and physical/geological resources of the region. From this portfolio, we can make recommendations based on the types of information available and how it may be used, interpreted and combined. Completion of this process will also identify:

- Gaps in our current knowledge.
- Gaps in the coverage of data.
- Options for future work aimed at improving knowledge to feed into marine spatial planning and Unitary Plan development for the West Coast.

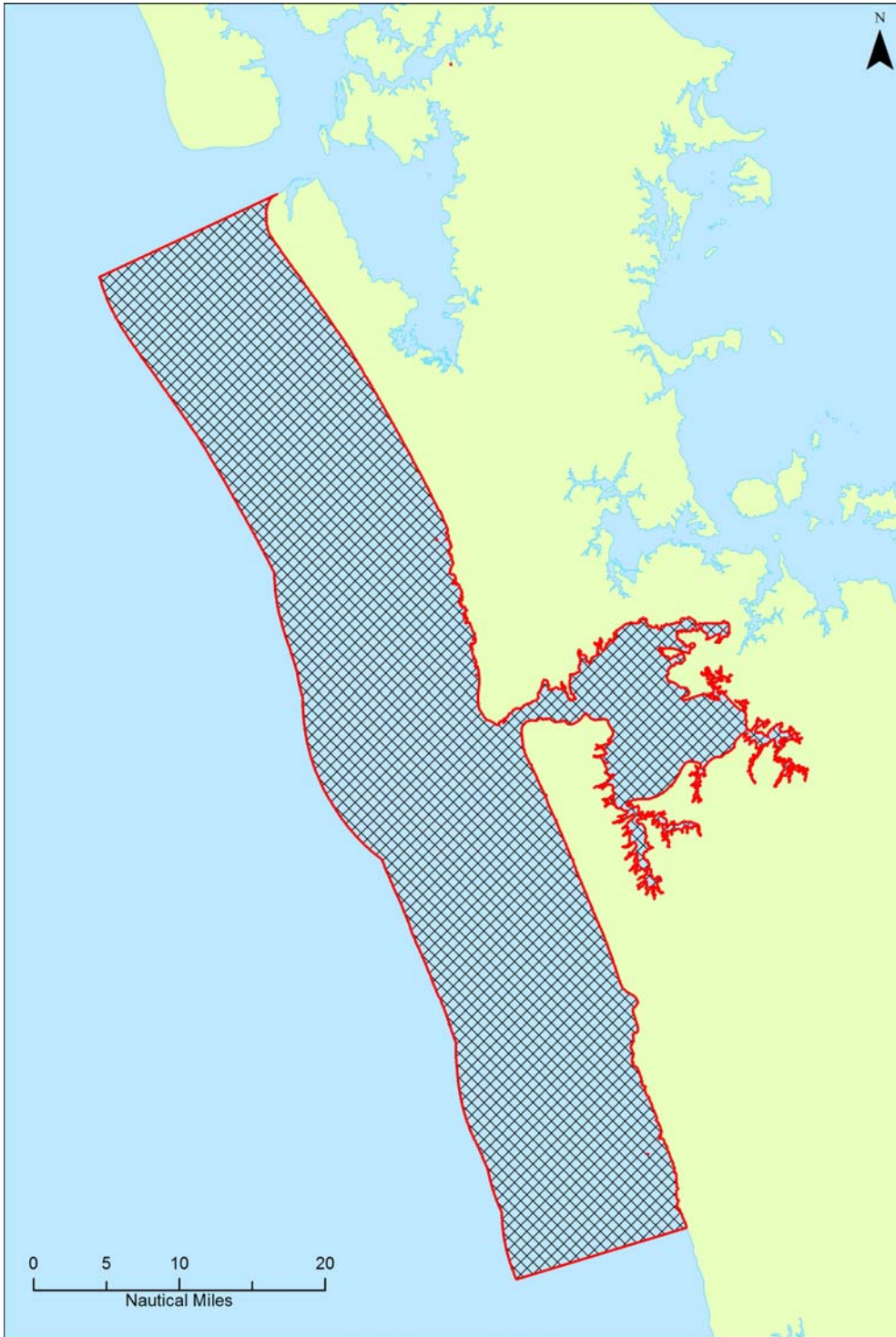


Figure 1. Map showing the Auckland Council's jurisdiction on the West Coast covered in this report, from the Waionui Inlet at the mouth of the Kaipara Harbour in the north to Waikaretu in the south (indicated in red), with the Manukau Harbour lying in between.

2.0 Methodology

2.2 Reviewing available literature

Literature was obtained from a number of sources: The provision of excel spreadsheets by Auckland Council was used as a starting point for compiling some of the available information. In addition, the NIWA online catalogue (NIWAcat) was explored. Finally, expert knowledge from NIWA staff who have worked in the Manukau Harbour since the mid 1980's was used to ensure that important information sources had not been omitted. Information was not considered from the grey literature; such as unpublished university research, smaller consultancy reports, more obscure material from the regional councils or mapped information which may be held within the resource consent process. Studies sourced are shown in Table 1. Studies were broadly categorized into the primary science discipline they represented (recognising that there is overlap in the majority of cases, bio-chemistry, physical-sedimentology, etc.). Figure 2 indicates that studies focusing on biological processes (principally ecology) are the most abundant followed by physical processes. Studies focusing exclusively on chemical or geological processes are rare, and these disciplines are more commonly included as smaller components of other studies.

Table 1. Catalogue of 80 studies from the Manukau Harbour and West Coast

Graham (1940)	Vant and Budd (1993)	Cahoon et al. (1999)
Beveridge et al. (1950)	Hewitt et al. (1993)	Turner et al. (1999)
McDougall (1961)	Trowbridge (1994)	Ringer (1999)
McDougall and Brodie (1967)	Thrush et al. (1994)	Thrush et al. (2000)
Paine (1971)	Gregory et al. (1994)	Brander et al. (2000)
Schofield (1975)	Cummings et al. 1995	Ellis et al. (2000)
Stephenson (1975)	Commito et al. (1995)	Green et al. (2000)
Esler (1975)	Turner et al. (1995)	Smith et al. (2001)
Hayward (1976)	Trowbridge (1996)	Morrison and Parkinson (2001)
Heath (1976)	Thrush et al. (1996a)	Morrison et al. (2002)
Grange (1977)	Thrush et al. (1996b)	Smith et al. (2002)
Grange (1979)	Hewitt et al. (1996)	Cahoon and Safi (2002)
Henriques (1980)	Grant et al. (1997)	Ferreira and Roberts (2003)
Paul (1983)	Thrush et al. (1997a)	Thrush et al. (2003)
Hamill et al. (1985)	Bell et al. (1997)	Irwin et al. (2003)
Quilter (1987)	Legendre et al. (1997)	Kelly (2003)
Partridge (1987)	Hewitt et al. (1997a)	Hayward and Morley (2004)
Fox et al. (1988)	Cummings et al. (1997)	Pegman and Rapson (2005)
Pridmore et al. (1990a)	Turner et al. (1997)	Swales et al. (2005)
Pridmore et al. (1990b)	Schneider et al. (1997)	King et al. (2006)
Roper et al. (1991)	Thrush et al. (1997b)	Walsh et al. (2006)
Vant (1991)	Hewitt et al. (1997b)	Pritchard et al. (2008)
Thrush et al. (1991)	Whitlatch et al. (1997)	Akroyd et al. (2008)
Ryan and Healy (1991)	Bell et al. (1998)	Kelly (2008)
Vant and Williams (1992)	Gorman and Neilson (1999)	Du Fresne (2010)
Williamson et al. (1992)	Thrush (1999)	Hayward (2011)
Holland et al. (1993)	Taylor (1999)	Donald et al. (2011)

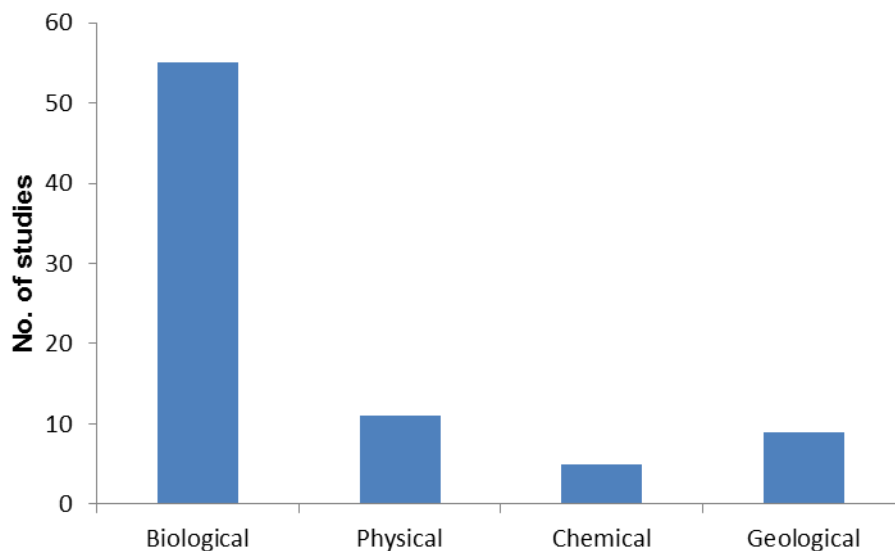


Figure 2. Major scientific disciplines represented from the studies identified for the Manukau Harbour and West Coast (excluding the ~11 Auckland Council Sentinel Manukau monitoring reports).

2.3 Establishing criteria to assess the relevance of information for mapping purposes

Different kinds of information can be useful from a mapping perspective and the process for establishing valuable information for the Manukau and West Coast region needs careful consideration (see Townsend et al. 2012). At the extremes, it is simple to determine whether information is appropriate or inappropriate: A study with clearly mapped variable(s) and a defined spatial extent (provision of coordinates and range) is likely to be highly pertinent to marine spatial planning and mapping, provided that the information is up to date. Similarly, at the other extreme, information that is poorly spatially defined, has insufficient methodological details and shows no clear pathway for extrapolation or interpolation is unsuitable. In between these limits exists a continuum, where the majority of studies will lie; containing both qualitative and quantitative information. It is important to recognise what can be extracted and used from these studies. Qualitative information can still be relevant to mapping. For example, a description of sediment appearance and underfoot “softness” can prove useful in the absence of quantitative granulometry. Furthermore, the necessary intensity of collecting/ processing quantitative results in qualitative information often having a broader spatial coverage. Studies that demonstrate detailed quantitative information at smaller spatial scales have potential for extrapolation across greater areas. For example, the standard Auckland Council sentinel intertidal monitoring site size is 0.009 km², whereas the intertidal area of the Manukau Harbour is ~220 km², meaning that even the summation of the six long term sites (which are rarely sampled simultaneously due to temporal nesting, Hailes and Hewitt 2011) is only 1/4000 of the total surface area. However, the patterns in community dynamics, diversity and sediment composition can be extrapolated to wider areas. Considering the aspects above, we developed a flow diagram for the assessment of the literature (Figure 3) and criteria below. Through this process studies were assessed for:

- Type of information.
- Age of the data.
- Methods of collection.
- Availability (source/permission).

The 'age of the data' is a key criterion relating to the reliability of information; with a greater likelihood of change with time past the point of data acquisition. Changes may occur at different rates depending on the variables of interest but also in response to human actions and environmental fluctuations. As a general guideline we consider information older than ten years as potentially less appropriate for describing the current status of the environment.

Historic information may still be useful in in MSP processes for documenting changes to the environment and looking at the causes of improvements or deteriorations. 'Method of collection' is important for assessing the validity of combining data sources into a single mapping layer, especially when multiple techniques exist for the same metric e.g., sediment particle size distribution.

2.3.1 Review Criteria

Title and reference

To identify and differentiate between studies.

Contains mapped information

Assessment to rapidly evaluate available spatial information with minimal additional effort.

Methods of interpolation

If something has been mapped, information may be provided on spatial sampling coverage (relative to mapped area) and methods of interpolation, e.g., software or by hand.

Project overview

Synopsis of the details/variables covered in the study and the overall achievement.

Date

Information on when the study was published, when data were collected and how the age of the study/data may affect the accuracy for describing the current environmental state.

Location and extent

Location of the study site in either a quantitative (co-ordinates, spatial area covered) or qualitative format (description, diagram). This can also include the temporal frequency of sampling if sampled on multiple occasions.

Method or techniques of sampling

Methods used to measure the variables/ processes of interest e.g., sieve sizes, grabs, cores. Relevant technical detail; sufficient to judge the validity of comparing or combining data.

Applicability to mapping

If data in the study has not yet been mapped, an assessment of the feasibility of extrapolating the data into spatial formats is required. This may be related to the type of information available (quantitative, qualitative), including the availability of explanatory co-variables that may facilitate mapping efforts. Assessments will indicate the likelihood (yes, no, possible with additional processing).

Data source

Identify the organisation of source; necessary if a study contains useful information that will be sourced for inclusion in future mapping work.

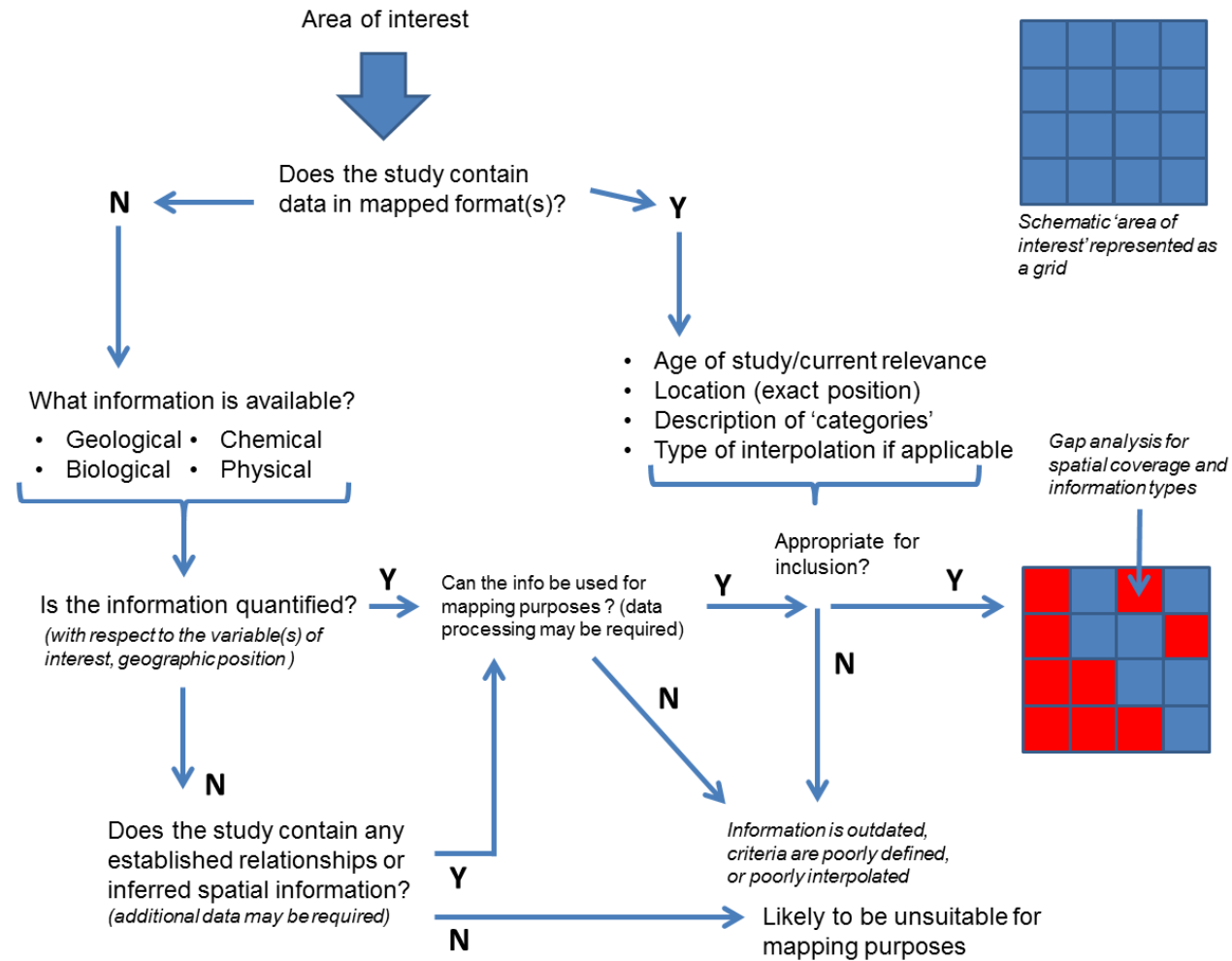


Figure 3. Flow diagram indicating the process used for assessing suitability of studies/information in their application for mapping in the Manukau Harbour and West Coast.

