CAWTHRON

REPORT NO. 3908

TASMAN AND NELSON COASTAL MARINE ENVIRONMENTS: BATHYMETRY AND HYDROSYSTEMS

TASMAN AND NELSON COASTAL MARINE ENVIRONMENTS: BATHYMETRY AND HYDROSYSTEMS

ANNA BERTHELSEN,[a] LEIGH STEVENS,[b] LISA FLOERL,[a] DON MORRISEY[a]

[a] Cawthron institute, Nelson
[b] Salt Ecology, Nelson

Prepared for Tasman District Council and Nelson City Council

CAWTHRON INSTITUTE
98 Halifax Street East, Nelson 7010 | Private Bag 2, Nelson 7042 | New Zealand
Ph. +64 3 548 2319 | Fax. +64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
Dana Clark

APPROVED FOR RELEASE BY:
Grant Hopkins

ISSUE DATE: 30 August 2023

RECOMMENDED CITATION: Berthelsen A, Stevens L, Floerl L, Morrisey D. 2023. Tasman and Nelson coastal marine environments: bathymetry and hydrosystems. Nelson: Cawthron Institute. Cawthron Report 3908. Prepared for Tasman District Council and Nelson City Council.

EXECUTIVE SUMMARY

Tasman District Council (TDC) and Nelson City Council (NCC) are currently reviewing their regional coastal plans (RCPs). As part of this process, the councils are required to review the provisions that protect sites of significant indigenous biodiversity within the coastal environment. To support the RCP reviews and to give effect to Policy 11 and other policies in the New Zealand Coastal Policy Statement 2010 (NZCPS; Department of Conservation 2010), NCC and TDC want to gather information regarding the indigenous biodiversity values of the coastal environment and the effects of activities on those values, as well as develop a policy response for the RCPs. To this end, NCC and TDC have initiated a marine and coastal indigenous biodiversity project, with four stages (Stage 1: Literature and data review, Stage 2: Assessment, Stage 3: Management, and Stage 4: Maintenance).

Cawthron Institute (Cawthron) and three collaborators (Salt Ecology, National Institute of Water and Atmospheric Research [NIWA], and Davidson Environmental Ltd) were contracted to carry out Stage 1. This report is one of five (relating to seven topics) that represent the outputs from Stage 1:

- Bathymetry (Report 1)
- Hydrosystems (Report 1)
- Habitats (Report 2a)
- Indigenous biodiversity (Report 2a)
- Historical data (Report 2b; TDC only)
- Publicly available sites of significance to iwi (Report 3; TDC only)
- Effects of activities (Report 4; TDC only).

The current report (Report 1) considers two topics, namely bathymetry and hydrosystems (estuaries). In summary, the scope was to collate bathymetry and hydrosystems information found during a literature and data search into a spatial data inventory with geographic information system (GIS) layers. Unavailable data and information gaps were also summarised. For hydrosystems, the scope also included discussion on whether hydrosystems could be considered 'naturally rare' under the NZCPS in respect to Policy 11(a)(iii) & (iv).

Main results for bathymetry and hydrosystems:

- Key details for mapped data relating to bathymetry and hydrosystems in the Nelson and Tasman Regions are presented. This includes layer names, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory.

Key data for bathymetry relate to:

- Current hydrographic survey

- Modelled New Zealand bathymetry
- Bathymetry (depth)
- Nautical charts
- LiDAR index tiles and the NZ elevation metadata layer
- Mean High Water Springs.

Key data for hydrosystems relate to:

- Broadscale estuarine habitats – substrates, water, estuary, intertidal, seagrass and salt marsh
- Hydrosystems.

Estuaries (hydrosystems) in the Nelson and Tasman Regions were assigned based on the New Zealand Coastal Hydrosystems classification, with all being either Tidal lagoon or Tidal river mouth (see report text for specific classification details). Estuaries were also classified using the New Zealand Estuary Trophic Index, with all being either Shallow intertidal-dominated estuaries (SIDEs) or Shallow, short residence time tidal river and tidal river with adjoining lagoon estuaries (SSRTREs). None of the estuaries as classified by Hume et al. (2016) were considered to represent rare typologies nationally. However, some of the typologies (especially at the level of 'subclass') are found in relatively low numbers regionally. Our assessment does not equate to the systems being ecologically rare or significant with respect to indigenous biodiversity.

Various information gaps are outlined for bathymetry and hydrosystems.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Context

Tasman District Council (TDC) and Nelson City Council (NCC) are currently reviewing their regional coastal plans (RCPs). As part of this process, the councils are required to review the provisions that protect sites of significant indigenous biodiversity within the coastal environment. To support the RCP reviews and to give effect to Policy 11 and other policies in the New Zealand Coastal Policy Statement 2010 (NZCPS; Department of Conservation 2010), NCC and TDC want to gather information regarding the indigenous biodiversity values of the coastal environment and the effects of activities on those values, as well as develop a policy response for the RCPs. To this end, NCC and TDC have initiated a marine and coastal indigenous biodiversity project, with the following four stages.

Stage 1: Literature and data review – collate existing marine and coastal indigenous biodiversity information, including spatial data; categorise the existing literature and data against the requirements of Policy 11 (NZCPS); and prepare reports based on the gathered data. The scope of the project includes assessing the quality of the literature and data and identifying any gaps in information. As part of the review, some information relevant to only TDC is reported and mapped for use in separate NZCPS work streams.

Stage 2: Assessment – determine the assessment criteria to identify sites of significance and assess the sites against these criteria, with the assistance of an expert panel and an iwi working group established by NCC and TDC. Field investigations may be required as part of this stage.

Stage 3: Management – determine locations for management, activities significantly affecting the sites of significance, and methods of protection.

Stage 4: Maintenance – add and assess new information as it becomes available. The project will continue and evolve beyond Stages 1–3.

Cawthron Institute (Cawthron) and three collaborators (Salt Ecology, National Institute of Water and Atmospheric Research [NIWA], and Davidson Environmental Ltd) were contracted to carry out Stage 1. This report is one of five that represent the outputs from Stage 1. We understand that Stages 2, 3 and 4 will follow on from this.

1.2. Stage 1 reports

The Stage 1 literature and data review is organised into seven topics and the results are presented in five reports:

- Bathymetry (Report 1)
- Hydrosystems (Report 1)
- Habitats (Report 2a)
- Indigenous biodiversity (Report 2a)
- Historical data (Report 2b; TDC only)
- Publicly available sites of significance to iwi (Report 3; TDC only)
- Effects of activities (Report 4; TDC only).

Key reference information for data sources, reports and publications is provided in each of the above reports.

1.3. This report and its associated spatial layers

This, the first report in the series, considers two topics, namely bathymetry and hydrosystems (estuaries) for the Nelson and Tasman Regions. Their scope is outlined in the following sections. Key reference information is provided in the data sources and references sections.

1.3.1. Bathymetry

Bathymetry information found in the literature and data search is included in the spatial data inventory as geographic information system (GIS) layers (Appendix 1). Unavailable data and information gaps are also summarised.

1.3.2. Hydrosystems

Hydrosystem information found in the literature and data search is included in the spatial data inventory as GIS layers (Appendix 1) and includes the following information (where available information allows):

- Spatial boundaries of each hydrosystem / estuary based on existing broadscale habitat mapping or drawn as part of the current project
- Hydrodynamic features of each hydrosystem / estuary calculated as part of the current project (Appendix 2).

The above information and its sources, as well as information gaps, are summarised. We also discuss whether hydrosystems could be considered ‘naturally rare’ under the New Zealand Coastal Policy Statement 2010 (NZCPS; Department of Conservation

2010) in respect to Policy 11(a)(iii)[1] & (iv).[2] Additional information on threats to hydrosystems is provided in Appendix 2.

[1] Indigenous ecosystems and vegetation types that are threatened in the coastal environment or are naturally rare (NZCPS). A naturally rare species was rare in Aotearoa New Zealand before the arrival of humans (NZCPS 2010 Glossary).

[2] Habitats of indigenous species where the species are at the limit of their natural range or are naturally rare (NZCPS).

2. BATHYMETRY

2.1. Data sources

This section on bathymetry-related data sources contains key information and maps for mapped data, and a brief summary of unavailable data.

2.1.1. Mapped data

Key details for mapped data relating to bathymetry are presented in Tables 1 to 6. This includes layer names, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory (refer to Appendix 1).

Table 1. Key details for mapped data relating to current hydrographic survey data. This includes group and layer name, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory (refer to Appendix 1).

Group name	CURRENT HYDROGRAPHIC SURVEY AREA
Layer name	TasmanArea_HydrographicSurvey
Data format and details	Polygon Feature Class, supplied by Land Information New Zealand (LINZ).
Description	Hydrographic survey areas in Tasman Region, currently in progress (2022).
Source reference	https://www.linz.govt.nz/resources/strategy/hyplan-new-zealand-long-term-prioritised-hydrographic-survey-plan

Table 2. Key details for mapped data relating to modelled New Zealand bathymetry. This includes group and layer name, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory (refer to Appendix 1).

