Unitary Plan - Coastline and Coastal Marine Area

Introduction

The coastal marine area (CMA) landward boundary delineates a jurisdictional limit for rules under New Zealand's Resource Management Act (RMA) policy and planning framework and is defined by the line of mean high water springs (MHWS). From a coastal management perspective, the CMA boundary is of significance as it defines the landward boundary for which various identified activities require a coastal permit. Conversely from a landward perspective, the CMA boundary is of significance as it defines the boundary along the coast for land based planning frameworks.

Mean high water springs is dynamic in terms of its position at any particular coastal location and also by its definition. An indication of the location of MHWS is currently provided by the CMA boundary on the Auckland Regional Plan: Coastal (ARP:C) map series. The existing ARP:C mapped boundary consists of a single line for the entire region. This line was developed during the early 1990's prior to the proposed plan being notified in 1995. The line does not adequately reflect the true coastline when viewed against modern aerial imagery that will be used for the unitary plan.

The definition of MHWS can also vary depending on the methods used in its calculation and the degree of accuracy (percentage of time MHWS is exceeded) that is required. A number of different definitions are used in New Zealand which impact on the final position of the CMA boundary. The most appropriate definition(s) needs to be reviewed.

The inclusion of the coastal plan in the Unitary Plan provides an opportunity to consider various definitions of MHWS, reassess requirements associated with mapping of the CMA boundary and explore alternative approaches for representing the coastline. This discussion document is aimed at investigating a new approach to coastline and coastal marine area boundary identification, where key elements include:

- A review of the currently available definitions of MHWS to determine the most appropriate method(s) for surveying CMA boundary locations in the Auckland Region;
- Development of a new representative coastline, whose position is established based on best available data that visually represents coastal environment extents when examined against modern aerial imagery. Note this coastline would be non-jurisdictional and indicative only.

Alternative options and issues for coastline development are also outlined.

Issues

With the advancement of GIS technology and the improved georeferencing of aerial photography, the existing ARP:C mapped coastline now appears relatively crude and inaccurate for large portions of the coast.

The Coastal Consents and Compliance team have provided feedback indicating that the identification of the line of MHWS on planning maps is often fraught because of its dynamic nature. They recommend that a key outcome of this review should be that any planning line approximating the

CMA boundary is irrelevant from a plan operations perspective, except for where a river mouth or other CMA boundary is specifically defined (Schedule 7).

An important component of the new Unitary Plan will be its graphical representation of zones and overlays. These layers will be viewable along with updated aerial photography, forming a spatial toolbox that provides a relatively accurate representation of planning boundaries. To assist in this process, the coastal margin, or coastline, needs to be represented in some manner as an important interface between landward and coastal environments and the different legislative frameworks that apply across this area.

Review of MHWS Definitions for CMA Boundary Determination

CMA boundary

The CMA boundary is defined in the RMA as;

- ***coastal marine area*** *means the foreshore, seabed, and coastal water, and the air space above the water—*
  (a) of which the seaward boundary is the outer limits of the territorial sea:
  (b) of which the landward boundary is the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of—
    (i) 1 kilometre upstream from the mouth of the river; or
    (ii) the point upstream that is calculated by multiplying the width of the river mouth by 5

A number of other policies and legislation also refer to MHWS and/or to the RMA definition of the CMA. A summary of associated legislation is provided in the attached Table 1.

Mean High Water Springs

The 'line of mean high water springs' is not defined any further in the RMA. Definitions of MHWS can vary significantly based on its height relative to the Highest Astronomical Tide (HAT) position. The current definition included in the ARP:C is provided below:

Mean High Water Springs (MHWS) *The height of mean high water springs shall be determined as:*

> *The average of the heights of each pair of successive high waters during that period of about 24 hours in each semi-lunation (approximately every 14 days) when the range of tides is greatest.*

This definition refers to a traditional nautical approach based on a quantitative 'tidal harmonic'. In some locations around New Zealand, this level can be exceeded by a significant proportion of all high tides. This variance can be as much as 15% on the West Coast (Port of Onehunga) and 20% for the East Coast at the Port of Auckland (Stephens et al 2011).