2.4 Reviewed Literature

The reviewed literature is separated by regions with section 4.1 addressing the West Coast region and section 4.2 the Manukau Harbour. Within each section literature has been listed in chronological order.

2.5 The West Coast Region

Reference 1.)

Title and reference

Beveridge, W.A. & Chapman, V.J. (1950) The zonation of marine algae at Piha, New Zealand, in relation to the tidal factor (studies in inter-tidal zonation 2). *Pacific Science* 4(3): 188-201.

Project overview

An inquiry into the role of tidal factors in determining littoral zonation. In most areas exposure to wave action elevated the limits of certain species, especially those higher up on the shore.

Date

1950

Location and extent

Piha

Method or techniques of sampling

Levelling survey was carried out to determine the upper and lower limits of the more important algal and animal species, only the optimal ranges were included (i.e., outliers excluded).

Applicable to mapping

No, the data is very old for marine algae so cannot be assumed to still be accurate.

Reference 2.)

Title and reference

McDougall, J.C. (1961) Ironsand deposits offshore from the west coast, North Island, New Zealand. *New Zealand Journal of Geology and Geophysics*, 4:3, 283-300.

Contains mapped information

Yes (see Figure 6 in this study for regional distribution of ironsand concentration).

Methods of interpolation

Hand interpolation

Project overview

Distribution of magnetic iron sands on the West Coast.

Date

Sampling prior to 1961

Location and extent

West Coast from Kaipara Heads to Wanganui; inclusive of Muriwai and Piha.

Method or techniques of sampling

Surface sediment samples were obtained from the near-shore portion of the shelf off the west from depths between 9 and 90 meters. The percentage of magnetic ironsand in the sediments was determined by magnetic separation.

Applicable to mapping

Possibly, the distribution of sand may have some use but the age of the data >50 years is a concern in these dynamic systems.

Data source

DSIR Wellington

Reference 3.)

Title and reference

McDougall, J.C. & Brodie, J.W. (1967) Sediments of the Western Shelf, North Island, New Zealand. New Zealand. *Memoirs of the New Zealand Oceanographic Institute* No. 35-40. 56pp

Contains mapped information

Yes, maps of depth contours (including transverse profiling), coastal formations (cliffs, beaches etc.), areal distribution of sediments (coarse sand, medium sand, fine sand, very fine sand and mud), with detailed focus on Muriwai, Piha and other locations.

Methods of interpolation

Hand interpolation

Project overview

Surface sediments from Kaipara to Wanganui are categorised by dominant grain-size.

Date

Sampled during two cruises (October 1959 and May 1960)

Location and extent

Kaipara to Wanganui, extending 1-2 degrees of longitude off the coast.

Method or techniques of sampling

Sediment sampled using gravity corer/modified Petersen grab/Hayward orange-peel grab. Sediment wet-sieved for size fractionation.

Applicable to mapping

Possibly, the distribution of sand may have use if more contemporary data is not sourced. Sampling is detailed but crudely interpolated (by hand) and possibilities of changes since sampling exist.

Data source

NZOI Wellington

Reference 4.)

Title and reference

Paine, R.T. (1971) A short term experimental investigation of resource partitioning in New Zealand rocky intertidal habitat, *Ecology*, Vol. 52 (6), 1096-1106.

Contains mapped information

No

Project overview

The study looks at the effects of single species removals on community composition and overt appearance and were examined in exposed, rocky, intertidal habitats in Anawhata. Two experiments were performed. In the first the removal of a carnivorous starfish caused a large growth in vertical distribution of mussel species and a decrease in overall species diversity. The second experiment involved the removal of the same starfish species as well as a large species of algae. The same mussel species took over and almost excluded all other fauna.

Date

Sampled in 1968/69, study published in 1971.

Location and extent

Rocky platform marking the northern boundary of a beach at Anawhata.

Method or techniques of sampling

The *Stichaster australis* removal experiment was initiated Sept. 6, 1968. Immigrant starfish were removed monthly, or whenever conditions allowed, from the experimental area; no other resident invertebrates were excluded. Changes in the zonation of the mussel (*Perna*) were evaluated by rough levelling measurements using a meter stick. Faunal and floral composition was determined from a series of 900 cm² quadrats placed haphazardly throughout the study area.

Applicable to mapping

No despite showing key relationships of resource competition of dominant rocky shore species, information is unlikely to be useful in a mapping format.

Data source

University of Washington

Reference 5.)

Title and reference

Esler, A.E. (1975) Vegetation of the sand country bordering the Waitakere range, Auckland: Piha beach, Proceedings of the New Zealand Ecological Society, vol. 22.

Contains mapped information

Yes, Figure 1 in this study shows the coastal vegetation from 1974 and the likely changes occurring since 1900.

Project overview

Documentation of the coastal vegetation at Piha; with particular reference to changes which have occurred over 75 years. Some changes in vegetation have been caused by the spread of exotic plants and others caused by erosion and accretion.

Date

1974

Location and extent

Piha Beach (northern, central and southern sections).

Method or techniques of sampling

Aerial photo survey and comparison with historical information.

Applicable to mapping

Yes, although more contemporary information exists for this area. Google Earth indicates that there has been subdivision and construction in some of the areas listed as vegetation in Figure 1 from this study.

Data source

Botany division, DSIR, Auckland.

Reference 6.)

Title and reference

Schofield, J.C. (1975) Sea-level fluctuations cause periodic, post-glacial progradation, South Kaipara Barrier, North Island, New Zealand, *New Zealand Journal of Geology and Geophysics*, 18:2, 295-316.

Contains mapped information

Yes, sediment distribution on the South Kaipara Barrier. Also contains synthesis information in the map from other studies.

Project overview

Sand movement between Mt Egmont and the Kaipara Harbour from post-glacial input of sand from landward sources into the system, and coastal deposits.

Date

Published in 1975

Location and extent

West Coast of South Kaipara Barrier.

Method or techniques of sampling

Principally a review and synthesis of available geological information for the West Coast region.

Applicable to mapping

Possibly, although the study is old now and more recent data could be sourced.

Data source

DSIR, New Zealand Geological Survey.

Reference 7.)

Title and reference

Stephenson, A. B. (1975) Sperm whales stranded at Muriwai Beach, New Zealand, *New Zealand Journal of Marine and Freshwater Research*, 9(3), 299-304.

Contains mapped information

No

Project overview

Documentation of sex and lengths of pod of stranded sperm whales. Provides evidence that sperm whales in this part of the Pacific reach the same lengths at sexual maturity and follow similar breeding patterns to those found elsewhere in the Southern Hemisphere.

Date

Single stranding event from 1974

Location and extent

Muriwai Beach

Method or techniques of sampling

Observation

Applicable to mapping

No, single beach stranding event does not yield suitable material for mapping purposes i.e., cetacean distributions or important off shore locations in their life cycle.

Data source

Auckland Institute and Museum

Reference 8.)

Title and reference

Hayward, B.W. (1976) Lower Miocene geology and sedimentary history of the Muriwai-Te Waharoa coastline, North Auckland, New Zealand. *New Zealand Journal of Geology and Geophysics*, 19:5, 639-662.

Contains mapped information

Yes

Project overview

Division of the rock groups along the Muriwai-Te Waharoa coastline into three formations.

Date

1976

Location and extent

Muriwai-Te Waharoa Point coast line (~6km).

Method or techniques of sampling

Observation

Applicable to mapping

Yes, presents geological maps for the sample area, however some changes may have occurred due to the age of this study (~36 years). Co-ordinates are not given so original data would need to be sourced or the map digitised and transformed.

Data source

University of Auckland

Reference 9.)

Title and reference

Paul, L.J. (1983) Distributions of temperature, salinity and demersal fish off the west coast, North Island, New Zealand, 1971-72. Fisheries Research Division, Occasional Publication No. 22.

Contains mapped information

Yes, trawling data, temperature and salinity.

Methods of interpolation

Hand

Project overview

Looking at the coastal hydrology and fish composition along the West Coast.

Date

A series of eight cruises between 1971-1973.

Location and extent

Sample stations between 90 Mile Beach and Golden/Tasman Bay (north of the South Island)

Method or techniques of sampling

Granton Trawl with 37 m ground rope and 73 m sweeps were used with cod-end mesh size of 11.4 cm. Temperature measured with a continuous hull mounted temperature recorder. Bottom water collected with Knudsen reversing bottles, salinity measure within five weeks of collection using a Beckman inductive salinometer.

Applicable to mapping

Possibly, but information would only be useful from a historical perspective rather than describing the current status due to age. More recent studies may provide a better point of reference e.g., Morrison and Parkinson (2001).

Data source

New Zealand Ministry of Agriculture and Fisheries (Wellington)

Reference 10.)

Title and reference

Hamill, P.F., & Balance, P.F. (1985) Heavy mineral rich beach sands of the Waitakere coast, Auckland, New Zealand, *New Zealand Journal of Geology and Geophysics*, 28:3, 503-511.

Contains mapped information

Yes, although basic format (simple annotation of map with point data).

Project overview

Sand characteristics (grain size and mineralogy) and processes acting on the beaches of the Waitakere coast.

Date

Sampling dates not indicated, paper published in 1985.

Location and extent

Waitakere coast, 25 km stretch of coast, sample location indicated in map but grid references are not indicated.

Method or techniques of sampling

42 samples taken along the 25 km stretch of coast. Each beach was sampled by means of channel samples taken from holes dug to the water table, approximately midway between high and low tide levels.

Applicable to mapping

Possibly, although mainly indicative of north-south gradients in geological properties along the coast Waitakere Ranges, rather than three-dimensional variation. Information could be of minor use from a historic perspective.

Data source

University of Auckland

Reference 11.)

Title and reference

Quilter, C.G. (1987) Foraging activity of the sand beach isopod *Scyphax ornatus* Dana, *New Zealand Journal of Zoology*, 14:4, 433-439.

Contains mapped information

No

Project overview

Adult isopods spent the daytime in burrows near the high water mark and then night times foraging over the uncovered middle beach feeding on carrion.

Date

1987

Location and extent

North Piha Beach, 36°57'S, 174°28'E

Method or techniques of sampling

Distribution of adult isopods was recorded during calm warm nights. Densities were too low for pitfall traps to be useful so they were simply counted visually using torchlight.

Applicable to mapping

No, this is a species specific study with limited spatial information (in relation to locations of transects). The study is now old and the information is largely not useful for mapping other than indicating the presence of *Scyphax ornatus* on North Piha Beach in the later 80s.

Data source

University of Auckland

Reference 12.)

Title and reference

Trowbridge, C.D. (1994) Life at the edge: population dynamics and salinity tolerance of a high intertidal, pool-dwelling ascoglossan opisthobranch on New Zealand rocky shores, *Journal of Experimental Marine Biology and Ecology*, Vol 182(1):65-84.

Contains mapped information

No

Project overview

Population dynamics of *Stiliger felinus* populations differ between NE (Hauraki Gulf) and NW (Piha) shores of New Zealand. The slugs have a high salinity tolerance but egg production, tenacity of adults and development rate of embryos all decline at salinity extremes.

Date

Sampled in 1992/1993 with study published in 1994.

Location and extent

Hauraki Gulf and Piha

Method or techniques of sampling

Experimental approach that had sample collection followed by laboratory experimentation.

Applicable to mapping

No, study focuses on a single species, *Stiliger felinus* at only one site on the west coast (Piha) with limited spatial information. The study findings on the environmental conditions limiting the range of *Stiliger felinus* could be useful under some limited context.

Data source

University of Auckland

Reference 13.)

Title and reference

Trowbridge, C. D. (1996) Introduced versus native subspecies of *Codium fragile*: how distinctive is the invasive species *tomentosoides*? *Marine Biology* 126: 193-204.

Contains mapped information

No

Project overview

Comparison between *tomentosoides* and *novae-zelandiae* to determine how morphologically and phenologically distinct the invasive species is. It was found to have different distribution, seasonality and number of fronds per thallus, thereby making it easy to distinguish from the native species.

Date

Sampled in 1992, 1993 and 1995, and published in 1996.

Location and extent

Intertidal rocky shore – Maori Bay (west coast) and Hauraki Gulf

Method or techniques of sampling

Tomentosoides: Patchy distribution, walked along low intertidal benches counting and measuring thallus length of all plants encountered. *Novae-zelandiae*: Dense distribution, 30 m transect, counted number of thalli in five randomly selected 0.25 m² quadrats and measured all fronds protruding from the basal holdfast.

Applicable to mapping

No, information is insufficient for mapping purposes; looking at macrophytes from a limited number of locations and data is between 16-20 years old.

Data source

University of Auckland

Reference 14.)

Title and reference

Brander, R.W. & Short, A.D. (2000) Morphodynamics of a large-scale rip current system at Muriwai Beach, New Zealand, *Marine Geology* 165 (2000) 27–39.

Contains mapped information

Partially – Shows physical processes across a 700 m stretch of beach, to an offshore distance of 300 m. However, exact location of study site is not given.

Project overview

Field measurements were made to investigate the morphodynamics of a large-scale rip current system at Muriwai Beach. Although the magnitude of the morphodynamic and hydrodynamic processes associated with these large rips are extreme, the behaviour of these systems is similar to that of much smaller-scale low energy rips. Evidence to suggest distinct morphodynamic scaling relationships exists between these environments.

Date

Sampled in 1997 and published in 2000.

Location and extent

Muriwai Beach, 3.5 km north of the southern end of the beach, study site 700 m wide stretch of beach.

Method or techniques of sampling

Data were collected on rip spacing, beach morphology and morphological change, near shore water surface elevation and both eulerian and lagrangian feeder and rip flow. Measurements of longshore rip were obtained. Nearshore morphology and topographic changes were surveyed. Water surface elevations and eulerian longshore and cross-shore current velocities were measured using strain gauge pressure sensors and bi-directional, ducted flow meters mounted on weighted, portable pods designed for use in the energetic surf zone.

Applicable to mapping

No unless there is a specific interest in rip current formation.

Data source

Victoria University (Wellington) University of Sydney

Reference 15.)

Title and reference

Morrison, M.A. & Parkinson D.M. (2001) Trawl survey of snapper and associated species off the west coast of the North Island, November 1999. NIWA Technical Report 100, 51p.

Contains mapped information

Yes, in the sense it shows surveyed areas and stratum boundaries for the study site, including station positions catch rates or juvenile/adult snapper (individuals per km²), gurnard, john dory, tarakihi, jack mackerel, trevally and school shark.

Project overview

Trawl survey of the West Coast for snapper and other fish species.

Date

Trawl completed during November 1999.