Group name	BATHYMETRIC DATA
Layer name	NZ Bathymetry 250m Imagery/Raster layer
Data format and details	Raster
Description	NIWA's bathymetry model of New Zealand as a 250 m resolution raster. The 2016 model is a compilation of data digitised from published coastal charts, digital soundings archive, navy collector sheets and digital multibeam data sourced from surveys. Map information and metadata: Offshore representation was generated from digital bathymetry at a grid resolution of 250 m; Sun illumination is from an azimuth of 315° and 45° above the horizon; Projection Mercator 41 (WGS84 datum). EPSG: 3994; Scale 1:5,000,000 at 41°S. For further information see: https://niwa.co.nz/our-science/oceans/bathymetry/further-information
Source reference	Added via path: https://gis.niwa.co.nz/arcgis/services/Reference/NZ_Bathymetry_250m/ImageServer

Table 3. Key details for Bathymetry (depth) data. This includes group and layer name, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory (refer to Appendix 1).

Group name	BATHYMETRIC DATA
Layer name	Bathymetry (depth)
Data format and details	Feature Service Feature Class, added from Department of Conservation Estuaries SeaSketch project.
Description	This dataset is compiled from hydrographic bathymetry datasets sourced from Land Information New Zealand (LINZ) nautical charts at three scales: 1:22,000–1:90,000, 1:90,000–1:350,000 and 1:350,000–1:500,000. The finest scale (1:22,000–1:90,000) was used first where it exists. Missing areas were filled with the 1:90,000–1:350,000 then the 1:350,000–1:500,000 datasets. Some gaps between the coastline and the bathymetry remained, so values from the 1:22,000–1:90,000 polygons were extrapolated into the 1:350,000–1:500,000 polygons where they touched the coastline.
Source reference	Added via path: https://seasketch.doc.govt.nz/arcgis/rest/services/National/Our_Estuaries/MapServer/82

Table 4. Key details for nautical charts for the Nelson / Tasman Regions. This includes group and layer name, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory (refer to Appendix 1).

Group name	NAUTICAL CHARTS (LINZ)
Layer name	LINZchart_NelsonHarbourEntrancePortNelson LINZchart_PortTarakohe_AbelTasman LINZchartnz6144_AbelTasman LINZchart_TasmanBay LINZchart_KarameaToStephensIsland
Data format and details	Raster
Description	Nautical charts for the Nelson / Tasman Regions, downloaded from Land Information New Zealand (LINZ) Data Service.
Source reference	https://data.linz.govt.nz/layer/51551-chart-nz-6142-nelson-harbour-and-entrance/ https://data.linz.govt.nz/layer/51408-chart-nz-6144-abel-tasman-port-golden-bay-tarakohe/ https://data.linz.govt.nz/layer/51325-chart-nz-6144-abel-tasman/ https://data.linz.govt.nz/layer/51283-chart-nz-614-tasman-bay-te-tai-o-aorere/ https://data.linz.govt.nz/layer/51253-chart-nz-61-karamea-river-to-stephens-island/

Table 5. Key details for LiDAR index tiles for the Nelson / Tasman Regions, and the NZ elevation metadata layer. This includes group and layer name, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory (refer to Appendix 1).

Group name	LiDAR
Layer name	a) TasmanGoldenBay_LiDARindexTiles_2017 b) Nelson_LiDARindexTiles_2021 c) TasmanBay_LiDARindexTiles_2022 d) NelsonTasman_LiDARindexTiles_2008to2015 e) NZ_elevation_metadata
Data format and details	Feature classes
Description	Layers a) to d) are index tiles for LiDAR (Light Detection and Ranging) datasets in the Nelson / Tasman Regions, sourced from Land Information New Zealand (LINZ) Data Service. Layer e) is a national dataset showing metadata and current coverage of different types of elevation data (1 m and 2 m DEM – LiDAR, 8 m DEM), along with URL links to datasets and index tiles. The data are also available as a 3D elevation surface (not included in this project), see: https://www.arcgis.com/home/item.html?id=2ce4fe7d77024e719f8a04d2155b3fd2
Source reference	https://data.linz.govt.nz/layer/95627-tasman-golden-bay-lidar-index-tiles-2017/ https://data.linz.govt.nz/layer/106835-nelson-lidar-index-tiles-2021/ https://data.linz.govt.nz/layer/112582-tasman-tasman-bay-lidar-index-tiles-2022/ https://data.linz.govt.nz/layer/95826-nelson-and-tasman-lidar-index-tiles-2008-2015/ https://services.arcgis.com/XTtANUDT8Va4DLwl/arcgis/rest/services/new_zealand_elevation_metadata/FeatureServer

Table 6. Key details for Mean High Water Springs data for the Nelson / Tasman Regions. This includes group and layer name, data format and details, description and source reference. The layer names relate directly to those in the spatial data inventory (refer to Appendix 1).

Group name	MEAN HIGH WATER
Layer name	TDC_MeanHighWaterSprings (MHWS6) NCC_MeanHighWaterSprings
Data format and details	Polygon Feature Class Polyline Feature Class
Description	The spatial extent of Mean High Water Springs in the Tasman District Council (TDC) and Nelson District Council (NCC) regions. Derived from the TRMPMeanHighWaterSprings (MHWS) dataset, which identifies the MHWS along the coastline of the Tasman Region. This is the line of average of each pair of successive high waters. AccuracyDetail: +/- 0.001 for 1 m Urban and +/- 0.001 for 20 m Rural for 90% of data. For details on the methodology used to develop the coastal hazards information, please see the report: Coastal Hazards Assessment in Tasman Bay / Te Tai-o-Aorere and Golden Bay / Mohua (2019) (pdf, 2MB). Note that the extent does not include the northern West Coast Region. Coastline (mean high water springs level) in the Nelson area, supplied by NCC. This version shows the coastline proposed for the Nelson Plan (NelsonPlanMHWS6172 = 'Yes'). This uses 1.72 m elevation contour (following advice from Tonkin + Taylor & NIWA), generated from LiDAR, then smoothed and adjusted based on instruction from Mark Leggett, Principal Planner, in Jan. 2019.
Source reference	Provided by TDC and NCC https://data.linz.govt.nz/layer/95627-tasman-golden-bay-lidar-index-tiles-2017/https://data.linz.govt.nz/layer/106835-nelson-lidar-index-tiles-2021/https://data.linz.govt.nz/layer/112582-tasman-tasman-bay-lidar-index-tiles-2022/https://data.linz.govt.nz/layer/95826-nelson-and-tasman-lidar-index-tiles-2008-2015/https://services.arcgis.com/XTtANUDT8Va4DLwI/arcgis/rest/services/new_zealand_elevation_metadata/FeatureServer

2.1.2. Unavailable data and data gaps

Hydrographic data, currently being collected and processed for areas in the TDC and NCC regions (see: Current Hydrographic Survey Area), are not yet available.

LiDAR datasets are not included in the collation of map data for this project, but index tiles and the NZ elevation metadata layer are provided. This approach was approved by TDC's Environmental Information Manager, as the councils already hold these datasets. URLs for datasets and tiles are provided in the NZ elevation metadata layer.

The modelled bathymetry data (NZ Bathymetry 250m), it may be useful for areas outside the extent of LiDAR coverage.

3. HYDROSYSTEMS

This section contains information on the spatial boundaries and hydrodynamic features of Nelson and Tasman hydrosystems (estuaries) found in the literature and data search and included in the spatial data inventory (Appendix 1). Information on data gaps and threats is also provided.

3.1. Estuary (hydrosystem) classification, including maps and threats

3.1.1. Estuary classification

There are a large number of frameworks for describing different estuary types (typologies), and their relevance is variable depending on the specific management questions being asked. In Aotearoa New Zealand, a relatively complex typology of 11 main classes and 21 subclasses (Table 7) has been developed based on broad physical (geomorphic) features (Hume et al. 2016).

Table 7. Geomorphic classes and 21 subclasses in the New Zealand Coastal Hydrosystems classification.

Geomorphic class	**Subclass**
1. Damp sand plain lake	
2. Waituna-type lagoon	A. Coastal plain depression; B. valley basin.
3. Hāpua-type lagoon	A. Large; B. medium; C. small; D. intermittent.
4. Beach stream	A. Hillside stream; B. damp sand plain stream; C. stream with pond; D. stream with ribbon lagoon; E. intermittent stream with ribbon lagoon.
5. Freshwater river mouth	A. Unrestricted; B. deltaic; C. barrier beach enclosed.
6. Tidal river mouth	A. Unrestricted; B. spit enclosed; C. barrier beach enclosed; D. intermittent with ribbon lagoon; E. deltaic.
7. Tidal lagoon	A. Permanently open; B. intermittently closed.
8. Shallow drowned valley	
9. Deep drowned valley	
10. Fjord	
11. Coastal embayment	

This system is based on a hierarchy and classification of coastal wetland, riverine, estuarine and marine types; these types are regarded as having properties and responses to natural and anthropogenic forcings that are different to an extent that they can be considered separate for management purposes (Hume et al. 2016). The classes and their subclasses are discriminated by their landscape and waterscape characteristics, such as geology, geomorphology and hydrodynamic characteristics arising from river and oceanic forcing and basin morphometry. A decision tree is used to determine the classification given to a waterbody (Figure 1), and a listing of classifications for approximately 500 estuaries throughout Aotearoa New Zealand was presented in Hume et al. (2016), table E-1.