The MfE Coastal Hazards and Climate Change Guidance Factsheet 17 suggests that:

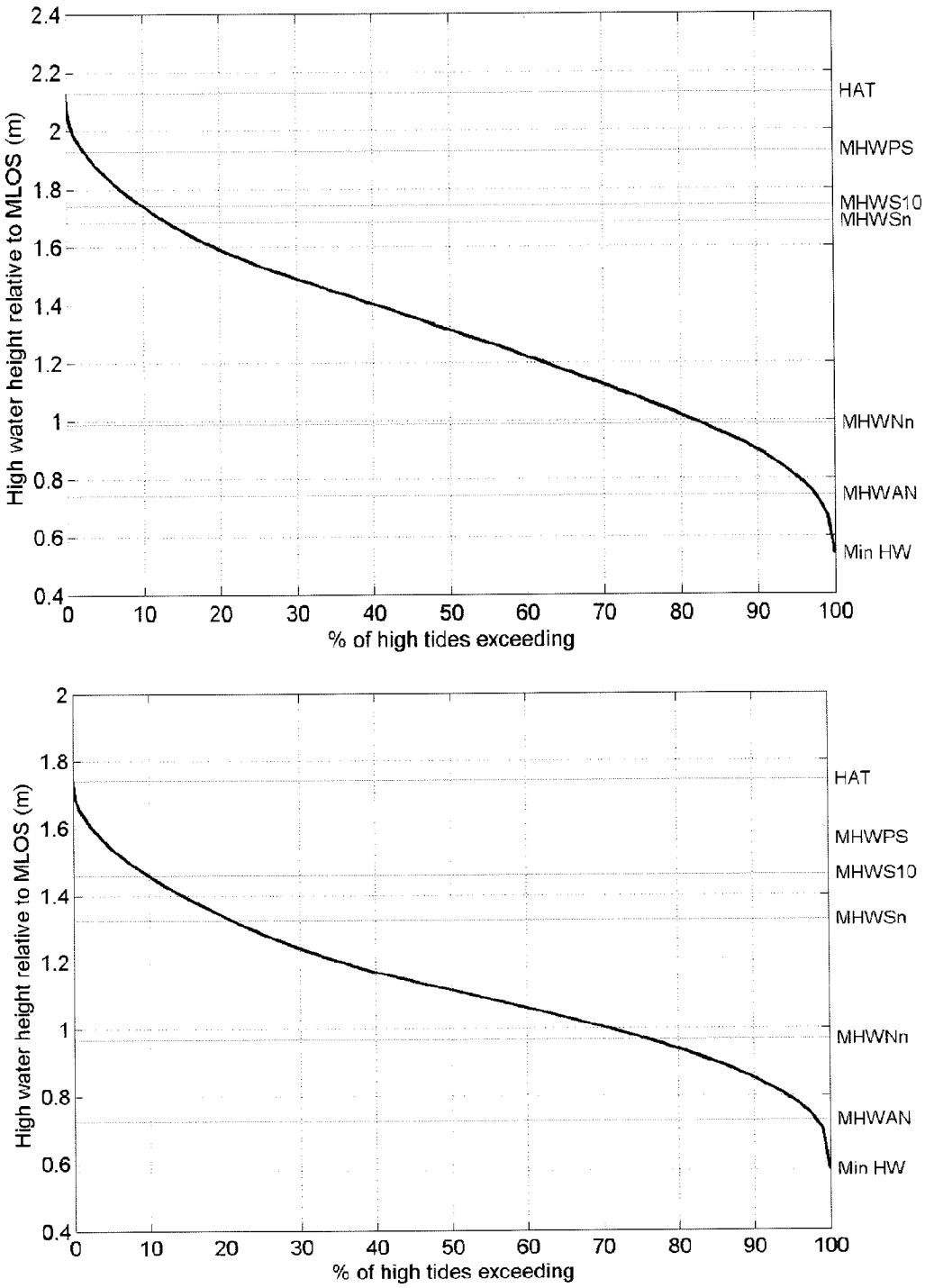
> *"...for central areas of the eastern coast of New Zealand, such a definition results in high tides that exceed such a MHWS level much more frequently than would be pragmatic for defining the boundary of the CMA."*

Whether this suggestion extends to the Auckland region requires further expert assessment of tidal harmonic based MHWS exceedances and the likely degree (inundation height) that they may be exceeded by. Cumulative high tide exceedance plots have been calculated by NIWA for the Ports of Auckland and Onehunga and are provided below. The tidal harmonic definition of MHWS is represented by MHWSn (n=nautical).