Location and extent

From 90 Mile Beach to Kawhia Harbour in the 10-200 m depth range.

Method or techniques of sampling

Randomised trawls in various sectors, using a stern trawler (28 m overall length) between hours of 0500 and 1700 (NZST). Catch was sorted by species and weight to the nearest 0.1kg. Length measured to the nearest centimetre below the actual length.

Applicable to mapping

Possibly, more at a qualitative level, information in this study may prove useful (biotic distribution of various fish species), while recognising that fish biomass and movement respond to seasonal and anthropogenic influences in the 13 years since data collection.

Data source

NIWA

Reference 16.)

Title and reference

Ferreira & Roberts (2003) Distribution and abundance of Maui's dolphins (*Cephalorhynchus hectori mau*) along the North Island west coast, New Zealand. *DOC Science Internal Series 93, Department of Conservation*.

Contains mapped information

Yes, contains maps of the various survey zones along the New Zealand West Coast. Also distribution of Maui's Dolphin sightings from surveys (geo-referenced abundance)

Project overview

Distribution and abundance of Maui's dolphins over a couple of years of surveying.

Date

Surveys conducted from 2000-2002.

Location and extent

All along the West Coast of New Zealand; but zones 3-5 relate to the Auckland Council catchment.

Method or techniques of sampling

Observations via aerial survey (from a four-seater Cessna 172): position recorded by flying over sighted dolphins and recorded the approximate position using on-board GPS.

Applicable to mapping

Yes, as shows relative spatial abundance of Maui's dolphins indicating importance of different areas. While this may include seasonal variability, the geo-reference information is a useful starting point for this species of cetacean. More recent information exists for Maui's dolphin (see Du Fresne 2010, Reference 21) which may supersede this study for specific locations.

Data source

Department of Conservation

Reference 17.)

Title and reference

Hayward, B.W., & Morley, M.S. (2004) Intertidal life around the Waitakere Ranges Coast, Auckland Regional Council Working Report No. 111.

Contains mapped information

Yes

Methods of interpolation

Distribution of macro-habitats, rocky substrates, distinctive macro-communities and key organisms was plotted on maps in the field and later traced onto a digital map using Corel Draw software. This map was later transferred onto GIS software by ARC staff and is published at the end of this report.

Project overview

Report gives general descriptive accounts and illustrations of the various intertidal communities that surround the Waitakere Ranges. Zonation patterns of the dominant rocky-shore-inhabiting organisms are presented in 13 transects spread around the coast and illustrate the effects of changing exposure to waves and storms. The six major zones recognised going down the rocky shore are: maritime lichen zone; bare rock zone; periwinkle zone; barnacle zone; mussel, tube-worm and coralline zone; and subtidal fringe seaweed zone. Data on habitat and geographic distribution around the Waitakere Ranges Coast are provided for each species.

Date

Sampled between January 1998 and March 2002, study published in 2004.

Location and extent

50 km of coastline extending from the south end of Muriwai Beach in the north, to Parau at the head of Big Muddy Creek. The area studied and mapped covers the full width of the intertidal zone from extreme low water spring level up to extreme high water spring (extreme tidal range ~4 m) and the splash zone above.

Method or techniques of sampling

All accessible areas of intertidal coastline were surveyed on foot by the authors. Coastline subdivided into 24 separate sections. Survey undertaken during a spring tide event. Detailed examination of all the intertidal habitats present, recording all the living taxa found, assessing their relative abundance and also recording any observed dead taxa. Specimens of taxa that needed microscopic or other detailed study for identification were taken back to the laboratory. The biotic composition of the infauna in soft sediment habitats was periodically surveyed by digging and sieving.

Applicable to mapping

Yes, study contains useful broad information of rocky macro-habitats. The age of the data means that aspects of it may be outdated, depending on the levels of change since the original sampling.

Data source

Auckland Regional Council

Reference 18.)

Title and reference

King, D.N.T., Nichol, S.L., & Hume, T.M. (2006) Rapid onshore sand flux in a high energy littoral cell: Piha Beach, New Zealand. *Journal of Coastal Research*, 22(6), 1360–1369.

Contains mapped information

Yes, various types. Low resolution maps in the sense of annotated photos showing the geomorphic environment at Piha Beach, determined by field observations and ground penetrating radar surveys. Figure 7 from this study shows sand storage in a three-dimensional map.

Project overview

Analysis of sand movement at Piha from surveys and aerial photography. Survey data indicates highly variable and fluctuating deposits of sand moving on and off the active beach face. However, net changes across the cell inferred from aerial photos show the shore line has been advancing at a rate of 0.4 – 1.0 m / year since 1940. Processes of beach building and degradation are similar to those found at other littoral cells along the west coast.

Date

Published in 2006; shore change shown from 1940 to 2000.

Location and extent

Piha Beach (co-ordinates and expanse given in Figure 2 of this study).

Method or techniques of sampling

A time series of seven vertical aerial photos spanning 1940 to 1993 formed the basis for building a composite map of shore line change at Piha. The existing (2000) shore was mapped by GPS survey and added to the time series. Short term variability was eliminated by time intervals of at least two years between successive aerial photos. A global positioning system (GPS) was used to provide positions for six ground control points (GCP) visible in all photos. Image registration and rectification was completed using the software IMAGINE 8.4. This enabled the absolute orientation of the photo group to be established by removing image distortions and linking the control points to real world coordinates. The dune toe was identified in all photos as a surrogate for the shore line and digitized in GIS ArcView 3.2.

Methods of interpolation

RTK GPS survey generated surface map (“krigging” method) of sand storage at Piha Beach.

Applicable to mapping

Yes, contains mapped information physical-geological in nature.

Data source

NIWA / University of Auckland

Reference 19.)

Title and reference

Walsh, C.; McKenzie, J.; Armiger, H. (2006) Spatial and temporal patterns in snapper length and age composition and movement, west coast North Island, New Zealand. *New Zealand Fisheries Assessment Report 2006/6*. 57 p.

Contains mapped information

Yes, principally in the Figure 1 and 14 in this report which show the zonation of fishing areas and the movement of recaptured snapper.

Project overview

Assessing snapper fish stock in SNA 8 on the West Coast (principally biomass estimates).

Date

Snapper tagging program from October 2002 to May 2003.

Location and extent

SNA 8 on the West Coast (from 90 Mile Beach to south of Taranaki), coastal zone.

Method or techniques of sampling

The length frequency and age-length key approach was employed in 2002-03 to estimate catch-at-age for snapper for the main fishing methods in five spatially distinct zones (Ninety Mile Beach, Kaipara, Manukau, North Taranaki Bight, and South Taranaki Bight). Length frequency samples were collected from the single trawl, pair trawl, and long line fisheries, and age data were collected randomly in the form of proportional allocation age-length keys, between spring 2002 and autumn 2003. A total of 161 landings was sampled with over 50 000 lengths measured and 1200 otoliths aged.

Applicable to mapping

Possibly, at a qualitative level, information in this study i.e., snapper movement, may prove useful.

Data source

MFish (now Ministry of Primary Industries)

Reference 20.)

Title and reference

Akroyd, J.; Walshe, K.; Manly, B.; Te Tuhi, J.; Searle, B.; Searle, R. (2008) Distribution and abundance of Toheroa (*Paphies ventricosa*) on Dargaville and Muriwai Beaches, 2006- 2007. *New Zealand Fisheries Assessment Report 2008/29*. 28 p.

Contains mapped information

No

Project overview

Estimation of *Paphies ventricosa* populations for Muriwai Beach (0.7 million (c.v. 14.6%). Toheroa on Muriwai Beach were found in all strata but the 80% were found in the northern 20 km of the beach.

Date

Surveyed in 2007, published 2008.

Location and extent

Transects allocated along the length of Muriwai Beach (~48 km).

Method or techniques of sampling

Used five geographic strata defined by Akroyd et al. (2001) sample consisted of 10 transects allocated to each of five strata covering the length of the beach (48 km). Within each stratum transects were systematically placed 1 km apart, with a random starting point. Each transect covered the area from high water to low water. Quadrats (0.5 m²) were positioned at 5 m intervals down the transect and excavated to 30 cm. The sample content was sieved and any toheroa in the sample were measured to the nearest millimetre. The number of quadrats sampled on each transect line depended on the width of the beach.

Applicable to mapping

Possibly, there is potential for some contribution to comparisons between beaches: qualitative information can be ascertained from the report in the sense it shows widespread distribution of *Paphies ventricosa* on the intertidal/shallow subtidal for characterising this habitat. However, Toheroa are highly mobile.

Data source

Akroyd Walshe

Reference 21.)

Title and reference

Du Fresne (2010) Distribution of Maui's dolphin (*Cephalorhynchus hectori maui*) 2000–2009. DOC Research & Development Series 322.

Contains mapped information

Yes

Project overview

The study synthesises several recent surveys on the distribution of Maui's dolphin. Offshore surveys show the species is regularly found between Kaipara Harbour and Kawhia Harbour and occasionally further south. Maui's dolphins regularly use areas outside of the current protective boundary of the Manukau Harbour.

Date

2000 - 2009

Location and extent

Kaipara to Kawhia Harbours, approximately 0-20km offshore

Method or techniques of sampling

Observational data

Applicable to mapping

Yes, useful and relatively recent spatial information on the Maui's dolphin

Data source

Department of Conservation

Reference 22.)

Title and reference

Hayward, B.W. (2011) Rate of Cliff Retreat, Muriwai, In: Grenfell, H. (editor), & Holzer, H. (editor), Geocene, Auckland GeoClub Magazine, No 6, April 2011.

Contains mapped information

No

Project overview

Cliff retreat in Muriwai between 1975 and 2005 estimated to be ~5 cm (or ~15 cm per 100 years).

Date

2011

Location and extent

Muriwai

Method or techniques of sampling

Comparisons made using photos of a specific feature of Fisherman's Rock.

Applicable to mapping

No, study is descriptive with a couple of photos and not applicable to mapping.

Data source

Bruce Hayward (Geoclub)

2.6 Manukau Harbour

Reference 23.)

Title and reference

Graham, D. H. (1940) Breeding Habits of Twenty-two Species of Marine Mollusca. *Transactions*.

Contains mapped information

No

Project overview

The report looks at 22 mollusc species and their habits during reproduction and spawning in the Manukau Harbour and Portobello (South Island).

Date

Observations from 1926

Location and extent

Manukau Harbour

Method or techniques of sampling

Observations were made in the laboratory on the 22 mollusc species, pictures were obtained and measurements and counts taken.

Applicable to mapping

No, data is spatially limited and over 70 years old.

Data source

Unknown

Reference 24.)

Title and reference

Heath, R.A. (1976) Broad classification of New Zealand inlets with emphasis on residence times, *New Zealand Journal of Marine and Freshwater Research*, 10:3, 429-444.

Contains mapped information

No

Project overview

Tentative classification of 32 New Zealand coastal inlets into groups with similar circulation patterns, based on ratios of their physical parameters. 18 of the coastal inlets had a predominant tidal flow, whilst the other 14 ranged from strong vertical circulation to strong mean horizontal circulation.

Date

1976

Location and extent

32 inlets range from Northern tip of the North Island (Parengarenga Harbour) to Stewart Island (Patterson Inlet) – Manukau Harbour was included in the study.

Method or techniques of sampling

Data for inlets (volume, tidal compartment, entrance width, surface area, length, and average width) compiled from a variety of different sources and used to define circulation patterns.

Surface areas were calculated from either Navy Hydrographic Charts or Lands and Survey Maps using a planimeter. Cross-sectional areas were calculated from the depths shown on hydrographic charts. The tidal compartment is taken as the product of the tidal range with the sum of the water surface area at low spring tide and half the area of the mudflat. The volumes of water at low tide were estimated from average depths for different fractional areas of the inlet concerned.

Applicable to mapping

No, limited spatial information

Data source

DSIR, NZOI

Reference 25.)

Title and reference

Grange, K.R. (1977) Littoral Benthos-Sediment Relationships in Manukau Harbour, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 11(1), 111-123.

Contains mapped information

No

Project overview

Sampling of 57 littoral stations for species composition, distribution, and abundance as part of a baseline ecological survey of the harbour shows that the community trophic structure is related to the sediment grain size. At most sites, the proportion of deposit feeders in the sample increases with decreasing grain size of the sediment.

Date

Sampled in 1975, published in 1977.

Location and extent

57 stations throughout the Manukau Harbour.

Method or techniques of sampling

Macrofaunal sampling, sieved on a 1.0 mm sieve and then identified. Sediment cores were also collected so that sediment size could be determined. In total 57 stations were surveyed.

Applicable to mapping

No, this information is outdated for the ecological variable of interest due to the duration since the study was undertaken. More recent information is available from the collective benthic studies which have been conducted since, although the spatial extent is less.

Data source

DSIR/NZOI

Reference 26.)

Title and reference

Grange, K.R. (1979) Soft-bottom macrobenthic communities of Manukau Harbour, New Zealand, New Zealand. *Journal of Marine and Freshwater Research*, 13:3, 315-329.

Contains mapped information

Yes, certain species and their distributions.

Methods of interpolation

Hand interpolation

Project overview

A survey of the macrobenthos at 42 stations in the channels and subtidal sand-flats in Manukau Harbour, Auckland, revealed four biotic associations separated by species composition, depth, sediment, and possibly salinity. The inner harbour has three communities separated from each other by depth, and, in the shallower areas, by sediment. The outer harbour community is separated from the inner communities by the narrow salinity tolerance of its dominant species.

Date

Sampled in 1977 and published in 1979.

Location and extent

Intertidal sand-flats of the Manukau Harbour. Stations were chosen to cover all the expected ranges in depth and sediment type from the channels and shallower sand flats.

Method or techniques of sampling

Forty-two stations, ranging in depth from 1 m to 16 m below low tide, were sampled throughout the harbour during March 1977. Samples were taken using a small naturalist's dredge covered with 1 mm mesh and fitted with large cutting blades to allow good penetration into the sediment. The dredge was towed for 4 min to collect more or less comparable samples at each station. All individuals were identified as far as possible to species level, counted, and an estimate made on whether they were juveniles, small adults, or adults. Sediment type was not analysed in detail, but each dredge was given a rough visual description.

Applicable to mapping

No, unlikely due to the duration since this information was recorded given the potential for change in macrofauna community.

Data source

DSIR/NZOI

Reference 27.)

Title and reference

Henriques, P.R. (1980) Faunal community structure of eight soft shore, intertidal habitats in the Manukau Harbour, *New Zealand Journal of Ecology*, 3, 97-103.

Contains mapped information

No

Project overview

Study investigates the effects of pollution (nutrient enrichment) and presence of macrovegetation on species diversity and density of large benthic fauna. Pollution was found to decrease density but only have a small effect on diversity.

Date

Collected between 1972-1975, published in 1980.

Location and extent

Eight soft shore intertidal habitats in Manukau Harbour (see Figure 1 in paper).

Method or techniques of sampling

A number of stations, located in different regions of the harbour. Sediment was characterised for fauna (0.25 m² quadrat, 6.25 mm mesh sieve) and sediment properties. Stations were placed in one of eight different habitats depending upon their tidal height, proximity to pollution sources, substrate characteristics, and type of vegetative cover. Species diversity was calculated using the Shannon-Wiener.

Applicable to mapping

No, the study is too old for the ecological variables of interest and more appropriate information is available.

Data source

University of Auckland

Reference 28.)

Title and reference

Partridge, T. R. (1987) *Spartina* in New Zealand, New Zealand. *Journal of Botany*, 25(4), 567-575.

Contains mapped information

No

Project overview

This report looks at the success of *Spartina* species colonisation within New Zealand and discusses species that are present in the Kaipara and Manukau Harbour.