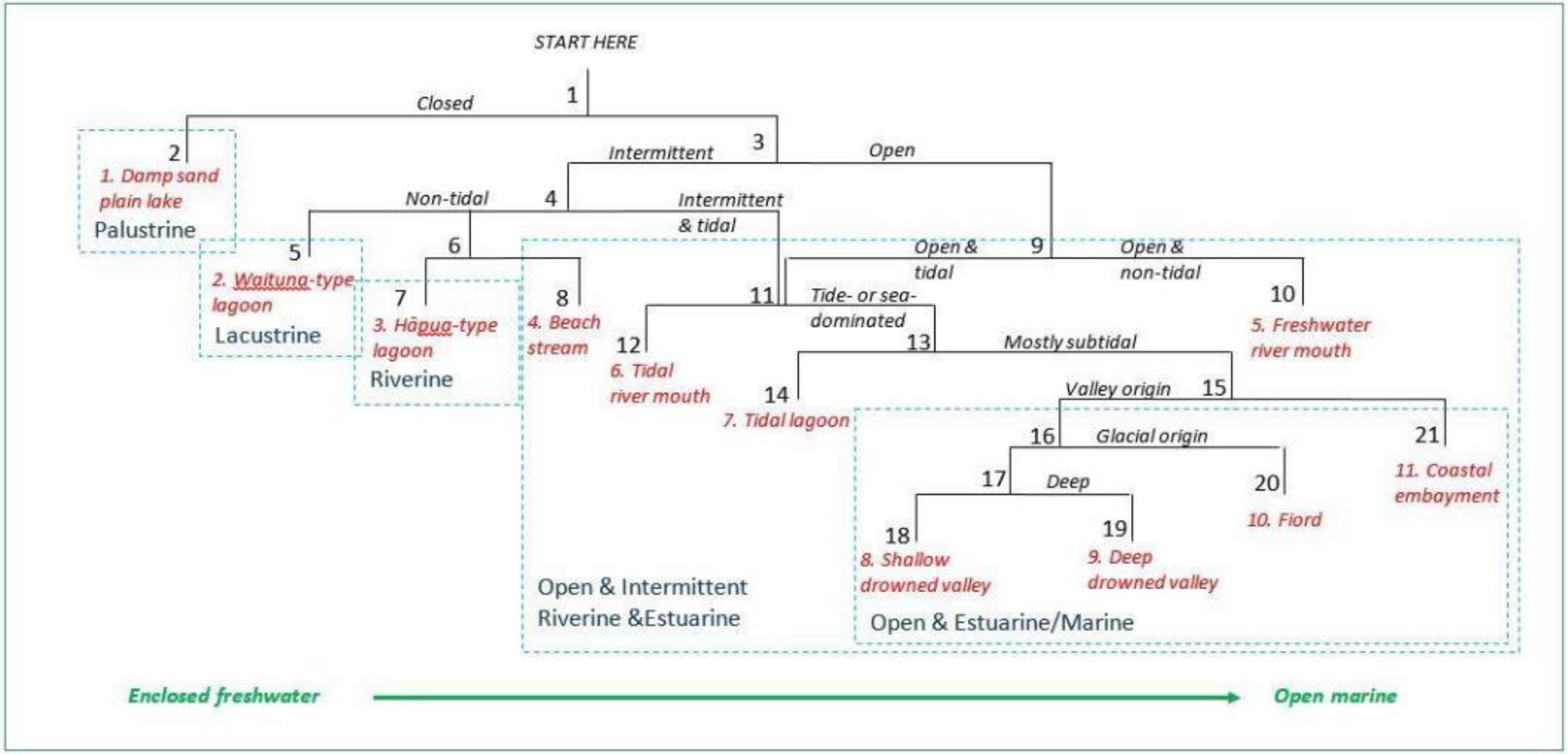

Figure 1. Tree diagram of hydrosystem types and geomorphic classes. The blue dotted lines describe the hydrosystem environment. Source: Hume et al. (2016), figure C-1.

While the project scope specifies that the Hume et al. (2016) classification approach is to be used, the classification system is difficult to reproduce, as there are inconsistences between the decision tree diagram and the narrative classification keys (described in more detail in Appendix 3). To address such inconsistencies, 69 estuaries in the Nelson and Tasman Regions were reclassified by Leigh Stevens (Salt Ecology) for the current project using updated local data (Appendix 2) and the Hume et al. (2016) tree diagram presented in Figure 1 as the primary determinant of estuary type. The resulting output classified all the estuaries in the Nelson and Tasman Regions as either a tidal river mouth or a tidal lagoon estuary (Table 8; Figures 2 and 3). Distinguishing features of these estuary types (from Hume et al. 2016) are:

- **Tidal Lagoons** are *shallow (mean depth 1-3 m), circular to elongate basins with simple (not dendritic) shorelines and extensive intertidal area. A narrow entrance to the sea, constricted by a spit or sand barrier. Ebb and flood tidal delta sand bodies form in the sea and bay sides of the entrance. Strong reversing tidal currents flow through the entrance. The tidal prism makes up a large proportion of the total basin volume. River input is small compared to tidal inflow so hydrodynamic processes are dominated by the tides. Despite the narrow entrance they generally have good flushing because much of the water leaves the estuary on the outgoing tide. River inputs dominate the hydrodynamics for short periods (days) during floods when seawater can be completely expelled. On the incoming tide flood waters get backed up by the tide causing low-lying land around the margins to be flooded. Wind-generated, mixing and resuspension of bottom sediments occur at high tide; this is more pronounced in larger and circular open water bodies with larger fetch. The combination of wave resuspension of the substrate and flushing results in generally homogeneous and sandy substrates. These classes are also well mixed because strong flushing, wind mixing and the shallow depths prohibit density stratification. Salinity is close to that of the sea. Water clarity is good because of the flushing and the sandy substrate. The spit or barrier can be overtopped by waves and breached in extreme events leading to multiple entrances. Dominant substrate is sand.*
- ➢ *7A: Permanently open. Circular to elongate planform and always open to the sea. Well flushed.*
- ➢ *7B: Intermittently closed. Lagoons bar off infrequently and can become eutrophic, until the entrance is breached and tidal exchange resumes.*

- ***Tidal River Mouth*** *estuaries are elongate, narrow and shallow (mean depth several metres) basins that have a permanent connection to the sea for most of the time. They occur where river and tidal flow are large and persistent enough to maintain a permanent subtidal channel through the shoreline and beach to the sea. River flow delivered during a tidal cycle is a significant proportion of the basin's volume, and is greater than the tidal volume entering. Thus, the hydrosystem-scale hydrodynamic processes are dominated by river* *flows and these classes are well flushed. Floods can expel all the seawater from the system for days. In deeper systems an estuarine circulation pattern can be set up where outflowing freshwater is balanced by the inflow of seawater entrained beneath freshwater and a salt wedge develops. Seawater can intrude kilometres up estuary in low-gradient coastal plains. Wind-generated mixing and wave-driven resuspension are minor as wind fetch and waves are small and depths are largely too great for significant bed stress to be produced. Thus sediments inside the waterbody tend to be muddy except in areas of high tidal flows.*

- *6A: Wide unrestricted mouth. Emerges on low-wave energy shores where there is insufficient littoral drift to build a spit or barrier across the entrance. Salt wedge present and saline intrusion occurs for kilometres upstream in flat land. Dominant substrate is fine sand and mud.*
- *6B: Narrow inlet restricted by sandy spit with lagoon or wide tidal channel upstream. Emerges on sufficiently high wave energy shores where littoral drift has built a spit or beach barrier across the entrance. Tidal flow through the entrance. Salt wedge present. Dominant substrate is fine sand or mud.*
- *6C: Similar to 6B but occurs on a mixed sand/gravel coast. Maintains a permanent connection to the sea for most of the time. Hydrodynamics are controlled by the flow in the main river channel; side arms, if present, play little role. Only minor lateral migration of the outlet compared to 6D.*
- *6D: Narrow, elongate and shallow; runs close to the shoreline up and down coast for kilometres along the dune slack and away from the main river inflow. May have multiple stream inflows. Mouth can breach anywhere along the barrier which can be kilometres long. Hydrodynamics controlled by both the flow in the main river channel, and also flows from adjacent wetlands into the side arms (this water is usually tannin-stained). Frequently connected to the sea (lower reaches are brackish) which sets it apart from 4D beach stream (which is never connected to the sea). Small systems are more sensitive to anthropogenic modifications (e.g., mechanical opening to alleviate flooding). Never closes.*
- *6E: Shallow channelised rivers discharging sandy or gravelly sediment to build a delta into a low-energy coastal environment such as a coastal embayment or fetch-limited sea. The delta can accumulate in the absence of longshore transport.*

Table 8. Estuary types located in the Nelson and Tasman Regions. Estuaries were classified using local data and the Hume et al. (2016) tree diagram in Figure 1 as the primary determinant of estuary type. Refer to Section 3.1.1 and Appendix 2 for further details.