Examples of the range of definitions available for MHWS include:

- Existing tidal harmonic using average of the heights of each pair of successive high waters during that period of about 24 hours in each semi-lunation (approximately every 14 days) when the range of tides is greatest;
- Use of average predicted MHWS values over the 18.6 year tidal cycle referenced to Chart Datum (LINZ tidal level information for surveyors approach, 2007);
- Use of a combined perigean-spring harmonic definition relating to Mean High Water Perigean Spring (MHWPS) that relates closer to the upper level of MHWS and which can be exceeded by between 3-7% of high tides in the Auckland region (Stephens et al 2011);
- Use of a MHWS(%) where a percentile of predicted tides would exceed a defined level, for example 10% (MHWS-10) (Bell and Lewis 2006; Stephens et al 2011);
- Practical application of natural indicators (e.g., strand line, saline vegetation) can be an approach to provide qualitative assessment for less critical or contentious decisions.

A decision on the most appropriate definition will assist in establishing survey methodology and data requirements for a given circumstance. With MHWS being such a dynamic indicator of the landward boundary, it is possible that different measures could be employed depending on land use or potential effects of a particular activity or degree of risk associated with the boundary location. For example, delineation of the coastal boundary for reserve land where no development is likely to occur may require little more than qualitative assessment (natural indicators) if at all, while sensitive coastal infrastructure in highly urbanised areas, or developments in close proximity to sensitive coastal protection areas, may require a more accurate approach like MHWPS to reduce risk from damage to infrastructure of protected habitats.



Cumulative high tide exceedance plot at Port of Onehunga (top) and Port of Auckland (bottom). High water heights relative to mean level of the sea (from Stephenson et al 2011).

Development of a Unitary Plan Indicative Coastline

Both LINZ and case law acknowledge that, at a regional scale, no single definitive method can be used to establish a natural boundary like MHWS which defines the CMA landward boundary. For Unitary Plan purposes however, an indicative coastline is required to provide a planning boundary that closely approximates the position of MHWS. This indicative coastline allows for the visual representation of the boundary between land and coastal environments and their associated zones and overlays on planning maps. With the planning maps likely to be online and supporting aerial images at small spatial scales, improved accuracy is required to better represent the indicative coastline compared to the coastline currently in use.

A number of different approaches are available for establishing a new coastline for the Unitary Plan, including:

- Mathematical models – the traditional quantitative tidal harmonic approach;
- Algorithms – search and average algorithms similar to the new LINZ approach;
- Local Surveys – specific surveys, natural indicators etc;
- Aerial photography qualitative assessment;
- Use of existing published terrain maps;
- Use of LiDAR data and appropriate high tide offsets.

The final coastline shown on the planning maps would only be used for indicative purposes and to assist with determining whether a detailed site specific MHWS survey is required and whether a coastal permit is needed for a particular development or activity. Where activities are in close proximity to, or overlap the indicative Unitary Plan coastline, a specific survey would still be required to determine the location of MHWS and the actual CMA boundary. This approach takes into consideration guidance from LINZ and Environment Court decisions.

An indication of available existing datasets, together with their strengths and weaknesses is provided in the table below.

Source	Strengths	Weaknesses
Existing ARP:C Coastline	• Currently mapped and available	• Obvious inaccuracies with aerial photography • Out of date with coastal developments
Topographic map 1:50,000	• Currently mapped and available	• Obvious inaccuracies with aerial photography • Out of date with coastal modifications
DCDB Layer (updated LINZ) CRS parcel information from LINZ	• Accurate land parcel boundaries • Updated regularly • Freely available	• Parcel boundaries can extend past MHWS • Blocky, does not follow natural contours • Subject to both undershoots and overshoots of coastal extents
Visual Qualitative DoC MEC	• Based on high resolution aerial photography (2006) • Includes other coastal features	• Only available for Hauraki Gulf • Qualitative • Linked polygons rather than distinct line • Limited groundtruthing
LiDAR	• Very accurate • Region wide coverage • Repeat surveys every couple of years	• Reference datum to MSL (Auckland Vertical Datum 1946), rather than MHWS. • MHWS would need to be estimated/modelled from MSL based on high tide extents • Sufficient tidal datum stations?