Date

Published in 1987 but data includes historical planting and expansion of beds.

Location and extent

Data is old and very vague in location. Description of *Spartina* beds from as far back as the 1960's.

Method or techniques of sampling

Descriptions of *Spartina* patch including estimations of rhizomes, blades, patch size and flowers.

Applicable to mapping

No, the age of data affects its contemporary usage, as *Spartina* patches have changed. Locations are also crude and not sufficiently detailed.

Data source

DSIR, Botany Division

Reference 29.)

Title and Reference

Fox, M. E., Roper, D. S., & Thrush, S. F. (1988). Organochlorine contaminants in surficial sediments of Manukau Harbour, New Zealand. *Marine Pollution Bulletin* 19:333-336.

Contains mapped information

No

Project overview

A broad-scale survey investigating concentrations of organochlorine contaminants in the Manukau Harbour.

Date

Sampling date not specified, study published in 1988.

Location and extent

5 sites across the extent of the Manukau Harbour

Method or techniques of sampling

At each site 5 sediment cores were collected for contaminant analysis using standard protocols for the specific chemicals involved.

Applicable to mapping

No, the data is >20 years old and spatially limited.

Data source

DSIR, Hamilton

Reference 30.)

Title and Reference

Pridmore, R. D., Roper, D. S., & Hewitt, J. E. (1990) Variation in composition and condition of the Pacific oyster, *Crassostrea gigas*, along a pollution gradient in Manukau Harbour, *New Zealand Marine Environmental Research* 30:163-177.

Contains mapped information

Samples sites shown on map

Project overview

A study focusing on the condition of the Pacific oyster, *Crassostrea gigas*, across a pollution gradient in the Manukau Harbour. Observed changes in condition agreed well with the pollution gradient.

Date

Samples collected on the 21st June 1988 and processed within 24 hours, study published in 1990

Location and extent

5 sites in the Wairopa Channel running from the Mangere Inlet out to the Harbour entrance. Sites are on the northern coast of the Manukau Harbour. The size extent of the sites from which 75 oysters were collected is not indicated, although these were at the mid tide level.

Method or techniques of sampling

Oysters were collected and measured for total weight, total volume, shell weight and shell volume and flesh extract for biochemical analysis. Pollution gradient had been established previously and is indicated from samples collected by Auckland Regional Water Board (1988).

Applicable to mapping

No, the data is >20 years old and spatially limited.

Data source

DSIR, Hamilton

Reference 31.)

Title and reference

Pridmore, R.D., Thrush, S.F., Hewitt, J.E., & Roper, D.S. (1990) Macrobenthic community composition of six intertidal sand-flats in Manukau Harbour, New Zealand, *New Zealand Journal of Marine and Freshwater Research*, 24:1, 81-96.

Contains mapped information

No

Project overview

Macrobenthic community structure was assessed on intertidal sand-flats of Manukau Harbour. Distribution of individuals amongst taxa was similar at the six sites, but there was a noticeable difference in the numbers of the most common taxa. Shift from polychaete dominated to bivalves dominated.

Date

Sampled in 1987, published in 1990

Location and extent

Six 9000 m² sites on the Manukau Harbour sand-flats - established at the mid-tide level near Auckland Airport (Site AA), Puhinui Spit (Site PS), Cape Horn (Site CH), Karaka Point (Site KP), Elletts Beach (Site EB), and Clarks Beach (Site CB).

Method or techniques of sampling

Each sampling site is divided into 12 equal sectors (30 m X 25 m) with three randomised macrofaunal sediment cores (13 cm diameter, 12 cm depth) were taken per sector. Sieved over 500 um aperture.

Applicable to mapping

No. more recent information is available for these sites, although the overall description of only one site (CH) has changed.

Data source

Water Quality Centre, Division of Water Sciences, Department of Scientific and Industrial Research, Auckland Council

Reference 32.)

Title and reference

Roper, D. S., Pridmore, R. D., Cummings, V. J., & Hewitt, J. E. (1991) Pollution related differences in the condition cycles of pacific oysters *Crassostrea gigas* from Manukau Harbour, New Zealand. *Marine Environmental Research*, 31(3), 197-214.

Contains mapped information

No

Project overview

Physical and biochemical condition indices used to assess seasonal fluctuations in condition of oysters at polluted and clean sites within the Manukau Harbour. Study conducted over a 22 month period with assessment of variations in shells, whole weight and other variables.

Date

Sampling carried out between 1988 and 1990. Study published in 1991.

Location and extent

Two locations (Onehunga and Taumatara) (cited as 37 ° 02' S, 174 ° 45' E).

Method or techniques of sampling

Oysters were collected from the two sites over a 22 month period (June 1988 – March 1990), physical conditions including total weight, total volume, shell weight and shell volume were measured as well as biochemical conditions to determine the contaminant loading.

Applicable to mapping

No, data is on the condition indices of oysters found in two locations in the Manukau Harbour; could only be useful if specific focus on oysters.

Data source

NIWA

Reference 33.)

Title and reference

Vant, W. N. (1991) Underwater light in the northern Manukau Harbour, New Zealand. *Estuarine, Coastal and Shelf Science*, 33(3), 291-307.

Contains mapped information

No

Project overview

Phytoplankton growth in relation to underwater light levels in the northern Manukau Harbour. Inorganic suspensoids were the major cause of PAR attenuation in both inner harbour and outer harbour sectors. Resuspension of harbour sediments by tidal currents and wind effects was an important cause of attenuation.

Date

June 1988 to October 1989

Location and extent

Sample area in the north of the Manukau Harbour (The area between and above the Cornwallis Peninsula and Auckland Airport).

Method or techniques of sampling

Study gives the mean attenuation for four locations (direct sectors) in the northern Manukau Harbour. Inorganic suspensoids are the major cause of Photosynthetically Active Radiation (PAR) which resuspension is thought to account for 57-71 % of the variability in PAR.

Applicable to mapping

No, information is not in a suitable format for spatial adaptation.

Data source

DSIR Water Quality Centre

Reference 34.)

Title and reference

Thrush, S. F., Pridmore, R. D., Hewitt, J. E., & Cummings, V. J. (1991) Impact of ray feeding disturbances on sand-flat macrobenthos: do communities dominated by polychaetes or shellfish respond differently? *Marine Ecology Progress Series*, 69, 245-252.

Contains mapped information

No

Project overview

A study of polychaete and bivalve dominated macrobenthic communities in two physically similar intertidal sand-flat sites to study differences in recolonisation of pits created by feeding eagle rays. This study assessed macrobenthic assemblages in and out of ray feeding pits to identify the extent of the disturbance and its importance to different communities.

Date

Observations made in 1988 whilst experiment was conducted in 1989, and published in 1991.

Location and extent

The two sites were adjacent to the AA and CH sites in the Manukau monitoring programme, but more specific information is not provided.

Method or techniques of sampling

All ray pits were marked out in a specified area and sets of five pits selected randomly to be sampled 1, 2, 4, 6, 9 and 24 and 1, 2, 4, 6, 13 and 24 tides after the creation at the bivalve dominate and polychaete dominate sites respectively. Two cores taken in each pit and two from adjacent undisturbed sediment, grain size and organics calculated also.

Applicable to mapping

No. only brief descriptions of Manukau Harbour habitats.

Data source

NIWA

Reference 35.)

Title and reference

Ryan, S.G., Healy, T.R. (1991) Investigation of the sedimentological impact of dredged material, Purakau Channel, Manukau Harbour, NZ. In: Bell, R.G. (editor), Hume, T.M. (editor), Healy, T.R. (editor): Coastal Engineering: Climate for Change; Proceedings of 10th Australasian Conference on Coastal Engineering, 1991. Hamilton, New Zealand: Water Quality Centre, DSIR Marine and Freshwater, 1991: 39-44.

Contains mapped information

No

Project overview

The study investigated the sediment characteristics at the Purakau Channel Disposal sites, and the sedimentation processes which affect the dredge material, in order to provide a basis for on-going monitoring of the site.

Date

1991

Location and extent

Purakau Channel

Method or techniques of sampling

Side scan sonar, seismic reflection profiling, sediment textural analyses.

Applicable to mapping

No, limited application to mapping.

Data source

Water Quality Center, DSIR Marine and Freshwater, University of Waikato

Reference 36.)

Title and reference

Vant, W.N., & Williams, B.L. (1992) Residence times of Manukau Harbour, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 26, 393-404.

Contains mapped information

No

Project overview

The paper presents findings of residence times and salinities of the three main channel systems of Manukau Harbour.

Date

Not specified

Location and extent

Manukau Harbour, all areas to the east of the Laingholm Peninsula.

Method or techniques of sampling

Water quality was measured at five sites fortnightly and the remaining four sites monthly. On all visits salinity profiles were taken and results summarised as depth average values for each site. Brief descriptions of the channels, catchment area and tidal movements are also given. Bathymetric Chart of the Harbour (NZ4314, Royal NZ Navy, 1984) and information from Bioresearchers 1987 were used to define the 10 tidal excursion segments. Models were applied to these areas to determine the residence times.

Applicable to mapping

No, limited application to mapping, although residence time and flushing are useful when comparing different harbours.

Data source

NIWA

Reference 37.)

Title and reference

Williamson, R.B., Blom, A., Hume, T.M., Glasby, G.P., Larcombe, M. (1992) Heavy metals in Manukau Harbour sediments. Water Quality centre DSIR, 1992.

Contains mapped information

Yes, Figure 3.1 in this study shows a sediment map with mean grain-size (ranging from coarse (2 mm) to mud (0.062 mm) and Figure 4.1 the location of the large number of samples sites.

Project overview

The study looks at, and is an examination of, the concentration of various heavy metals (copper, lead, zinc, chromium, iron, manganese, nickel) at various sites around the Manukau Harbour. It assesses the sources and factors controlling these pollutants.

Date

Samples collected 1985 to 1990

Location and extent

Throughout the Manukau Harbour

Method or techniques of sampling

Sampling and processing conducted by Bioresearchers Ltd.

Applicable to mapping

No. It is highly unlikely this would be of value given the age of the study (22-27 years since collection) and non-digitised nature of maps result in reduced value to current mapping approaches. More recent contaminant information exists for multiple location in the Manukau Harbour e.g., benthic health monitoring programme.

Data source

DSIR Marine and Freshwater, Hamilton

Reference 38.)

Title and reference

Holland, P. T., Hickey, C. W., Roper, D. S., & Trower, T. M. (1993) Variability of organic contaminants in inter-tidal sand-flat sediments from Manukau Harbour, New Zealand. *Archives of Environmental Contamination and Toxicology*, 25(4), 456-463.

Contains mapped information

No

Project overview

Sediments from five stations within the Manukau Harbour were sampled using a systematic design to give three representative bulked replicates per station. Particle size, readily oxidizable carbon contents, organo-chlorine insecticides, PCBs determined.

Date

1993

Location and extent

Intertidal sites across the Manukau Harbour

Method or techniques of sampling

Intertidal sand-flats sampled within the Manukau Harbour and analysed on a single occasion for organic contaminants. Results suggested multiple sources of contamination which had little or no association with particle size, but only PCB's and carbon levels.

Applicable to mapping

No, the study is old (19 years) and data are too limited for spatially extrapolation.

Data source

NIWA

Reference 39.)

Title and Reference

Hewitt, J.E., McBride, G.B., Pridmore, R.D., Thrush, S.F. (1993) Patchy Distributions: optimising Sample Size. *Environmental Monitoring and Assessment*, 27: 95-105.

Contains mapped information

No

Project overview

An application of the Bros-Cowell technique, a randomisation technique for optimising sample size, using data from the Manukau Harbour.

Date

Data used from 1987 pilot study for Manukau Harbour Monitoring programme

Location and extent

9000m² intertidal Sites distributed throughout the Manukau Harbour: Auckland Airport (AA), Clarks Beach (CB), Cape Horn (CH), Elletts Beach (EB), Karaka Point (KP) and Puhinui Stream (PS).

Method or techniques of sampling

Sites analysed for community composition (based on 36 replicate cores for pilot study, 13cm dia, 10cm deep).

Applicable to mapping

No, more contemporary data exists (see Reference 80)

Data source

NIWA

Reference 40.)

Title and reference

Vant, W. N., & Budd, R. G. (1993) Phytoplankton photosynthesis and growth in contrasting regions of Manukau Harbour, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 27(3), 295-307.

Contains mapped information

No

Project overview

This paper assesses the nutrient levels throughout the Manukau Harbour in relation to phytoplankton photosynthesis, growth and distribution.

Date

Sampled in July 1991 and June 1992, and published in 1993.

Location and extent

Not available in the report but record of site positions and raw measurements likely still exist. Report gives a good general description of the Manukau Harbour.

Method or techniques of sampling

Five sites within the Manukau Harbour were sampled monthly (early morning) and analysed for DRP, TIN (as a sum of nitrate N and ammonium N), dissolved inorganic carbon and chlorophyll a. Water temperature and salinity, secchi depth and the attenuation coefficient for down-welling were also measured.

Applicable to mapping

No, study uses point source information with low spatial resolution. Information is likely to be temporally variable and is ~20 years old.

Data source

NIWA

Reference 41.)

Title and reference

Gregory, M.R. et al. (1994) Manukau and Waitemata Harbour Sediments, New Zealand Oceanography Institute Chart, Miscellaneous series, No. 70, 1:75000.

Contains mapped information

Yes, this is a sediments map of the Manukau Harbour.

Methods of interpolation

By hand. On steep slopes where samples are sparse, bathymetry is used as a guide in contouring.

Project overview

Sediment map

Date

Published in 1994, chart does not indicate sample collection dates.

Location and extent

Shows sediment particle size for the whole of the Manukau Harbour and part of the West Coast (West Coast coverage of the sediment map extends from south of the Manukau heads to level with Waiuku, to approximately 8 km offshore)

Method or techniques of sampling

Sediment collection from numerous sources, sediment classified using Folk (1965).

Applicable to mapping

Yes, while sediment data can be improved and certain areas of the chart will contain errors due sediment changes since the time of data collection and compilation, it represents a large scale source of spatial information for sediments.

Data source

New Zealand Oceanography Institute

Reference 42.)

Title and reference

Thrush, S. F., Pridmore, R. D., & Hewitt, J. E. (1994) Impacts on soft-sediment macrofauna: the effects of spatial variation on temporal trends. *Ecological Applications*, 4(1), 31-41.

Contains mapped information

No

Project overview

This paper illustrates the potential problems encountered when spatial variation confounds temporal patterns from data collected during routine monitoring programmes on intertidal sand-flat communities in the Manukau Harbour.

Date

October 1987 to June 1991, bimonthly sampling.

Location and extent

Six intertidal sites of 9000 m², distributed throughout the Manukau Harbour (see monitoring reports for sites co-ordinates, e.g., Hailes and Hewitt 2011).

Method or techniques of sampling

Data used in this study has been previously collected from the Manukau Monitoring Programme.

Applicable to mapping

No, there are some brief descriptions of the Manukau Harbour but no more than in references e.g., Reference 80.

Data source

Auckland Council/NIWA

Reference 43.)

Title and reference

Commito, J.A., Thrush, S.F., Pridmore, R.D., Hewitt, J.E., & Cummings, V.J. (1995) Dispersal dynamics in a wind-driven benthic system. *Limnology and Oceanography*, 40(8), 1513-1518.

Contains mapped information

No

Project overview

Wind and water velocity measurements were made to study post larval macrofaunal dispersal dynamics in the Manukau Harbour. Results indicated that post larval dispersal may influence the benthic abundance over a wide range of spatial scales.

Date

1998

Location and extent

Descriptions of the intertidal site locations where samples were collected.