NZCHS class	NZCHS subclass	NCC	TDC	Grand total
6. Tidal river mouth	6A. Unrestricted		2	2
	6B. Spit enclosed		6	6
	6C. Barrier beach enclosed	2	8	10
	6D. Intermittent with lagoon		1	1
	6E. Deltaic		9	9
	6E. Unrestricted		1	1
6. Tidal river mouth total		2	27	29
7. Tidal lagoon	7A. Permanently open	4*	33	37
	7B. Intermittently closed		3	3
7. Tidal lagoon total		4	36	40
Grand total		6	63	69

* Waimea Inlet is included under the Tasman Region.

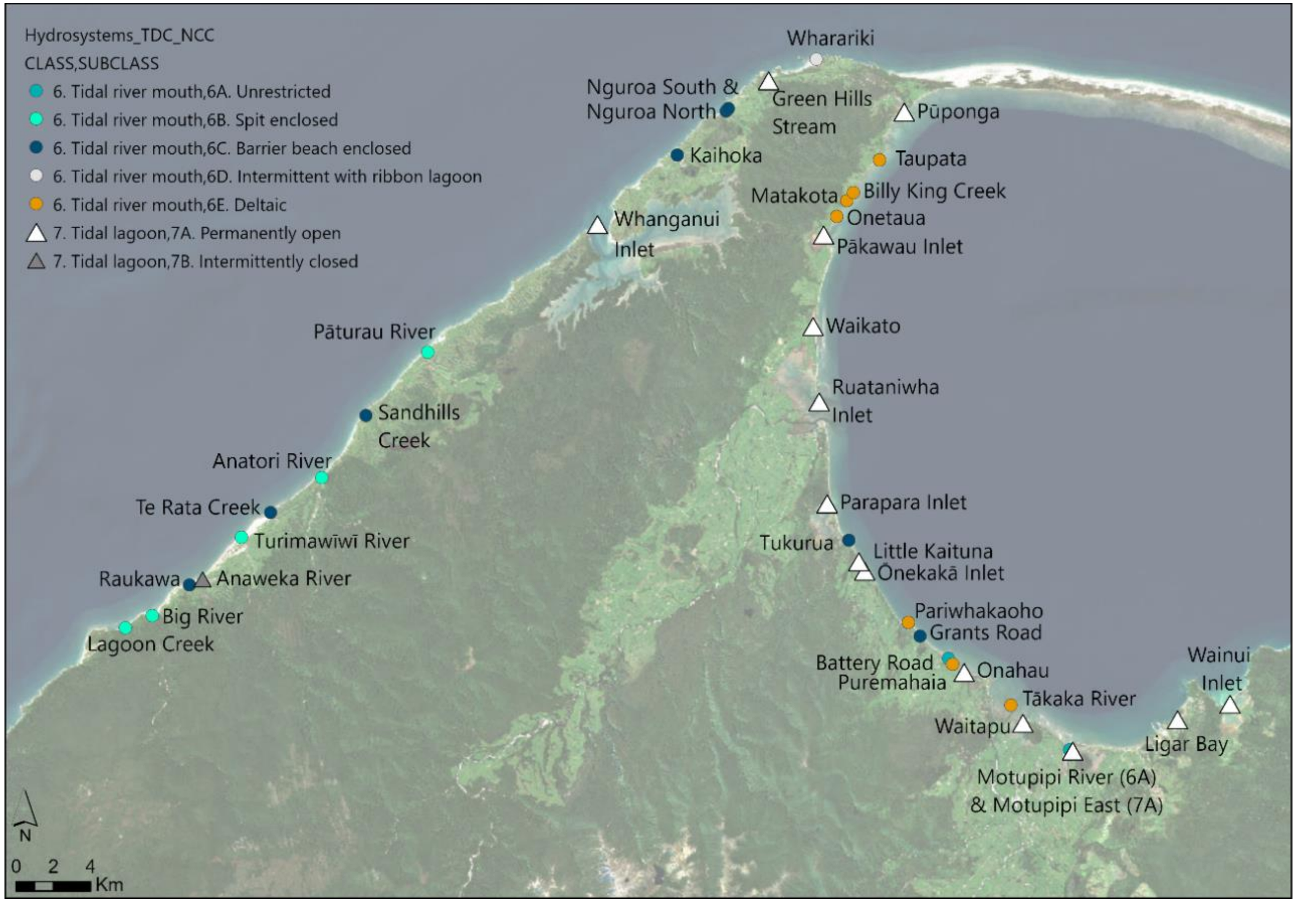

Figure 2. Location of estuary types in Golden Bay / Mohua and the west coast of the Tasman Region. Estuaries were classified using local data and the Hume et al. (2016) tree diagram in Figure 1 as the primary determinant of estuary type. Refer to Section 3.1.1 and Appendix 2 for further details. Basemap credit: Land Information New Zealand (LINZ) NZ imagery.

Figure 3. Location of estuary types in Tasman Bay / Te Tai-o-Aorere. Estuaries were classified using local data and the Hume et al. (2016) tree diagram in Figure 1 as the primary determinant of estuary type. Refer to Section 3.1.1 and Appendix 2 for further details. Basemap credit: Land Information New Zealand (LINZ) NZ imagery.

In addition to Hume et al.'s (2016) classification, each estuary system has also been classified using a simple typology originally described in the New Zealand Estuary Trophic Index (ETI) by Robertson et al. (2016) for the assessment of estuarine eutrophication (nutrient enrichment) susceptibility. The ETI recognised that susceptibility to eutrophication (and sedimentation) in estuaries, and therefore the ability to appropriately manage and protect them effectively, is more strongly influenced by specific physical modifying characteristics – including dilution, flushing, residence time, depth and intertidal extent – than geomorphic class; moreover, applying a geomorphic typology can become unnecessarily complex. The simplified typology, subsequently modified by Robertson and Stevens (2016), is as follows:

- Shallow intertidal-dominated estuaries (SIDEs)
- Shallow, short residence time tidal river and tidal river with adjoining lagoon estuaries (SSRTREs)
- Deeper subtidal-dominated, longer residence time estuaries (DSDEs).

This simplified typology varies from the ETI by classifying Intermittently Closed / Open Lakes and Lagoons (ICOLLs) as sub-types of SIDEs and SSRTREs with Intermittently Constricted / Closed or Open Entrances (ICOEs). The estuaries in the Nelson and Tasman Regions fall into the following two categories:

- **SIDEs** are the dominant estuary type in Aotearoa New Zealand and are characterised as shallow (mean depth < 3 m), short residence time (< 3 days, and often < 1 day) and predominantly intertidal (> 40%) tidal lagoon estuaries. In estuaries with permanently open mouths, flushing is generally too strong for significant retention of dissolved nutrients and thus sustained phytoplankton blooms are uncommon. However, tidal lagoon estuaries with settlement basins retain sediment and sediment-bound nutrients, particularly in the upper estuary tidal flats where salinity driven flocculation and hydrodynamic deposition is promoted. If catchment nutrient inputs are elevated, and suitable growing conditions exist, nuisance opportunistic macroalgae (especially *Ulva* spp. and *Agarophyton* spp.) can establish. Because of their capacity to retain fine sediment and sediment-bound nutrients, the susceptibility of this estuary type to nutrient loads is moderate to high. Local examples of SIDEs are the Kokorua, Delaware, Waimea, Moutere, Motupipi and Whanganui / Westhaven estuaries.

- **SSRTREs** are shallow (mean depth < 3m), short residence time (< 3 days and often < 1 day) and often subtidal-dominated tidal river estuaries, but they also include those that exit via a very well-flushed small lagoon or a coastal delta. They have such strong flushing that the majority of fine sediment and nutrients are exported directly to the sea. In general, these estuary types have extremely low susceptibilities and can often tolerate nutrient loads an order of magnitude greater than SIDEs. Where nutrient concentrations are high and rivers are long, phytoplankton can reach high concentrations, but little growth occurs in the estuary itself unless there are deep poorly flushed holes and / or stratified basins / channels. Macroalgae can establish where there is stable substrate for attachment or where significant areas of tidal flats or shallow channel margins allow muds to settle. In such cases, eutrophic symptoms of macroalgal growth can develop, particularly under stable low-flow conditions, but are generally removed by flood flows. Local examples of larger SSRTREs are the Paturau, Ruataniwha, Tākaka and Moutere River estuaries. Smaller SSRTREs are present throughout the region, e.g. Sandhills Creek, Taupata and Parewhakaoho estuaries.

SIDEs or SSRTREs with ICOEs have the highest susceptibility to nutrient retention and eutrophication, with the most susceptible being those with closure periods of months (e.g. Waituna Lagoon, Southland) rather than days (e.g. Lake Onoke, Wellington). In general, tidal river ICOEs have shorter periods of mouth closure (unless they are very small) than the more buffered tidal lagoon ICOEs. The high susceptibility arises from reduced dilution (absence of tidal exchange at times) and increased nutrient retention (through both enhanced plant uptake and sediment deposition). Excessive phytoplankton and macroalgal growths and reduced macrophyte growth are characteristic symptoms of ICOE eutrophication. Local examples of SSRTRE ICOEs are Big River Estuary, Lagoon Creek and Grants Road, and examples of SIDE ICOEs are Sandfly Bay, Frenchman Bay and Apple Tree Bay.

