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# Guidance on restoration options for macroalgae, salt marsh and sand dunes in Southland

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# Guidance on restoration options for macroalgae, salt marsh and sand dunes in Southland

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July 2021


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For the environment
Mō te taiao

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# SUMMARY

In 2019, Environment Southland commissioned a report on "Remediation Options for Southland Estuaries" to identify the high-level benefits and feasibility of eight different estuary remediation options. The report included knowledge gaps, potential ecological side-effects, and the likelihood of success with respect to restorative targets. To extend this initial work and explore restoration options able to be more readily implemented at a community level, Environment Southland engaged Salt Ecology to provide additional advice on the active on-site restoration that could be undertaken for:

1) Removal of nuisance macroalgae (seaweed)
2) Protection and restoration of salt marsh
3) Protection and restoration of dunes

Summary tables outlining each option are presented below, followed by overall recommendations.

## REMOVAL OF NUISANCE MACROALGAE (SEAWEED)

When high nutrient inputs combine with suitable growing conditions, nuisance blooms of rapidly growing seaweed species can occur. In Southland, it is imperative that catchment nutrient loads are significantly reduced if changes in estuary state are to be achieved. To mitigate adverse impacts while the source of the problem is addressed, one option is to remove or reduce established nuisance macroalgal beds in otherwise healthy parts of the estuary before they develop into persistent eutrophic areas, or remove overwintering nursery plants that seed summer growths to reduce the spread of macroalgae.

| Timeframe | Option | Benefits | Likelihood of success |
|---|---|---|---|
| Short-term | Remove macroalgae from newly established areas or areas of expansion | Removal of macroalgae reduces sediment trapping, algal smothering, stored nutrients and organic matter, decreasing the likelihood of poor sediment conditions developing.<br>Removal slows down the expansion of established beds and decreases the likelihood of further macroalgal establishment. | Until catchment sediment and nutrient loads are significantly reduced, removing macroalgae from priority areas will, at best, slow the expansion and adverse impacts of macroalgae beds but will not resolve the problem. As macroalgae will continue to re-establish, ongoing removal will be required. |
| Mid-term | Reduce overwintering biomass | Harvesting overwintering biomass may minimise seasonal regrowth and reduce fine sediment accrual that would otherwise occur. Exposing sediments previously covered in algae may promote locally beneficial fine sediment removal through natural processes such as wind driven waves or flood flows. | Until catchment sediment and nutrient loads are significantly reduced, removing overwintering biomass will help reduce summer regrowth, but seaweed fragments will remain and are likely to rapidly regrow. Continued harvesting may reduce biomass over time although due to the large scale of the problems now present, effort will need to be substantial. |
| Long-term | Explore commercial harvesting of wild macroalgae | Commercial harvesting of macroalgae may offset restoration costs associated with macroalgal removal. Regular removal over time could reduce macroalgae stocks and lead to the benefits discussed above. | Commercial removal in other countries has seen a significant reduction in macroalgal stocks, which would be the desired outcome in Southland estuaries. |

## RECOMMENDATION

- Assess the feasibility and potential impact of small-scale harvesting for mitigation of localised problems.
- Explore options for commercial harvesting for larger-scale long-term benefits.

## PROTECTION AND RESTORATION OF SALT MARSH AND DUNES

Vegetated estuarine habitats (salt marsh) are some of the most productive habitats on Earth. Along with less productive native dune systems they provide tremendous additional benefits for humans including flood and erosion control, maintenance of water quality, nutrient and sediment assimilation, and a wide variety of opportunities for recreation. Reducing the loss of existing salt marsh and dune habitat is usually the cheapest and easiest way of protecting it, although active replanting is also possible.