Method or techniques of sampling

Macrofaunal sampling on intertidal sand-flat coupled with wind and water velocity measurements.

Applicable to mapping

No, there are some brief descriptions of the intertidal but no more than in references e.g., Reference 80.

Data source

NIWA

Reference 44.)

Title and reference

Turner, S.J., Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., & Maskery, M. (1995) Are soft-sediment communities stable? An example from a windy harbour. *Marine Ecology Progress Series*, 120, 219-230.

Contains mapped information

No

Project overview

The macrobenthic soft-sediment communities at six sites in the Manukau Harbour were quantitatively sampled at bimonthly intervals since Oct 1987 – Feb 1993. Mean wind conditions were found to play an important role in contributing to variability in community structure probably as a result of sediment disturbance by wind-induced waves and bottom turbulence.

Date

Sampled from 1987, published in 1995.

Location and extent

This data has been collected from specific locations within the Manukau Harbour, sites are 9000 m².

Method or techniques of sampling

Analysis was carried out on the macrofaunal community composition over time. This study uses long-term data of macrofaunal communities and sediment characteristics. Six sampling locations, characteristic and representative of intertidal sand-flat habitats, were selected for their similarity in overall physical appearance. 12 macrofaunal cores of 13 cm were collected at each site bimonthly.

Applicable to mapping

No. not quantitatively, but report gives a good description of the kinds of intertidal sandy habitats present in the Manukau Harbour.

Data source

NIWA/ Auckland Council

Reference 45.)

Title and Reference

Cummings, V.J., Pridmore, R.D., Thrush, S.F., & Hewitt, J.E. (1995) Post-settlement movement by intertidal benthic macro-invertebrates: Do common New Zealand species drift in the water column? *New Zealand Journal of Marine and Freshwater Research*, Vol. 29: 59-67.

Contains mapped information

No

Project overview

Study focuses on the post-settlement behaviour of juveniles for several species (including bivalves and polychaetes).

Date

October –December 1991

Location and extent

Wairoa Island, Manukau

Method or techniques of sampling

Plankton net sampling of the water column at various distances from the sediment surface

Applicable to mapping

No, probably unsuitable for mapping approaches as only small areas of the sediment are investigated for macrofauna at a well-known site over 20 years ago.

Data source

NIWA

Reference 46.)

Title and reference

Thrush, S.F., Whitlatch, R.B., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., & Wilkinson, M.R. (1996) Scale-dependent recolonisation: the role of sediment stability in a dynamic sand-flat habitat. *Ecology*, 77 (8), 2472-2487.

Contains mapped information

No

Project overview

Field experiment designed to test how differences in the aerial extent of disturbance affected macrofaunal recolonisation on a sand-flat.

Date

Study from 1993, published in 1996.

Location and extent

Only at one site within the Manukau (Wairoa). Study used multiple blocks within this site.

Method or techniques of sampling

Different-sized patches of sediment were defaunated by covering the sediment surface with black polyethylene sheeting weighted with concrete paving slabs. Macrofaunal cores were taken at intervals from time zero to look at faunal recovery.

Applicable to mapping

No, probably unsuitable for mapping approaches as only small areas of the sediment are investigated for macrofauna at a well-known site, close to 20 years ago.

Data source

NIWA

Reference 47.)

Title and Reference

Hewitt, J.E., Thrush, S.F, Cummings, V.J., Pridmore R.D. (1996) Matching Pattern with processes: predicting the effect of size and mobility on the spatial distribution of the bivalve *Macomona liliانا* and *Austrovenus stutchburyi*. *Marine Ecology Progress Series*, 135, 57-67.

Contains mapped information

No

Project overview

Study looking at the spatial patterns of *Macomona liliانا* and *Austrovenus stutchburyi* in relation to measured variables. Many patterns were consistent across sites suggesting the importance of biological rather than environmental variables. Over the scales looked at in this study, individual mobility and inter-individual interactions appeared important process influencing the observed spatial patterns in juveniles and adults for both species.

Date

January-February 1991

Location and extent

2 mid-tidal sites at the mouth of the Pukaki Creek on the eastern side of the Manukau Harbour. One site located on the exposed sand-flat just outside the creek mouth with the other located 1km away on a sheltered mudflat within the creek.

Method or techniques of sampling

Intensive sampling design for macrofauna and environmental variables

Applicable to mapping

Possibly, this study does not contain information that can be directly mapped, however, its insight into processes controlling the distribution of bivalves, could be useful.

Data source

NIWA

Reference 48.)

Title and reference

Thrush, S.F., Hewitt, J.E., Pridmore, R.D., & Cummings, V.J. (1996) Adult/juvenile interactions of infaunal bivalves: contrasting outcomes in different habitats. *Marine Ecology Progress Series*, 132(83-92).

Contains mapped information

No

Project overview

Field experiments were used to assess the influence of density variations of adult bivalves (two species; *Macomona liliiana* and *Austrovenus stutchburyi*) on recruitment of juveniles. The generality of these results was tested by running the experiment con-currently at two sites of different sediment grain-size and wave exposure in the Manukau Harbour.

Date

January 1991 for approximately 3 months.

Location and extent

Extensive intertidal flats near Wairoa Island in Manukau Harbour (37° 02'S, 174°4), Two sites differing in sediment properties.

Method or techniques of sampling

Manipulation of species in various combinations of density treatments (combination of densities of live adults or empty shells) placed in tubes. Samples were collected at 3, 6 and 9 weeks after the initiation of the experiment.

Applicable to mapping

No, information of limited spatial extent.

Data source

NIWA

Reference 49.)

Title and reference

Legendre, P., Thrush, S.F., Cummings, V.J., Dayton, P.K., Grant, J., Hewitt, J.E., Hines, A.H., McArdle, B.H., Pridmore, R.D., Schneider, D.C., Turner, S.J., Whitlatch, R.B., & Wilkinson, M.R. (1997) Spatial structure of bivalves in a sand-flat: Scale and generating processes, *Journal of Experimental Marine Biology and Ecology*, 216, 99-128.

Contains mapped information

Yes, in the sense that all sampled locations are demonstrated on a geo-referenced diagram.

Project overview

Survey conducted to identify factors controlling the spatial distributions of *Macomona liliiana* and *Austrovenus stutchburyi*. Most of the large scale spatial structure could be explained by physical and biological variables. Results of analysis suggest different factors are controlling the distribution of adults and juveniles. Adults of both species displayed significant special structure, whilst juveniles were much less spatially structured.

Date

Sampled in 1994, published in 1997.

Location and extent

Sand-flat off Wairoa Island, Manukau. 378 019 S, 1748 499 E, 12.5 hectares in extent shown in schematic.

Method or techniques of sampling

12.5 Ha area divided into 200 grid cells (25 m x 25 m) with a sampling station was randomly selected and marked within each cell. At each location three cores totalling 0.04 m² were collected and sieved through a 500 um mesh sieve. The remaining sediment in the 0.25 m² quadrat was excavated to a depth of 15 cm and then sieved through a 4 mm mesh to collect large animals. Bivalves were counted, sized and split into size classes. Mass of shell hash, grain size and site elevation were also measured.

Applicable to mapping

Yes, while this study demonstrates the direct distribution of bivalve species over a 12.5 hectare area in the Manukau Harbour, its greatest value could stem from the identified factors controlling bivalve distributions. Although this study is now 18 years old and bivalve populations will have changed, the identified factors could be used to predict bivalve distribution in the absence of actual faunal information.

Data source

NIWA

Reference 50.)

Title and reference

Thrush, S.F., et al. (1997) The sand-flat habitat: scaling from experiments to conclusions. *Journal of Experimental Marine Biology and Ecology*, 216, 1-9.

Contains mapped information

No

Project overview

NIWA sponsored a workshop to examine how spatial patterns interact with ecological processes and affect our ability to make generalisations.

Date

1997

Location and extent

General field descriptions are available but it is isolated to the Wairoa Island area of the Manukau Harbour.

Method or techniques of sampling

Density variation with a grid to measure adult/juvenile *Macomona* interactions.

Applicable to mapping

No, limited spatial information for a well-known location

Data source

NIWA

Reference 51.)

Title and Reference

Turner, S.J., Grant, J., Pridmore R.D., Hewitt J.E., Wilkinson M.R., Hume T.M., Morrisey D.J. (1997) Bedload and water-column transport and colonization processes by post-settlement benthic macrofauna: Does infaunal density matter? *Journal of Experimental Marine Biology and Ecology*, 216, 51–75.

Contains mapped information

Yes, shows map of the study site and density distributions of *Macomona* with a 250 x 500 m study area.

Methods of interpolation

Not indicated

Project overview

The study focuses on dispersal and colonization by post-settlement benthic macrofauna in relation to natural densities of *Macomona liliiana*. The greatest level of macrofauna colonization occurred in areas of high sediment reworking and deposition suggesting that post settlement stages may be passive processes (while not excluding active processes).

Date

Two week period, February 1994.

Location and extent

22 experimental sites within a 250 x 500 m study area by Wairoa Island

Method or techniques of sampling

Densities of large *Macomona* were mapped within the study site and bedload traps and pans were then deployed to collect juveniles over a 2 week period and determine their movement and abundance.

Applicable to mapping

Possibly, the study contains mapped information of *Macomona liliiana* distributions although this is unlikely to be useful per se due to the age of the data (>10 years). There is potential that information on macrofaunal colonization conditions could have some application.

Data source

NIWA

Reference 52.)

Title and Reference

Schneider, D.C., Walters, R., Thrush, S., Dayton, P. (1997) Scale-up of ecological experiments: Density variation in the mobile bivalve *Macomona liliana*, *Journal of Experimental Marine Biology and Ecology*, 216 129–152.

Thrush, S.F., Schneider, D.C., Legendre, P., Whitlatch, R.B., Dayton, P.K., Hewitt, J.E., Hines, A.H, Cummings, V.J., Lawrie, S.M., Grant J., Pridmore, R.D., Turner, S.J., McArdle, B.H. (1997) Scaling-up from experiments to complex ecological systems: Where to next? *Journal of Experimental Marine Biology and Ecology*, 216, 243–254.

Contains mapped information

No

Project overview

These studies examine the process of scaling up from small-scale and controlled experiments to higher levels of regional and greater importance.

Date

Data from Manukau monitoring time series

Location and extent

9000m² intertidal Sites distributed throughout the Manukau Harbour: Auckland Airport (AA), Clarks Beach (CB), Cape Horn (CH), Elletts Beach (EB), Karaka Point (KP) and Puhinui Stream (PS).

Method or techniques of sampling

The use of scope analysis and a spatially explicit model of population dynamics.
Review of existing information on scaling processes.

Applicable to mapping

Yes, these studies have relevance to mapping approaches as they deal with scaling information up from smaller to larger scales. These studies could be of high importance and consideration if ecological data collected at small spatial scales is to be successfully extrapolated upwards.

Data source

NIWA

Reference 53.)

Title and Reference

Hewitt, J.E., Legendre, P., McArdle, B.H., Thrush, S.F., Bellehumeur, C., Lawrie, S.M., (1997) Identifying relationships between adult and juvenile bivalves at different spatial scales, *Journal of Experimental Marine Biology and Ecology*, 216 77–98.

Contains mapped information

Samples sites shown on map

Project overview

This study examines relationship between adults and juveniles *Macomona* along different gradients on an intertidal sand-flat. It found different intensities and direction of relationships at different scales and at different sites; supporting the hypothesis of larger scales than those commonly examined in small-scale field experiments contributing to the variability of results of adult–juvenile interaction experiments.

Date

December 1993

Location and extent

Intertidal sand-flat near Wiroa Island, 3 sites spanning 1km of sand-flats located at mid-tidal height.

Method or techniques of sampling

At each site samples were collected from 2 transects running perpendicular to each other. Macrofaunal core samples were collected at small intervals (1m) nested within larger lags (5m). Sediment samples were collected to assess environmental parameters.

Applicable to mapping

No, limited spatial information and old faunal information which may have changed over time.

Data source

NIWA

Reference 54.)

Title and Reference

Whitlatch, R. B., Hines A.H., Thrush, S.F., Hewitt, J.E. Vonda Cummings, V.J. (1997) Benthic faunal responses to variations in patch density and patch size of a suspension-feeding bivalve, *Journal of Experimental Marine Biology and Ecology*, 216, 171–189.

Contains mapped information

Samples sites shown on map

Project overview

The study investigated the response of benthic macrofauna and epibenthic predators to controlled densities and patch sizes of *Austrovenus stutchburyi*. Bivalve density manipulations greater than 600m⁻² had mixed effects on macrofauna colonisation with 2 species reduced, 3 enhanced and 3 unaffected. The biggest effect of high-density cockles was a reduction in *Macomona*.

Date

January-February 1994

Location and extent

Wiroa Island in Manukau Harbour (37 8029 S, 174 8419 E).

Method or techniques of sampling

Experimental plots manipulating patch size and density of *Austrovenus stutchburyi*. Pitfall traps used to sample small mobile predators and siphon nipping assessed from randomly sampled cockles in each plot (10-50). At the end of the experiment 0.25m² quadrants were used to sample and estimate the density of bivalves.

Applicable to mapping

No, limited spatial information and the faunal composition may have changed over time.

Data source

NIWA

Reference 55.)

Title and reference

Bell, R.G., Hume, T.M., Dolphin, T.J., Green, M.O., & Walters, R.A. (1997) Characterisation of physical environmental factors on an intertidal sand-flat, Manukau Harbour, New Zealand. *Journal of Experimental Marine Biology and Ecology*, 216(1–2), 11-31.

Contains mapped information

Yes

Methods of interpolation

Digital terrain model was used to form a topographical image of the entire study area.

Project overview

Physical environmental factors including sediment characteristics, inundation time, tidal currents and wind waves are measured to portray a complex picture of the sand-flat.

Date

1997

Location and extent

The intertidal sand-flats off Wairoa Island (37 8 1.39 S, 174 8 49.29 E).

Method or techniques of sampling

The meso-scale topography of the entire sand-flat off Wairoa Island and adjacent channels was surveyed using a combination of land-based levelling during low-tide and boat-mounted echo sounding during high tides. Broad-scale pattern of the normal surficial sediments on the sand-flat was determined by sampling at 50 m intervals along three shore-normal profiles. Also measured in this report were sediment transport and reworking depths, hydrodynamic and wind measurements that were used to produce/simulate tide and wind driven currents, wind waves, sand-flat topography and inundation, sediment mobilisation.

Applicable to mapping

Yes, high detailed bathymetry/topography for the study location, although this may have shown some minor changes.

Data source

NIWA

Reference 56.)

Title and reference

Hewitt, J.E., Pridmore, R.D., Thrush, S.F., & Cummings, V.J. (1997) Assessing the short term stability of spatial patterns of macrobenthos in a dynamic estuarine system, *Limnology and Oceanography* 42(2), 282-288.

Contains mapped information

No

Project overview

Short-term (3 weeks) study on the stability in spatial patterns of eight common, near-surface, potentially mobile macrofaunal species. During this period wind conditions re-worked the sediment to a depth of 3 cm, resulting in the movement of both animals and sediment. Despite this movement the majority of the species exhibited stable spatial patterns. This indicates that spatial arrangement can persist despite regular sediment transportation.

Date

Sampled in 1990 and published in 1997.

Location and extent

Wairoa Island sand-flat, Manukau.

Method or techniques of sampling

55 2 m x 2 m quadrats were placed 10 m apart in five rows oriented parallel to the shoreline. Three cores (13cm diameter 15 cm deep) were collected from each quadrat. Cores from each quadrat were combined and sieved through a 500 um mesh, then preserved. These were then taken back to the lab to be sorted, identified to lowest possible taxonomic level and counted. Bivalves were sized to nearest 0.1 mm (longest shell axis). Nets (mesh size 250 um) were erected perpendicular to the incoming tide to provide a quantitative assessment of species undergoing post-settlement dispersal in the water column.