Existing Coastal Representations

The existing ARP:C coastline, topographic map and land parcel information boundaries all suffer similar limitations, their boundaries not matching true coastal extents when applied to updated aerial photography. They all suffer from significant undershoots or overshoots of the true coastal extent and can be very confusing to interpret.

Visual Qualitative

Visual qualitative information has not been undertaken for the entire Auckland coastal extent. It also suffers from error where the coastline may be obscured in the aerial image (for example, areas associated with dense cover of trees), in areas of steep topography like coastal cliffs and sandy beach areas.

LiDAR

The availability of detailed, consistent LiDAR data for the entire Auckland region represents a significant geospatial improvement in topographic mapping and accuracy since the existing ARP:C was developed.

LiDAR data produces high resolution digital elevation maps in a more accurate and regionally consistent manner than traditional topographic surveys. LiDAR data utilises the Auckland Vertical

Datum 1946 for its height benchmark, which equates to mean sea level (MSL). The zero LiDAR contour therefore provides an estimate of MSL for the entire region based on the benchmark survey location. Contouring above this line typically has a resolution of 0.125m GSD (ground sample distance) for urban areas and 0.5m GSD for rural areas.

The high resolution and region wide accuracy of the dataset can potentially allow for the development of a coastline that more consistently matches aerial imagery which, for the most part, is collected during the same survey as the LiDAR. A landward offset to the MSL to take into account the high tide range can be developed which would bring the MSL LiDAR line to a closer approximation of MHWS tidal extents. This offset can be either standardised or more variable across the region based on known differences in tidal extents, to produce an indicative coastline.

Options for developing a LiDAR based offset include:

- Development of a standard high tide offset across the region as a whole;
- Development of separate offsets between east and west coasts;
- Development of more variable offsets to take into account local variations known to occur in the Auckland region.

Options for development of coastal offsets include:

- Use of tidal level information standardised for surveyors from LINZ;
- Use of cumulative frequency plots on tidal ranges from Standard Ports (refer above figures);
- Expert advice;
- Specific modelling.

A preliminary assessment of fixed width offsets at +1.5 m MSL +/- 0.5 m has been generated for the North Shore coastline to assess how closely this offset would represent the existing coastline. Output from this assessment has been compared against aerial photography and the CRS parcel boundaries which are currently being used on the Auckland Council GIS Viewer. Examples from this assessment for representative cliff, beach and estuarine areas, are appended to this document.

Note, the 1.5 m offset trialled was selected as 0.5 m contours were already calculated from the LiDAR dataset, and therefore readily available with no additional processing required. Indicative setback tidal heights from MSL to best represent MHWS would likely be around 1.7-1.9 m for the west coast based on Onehunga data and 1.3-1.6 m for the east coast based on Ports of Auckland data.

Other Options Considered

A number of other options were initially considered for developing an indicative coastal boundary including:

- Are there any other off-the-shelf datasets available that could be utilised as an indicator of MHWS?
- Is there a database of information from MHWS surveys associated with permits?
- Could information be surveyed and collated on a priority basis for ground truthing?
- Could a new coastline be modelled based on regional tidal ranges?

Outcomes of these assessments suggested these alternatives were either not currently available, prohibitively expensive and/or unable to be completed within Unitary Plan time constraints.

MHWS Buffer

An alternative approach considered involved establishing an indicative zone or buffer where the MHWS extent would likely occur, rather than a single line representing the coastline. This buffer area could be derived though a combined approach using survey and mathematical/algorithm information to generate tidal offsets encompassing tidal heights between Mean High Water (MHW) and the Highest Astronomical Tide (HAT). These tidal ranges would be combined with detailed coastal LiDAR survey information to establish a narrow zone covering the range of high tides for different parts of the coastline. The MHWS mark, regardless of the final definition used, would fall somewhere within the MHW - HAT buffer zone.

Creation of a buffer zone incorporating HAT as an upper extent could be utilised as a trigger for the requirement to conduct an independent survey of MHWS associated with any coastal development. The buffer zone could also incorporate other risk factors like predicted sea level rise throughout the operative period of the plan.

An assessment of the practicality of this buffer zone was trialled by examining the LiDAR contours between 1.0 – 2.0 m above MSL for the North Shore coastline (also shown in attached examples). The buffer zone was highly variable throughout the coast and introduced additional topographic complexity to the dataset which could lead to difficulties in interpretation. In addition, the buffer zone would likely require increased effort (time and labour cost) for data grooming and correction of topological errors which could compromise its ability to be completed within the unitary plan timeframe.