The results show that of the 69 estuaries included in the mapped coverage, 37 were SIDEs, three were SIDE ICOEs, 14 were SSRTREs and 15 were SSRTRE ICOEs (Table 9; Figures 4 and 5). Most of the SSRTREs were located on the West Coast and northern part of Golden Bay / Mohua, while SIDEs were the dominant estuary type in Tasman Bay / Te Tai-o-Aorere.

Of the 69 estuaries included, 26 were less than 4 ha, a size commonly excluded from national datasets such as NIWA's Coastal Explorer. These comprised seven SIDEs, one SIDE ICOE, seven SSRTREs and 11 SSRTRE ICOEs. Twenty-nine estuaries were between 4 ha and 100 ha and included 18 SIDEs, five SSRTREs, four SSRTRE ICOEs and two SIDE ICOEs. Fourteen estuaries were greater than 100 ha and included 12 SIDEs and two SSRTREs.

Table 9. The number of estuaries in the Tasman District Council and Nelson City Council regions based on the New Zealand Estuary Trophic Index (ETI) classification system. This information is also provided in Appendix 2.

Estuary classification (ETI)	Tasman	Nelson
SIDE	33	4*
SIDE ICOE	3	
SSRTRE	14	
SSRTRE ICOE	13	2

*Waimea Inlet is included under the Tasman Region.

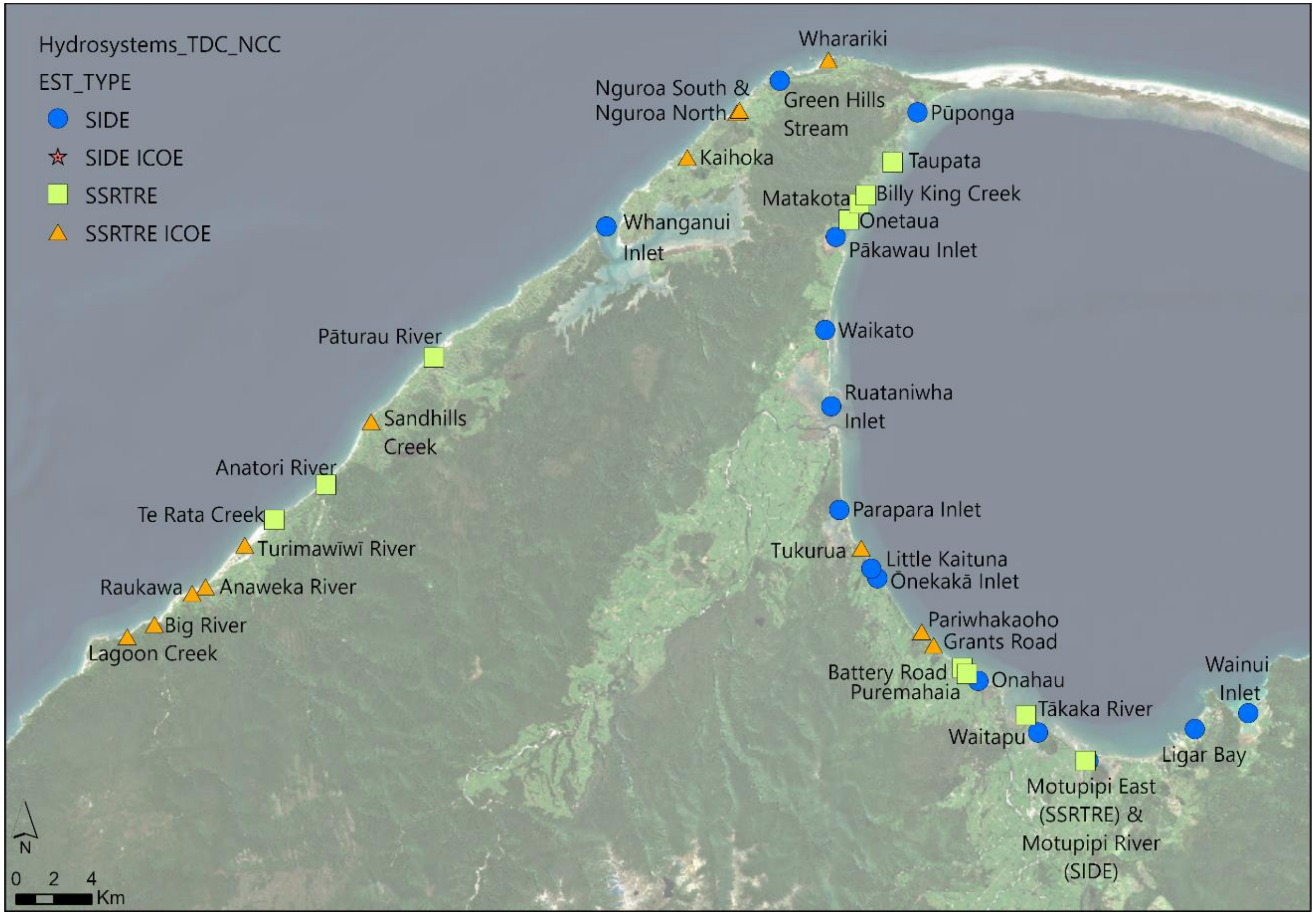

Figure 4. Location of estuary types (based on the New Zealand Estuary Trophic Index classification) in Golden Bay / Mohua and the west coast of the Tasman Region. Basemap credit: Land Information New Zealand (LINZ) aerial imagery.

Figure 5. Location of estuary types (based on the New Zealand Estuary Trophic Index classification) in Tasman Bay / Te Tai-o-Aorere. Basemap credit: Land Information New Zealand (LINZ) aerial imagery.

3.1.2. Hydrosystem Policy 11 considerations

We consider that none of the estuaries classified by Hume et al. (2016) represent rare typologies nationally. However, some of the typologies (especially at the level of 'subclass') are found in relatively low numbers regionally. For example, there are four hydrosystem types represented by three or fewer estuaries in the Nelson and Tasman Regions combined. These are Tidal River mouth 6A Unrestricted, Tidal River mouth 6D Intermittent with lagoon, Tidal river mouth 6E Unrestricted and Tidal lagoon 7B Intermittently closed (Table 8). Note that this assessment does not equate to the systems being ecologically rare or significant with respect to indigenous biodiversity. This includes for indigenous ecosystems and vegetation types and habitats of indigenous species, which are mentioned in Policy 11(a)(iii)[3] & (iv).[4]

3.1.3. Threats

It is primarily not the hydrosystems themselves that are threatened, but the habitats and biodiversity within them; therefore, the relevant threat assessment (conducted at a high level) is within our Report 2a (Berthelsen et al. 2023b; see appendix 5). There can be multiple threats to specific estuary habitats and biodiversity; for example, sediment may not threaten the hydrosystem type itself, but it could be a direct threat to seagrass or shellfish and indirectly threaten birds and fish through changed clarity. However, additional detailed information on threats (based on a vulnerability assessment) to estuaries is provided in Appendix 2 given this relates to the data in Table A2.1. Information on threats to estuaries is also provided in Report 4 (Handley et al. 2023b).

3.2. Data sources

This section on data sources for hydrosystems contains key information for mapped data and a brief summary of information gaps. Data included on each estuary system has been sourced from existing GIS-based mapping undertaken for both TDC and NCC and are listed in Tables 10 to 13 and the References section. There was also additional desktop mapping prepared as a specific output for the current project (see Appendix 2).

3.2.1. Mapped data

Tables 10 to 13 contain key details for mapped data relating to hydrosystems. This includes the layer name, data source and format, and description. The layer names relate directly to those in the spatial data inventory (see Appendix 1). Spatial data

[3] Indigenous ecosystems and vegetation types that are threatened in the coastal environment or are naturally rare (NZCPS). A naturally rare species was rare in Aotearoa New Zealand before the arrival of humans (NZCPS 2010 Glossary).

[4] Habitats of indigenous species where the species are at the limit of their natural range or are naturally rare (NZCPS).

relating to habitats and biodiversity for estuaries is included in Report 2a (Berthelsen et al. 2023b).

Estuary boundaries were exported from existing datasets or were redrawn where accurate data were lacking, i.e. Abel Tasman National Park, West Coast. For each estuary, the mapped high tide boundary was used to delineate estuary extent, and the low tide water polygon used to delineate subtidal extent. Tidal ranges were determined by extrapolation from Hume et al. (2016), mouth width (m) was measured from GIS shapefiles, and computer coding was used to calculate shoreline perimeter (m), estuary area (m^2), intertidal area (%), tidal volume (m^3), tidal prism (m^3) and river inflow volume (m^3). Mean low tide depth (m) of the subtidal portion of the estuary was estimated based on expert opinion / local knowledge and used in the above calculations to determine tidal prism.