Applicable to mapping

No, faunal information over 20 years old and of limited spatial use.

Data source

NIWA

Reference 57.)

Title and reference

Grant, J., Turner S.J., Legendre P., Hume T.M., Bell R.G. (1997) Patterns of sediment reworking and transport over small spatial scales on an intertidal sand-flat, Manukau Harbour, New Zealand. *Journal of Experimental Marine Biology and Ecology*, 216, 33–50.

Contains mapped information

Yes, detailed bathymetry of the 250 x 500 m study site referenced to mean low sea level.

Project overview

This study measured physical sediment reworking and transport at 22 experimental sites at Wiroa Island in order to examine spatial patterns of sediment transport, and its relationship to passive advection of benthic fauna. Sediment reworking replaced about 2–3 mm of sand per day. Variance in reworking was influenced by location within the study site, tidal shear stress (model generated), and elevation on the sand-flat.

Date

February 1997

Location and extent

Large intertidal sand-flat attached to Wiroa Island (378 029 S, 1748 419 E). Exact location is shown in Figure 1 in this study.

Method or techniques of sampling

Sediment reworking was measured by two methods: Dyed sand placed in buried pans to track reworking by currents and waves (observed as replacement by ambient sand). Changes in bed level examined using a buried plate with measurements of sediment column height above this fixed reference as indicators of deposition.

Applicable to mapping

No. of minor value, the mapped bathymetric area is relatively small so of little use to the majority of larger scale mapping approaches.

Data source

NIWA

Reference 58.)

Title and Reference

Cummings, V., J. D. C. Schneider, and M. R. Wilkinson (1997) Multi-scale experimental analysis of aggregative responses of mobile predators to infaunal prey. *Journal of Experimental Marine Biology and Ecology* 216, 211-227.

Contains mapped information

Samples sites and transects shown on map

Project overview

This study investigated the impacts of predators (three wading bird species) on the density of bivalves at small spatial scales. No response to predation was found at the plot scale or at the larger scale in this study.

Date

January to February 1994

Location and extent

0.5 x 0.5m plots within a 250 x 500m study site by Wairoa Island (shown in Figure 1 in this study)

Method or techniques of sampling

Faecal droppings were used to identify bird diet. Bivalve densities were manipulated in 0.5 x 0.5m plots and measured before, during and after the experiment, to establish predation rates. Birds were predicted to focus foraging efforts in the high density plots.

Applicable to mapping

No, spatially limited and faunal information may have changed over 18 years since the study was conducted.

Data source

NIWA

Reference 59.)

Title and reference

Bell, R.G., Dumnov, S.V., Williams, B.L., & Greig, M.J.N. (1998) Hydrodynamics of Manukau Harbour, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 32(1), 81-100.

Contains mapped information

Yes

Methods of interpolation

The finite-element model RMA-2 was used in this report along with in situ variables from a one month study in the harbour as well as other available data collected in the same area.

Project overview

This study is on a model that has produced information on tidal propagation in Manukau Harbour. It establishes the dominance of tidal-driven circulation over wind-driven circulation in most of the harbour with the exception of the upper intertidal areas.

Date

Sampling in 1994, published in 1998

Location and extent

Data was collected from the field study as well as compiled from other sources. There is a brief description of the Manukau Harbour.

Method or techniques of sampling

Field data collected along with the implementation of the hydrodynamic model, have given more confidence to the model in the prediction of tidal propagation in the Manukau Harbour. Spatially robust with eight sites within the harbour and sampling done over a one month period (so the intensity of the sampling was short).

Applicable to mapping

Yes, spatial maps of wind induced residual circulation and M_2 residual currents, with detailed focusing on specific areas. A very useful study for mapping physical parameters of the Manukau Harbour; data is old but still appropriate and useful.

Data source

NIWA

Reference 60.)

Title and reference

Taylor, M.D. (1998) The influence of environmental factors on reproduction and recruitment of *Macomona liliانا* (Class: Bivalvia) in Manukau Harbour, New Zealand, Thesis, University of Auckland.

Contains mapped information

No

Project overview

The thesis reports on features of the reproductive, larval supply and recruitment biology of *Macomona* in relation to environmental factors in the harbour.

Date

1998

Location and extent

Auckland Airport site (37° 02'S, 174° 41' E).

Method or techniques of sampling

Site observations, surface sediment samples, fresh samples collected, histology and core samples.

Applicable to mapping

No, limited spatial information.

Data source

University of Auckland

Reference 61.)

Title and reference

Cahoon, L.B., Nearhoof, J.E., & Tilton, C.L. (1999) Sediment grain size effect on benthic microalgal biomass in shallow aquatic ecosystems, *Estuaries* Vol. 22, No. 3B, p. 735-741.

Contains mapped information

No

Project overview

Comparisons of benthic microalgal biomass and sediment grain size in coastal and estuarine ecosystems in North Carolina and Manukau Harbour. A negative relationship between the proportion of fine sediments and benthic microalgal biomass suggests anthropogenic loadings of fine sediment may reduce the biological productivity of shallow water ecosystems.

Date

Sampling date not specified, published 1999.

Location and extent

Intertidal and shallow (<1 m depth) sub-tidal sites in Manukau Harbour (exact location not specified).

Method or techniques of sampling

Sediment cores (2.5 cm diameter to a minimum depth of 3 cm) were collected by hand or with the aid of a small Peterson grab. Benthic microalgal biomass in sediment samples was measured as chlorophyll *a*. Sediment grain-size was analyzed by a combination of dry and wet sieving.

Applicable to mapping

No. result from the Manukau Harbour are only a small component of this study and not applicable to mapping approaches.

Data source

University of North Carolina/Oregon State University

Reference 62.)

Title and reference

Gorman, R.M., & Neilson, C.G. (1999) Modelling shallow water wave generation and transformation in an intertidal estuary. *Coastal Engineering*, 36(3), 197-217.

Contains mapped information

Yes

Methods of interpolation

SWAN third-generation spectral model

Project overview

The Manukau Harbour has relatively large fetches and extensive intertidal flats. Data collected was input into a model to simulate wave transformation along a transect.

Date

1999

Location and extent

Harbour wide

Method or techniques of sampling

Wave growth was measured in the Manukau Harbour and then used (SWAN third-generation spectral model) to simulate wave transformation during a part of the study period which consistent south-westerly winds blew along the instrument transect.

Applicable to mapping

Yes, contains relatively recent bathymetry, current (3DD grid contours).

Data source

NIWA

Reference 63.)

Title and reference

Thrush, S.F. (1999) Complex role of predators in structuring soft-sediment macrobenthic communities: Implications of changes in spatial scale for experimental studies. *Australian Journal of Ecology*, 24(4), 344-354.

Contains mapped information

No

Project overview

Case studies from Manukau Harbour that illustrate how small changes in the spatial scale can affect results, due to predator perceptions and prey mobility, in relation to the role that predators play in structuring communities (the rate of prey consumption, the behaviour, morphology, mobility of the predator, in soft sediment communities-sediment disturbances associated with feeding).

Date

Various times due to review nature of this study.

Location and extent

Various case-studies from around the Manukau Harbour, namely the Wairoa Island sand-flat and Te Tau Bank.

Method or techniques of sampling

Various techniques due to the review nature of this study.

Applicable to mapping

No, limited spatial information of use.

Data source

NIWA

Reference 64.)

Title and Reference

Turner, S. J., J. E. Hewitt, M. R. Wilkinson, D. J. Morrisey, S. F. Thrush, V. J. Cummings, and G. Funnell (1999) Seagrass patches and landscapes: the influence of wind-wave dynamics and hierarchical arrangements of spatial structure on macrofaunal seagrass communities. *Estuaries* 22, 1016-1032.

Contains mapped information

No

Project overview

The study looks at the influence of patch size, landscape scale and wave exposure on the infaunal community composition within seagrass patches at 3 site; including 2 within the Manukau Harbour.

Date

Sampling began in April 1994 and repeated in October 1994, April 1995 and October 1995

Location and extent

Three sites, two of which are in the Manukau Harbour: Wiroa Island and Clarks Beach. At each site, 12 seagrass patches were selected within a 200 x 200 m plot.

Method or techniques of sampling

Sea grass patches were identified in each area and marked out. Over the period of 1.5 years, cores for macrofauna were periodically collected, sieved, sorted and identified. Seagrass attributes were identified (patch size, seagrass % cover, total seagrass biomass (aboveground and belowground) patch perimeter, and nearest neighbour distances between patches). This was facilitated through aerial photographs (vertical colour and colour infrared at scales of 1:1,500 and 1:3,000) taken in October 1994 and April 1995.

Applicable to mapping

Possibly, the data is old (~20 year) relative to the timeframe over which seagrass patches can change in extent (e.g., see Townsend et al. 2010 for Whangateau). The paper provides minimal direct information on seagrass patch sizes, however the data and aerial photos used in this study may be of use if they can be sourced. More up-to-date photos, if available, would be of greater strategic value for mapping.

Data source

NIWA, Hamilton

Reference 65.)

Title and reference

Ellis, J. I., Schneider, D. C. et al. (2000) Detecting anthropogenic disturbance in an environment with multiple gradients of physical disturbance, Manukau Harbour, New Zealand. *Hydrobiologia* 440(1): 379-391.

Contains mapped information

No

Project overview

This report concentrates on point source data collected from the old sewage discharge point (North-west area of the harbour/Puketutu Island). It uses a gradient design (BACI) approach with natural spatial variability in macrofaunal data to detect point source impacts that may be occurring. Useful information includes: grain size and organic content away from the outfall, depth averaged mean tidal currents and orbital speed at the bed and macrofaunal data.

Date

Sampling prior to 2000

Location and extent

Two transects set up in the north-west of the Manukau Harbour – near to Puketutu Island/sewage outfall. Exact locations were not provided.

Method or techniques of sampling

Two transects set up from the outfall, with five and six sites along each, where macrofaunal (sieved on 500 micron and id'ed to lowest possible taxonomic level), grain size and organics samples were collected, tidal current values and orbital velocities calculated, depth averaged water velocities while a numerical model was used to determine the wind stress.

Applicable to mapping

No, not relevant now sewage outfall disestablished.

Data source

NIWA

Reference 66.)

Title and reference

Green, M.O., Bell, R.G., Dolphin, T.J., & Swales, A. (2000) Silt and sand transport in a deep tidal channel of a large estuary (Manukau Harbour, New Zealand). *Marine Geology*, 163 (1–4), 217-240.

Contains mapped information

Yes

Project overview

Time series of suspended-silt concentration and suspended-sand concentration in a deep channel are analysed. The harbour was found to be broadly ebb-dominant and therefore self-flushing of sand, and silt suspension in the channel was not related to local boundary-layer dynamics, but was explained in terms of movement up and down the channel of a horizontal gradient in silt concentration, which implies the existence of a turbid water mass that is perched on the surrounding intertidal flats at high tide and that drains into the channel during the ebb tide.

Date

Surveyed in December 12-18th 1997, published in 2000.

Location and extent

Hangore Bank/Poutawa Channel

Method or techniques of sampling

Data are from an experiment in the 14 m deep channel on the south-western edge of Hangore Bank. The experiment centred on deployment of the bottom-mounted instrument tripod ALICE in Poutawa Channel. There is data available on the suspended sediment in this location and there are maps that have been produced from a finite-element model (RMA-2) to simulate tide and wind currents as well as simulation of wind waves.

Applicable to mapping

Yes, tidal current velocities are mapped for subtidal regions of the harbour. This study would be of use if mapping physical attributes across the harbour.

Data source

NIWA

Reference 67.)

Title and Reference

Thrush, S.F, Hewitt, J.E., Cummings, V.J., Green, M.O., Funnell, G.A., Wilkinson, M.R. (2000). The Generality of Field Experiments: Interactions between Local and Broad-Scale Processes. *Ecology*, 81(2), 399–415.

Contains mapped information

Samples sites shown on map

Project overview

This study investigated the influences of differences in wave climate on local ecological interactions between adult and juvenile bivalves, looking for generalities across local and broad-scale processes. The study was conducted at 3 locations in New Zealand, one of which was the Manukau Harbour.

Date

January 1997

Location and extent

3 sites within the Manukau Harbour: two by Wairoa Island and a single site at Clarks Beach. At each experimental site, five blocks (separated by 25 m) were established with each occupying an area of 4 m² and composed of four (0.5 x 0.5 m) experimental plots.

Method or techniques of sampling

Manipulative experiment, adjusting the densities of *Macomona liliiana* on sand-flat habitats. The experiment ran for 35 days and experimental plots were sampled to estimate the density of bivalves. Sediment samples were collected to look at grainsize and chlorophyll a concentration and DOBIES were used to monitor wave climate.

Applicable to mapping

No, limited spatial application and more recent information exists for these Manukau Harbour sites.

Data source

NIWA

Reference 68.)

Title and reference

Smith, M.J., Stevens, C.L., Gorman R.M., McGregor, J.A. & Neilson C.G. (2001) Wind-wave development across a large shallow intertidal estuary: A case study of Manukau Harbour, New Zealand, *New Zealand Journal of Marine and Freshwater Research*, 35(5), 985-1000.

Contains mapped information

Yes, but only bathymetry map shown as example of study area. Mapping does not feature as a novel part of this study.

Project overview

Study focuses on the importance of locally generated wind-waves in estuaries for sediment dynamics and the transport of biota.

Date

Weather station data from 9 December 1996 to 14 January 1997.

Location and extent

Weather stations were setup across the width of the harbour. Three 10 m high meteorological masts were deployed at: a ground-based upwind site; a central site 40% of the way across the estuary and a downwind platform 1 km out from Wiroa Island.

Method or techniques of sampling

Meteorological masts recorded wind patterns and Dobies were deployed to measure wave pressure.

Applicable to mapping

No, variables recorded unlikely to have application or be of use.

Data source

NIWA

Reference 69.)

Title and reference

Morrison, M. A., Francis, M. P., Hartill, B. W., & Parkinson, D. M. (2002) Diurnal and Tidal Variation in the Abundance of the Fish Fauna of a Temperate Tidal Mudflat. *Estuarine, Coastal and Shelf Science*, 54(5), 793-807.

Contains mapped information

Yes, Figure 1 in this study demonstrates an area near Pahurehure Inlet with respect to reef, land, and tidal flats areas. Also demonstrates sites of sampling. Although not all spatial information is demonstrated within this paper there is an indication that geo-referenced data is in existence.

Project overview

Small fish assemblages were sampled with respect to tide and diurnal phases on mud and sand intertidal flats habitats (in the Manukau Harbour).

Date

Conducted prior to 2002, specific field sampling dates are not provided.

Location and extent

Pahurehure Inlet, on the mid-eastern coast of the Manukau Harbour.

Method or techniques of sampling

Counts and measurements of fish taken over the sample time. Beach seine and outrigger trawls (a form of push net) were used to quantify the fish on the sand/mud flats.

Applicable to mapping

Yes, some of this information could be used, particularly if original geo-referenced data sets are sourced. Abundances and even the presence of species may have changed in the >10 years since the study was completed (dates of field sampling would need to be ascertained) but as one of the few studies of fish in the inner Manukau Harbour, the qualitative information may have value.

Data source

NIWA

Reference 70.)

Title and reference

Smith, M., Gorman, R., Stevens, C., & McGregor, J. (2002) Waves in Shallow Water. *Water & Atmosphere*, 10(2), 20-21.