Other Considerations

An additional area where confusion over the location of the CMA boundary can arise is associated with creek/river/estuary mouths (river mouths) and how far the coastal influence tidal extends up watercourses. Again, the RMA provides a definition for determination of the boundary in these areas;

> *(i) 1 kilometre upstream from the mouth of the river; or*
> *(ii) the point upstream that is calculated by multiplying the width of the river mouth by 5*

- **mouth**, *for the purpose of defining the landward boundary of the coastal marine area, means the mouth of the river either—*

- *(a) as agreed and set between the Minister of Conservation, the regional council, and the appropriate territorial authority in the period between consultation on, and notification of, the proposed regional coastal plan; or*
- *(b) as declared by the Environment Court under section 310 upon application made by the Minister of Conservation, the regional council, or the territorial authority prior to the plan becoming operative,—*

and once so agreed and set or declared shall not be changed in accordance with Schedule 1 or otherwise varied, altered, questioned, or reviewed in any way until the next review of the regional coastal plan, unless the Minister of Conservation, the regional council, and the appropriate territorial authority agree

However, this definition can be very difficult to apply. For example, at what point is the measurement of the river mouth width taken (braided flows across sandy beaches at approximate MHWS may not best represent river mouth width)? Where should the measurement of the 1 km distance begin for large, gently grading tidal creeks and estuaries?

The current ARP:C planning maps provide the locations of 252 river mouth CMA boundaries throughout the region, which are described in Schedule 7 and identified on the planning maps. However a significant number of stream and river mouth boundaries remain undefined.

The development of the new unitary plan provides the opportunity for improved clarity associated with river mouth CMA boundaries, the best practicable options for determining their locations and improved integration with freshwater habitats.

There is an opportunity to review existing boundaries described in Schedule 7 to facilitate the improved marine/freshwater integration process.

Increasing the numbers of river mouth CMA boundaries defined in Schedule 7 may also be achievable once improved assessment criteria are agreed upon.

Options for refinement of CMA boundaries could include:

- Use of improved GIS capability;
- Use of LiDAR data;
- Use of aerial imagery;
- Use of a combined approach from the above listed tools.

Note any decision made associated with refinement of the river mouth CMA boundary method would also need approval from the Department of Conservation.

Discussion

A decision is required on the most appropriate definition(s) for MHWS to be applied in the Auckland region.

The CMA boundary is of significance from coastal and land management perspectives, as it defines the landward boundary for which various specified activities require a coastal permit. However accurately identifying MHWS across the region is complex. Both LINZ and the Environment Court support an approach where no single definitive method is used to establish a natural boundary like MHWS (Bell and Lewis 2006). Judgement is needed in final delineation with survey approaches customised to an individual location, the type and value of the land concerned and the accuracy of the survey required (Bell and Lewis 2006). As a jurisdictional boundary, its exact location therefore needs to be defined on a case by case basis. The agreed location would be established using survey information customised to an individual location and based on an agreed definition of what MHWS actually represents.

A decision is required on how best to represent the coastline and associated mapped landward and coastal zones and overlays on the final planning maps for the Unitary Plan.

While accurate delineation of the MHWS boundary requires site specific assessment, the coastline still requires some form of representation on planning maps. This is because an important concept of the new Unitary Plan is accessibility and detailed spatial representation (at an individual property scale) of the overlays and zones that will form the basic elements to the plan. These layers will be visually represented on updated aerial photography and will form a spatial toolbox that provides a representation of planning boundaries. Providing a more accurate indicative coastline than those currently available is therefore considered an important component of the Unitary Plan to provide a transitional point between the different zones and overlays that may operate in land and coastal space.

Improved clarity is required to determine CMA boundaries associated with river mouths.

Delineation of the CMA boundary can also become complex at river mouths and estuaries in the Auckland region, particularly where estuarine conditions and associated coastal community types can extend long distances inland along gently grading lowland floodplains and in soft sediment environments where substrates are mobile and can change in response to weather events. Improved clarity is required to determine best practice approaches for determining CMA boundaries at river mouths, along with a review of existing Schedule 7 boundaries based on outcomes of the investigation.