| Timeframe | Option | Benefits | Likelihood of success |
|---|---|---|---|
| All timeframes | Protection | It is more difficult and expensive to recreate the natural biodiversity of lost habitat than it is to retain it. | High as coastal habitats should already be protected under Environment Southland's Regional Coastal Plan (2013), however ongoing losses and degradation are evident. |
| Short-term | Education and community engagement | Improves community understanding of the importance of natural dune and salt marsh habitats and management required to maintain them. Increases buy-in for protection and restoration. | High localised success. Community buy-in underpins successful coastal protection and community behaviour and aspirations can significantly change the impact on coastal habitats. |
| | Exclusion of Stock | Preventing stock feeding and trampling on sensitive habitat can maintain habitat integrity. In dunes, exclusion can reduce the risk of erosion and blowouts. | Can be successfully managed (currently under Environment Southland's Regional Coastal Plan, 2013). However, requires more enforcement and education around the importance of these habitats to improve compliance particularly in vulnerable areas. |
| | Weed and pest control | Reducing pest browsing on native seedlings and young native plants, and managing weeds, allows native species to establish with benefits including increased native biodiversity, habitat and amenity. | Can be successful in localised areas, however weed and pest control is costly and requires on going management. |
| | Exclusion of vehicles, domestic animals and people | Reducing the physical impact of vehicles and trampling from people and animals decreases vegetation loss through the crushing of roots. Exclusion leads to greater vegetation cover, less erosion and improved habitat for fauna including birds and invertebrates. | Can be successfully managed. Is currently managed under Environment Southland's Regional Coastal Plan (2013). Beach and estuary access is restricted in some areas. Education, signage and fencing also promote exclusion from vulnerable areas. |
| Mid-term | Restore natural tidal connections and undertake infill salt marsh planting | Tidal reconnection increases the available area for salt marsh habitat and can establish natural vegetation corridors increasing biodiversity (e.g. birds, fish, insects, etc).<br>Many areas can re-establish on their own (e.g. herbfields) if physical habitat is protected or enhanced.<br>Infill planting can quickly increase resilience to erosion or rectify past damage. | Reconnection can be in direct conflict with existing land use activities, or the wishes of landowners. Appropriate consultation and a shared vision is needed to be effectively implemented<br>Infill planting is relatively straightforward but needs to account for long term changes such as sea level rise. |
| | Restoring salt marsh habitat | Improved ecological condition in localised areas and can be useful for community engagement and awareness. | Unlikely to have a significant effect on salt marsh extent in Southland estuaries unless large areas are restored or reclaimed. Will have positive benefits in localised areas. |
| | Improving degraded dunes as an alternative to hard structures | More cost effective and natural than hard structures, maintains beach amenity and biodiversity. | Success of natural dune buffers at protecting infrastructure against coastal hazards is heavily site-dependent. There needs to be adequate room for dune development, and they should only be restored where dunes would have occurred naturally. |

| Timeframe | Option | Benefits | Likelihood of success |
|---|---|---|---|
| Mid-term continued… | Removal of marram grass and re-planting foredunes in natives | Reinstates natural active dune habitat and native vegetation. Increased native biodiversity, habitat and amenity. | Demonstrated to be effective, but is costly, resource intensive and requires ongoing management to control re-incursions.<br>Unless the site has been prioritised as a high value site for restoration, management should focus on protecting high value areas of native habitat from the incursion of marram grass. |
| | Re-planting mid and back dune habitat | Increased biodiversity and habitat value and a natural buffer against coastal hazards. | Commonly in direct conflict with existing land use activities, or the wishes of landowners (many dunes in Southland are currently farmed would require retirement from intensive land use).<br>Can be effective but management should focus on protecting high value areas of existing habitat or where restoration could improve remnant mid and back dune habitat. |
| Long-term | Build resilience to climate change | Dunes and salt marsh can provide natural buffers against storm surges and sea level rise. | Dunes and salt marsh provide natural coastal hazard protection. Success in the long term will need to allow for migration in response to sea level rise and is heavily dependent on the site.<br>Coastal habitats should only be restored where they have naturally been present. |

## RECOMMENDATION

- Implement more active management to retain high value coastal habitats, including salt marsh and dunes.
- Focus on identifying vulnerable areas of existing high value habitat using desktop approaches like GIS inundation mapping, aerial photography, and existing knowledge. Prioritise protecting and enhancing existing sites ahead of attempting to create new habitat areas.
- Undertake relatively small-scale restorations where the major causes of degradation can be directly addressed e.g. vehicle damage, and where there are clear benefits from community engagement and education.
- Plan and undertake or facilitate more ambitious restoration which will result in long-term ecological gains e.g. reconnecting tidal flows to previous estuary areas likely to be inundated under predicted sea level rise scenarios.

## CONCLUSION

Restoration options, like those discussed above, are generally only considered when the existing environment has been severely degraded or has been previously lost. While options are available to improve degraded habitats (as discussed in this report) the most effective method of restoration remains protection (e.g. manage threats) and enhancement (e.g. infilling planting). This is because it is generally more difficult and expensive to recreate the natural biodiversity of lost habitat than it is to retain it.

# 1. INTRODUCTION

Estuaries and coasts are some of the most productive ecosystems on earth, however human impacts including over-exploitation, habitat transformation, and pollution have led to significant degradation that has undermined the ecological resilience of these systems (Lotze et al. 2006).