Table 10. Key details for mapped data relating to Broadscale estuarine habitats – substrates, water, estuary, intertidal (master). This includes layer name, data source, format, description, and reporting references. The layer name relates directly to that in the spatial data inventory (refer to Appendix 1).

Group name	BROADSCALE ESTUARINE HABITATS – SUBSTRATES, WATER, ESTUARY, INTERTIDAL, (MASTER)
Layer name	TDC_NCC_SitesofMarineSignificance_Substrate TDC_NCC_SitesofMarineSignificance_Water TDC_NCC_SitesofMarineSignificance_EstuaryExtent TDC_NCC_SitesofMarineSignificance_IntertidalExtent TDC_NCC_SitesofMarineSignificance_2022MASTER
Data format and details	Polygon feature classes. Geodatabase containing all layers was supplied by Salt Ecology. SUBSTRATE data are organised by SubClass: Artificial; Boulder / Cobble / Gravel; Sand (0–10% mud); Muddy Sand (> 10–25% mud); Muddy Sand (> 25–50% mud); Sandy Mud (> 50–90% mud); Mud (> 90% mud); and Zootic, and are symbolised in the map based on dominant habitat data (DomHab). The dataset also contains fields for up to four subdominant habitats (SubDom), estuary name (ESTUARY) and year of survey (YEAR). The extent polygons for WATER (subtidal), INTERTIDAL and ESTUARY (sub- and intertidal areas), along with the MASTER dataset, are included. *Note that the MASTER layer is used to derive all other data layers using GIS computer scripting tools created by Salt Ecology. It contains coded descriptions of key features and is not intended to be used as a data output layer but has been included for completeness.* USE LIMITATIONS: Data have been collated for the specific use of Tasman District Council (TDC) and Nelson City Council (NCC). The data may only be used by members of the project team for the purpose of delivering data outputs to TDC and NCC. No copies of the supplied data are to be retained by members of the project team following delivery of the project outputs to TDC and NCC. Any use of the data should include the following acknowledgement: Broadscale mapping data and GIS files were collated by Salt Ecology for the exclusive use of Tasman District Council and Nelson City Council.
Description	Collation of existing broadscale habitat mapping of the most recent surveys of dominant SUBSTRATE features, and the spatial extent of WATER (subtidal) / INTERTIDAL AREA / ESTUARY (which includes both intertidal & subtidal) of the estuaries of the Nelson and Tasman Regions. Surveys were undertaken by Salt Ecology from Sept. 2022–Jan. 2023, with mapping covering the period from 1991–2022. Original features were recorded at the dates specified in the attribute tables and digitised directly onto colour aerial photos supplied by council or sourced from the Land Information New Zealand (LINZ) Online Data Service available at the time (see individual source reports for specific details). Mapping was supported by the use of georeferenced field photos collected during ground-truthing undertaken by Wriggle Coastal Management or Salt Ecology between 2012 and 2022. Maps of Abel Tasman National Park were digitised in

Group name	BROADSCALE ESTUARINE HABITATS – SUBSTRATES, WATER, ESTUARY, INTERTIDAL, (MASTER)
Description	Jan. 2023 by Salt Ecology based on hard copy maps in Davidson (1992). For data collation, each digitised feature was ascribed a field code, which was recorded in a master layer that combined all estuary data. Field codes were standardised across estuaries, and in-house scripting was used to validate field codes and check for any errors in geometry or typology. Validated codes were then used to produce individual summary output layers. Spatial accuracy is variable and reflects the individual surveys undertaken. For example, the 2012 survey of the Tasman Region was constrained by relatively low-resolution imagery and limited ground-truthing (estuaries on the West Coast were assessed as a desktop only with no site visits). Consequently, spatial accuracy is often approx. 50 m depending on the extent of ground-truthing undertaken. For more recent surveys, e.g. Waimea Inlet 2020, spatial accuracy is approx. 2–10 m for features that are easy to distinguish on aerial photos.
Source reference	Abel Tasman: Davidson (1992; redrawn by Salt Ecology in Jan. 2023); Ōmōkau and Ōananga: Forrest et al. (2022); Moutere Delta / Wainui / Waitapu / Waikato / Pākawau / Pūponga / Onetaua / Billy King Creek / Matakota / Taupata / Tākaka River / Onehau / Parapara Inlet / Onekaka Inlet / Puremāhaia / Little Kaituna / Grants Road / Tukurua / Pariwhakaoho: Robertson and Stevens (2012, with minor edits to spatial data made by Salt Ecology in Jan. 2023); Wainui: Robertson and Stevens (2012, with minor edits to spatial data made by Salt Ecology in Jan. 2023); Battery Road / Big River / Ruakawa / Green Hills Stream / Kaihoka / Lagoon Creek / Anaweka / Turimawiwi / Te Rātā Creek / Anatori River / Sandhills Creek / Paturau River / Ngūroa South & North / Wharariki / Ligar Bay / Mārahau / Kaiteriteri / Ngaio Stream / Otūwhero: Robertson and Stevens (2012, redrawn by Salt Ecology in Jan. 2023); Tapu Bay: Scott-Simmonds (2022, unpublished TDC data); Kokorua: Scott-Simmonds et al. (2022); Delaware: Stevens and Forrest (2019a); Nelson Haven: Stevens and Forrest (2019b); Ruataniwha Inlet: Stevens and Robertson (2015c, with minor edits to spatial data by Salt Ecology in Jan. 2023); Motupipi East & West: Stevens and Robertson (2015a, with minor edits to spatial data by Salt Ecology in Jan. 2023); Whanganui Inlet: Stevens and Robertson (2017a); Moutere Inlet: Stevens et al. (2020b); Motueka River Delta & Motueka Estuary / Riuwaka / Ferrer Creek: Stevens et al. (2020a); Waimea / Tāhunanui: Stevens et al. (2020c). Also refer to appendix 6 in Report 2a for data relating to estuary broadscale habitat mapping (Berthelsen et al. 2023b).

Table 11. Key details for mapped data relating to Broadscale estuarine habitats: seagrass and saltmarsh. This includes layer name, data source, format, description and reporting references. The layer name relates directly to that in the spatial data inventory (refer to Appendix 1).

Group name	BROADSCALE ESTUARINE HABITATS: SEAGRASS & SALTMARSH
Layer name	TDC_NCC_SitesofMarineSignificance_Seagrass TDC_NCC_SitesofMarineSignificance_SaltMarsh
Data format and details	Polygon feature classes. Geodatabase containing all layers supplied by Salt Ecology. SEAGRASS data are symbolised using percent cover data (CrsPctCov). Categories: Complete (> 90%), Dense (70% to < 90%); High-Moderate (50% to < 70%); Low-Moderate (30% to < 50%); Sparse (10% to < 30%); Very sparse (< 1%); Trace (< 1%). SALTMARSH data are symbolised based on SubClass: Estuarine Shrub; Grassland; Herbfield; Reedland; Rushland; Sedgeland; Tussockland. SubstrCode contains information about underlying substrate type for seagrass & saltmarsh patch area and has been calculated in hectares (Area_ha). The dataset also contains fields for up to four subdominant habitats (SubDom), estuary name (ESTUARY) and year of survey (YEAR). See BROADSCALE ESTUARINE HABITATS – MASTER for use limitations.
Description	Collation of existing broadscale habitat mapping of the most recent surveys of dominant SEAGRASS & SALTMARSH features of the estuaries of the Nelson and Tasman Regions. See BROADSCALE ESTUARINE HABITATS – MASTER for general description of data.
Source reference	See BROADSCALE ESTUARINE HABITATS – MASTER for list of corresponding reports.

Table 12. Key details for mapped data relating to Hydrosystems_TDC_NCC. This includes layer name, data source, format, description and reporting references. The layer name relates directly to that in the spatial data inventory (refer to Appendix 1).

Layer name	Hydrosystems TDC_NCC
Data source and format	A classification of New Zealand's coastal hydrosystems – appended estuary summary data (Appendix 2). This dataset is symbolised in two ways in the map: CLASS and SUBCLASS, based on classifications presented in Hume et al. (2016). EST-TYPE, based on the New Zealand Estuary Trophic Index classification (refer to Section 3.1.1).
Description	Variable accuracy. Estuary features determined using a desktop approach were originally sourced from NIWA's Coastal Explorer dataset and relied on expert judgement. Estuary boundaries and physical parameters (e.g. estimated depths) often inaccurate. Classification of hydrosystems in the Tasman District Council (TDC) and Nelson City Council (NCC) regions and supporting data, including: NAME, REG_COUNCIL = regional council, WIDTH_OF_M = width of mouth (m), SHLN_PERMIN = shoreline perimeter (m), SURFC_AREA = surface area (m^2), INTRTDL_AR = intertidal area (% of total estuary area), MEAN_DEPTH (m), TOTAL_VOL = total volume (m^3), TDAL_RANGE = tidal range (m), TDAL_PRISM = tidal prism (m^3), CATCHMT_AR = catchment area (km^2), R_INLF_VOL = river inflow volume (m^3), SUBTDL_AR = subtidal area (m^2), CLASS and SUBCLASS = classes and subclasses based on Hume et al. (2016) classification, MeanLTdpth = mean low tide depth (m), EST_TYPE = classes based on the New Zealand Estuary Trophic Index classification.
Reporting references	Hume et al. (2016)

Table 13. Key details for mapped data relating to Hydrosystems_Polygons_TDC_NCC. This includes layer name, data source, format, description and reporting references. The layer name relates directly to that in the spatial data inventory (refer to Appendix 1).