Recommendations

Investigations with the use of LiDAR technology combined with an approximate high tide offset for the North Shore region have demonstrated very promising output. The trial generated a more consistent and accurate representation of the coastline shown on aerial imagery than either the current CMA boundary representation or the updated CRS parcel boundary information, even with a standard 1.5 m offset applied across the region examined.

With the importance of online mapping and the use of aerial imagery for development and use of the Unitary Plan, it is recommended that additional investigations take place over the suitability of developing a new, LiDAR based coastline for the unitary plan.

Investigations required to further develop the concept include:

- Expand assessment to the entire region and investigate areas where tidal offset variations have previously been identified.
- Expert advice associated with most appropriate coastal high tide offsets for the Auckland region.
- Expert advice on variations to offsets that could readily be achieved to further improve accuracy.
- Expert advice associated with generation of non-standard contours from LiDAR data, if required (i.e. contours other than 0.5 m intervals).
- Additional consideration for complex areas like urban beaches and river mouth boundaries.
- Further assessment of planning considerations and impacts on mapping zones and overlays (risk assessment).
- Legal considerations associated with implementing a new coastline.

The CLAW Natural Hazards team and Stormwater Unit current have a joint project underway investigating coastal inundation and storm tide levels in the Auckland region, with experts already identified and generating similar datasets for analysis. The strong synergies between this project and investigations currently underway opens opportunities for collaboration shared output. This is currently being investigated.

In addition to the above, consideration is required associated with GIS based issues including:

- Differences in LiDAR survey accuracy between urban and rural areas.
- Capacity to generate recommended offsets from LiDAR data.
- Implications associated with mapping of zones and overlays on the immediate landward and seaward side of a new indicative CMA boundary.
- Long term maintenance and inclusion of updated site specific survey data when it becomes available.

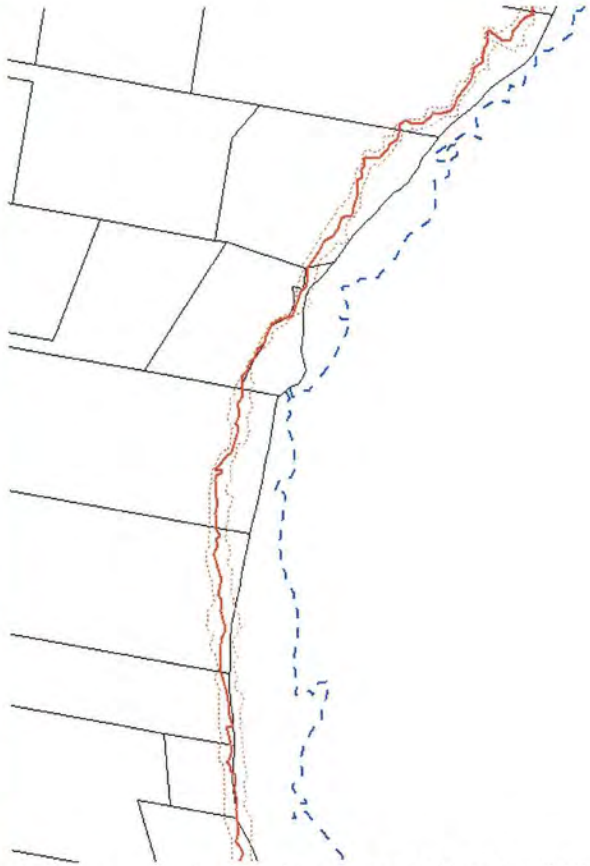
Table 1: Overview of legislation with reference to CMA boundaries