Contains mapped information

Yes

Project overview

This study took field measurements from the Manukau Harbour and applied it to the wave model SWAN (developed in the Netherlands). By taking real life measurements it gives more confidence in the model. This particular model is focused on forcing (applied by wind direction) and attenuation (refers to the reduction in size of waves by wave breaking and friction with the seabed).

Date

2002

Location and extent

The data discussed in this report would be available but is not included in this particular report. Positions of the sampling locations, pressure sensor, current meter and wave gauge data would be recorded somewhere.

Method or techniques of sampling

Measurements at six sites along a 15 km line across the estuary using pressure sensors, current-meters, and high-frequency wire wave gauges. Measurements of wind speed at four sites across the estuary were also taken, which changed significantly according to the surrounding topography. SWAN model was used in this report, along with bathymetric maps of the Manukau Harbour

Applicable to mapping

Yes, article demonstrates mapped bathymetry, wave height and wave motion at the seabed for the whole of the Manukau Harbour. The information in this article is a synthesis of work from FRST work and publications. Data underpinning the figures in this article would be of high value to mapping approaches.

Data source

NIWA

Reference 71.)

Title and reference

Cahoon, L.B., & Safi, K.A. (2002) Distribution and biomass of benthic microalgae in Manukau Harbour, New Zealand, *New Zealand Journal of Marine and Freshwater Research*, 36(2), 257-266.

Contains mapped information

No

Project overview

Benthic microalgae biomass and taxonomic composition were investigated at intertidal locations throughout the Manukau Harbour. Found that loading of fine sediments may affect amount and distribution of benthic microalgae. The physical characteristics of Manukau Harbour and similarity in taxonomic composition of the phytoplankton and benthic microalgae suggest that resuspended benthic microalgae are an important component of the harbour's phytoplankton biomass.

Date

Collected in 1996 and published in 2002.

Location and extent

Locations throughout the Manukau Harbour intertidal zone chosen to represent the various sediment textures. Manukau littoral, Wairoa Island, Weymouth, TeTau/Karore Bank, Hikihiki Bank, Karore Bank, Hangore Bank.

Method or techniques of sampling

Sediment samples were collected by hand held 2.5 cm diameter corers to a depth >2 cm. One to six replicate cores were collected at each sample location. Benthic microalgal biomass was measured as chlorophyll *a* using the double extraction, spectrophotometric technique of Whitney & Darley (1979). Sediment samples were also collected for analysis of grain-size distribution. High Performance Liquid Chromatography (HPLC) analysis of pigments carried out on sub-set of cores as a means of determining the higher level taxonomic composition of the benthic microalgae in different locations and sediment types.

Applicable to mapping

No, data relating to turbidity will be temporally variable.

Data source

NIWA

Reference 72.)

Title and reference

Thrush, S.F., Hewitt, J.E., Norkko, A., Nicholls, P.E., Funnell, G.A. & Ellis, J.I. (2003) Habitat change in estuaries: predicting broad-scale responses of intertidal macrofauna to sediment mud content. *Marine Ecology Progress Series*, 263: 101–112.

Contains mapped information

No

Project overview

Investigation into the macrofaunal distribution across mud to sand gradient in 19 estuaries located around the North Island. Transects were set up at 19 estuaries and measurements of elevation, geotechnical properties, macrofauna, sediment (grain size/organics/chlorophyll *a*) taken from all localities. Models were developed for different species and highlighted the potential variation in response to habitat change, concluding that changes in both occurrence and density need to be considered when predicting likely responses to changes in habitat.

Date

Sample collection between October and December 2000

Location and extent

Sampled in the Manukau Harbour as well as other locations. All sampling was done on intertidal sand-flats, along a gradient of mud to firm sand. GPS measurements were taken along the transects.

Method or techniques of sampling

At each location a transect was divided in to 12 strata and the positions of haphazardly chosen sample locations within each strata were recorded with hand held GPS.

Applicable to mapping

Yes, if appropriate environmental data is available models may help predict the potential distributions of certain species. Models will only be capable of forecasting over large spatial scales (>100m) rather than fine scale (i.e., on a per meter basis).

Data source

NIWA

Reference 73.)

Title and reference

Kelly, M., Pelly, L., Morrison, M. (2003) Nga Kararehe o Nga Kuia e Toru, Manukau Harbour – getting to know our traditional kai moana reef again.

Contains mapped information

Yes, shows oyster reef for Nga Kuia e Toru off Puketutu Island.

Project overview

A historical synopsis of the Manukau Harbour from the perspective of the Makaurau Marae; focusing on the changes which have been observed in the coastal system over 50 years, specifically the discontinuation of the oxidative ponds at Puketutu Island.

Date

Historical perspective from 1960 to 2000

Location and extent

Principally around Puketutu Island

Method or techniques of sampling

Various

Applicable to mapping

Yes, oyster reef information and changes over time may be of interest.

Data source

NIWA, Makaurau Marae

Reference 74.)

Title and reference

Irwin, A., Hallegraef, G.M., McMinn, A., Harrison, J., Heijnis, H. (2003) Cyst and radionuclide evidence demonstrate historic *Gymnodinium catenatum* dinoflagellate populations in Manukau and Hokianga Harbours, New Zealand, Harmful Algae, 2(1), 61-74.

Contains mapped information

No

Project overview

This study documents a major toxic dinoflagellate bloom that affected over 1500 km of New Zealand coastline including the Manukau Harbour. The report suggests that a broad scale environmental change had occurred resulting in the major bloom of *Gymnodinium catenatum* causing Paralytic Shellfish Poisoning (PSP).

Date

Sampled in 2001 and study published in 2003.

Location and extent

Resting cysts of *G. catenatum* collected from the Manukau Harbour in the Waiparua Channel, off White Bluff, in ~ 3.5 m water.

Method or techniques of sampling

Sediment cores (40 cm long/4.5 cm internal diameter) were collected by SCUBA divers. Cores were then frozen, sliced into 1 cm increments and then processed (palynological processing and ²¹⁰Pb radiometric dating).

Applicable to mapping

No, not relevant with respect to spatial information.

Data source

University of Tasmania/Australian Nuclear Science and Technology Organisation

Reference 75.)

Title and reference

Pegman, A.P. McK. & Rapson, G.L. (2005) Plant succession and dune dynamics on actively prograding dunes, Whatipu Beach, northern New Zealand, *New Zealand Journal of Botany*, 43(1), 223-244.

Contains mapped information

Yes, schematic map of changes that have occurred in sand dune vegetation from as early as 1940 up until 2000.

Project overview

Sand dune vegetation quantitatively described and related to successional stage, local environment and progradation dynamics. At Whatipu the rates indicate that shrub land develops within 50 years, suggesting that spatial analogues of dune succession can mis-represent the longevity of early seral stages. Unusual successional patterns and the presence of rare flora and fauna make Whatipu Beach important for conservation. This study describes the vegetation pattern on the southern Whatipu dunes where old shorelines have been mapped in the past, to assess how the vegetation is related to the degrees of dynamism and progradation of the shore and to site age.

Date

Information included from 1840 to 2000

Location and extent

South Whatipu beach, on the North tip of the Manukau Harbour mouth.

Method or techniques of sampling

The study area extended from the harbour entrance approximately 400 m east of Cutter Rock to 2000 m north-west of Cutter Rock. 99 quadrats, each 10 x 10 m, were placed randomly over the study area and the shoot presence of all vascular and bryophytic plant species was recorded, sediment collected to determine water content and particle size. Two transects set up with elevation measured every 10 m, presence and absence of water noted, sand samples taken every 50 m (%OC), sand traps (sediment movement), aerial photos from 1940-2000 (NZAM and AL) used to draw shorelines on locality maps and topography, OC and plant communities superimposed onto these maps.

Applicable to mapping

Yes, this study gives a good quantitative description of the dune habitat and could be used in habitat mapping for this area although some changes may have occurred since 2000.

Data source

Conducted by Institute of Natural Resources, Massey University.

Reference 76.)

Title and reference

Swales, A. Ovenden, R., MacDonald, I.T., Lohrer, A.M & Burt, K.L. (2005) Sediment remobilisation from decomposing cordgrass (*Spartina anglica*) patches on a wave-exposed intertidal flat, *New Zealand Journal of Marine and Freshwater Research*, 39:6, 1305-1319.

Contains mapped information

No

Project overview

An experiment to determine remobilisation rates from herbicide-treated patches were monitored at different wave exposures.

Date

Sampled around 2004

Location and extent

The study was carried out in one location within the Manukau Harbour (37°05'S 174°51'E).

Method or techniques of sampling

Investigated the effects that *Spartina* had on resuspension rates/sediment remobilisation.

Applicable to mapping

No, information is not applicable to mapping.

Data source

NIWA

Reference 77.)

Title and reference

Pritchard, M., Gorman, R., & Lewis, M. (2008) South-eastern Manukau/Pahurehure inlet contaminant study: hydrodynamic, wave and sediment-transport model implementation and calibration. *Auckland Regional Council Technical Report, 056*.

Contains mapped information

Yes

Project overview

The main aim of this study was to model contaminant accumulation for the purposes of identifying significant contaminant sources and testing the efficiency of stormwater treatment options.

Date

2008

Location and extent

Concentrates on the southern Manukau Harbour catchment.

Method or techniques of sampling

Modelling study

Applicable to mapping

Yes, numerous physical parameters are modelled and spatially referenced for the Manukau Harbour: bed roughness, bathymetry, wave information. Report contains/demonstrates a large quantity of data, some of which stems from other literature.

Data source

NIWA

Reference 78.)

Title and reference

Kelly, S., (2008) Environmental Condition and Values of Mangere Inlet, Whau Estuary and Tamaki Estuary. Prepared by Coast and Catchment Ltd for Auckland Regional Council. Auckland Regional Council Technical Report 2008/031.

Contains mapped information

Yes, shows maps of Coastal Protection Areas (CPA) for the Mangere Inlet, in addition to multiple environmental parameters, at point sources, in the region.

Project overview

Environmental quality assessment of various areas, including Mangere, in relation to stormwater impacts.

Date

Multiple sources of data, ranging from 1990's to 2000's.

Location and extent

Location relevant to Manukau Harbour is the Mangere Inlet.

Method or techniques of sampling

Various

Applicable to mapping

Yes, geo-referenced information from this study may be of use, but is of limited spatial extent.

Data source

Auckland Council

Reference 79.)

Title and reference

Donald, K.M., Keeney, D.B., Spencer, H.G. (2011) Contrasting population makeup of two intertidal gastropod species that differ in dispersal opportunities, *Journal of Experimental Marine Biology and Ecology* 396 (2011) 224–232.

Contains mapped information

No

Project overview

Polymorphic DNA microsatellite sequences were used to reveal the level of genetic connectedness among populations of two intertidal species, *Diloma nigerrima* and *Diloma subrostrata*.

Date

Published in 2011

Location and extent

Cornwallis (Northern Manukau Harbour near Manukau Heads).

Method or techniques of sampling

Diloma nigerrima and *Diloma subrostrata* were collected from around the coast of New Zealand, and *Diloma nigerrima* was also collected from Chile and two sites in the Auckland Islands. Snails were crushed on collection and preserved. Polymorphic loci were then isolated and characterised.

Applicable to mapping

No, information not suitable for mapping.

Data source

University of Otago/Le Moyne College

Reference 80.)

Title and reference

The catalogue of monitoring reports conducted for Auckland Council and its previous incarnations:

Thrush, S.F.; Pridmore, R.D.; Hewitt, J.E.; Roper, D.S. (1988) Design of an Ecological Monitoring Programme for the Manukau Harbour. Report prepared by the Water Quality Centre for Auckland Regional Water Board, Auckland Regional Authority. *Technical Publication Number 79*. 62 p.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., Latimer (1990) Ecological Monitoring programme for the Manukau Harbour: Presentation of data collected up to February 1990. Unpublished report for Auckland Regional Water Board. Water Quality Centre Consultancy Report 8046 53pp.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., Latimer (1991) Ecological Monitoring programme for the Manukau Harbour: Presentation of data collected up to February 1991. Unpublished report for Auckland Regional Water Board. Water Quality Centre Consultancy Report 6120 67pp.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., Latimer (1992) Ecological Monitoring programme for the Manukau Harbour: Presentation of data collected up to February 1992. Unpublished report for Auckland Regional Water Board. Water Quality Centre Consultancy Report 6120/2 78pp.

Hewitt, J.E., Thrush, S.F., Pridmore, R.D., Cummings, V.J. (1993) Ecological Monitoring programme for the Manukau Harbour: Analysis and Interpretation of data collected October 1987 to February 1993. Prepared for Environment and Planning Division Auckland Regional Council. Consultancy Report ARC120/5

Hewitt, J.E.; Thrush, S.F; Pridmore R.D.; Cummings, V.J. (1994) Ecological Monitoring Programme for Manukau Harbour: analysis and interpretation of data collected October 1987 to February 1993 Unpublished report for Environment and Planning Division, Auckland Regional Council. NIWA Client Report No. ARC120/6 81pp.

Hewitt, J.E.; Cummings, V.J. Thrush, S.F; Pridmore R.D.; Maskery, M.R. (1995) Ecological Monitoring Programme for Manukau Harbour: analysis and interpretation of data collected February 1994 to February 1995 Unpublished report for Environment and Planning Division, Auckland Regional Council. NIWA Client Report No. ARC120/7 15pp.

Hewitt, J.E.; Thrush, S.F; Funnell, G.A.; (1997) Ecological Monitoring Programme for Manukau Harbour: Report on data collected up to February 1997. Unpublished report for Auckland Regional Council. NIWA Client Report No. ARC00206, 24p.

Funnell, G.A.; Hewitt, J.E.; Thrush, S.F. (1999) Ecological Monitoring Programme for Manukau Harbour: Report on data collected up to February 1999. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 110*. 24 p.

Funnell, G.A.; Ellis J.I.; Hewitt, J.E.; Thrush, S.F. (2001) Ecological Monitoring Programme for Manukau Harbour: Report on data collected up to April 2001. Unpublished report for Auckland Regional Council. NIWA Client Report No. ARC03206, 35p.

Funnell, G.A.; Hewitt, J.E.; Thrush, S.F. (2003) Ecological Monitoring Programme for Manukau Harbour: Report on data collected up to February 2003. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Report TR 2003/224*.

Funnell, G.A.; Hewitt, J.E. (2005) Ecological Monitoring Programme for Manukau Harbour: Report on data collected up to February 2005. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 293*. 41 p.

Hewitt, J.E.; Hailes, S.F. (2007) Manukau Harbour Ecological Monitoring Programme: Report on data collected up until February 2007. Prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 334.

Hailes, S.F.; Hewitt, J.E. (2009) Manukau Harbour Ecological Programme: Report on data collected up until February 2009. Prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Report 2009/121*.

Hailes, S.F.; Hewitt, J.E. (2011) Manukau Harbour Ecological Programme: Report on data collected up until February 2011. Prepared by The National Institute of Water and Atmospheric Research for Auckland Council.

Contains mapped information

No

Project overview

Monitoring of sentinel sites in the Manukau Harbour with results reported from 1987 October 1987 till February 2011.

Date

1987-2011

Location and extent

9000 m² intertidal sites distributed throughout the Manukau Harbour: Auckland Airport (AA), Clarks Beach (CB), Cape Horn (CH), Elletts Beach (EB), Karaka Point (KP) and Puhinui Stream (PS).

Method or techniques of sampling

Sites analysed for community composition (based on 12 replicate cores 13 cm diameter, 10 cm deep), sediment particle size and chlorophyll *a* and phyophytin concentrations, collected bimonthly (although temporal nesting is in place for several sites).