Layer name	Hydrosystems_Polygons_TDC_NCC
Data source and format	New Zealand Estuary Trophic Index (ETI) Coastal Explorer national estuary polygon dataset, sub-set to Tasman District Council (TDC) and Nelson City Council (NCC) regions.
Description	Variable accuracy. Estuary features were determined using a desktop approach and relied on expert judgement. Estuary boundaries and physical parameters (e.g. estimated depths) often inaccurate. Polygons representing hydrosystems in the TDC and NCC regions and their classifications were sourced from the ETI Coastal Explorer national estuary polygon dataset. Dataset includes NAME, SURFC_AREA = surface area (m^2) and SURFC_LEN = surface length (m), CLASS and SUBLCASS classifications (based on Hume et al. 2016)
Reporting references	Unspecified

3.2.2. Information gaps

Information gaps relating to threats to estuarine habitats and biodiversity are covered at a high level in Report 2a (Berthelsen et al. 2023b). However, information gaps for threats to estuaries habitats and biodiversity are summarised in Appendix 2 of this report (see further details below) because these relate to additional information included in Table A2.1.

4. APPENDICES

Appendix 1. Tasman and Nelson coastal marine environments: spatial data inventory

Spatial data layers for the overall project (including those relevant to bathymetry and hydrosystems) are supplied as part of an ArcGIS Pro project package (spatial data inventory, TasmanNelsonCoastalEnvironment_SpatialData.ppkx).

Datasets available in spatial format (shapefiles, file geodatabase feature classes, rasters) were imported to an ArcGIS Pro (version 3.0.1) project (.apr) and presented in the Bathymetry and Hydrosystems map. In the map's contents panel (shown in Figure A.1), group layers and sub-groups can be expanded to view and turn on or off individual data layers. Key details for mapped data are outlined in Tables (1 to 6 and 10 to 13) in the report text and are appended to data layers as metadata, accessible through layer properties. These include group and individual layer names (as they appear in the spatial data inventory), data format, details, description and source reference.

Data layers collated for the other reports in this overall project are also included in the spatial data inventory and are presented in a series maps associated with each report (Berthelsen et al. 2023a, 2023b; Handley et al 2023a, 2023b). The ArcGIS Pro project was packaged to form the project package (TasmanNelsonCoastalEnvironment_SpatialData.ppkx) and its associated geodatabases, which include all the data layers.

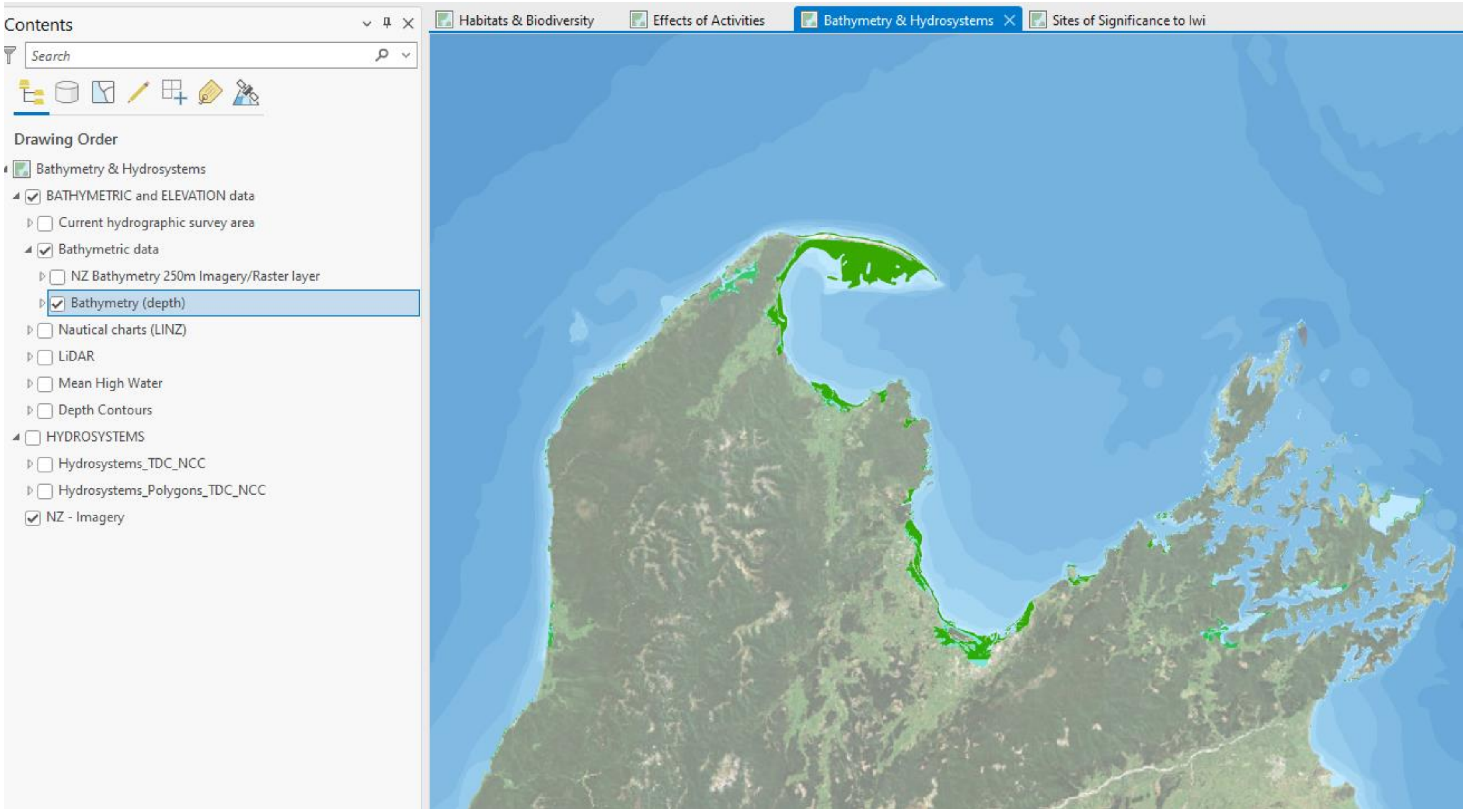

Figure A.1. Screenshot of our ArcGIS Pro project package demonstrating the layout to package users.

Appendix 2. Summary of environmental variables and vulnerabilities of Nelson and Tasman estuaries

A summary of environmental variables calculated for the current project based on mapped estuary features (Table A2.1). All metrics included are fully described in appendix E of Hume et al. (2016). This is based on more accurate field data collected by Salt Ecology and thus should be used in preference to the data included in the desktop analysis of Hume et al. (2016).

Additional information on threats (based on vulnerability assessment) to estuaries and associated information gaps is also provided given these relate to the data in Table A2.1.

Table A2.1. (Provided as an electronic appendix) A summary of environmental variables and vulnerabilities of estuaries in the Nelson and Tasman Regions.

Threats to estuary habitats and biodiversity

Vulnerability assessments of key estuary stressors in the Tasman and Nelson Regions are presented in Robertson and Stevens (2008, 2010) and Stevens and Robertson (2010, 2017b). The detail contained in these reports, which identify a wide range of potential threats to estuaries, is not repeated here. Instead, summary columns have been added to Table A2.1 to highlight the relative risk to each estuary from the key pressures of fine sediment ('muddiness') and eutrophication (nutrient enrichment), as these are the primary catchment-based stressors that can be directly managed by councils. The relative risks are grouped into categories of very high, high, moderate and minimal as a general guide to assist with assessing potential pressures to each estuary. When applying the ratings, subjective criteria have been used to group estuaries as outlined below:

Eutrophication risk was based on potential nutrient concentrations delivered to the estuary derived from the data presented in Table A2.1, and screening criteria described in Plew et al. (2020). The relative risk thresholds are:

- Very High > 320 mg/m^3
- High > 200 to ≤ 320 mg/m^3
- Moderate > 80 to ≤ 200 mg/m^3
- Minimal ≤ 80 mg/m^3.

Fine sediment (muddiness) risk was assessed relative to the predicted sediment deposition rate in the estuary (catchment sediment load [kg/yr] / estuary area [m^2]), with 50% of the delivered sediment assumed to be retained and the remaining portion flushed directly to the coast or exported following remobilisation or resuspension. It is recognised that actual retention rates will be variable between estuary types (e.g. higher for SIDEs than SSRTREs) and that further work beyond the scope of the current project is required to determine actual deposition. The relative risk thresholds are:

- Very High > 50 mm/yr
- High > 10 to ≤ 50 mm/yr
- Moderate > 2 to ≤ 10 mm/yr
- Minimal ≤ 2 mm/yr.