Legislation	Delineation	Key sections of legislation
Resource Management Act 1991	Mean High Water Springs	Section 2 Interpretation coastal marine area means the foreshore, seabed, and coastal water, and the air space above the water— (a) of which the seaward boundary is the outer limits of the territorial sea: (b) of which the landward boundary is the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of— (i) 1 kilometre upstream from the mouth of the river; or (ii) the point upstream that is calculated by multiplying the width of the river mouth by 5
	Mean spring tides (high and low)	Section 2 foreshore means any land covered and uncovered by the flow and ebb of the tide at mean spring tides and, in relation to any such land that forms part of the bed of a river, does not include any area that is not part of the coastal marine area
NZCPS 2010	Mean High Water Springs	(explicit reference to MHWS): Policy 4 Integration Provide for the integrated management of natural and physical resources in the coastal environment, and activities that affect the coastal environment. This requires: ... (c) particular consideration of situations where: (i) subdivision, use, or development and its effects above or below the line of mean high water springs will require, or is likely to result in, associated use or development that crosses the line of mean high water springs; or...
Local Government Act 1974	Mean High Water Springs	Section 345 Disposal of land not required for road (3) Where any road or any part of a road along the mark of mean high water springs of the sea, or along the bank of any river with an average width of 3 metres or more, or the margin of any lake with an area of 8 hectares or more is stopped, there shall become vested in the council as an esplanade reserve (as defined in section 2(1) of the Resource Management Act 1991) for the purposes specified in section 229 of the Resource Management Act 1991— (a) a strip of land forming part of the land that ceases to be road not less than 20 metres wide along the mark of mean high water springs of the sea, or along the bank of any river or the margin of any lake (as the case may be); or (b) the full width of the land which ceases to be road— whichever is the lesser.

Hauraki Gulf Marine Park Act	Mean High Water Springs	coastal marine area - same as RMA definition
West Coast Marine Mammal Sanctuary	Mean High Water Springs	landward limit = MHWS
Marine and Coastal Area (Takutai Moana) Act 2011	Mean High Water Springs	Section 9 Interpretation Marine and coastal area- (a) means the area that is bounded,— (i) on the landward side, by the line of mean high-water springs; and (ii) on the seaward side, by the outer limits of the territorial sea; and (b) includes the beds of rivers that are part of the coastal marine area (within the meaning of the Resource Management Act 1991); and (c) includes the airspace above, and the water space (but not the water) above, the areas described in paragraphs (a) and (b); and (d) includes the subsoil, bedrock, and other matter under the areas described in paragraphs (a) and (b)
Territorial Sea, Contiguous Zone and Exclusive Economic Zone Act 1977	Low-water line or low-water mark	means the line representing the intersection with the shore of the plane of the Lowest Astronomical Tide (LAT)
	Lowest Astronomical Tide (LAT)	means the lowest tide level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions
	Internal waters	Section 4 The internal waters of New Zealand include any areas of the sea that are on the landward side of the baseline of the territorial sea of New Zealand.
	Baseline of territorial sea	Section 5 Except as otherwise provided in section 6 or section 6A of this Act, the baseline from which the breadth of the territorial sea of New Zealand is measured shall be the low-water mark along the coast of New Zealand, including the coast of all islands (Section 6 relates to baseline of territorial sea adjacent to bay, where straight baselines apply)

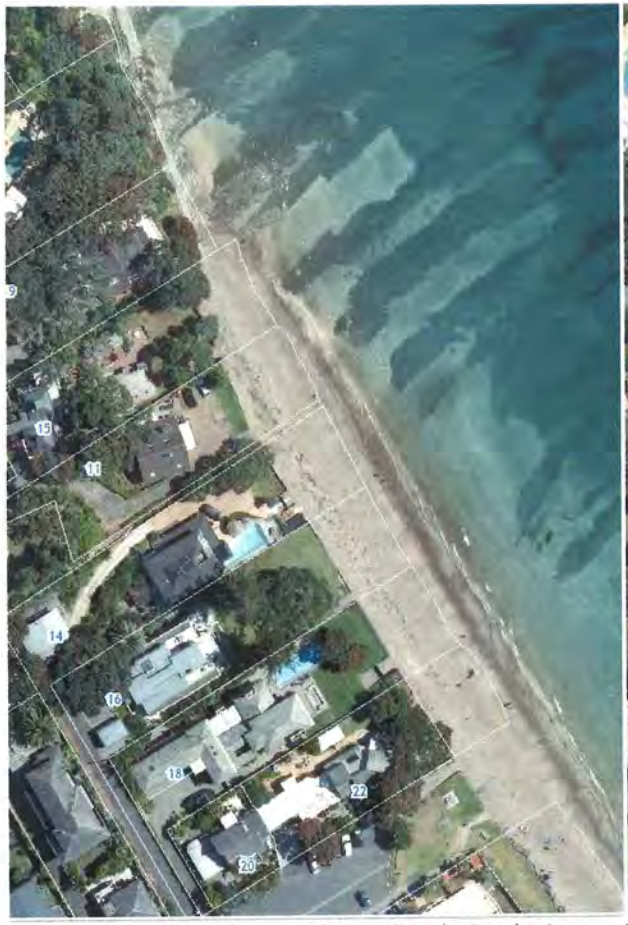
Auckland Council GIS Viewer with Coastline depicted using CRS Parcel boundaries, 2010 aerial photography