Applicable to mapping

Yes, these reports represent a significant understanding of the sediment environments and their change over time and response to external factors. The six monitoring sites are distributed across the harbour (one site, CH, in the northern area and the remaining five running from the east, AA, to the South, CB) and are representative of wider sand-flat areas, so information has greater value than just the 9000 m² site. The report provides information on the sediment environment with respect to grain-size and chlorophyll *a* and the community composition, diversity and functional health of the communities. Future mapping initiatives which includes any focus on benthic habitats, will find this collection valuable.

Data source

NIWA, Auckland Council

Reference 81.)

Title and reference

Manukau Harbour: A bibliography of publication relating to the Manukau Harbour, New Zealand. Manukau City Council, 2nd ed. Compiled by J.B. Ringer (1999).

Project overview

This is a bibliography which lists 2147 studies conducted in or around the Manukau Harbour region. References are divided by subject area including, climate, geology, ecology, fisheries, Maori, history, navigation and shipping, pollution, sewage and waste disposal, developments affecting the harbour, conservation and restoration and recreation and parks.

Date

Studies span the 19th and 20th centuries, with much of the literature from the 1960-80s.

Location and extent

Manukau Harbour

Method or techniques of sampling

Various

Applicable to mapping

The bibliography itself does not contain information pertinent to mapping, however several of the studies within it may. However, much of this would be termed 'grey literature' as it is difficult to source, there is a mixture of peer- and non-peer reviewed material so some caution must be applied for certain studies. Improvements in techniques and equipment mean that many of these studies have been superseded. Ecological information from this period is also likely to have less relevance, again given the volume of more recent and applicable studies.

Data source

Various

3.0 Discussion

The reviewed literature in Section 4 collectively provides insight into the spatial information currently available for the Manukau Harbour and West Coast (Table 2) and consequently, through a process of elimination, where the gaps in spatial coverage are and where specific science disciplines are lacking.

Table 2. Overview of the 80 studies from the West Coast (References 1-22) and Manukau Harbour (References 23-80) with their potential use for mapping the historic and/or current status of environmental attributes. Reference numbers (Ref) from Section 4. Suitability: Yes (Y), No (N) or Possible (P), Context of information use as historic (H), contemporary (C), possibly contemporary (C?) or application through scaling (S). Reference 81 is a bibliography so is not included in this assessment.

Ref	Suitability	Ref	Suitability	Ref	Suitability	Ref	Suitability	Ref	Suitability
1	N	17	Y, H, C?	33	N	49	Y, H, C	65	N
2	P, H, C?	18	Y, H, C	34	N	50	N	66	Y, C
3	P, H, C?	19	P, H	35	N	51	P, H, S	67	N
4	N	20	P, C	36	N	52	Y S	68	N
5	Y, H	21	Y, C	37	N	53	N	69	Y, H, C?
6	P, H, C?	22	N	38	N	54	N	70	Y, C
7	N	23	N	39	N	55	Y, C	71	N
8	Y, H, C?	24	N	40	N	56	N	72	Y, S
9	P, H	25	N	41	Y, C	57	N	73	Y, H,
10	P, H, C?	26	N	42	N	58	N	74	N
11	N	27	N	43	N	59	Y, C	75	Y, C
12	N	28	N	44	N	60	N	76	N
13	N	29	N	45	N	61	N	77	Y, C
14	N	30	N	46	N	62	Y	78	Y, C
15	P, H	31	N	47	P	63	N	79	N
16	Y, H	32	N	48	N	64	Y, H, C?	80	Y, H, C

3.1 By science disciplines

Studies focusing on physical science have been conducted at small spatial scales (e.g., Grant et al. 1997; 250 x 500 m site) and at scales covering the whole of the Manukau Harbour (e.g., Smith et al. 2002, Pritchard et al. 2008). It is notable however that the majority of physical studies exist at wider spatial scales than most of the other scientific fields. One reason for this is that modeling is fundamental to many physical studies. Modeling utilises theory and equations to extrapolate and predict processes at a variety of spatial and temporal scales, but it is generally used to scale up and to provide estimates where empirical data cannot be or were not collected. Models are usually initialized or ground-truthed with empirical data (e.g., Smith et al. 2001), but the scales of the models are usually far more expansive than the empirical data alone. Thus, although there were fewer physical studies available for the Manukau Harbour and West Coast domain (Figure 2), they tended to have the broadest overall coverage (Figure 4).

Geological studies, those focusing on the distribution of sediments and rocks rather than their physical transport/reworking *per se*, also have wide spatial coverage relative to the areas of interest. For example, Gregory et al. (1994) covers the Manukau Harbour, and Schofield (1975) and McDougall (1961) cover large sections of the West Coast for sediment distribution. However, there are two key aspects to the reliability of information: Firstly the information is dated (>35 years old for the West Coast, and just short of 20 years for Manukau Harbour) and sediment distribution can change over this period, particularly given the elevated rates of sedimentation in many New Zealand estuaries. This could affect the accuracy of the information within the Manukau Harbour; potentially around the Waiuku and Taihiki Rivers, Clarks Creek and the Pahurehure and Mangere Inlets. In this respect, the Manukau Harbour may be more susceptible to change than the West Coast *per se*, which remains a physically dominated, exposed coastline. Secondly, the creation of sediment maps, such as Gregory et al. (1994), originate from point source information from sampled locations, which are extrapolated out to cover the harbour. Therefore, there is concern with these approaches with the level of extrapolation and consequent effect on accuracy, particularly if the maps are used without reference to the original point source data.

When chemical information appeared in the reviewed studies, it was generally a component of the investigations rather than a primary focus (Section 4). Information on heavy metals and contamination chemistry is typically point source information and has not been mapped. Sampling effort for chemical data has generally been restricted to the northeastern part of the Manukau Harbour (Kelly et al. 2008, Williamson et al. 1992, Roper et al. 1991) with no chemical information for the West Coast (Figure 4). This reflects the interest in understanding the effects of urban pollution in the areas of highest human population density (and the cost-to-benefit ratio of obtaining chemical contaminant information). Due to the history of anthropogenic activity in the Harbour, information from older studies may not represent present day conditions. Auckland Council, through the Regional Discharge Project/ Benthic Health Programme (RDP, BHP), is likely have the most up to date information available for this area.

Biological information spans a wide variety of information types; ranging from specific habitat and biotope mapping (Hayward and Morley 2004), monitoring of a few sentinel locations within the harbour (Hailes and Hewitt 2011, Anderson et al. 2006), to experiments designed to understand ecological functioning and the interactions between species (typically bivalves such as *Austrovenus stutchburyi* and *Macomona lilliana*) and their surrounding environment (Thrush et al. 1996a, 1996b, 2003, Legendre et al. 1997). A large proportion of the information available originates from the NIWA Hamilton Marine Ecology Group (and associates) and, rather than being scattered throughout the harbour, is focused in the area near to Wairoa Island (Figure 4). While many of these studies are focused over a limited spatial scale, the effects they show, in terms of organism-environment interactions, are applicable over wider extents. Furthermore, the long history of ecological monitoring (1987 to the present), in different regions of the harbour means that we have a good understanding of the fauna and communities present, their behaviour in terms of population cycles and responses to external stimuli (ENSO, toxicity, sedimentation). Thus while there are no current detailed habitat maps for the Manukau Harbour, information from the monitoring projects could be used to start characterizing the larger sand flats areas and making progress toward this.

3.2 By geographic region

Examining by geographic region, it is clear much of the West Coast has an absence of detailed ecological information (Figure 4). While invertebrates are a small component of this information and the data is limited in spatial coverage, they are considered effective indicator taxa for restoration monitoring and assessment (Rosenberg et al. 1986; McGeoch 1998). Their ubiquitous and abundant presence, taxonomic and functional diversity make them particularly sensitive to ecological changes (; Andersen 1997; Watts & Gibbs 2002; Boyd 2002; Lassau & Hochuli 2004; Shepherd & Debinski 2005). For the West Coast there is only limited information available for toheroa (*Paphies ventricosa*) and rocky shore fauna (Hayward and Morley 2004,

Akroyd et al. 2008). The data that does exist comes from locations close to human settlements such as Piha and Muriwai, but there is no invertebrate information from anywhere south of Manukau Heads on the West Coast in the reviewed studies. Fish data is available for a larger area, but the variability in collection methods, population dynamics and seasonality means that a qualitative summary of this information may be the most appropriate data to use for mapping. For example, maps could simply present the types of fish species that are present in particular sectors; this would probably be more useful than questionable extrapolations from quantitative data collected by various means. Information on Maui's dolphin sightings (Fresne 2010) was more detailed and could be used quantitatively; showing their associations with certain locations and habitats; although temporal variability should be considered. West Coast studies tended to have a focus on geological information (see maps from McDougall 1961, McDougall and Brodie 1967) and physical information, reflecting this region's high energy environments.

For the Manukau Harbour, the majority of data came from the north-eastern population centres of Mangere, Onehunga, Manurewa and by Auckland International Airport. Areas in the South and West e.g., Grahams Beach and Awhitu, are much less studied (but see monitoring site at Clarkes Beach, Hailes and Hewitt 2011). Some of this information was chemistry based, although there was plenty of biological information in this area as well.

The long term ecological monitoring programme established in the Manukau Harbour in 1987 (Thrush et al. 1988, Hailes and Hewitt 2011) provides a largely continuous record of environmental data through to the present. This is useful for understanding how different sections of the harbour have changed over time and can be used to infer the causes of these changes. Information here has potential for extrapolation given that sample sites are representative of wider sand-flat areas beyond their 9000 m² size. Complementary to the survey data, there are experimental studies that show how different environmental variables affect fauna (e.g., Legendre et al. 1997).

Physical information for the Manukau Harbour seems the most comprehensive with respect to spatial coverage and detail applicable to marine spatial planning (bathymetry, tidal current, wave orbital velocity, see Townsend et al. 2012). There is a vast body of information in the grey literature, but a brief assessment of this indicates it may be difficult to source, much of it has never been peer-reviewed and it has largely been superseded by more recent and detailed studies. However, for specific locations within Manukau Harbour, this may be the only information available and therefore have value for mapping; particularly from an historical perspective (see Ringer 1999).

3.3 Future Considerations

The review of literature indicated that many studies contained mapped variables, but that not all of this was useful due to the age of the data, resolution and reliability of information. Conversely, other studies did not actively 'map', but contained geo-referenced information which may be useful in marine spatial planning. Finally, there were local-scale process-based studies that may facilitate broader scale mapping. For example, Legendre et al. (1997) investigated the physical and biological variables that controlled the spatial distributions of *Macomona* and *Austrovenus*. With harbour wide information on the physical variables, it may be possible to map distributions of *Macomona* and *Austrovenus* over the same extent. This highlights the need for careful assessment of literature in the future to avoid overlooking useful information.

The review of literature has identified the gaps in spatial information; future sampling efforts could be used to ameliorate this. Physical and geological information has broad coverage, although the precision of the latter, given the time since sampling and crude interpolation methods, may need to be verified. Spatial information on the biology is lacking for much of the harbour and the West Coast (e.g., nothing south of the Manukau Heads on the West Coast), and consideration should be given to sampling in these locations as per Hewitt (2000). The physically dominated environment of the West Coast may result in similar communities along

much of the coastline. Thus, rapid habitat assessment (Hewitt 2000) may be the most appropriate initial sampling strategy. Further information in the Manukau Harbour could also be obtained from some broad scale surveying or mapping assessments similar to that used for Weiti, Whangateau and Wairoa (Hewitt 2008, Townsend et al. 2010, Lohrer et al. 2012); although recognizing the substantially greater distances/areas involved. Consideration needs to be given to the extrapolation of data from the monitoring programme (Hailes and Hewitt 2011) and how this may be most appropriately used and interpolated.

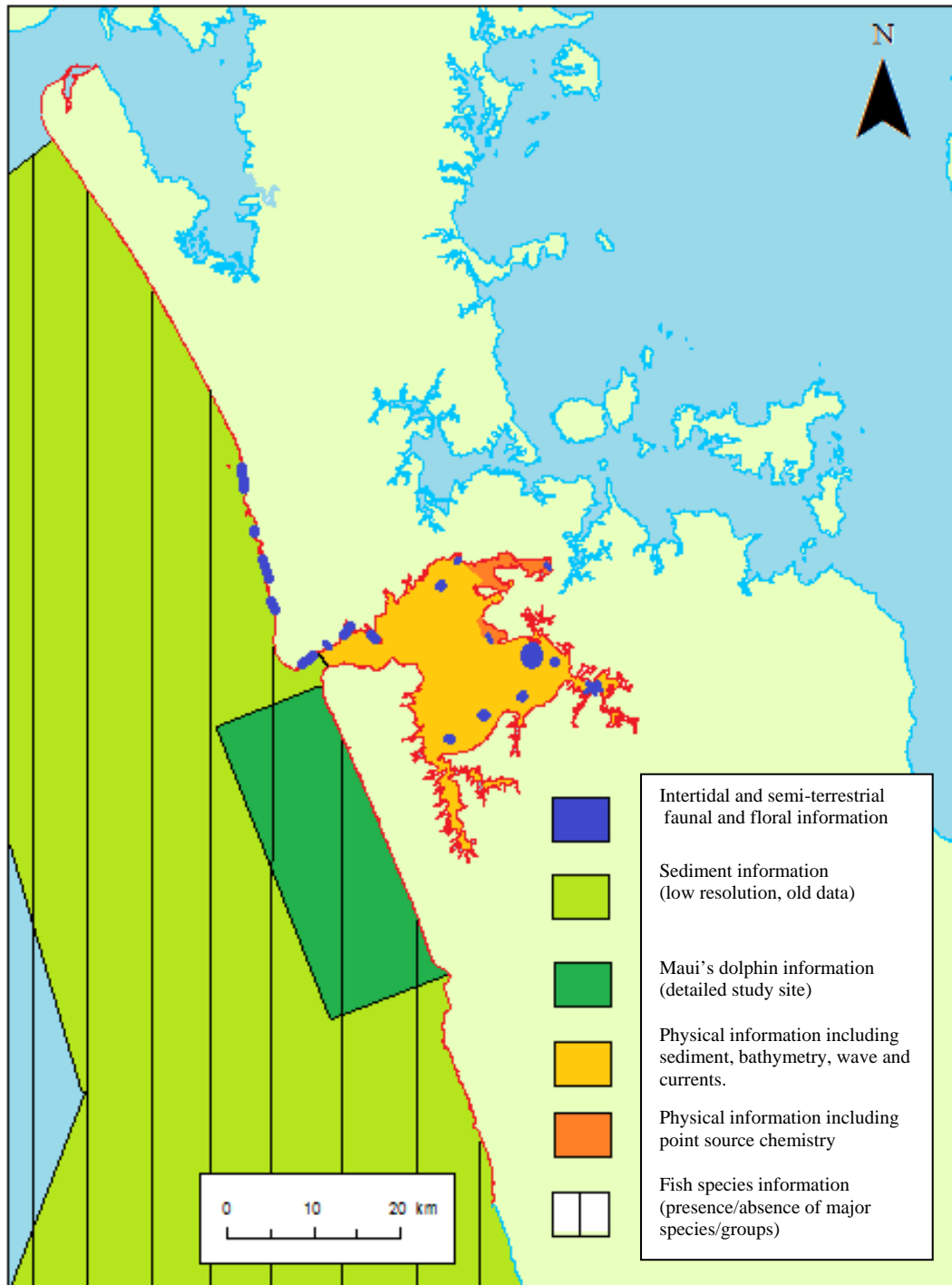


Figure 4 Schematic to illustrate the main types of information and their spatial coverage from the reviewed literature.

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