These categories should be viewed as relative rankings between estuaries as opposed to absolute values of impact or condition and are intended as an initial screening measure to highlight where more refined assessments may be needed.

Information gaps for threats to estuaries

No assessments of ecological vulnerability are known to have been undertaken for the estuaries in Abel Tasman National Park, and the most recent habitat mapping data are from 1991 (see Davidson 1992). Changes in habitat features are almost certain to have occurred in the interim.

The previous assessments of ecological vulnerability undertaken in 2012 for Tasman (Robertson and Stevens 2012) and 2017 for Nelson (Stevens and Robertson 2017b) were limited in scope and did not include all estuaries in the regions. Improvements to assessment criteria have subsequently been made to reduce subjectivity and improve consistency in the assessment of estuary state and identification of pressures (e.g. Roberts et al. 2022). Reviewing the assessment criteria and pressures to key estuaries is recommended. This information has also been included in Report 4 for this project (Handley et al. 2023b).

Appendix 3. Notes on inconsistencies in Hume et al. (2016)

Hume et al.'s (2016, table E-1) classification of estuary hydrosystems in the Tasman and Nelson Regions determined that the Tasman Region contained 23 tidal lagoons (7A), three shallow drowned valleys (8), three freshwater river mouths (5C), three hāpua-type lagoons (2 x 3B and 1x 3C), two tidal river mouth (1 x 6B and 1 x 6C) and one beach stream (4B) type estuaries. The Nelson Region contained three tidal lagoons (7A). However, there are some inconsistencies or uncertainties in how hydrosystems are classified using the Hume et al. (2016) approach. These exist between the tree diagram of hydrosystem types (Figure 1 in the main body of this report) and the key to geomorphic classes (table C-2 in Hume et al. 2016), as well as within the key to geomorphic classes. For example, in the key to geomorphic classes, a beach stream (4) is defined as a '*stream or river mouth* <u>*without elongated*</u> *and narrow lagoon parallel to the sea*', while in the same key, Beach Stream subclass 4E is described as a '*narrow elongate water body running parallel to the coast (typically found along West Coast SI), connected to large coastal wetland system that drains into a river mouth'*. The upper part of the decision tree appears to exclude the option that appears subsequently in the decision tree. Another example is for drowned valleys, for which the tree diagram requires the estuary to be mostly subtidal. None of the estuaries classified as drowned valleys by Hume et al. (2016) in the Nelson and Tasman Regions fit this drowned valley classification, as all are predominantly intertidal (refer to data in Appendix 2). Therefore, while the estuary systems may be drowned valleys, it is not possible to classify them as such by following the classification tree.

In addition, estuaries defined as non-tidal systems (i.e. Waituna- and hāpua-type lagoons, beach streams and freshwater river mouths) by Hume et al. (2016) have no tidal incursion, no tidal prism and no intertidal area. Yet many of the estuaries classified as non-tidal by Hume et al. (2016) exhibit all of these features (Leigh Stevens, Salt Ecology).

In many cases, the desktop data used by Hume et al. (2016) to classify estuaries in table E-1 were inaccurate (Leigh Stevens, Salt Ecology). Consequently, updated data (Appendix 2) based on field assessments were used to reclassify estuaries more accurately for the current report (refer to Section 3.1.1).

5. ACKNOWLEDGEMENTS

We thank Emma Newcombe (Cawthron) for her contribution during the early stages of this project. We also acknowledge TDC, NCC and any external parties for their review of the report.

6. REFERENCES

Berthelsen A, Floerl L, Morrisey D. 2023a. Tasman coastal marine environments: publicly available sites of significance. Nelson: Cawthron Institute. Cawthon Report 3894. Prepared for Tasman District Council.

Berthelsen A, Floerl L, Morrisey D, Handley S, Davidson R, Stevens L. 2023b. Tasman and Nelson coastal marine environments: habitats and indigenous biodiversity. Nelson: Cawthron Institute. Cawthon Report 3897. Prepared for Tasman District Council and Nelson City Council.

Davidson RJ. 1992. A report on the intertidal and shallow subtidal ecology of the Abel Tasman National Park, Nelson. Nelson: Department of Conservation, Nelson / Marlborough Conservancy. Occasional Publication. No. 4.

Forrest BM, Stevens LM, Scott-Simmonds T. 2022. Synoptic ecological survey of Ōmōkau and Ōananga Bay Coastal Margins. Nelson: Salt Ecology. Report 099. Prepared for Nelson City Council.

Handley S, Berthelsen A, Davidson R, Floerl L, Morrisey D. 2023a. Tasman coastal marine environments: historical data. Nelson: Cawthron Institute. Cawthon Report 3965. Prepared for Tasman District Council.

Handley S, Berthelsen A, Floerl L, Morrisey D, Stevens L. 2023b. Tasman coastal marine environments: effects of activities. Nelson: Cawthron Institute. Cawthon Report 3896. Prepared for Tasman District Council.

Hume T, Gerbeaux P, Hart D, Kettles H, Neale D. 2016. A classification of New Zealand's coastal hydrosystems. Hamilton: National Institute of Water & Atmospheric Research Ltd. NIWA Client Report No. HAM2016-062. Prepared for Ministry of the Environment.

Plew DR, Zeldis JR, Dudley BD, Whitehead AL, Stevens LM, Robertson BM, Robertson BP. 2020. Assessing the eutrophic susceptibility of New Zealand estuaries. Estuaries and Coasts. 43:2015–2033.

Roberts KL, Forrest BM, Stevens LM, Wade O, Southwick M, Mitterwallner P. 2022. Marlborough estuaries: ecological vulnerability assessment and monitoring plan. Nelson: Salt Ecology. Report 096. Prepared for Marlborough District Council.

Robertson BM, Stevens LM. 2008. Motupipi Estuary vulnerability assessment and monitoring recommendations, March 2008. Nelson: Wriggle Limited. Prepared for Tasman District Council.

Robertson BM, Stevens LM. 2012. Tasman Coast: Waimea Inlet to Kahurangi Point. Habitat mapping, ecological risk assessment, and monitoring recommendations. Nelson: Wriggle Limited. Prepared for Tasman District Council.

Robertson BM, Stevens L. 2016. Manawatu-Wanganui Region Estuaries: habitat mapping, vulnerability assessment and monitoring recommendations related to issues of eutrophication and sedimentation. Nelson: Wriggle Limited. Prepared for Envirolink Medium Advice Grant: 1624-HZLC127 Assessment of the susceptibility of Horizons' estuaries to nutrient enrichment and sedimentation. MBIE/NIWA Contract No:CO1X1513.

Robertson BM, Stevens LM, Robertson BP, Zeldis J, Green M, Madarasz-Smith A, Plew D, Storey R, Hume T, Oliver M. 2016. NZ Estuary Trophic Index. Screening tool 1. Determining eutrophication susceptibility using physical and nutrient load data. Nelson: Wriggle Limited. Prepared for Envirolink Tools Project: Estuarine Trophic Index. MBIE/NIWA Contract No: C01X1420.

Scott-Simmonds T, Stevens LM, Roberts KL, Forrest BM. 2022. Broad scale intertidal habitat mapping of Kokorua Inlet. Nelson: Salt Ecology. Report 095. Prepared for Nelson City Council.

Stevens LM, Forrest BM. 2019a. Broad scale intertidal habitat mapping of Delaware Inlet 2018. Nelson: Salt Ecology. Report 011. Prepared for Nelson City Council.

Stevens LM, Forrest BM. 2019b. Broad scale intertidal habitat mapping of Nelson Haven. Nelson: Salt Ecology. Report 022. Prepared for Nelson City Council.

Stevens LM, Robertson BM. 2010. Waimea Inlet 2010: vulnerability assessment and monitoring recommendations. Nelson: Wriggle Limited. Prepared for Tasman District Council.

Stevens LM, Robertson BM. 2015a. Motupipi Estuary 2015: broad scale habitat mapping. Nelson: Wriggle Limited. Prepared for Tasman District Council.

Stevens LM, Robertson BM 2015c. Ruataniwha Inlet 2015: broad scale habitat mapping. Nelson: Wriggle Limited. Prepared for Tasman District Council.

Stevens LM, Robertson BM 2017a. Whanganui Inlet: 2016 broad scale habitat mapping. Nelson: Wriggle Limited. Prepared for Tasman District Council.

Stevens LM, Robertson BP. 2017b. Nelson Region estuaries: vulnerability assessment and monitoring recommendations. Nelson: Wriggle Limited. Prepared for Nelson City Council.

Stevens L, Scott-Simmonds T, Forrest BM. 2020a. Broad scale intertidal habitat mapping of estuaries of the Motueka delta 2019. Nelson: Salt Ecology. Report 035. Prepared for Tasman District Council.

Stevens L, Scott-Simmonds T, Forrest BM. 2020b. Broad scale intertidal habitat mapping of Moutere Inlet 2019. Nelson: Salt Ecology. Report 034. Prepared for Tasman District Council.

Stevens L, Scott-Simmonds T, Forrest BM. 2020c. Broad scale intertidal habitat mapping of Waimea Inlet. Nelson: Salt Ecology. Report 052. Prepared for Tasman District Council and Nelson City Council.