LiDAR output showing MSL (blue line) and MSL + 1.5 m (red line). Dotted red line shows +/- 0.5 m of the red line. Aerial photography (2008)



LiDAR output showing MSL (blue line) and MSL + 1.5 m (red line). Dotted red line shows +/- 0.5 m of the red line. Output overlying CRS parcels

Coastline associated with an urbanised coastal cliff example. CRS Parcel boundaries extend below cliff line well below where MHWS would likely be. The indicative LiDAR line appears to more accurately depict the base of the cliff and appears to more closely follow the natural form of the coastline.



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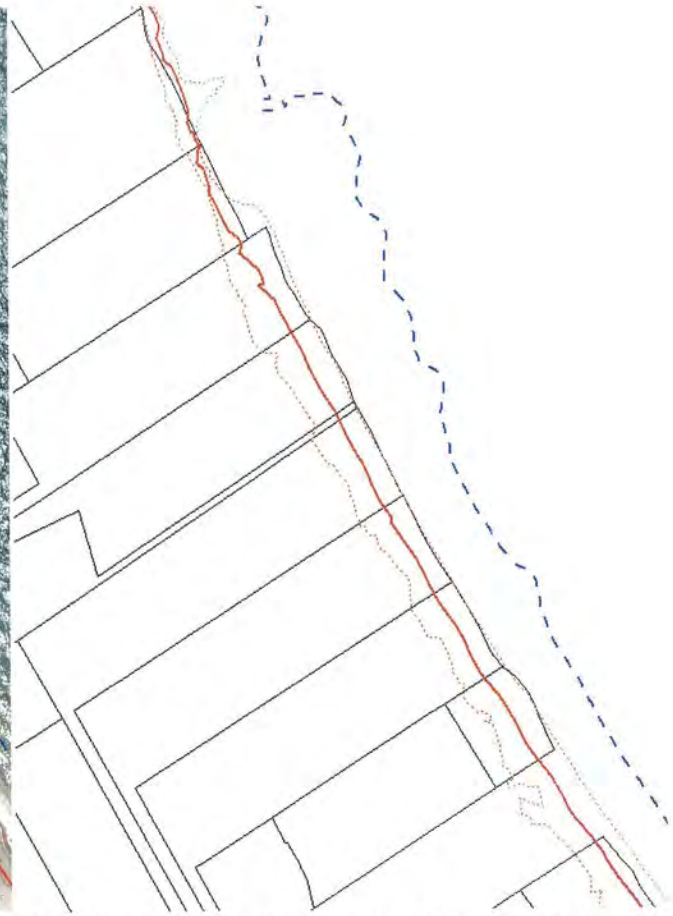

LiDAR output showing MSL (blue line) and MSL + 1.5 m (red line). Dotted red line shows +/- 0.5 m of the red line. Output overlying CRS parcels

Coastline associated with an urbanised exposed beach environment. Both CRS parcel boundaries and LiDAR extend below the natural landform associated with the beach. In this instance, build up of sand on the foreshore (beach cusps) push the MSL+1.5 m line down the beach. The more natural coastline form would extend up to the edge of the beach bounded by seawalls in this instance. Note this upper foreshore area should be considered to be mobile and subject to storm related fluctuation.

Auckland Council GIS Viewer with Coastline depicted using CRS Parcel boundaries, 2010 aerial photography

LiDAR output showing MSL (blue line) and MSL + 1.5 m (red line). Dotted red line shows +/- 0.5 m of the red line. Aerial photography (2008)

LiDAR output showing MSL (blue line) and MSL + 1.5 m (red line). Dotted red line shows +/- 0.5 m of the red line. Output overlying CRS parcels

Estuarine coastline example. Undershoots and overshoots from the CRS parcel boundaries. Complex relief within the mangrove areas with small areas of habitat above the 1.5 m contour, improved resolution of upper extents of creeks.

Example of LiDAR applied to a complex estuary receiving input from three tributary streams. LiDAR river mouth extents closely match coastal plan Schedule 7 CMA boundaries for all three tributaries.