In New Zealand, and in Southland, estuaries in developed catchments are commonly degraded, suffering from excessive sedimentation, nutrient enrichment, poor water quality, loss of habitat and other symptoms of eutrophication (e.g. nuisance levels of seaweed and algal growth). These impacts are exacerbated by reclamation and foreshore hardening to protect infrastructure, which reduces the capacity of ecosystems to retreat and adapt to a changing climate (PCE, 2020).

Similar pressures are experienced in other coastal habitats. For example, New Zealand's active dunes have declined ~70% since the introduction of marram grass (*Ammophila arenaria*), with a >30% decline observed in Southland since 1950 (Hilton 2006). Other threats include loss of native species through introductions of pest plant and animal species, development (often for farming), and physical damage from vehicle use.

Marram covered dunes Ōreti Beach

The Parliamentary Commissioner for the Environment (PCE) has acknowledged the cumulative pressures on estuaries and the coast across New Zealand, highlighting that simply reducing or removing pressures might be insufficient to reverse degradation, with active restoration likely to be required to improve estuary health (PCE, 2020). This is also applicable to other habitats, including the coast (Atkinson 1994), and requires consideration of various time frames (Fig. 1).

The need for effective policy, management and restoration in Southland estuaries is evident with multiple studies highlighting their modification and poor condition (e.g. de Winton 2020; Forrest & Stevens 2019; Stevens & Forrest 2020a-d; Stevens et al. 2020).

New River Estuary, widespread nuisance seaweed cover over muddy sediments indicating high eutrophication

Environment Southland manages estuaries and the coastal environment through their existing regional plans in addition to non-regulatory tools (e.g. community programmes and advice). More recently the council established the People, Water and Land Programme to implement the statutory requirements of the National Policy Statement for Freshwater Management (NPSFM). The NPSFM requires councils to set state objectives for freshwater

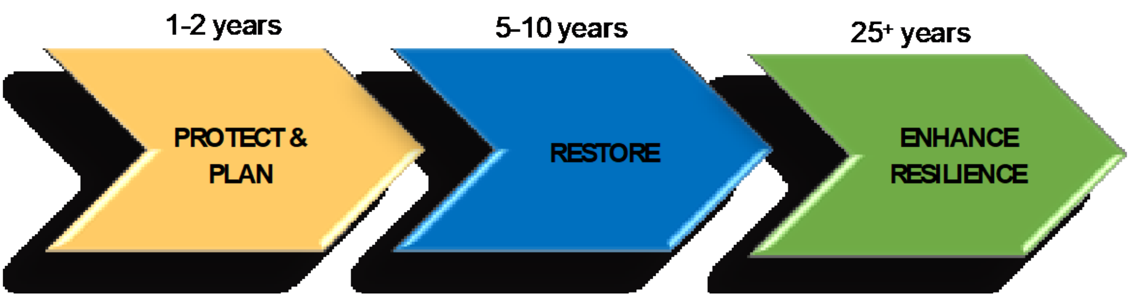



Fig. 1. Time frame for restoration options.

waterbodies where at a minimum current state must be maintained or improved. This process also requires councils to set limits to resource use to meet state objectives. Based on the ki uta ki tai (mountains to sea) approach Environment Southland included estuaries in this process and therefore both state objectives and limits will be set for estuaries with the intent to maintain or improve current state.

In addition to these regulatory focused approaches, remediation options have been recognised by Environment Southland as an important component of environmental management. A high-level document was recently commissioned to explore a range of remediation options for Southland estuaries (Zeldis et al. 2019). The options considered were:

- Removal of macroalgal (seaweed) biomass
- Restoration of sediments
- Restoration of seagrass cover
- Cockle bed restoration
- Restoration of estuary riparian margins
- Engineered estuary mouth openings to improve estuary resilience
- Partial diversion of Ōreti River
- Diversion of effluent from the Invercargill wastewater treatment plant

The report identified the high-level benefits and feasibility of applying each option, knowledge gaps, potential ecological side-effects, and the likelihood of success with respect to restorative targets.

To further explore restoration options, Environment Southland engaged Salt Ecology to provide additional advice on the active on-site restoration that could be undertaken for:

1. Removal of nuisance macroalgae (seaweed)
2. Protection and restoration of salt marsh
3. Protection and restoration of dunes

This report provides guidance on how to approach a restoration project for each habitat type using example case studies from New River Estuary and Ōreti Beach.

For each habitat type, guidance for three timeframes is considered:

**Short-term**: what can be done now? (i.e. within 5 years)

**Mid-term:** what can be done in the next 5-10 years?

**Long Term:** what can be done in the next 25+ years?

As the focus of the report is on active on-site restoration, it is outside the report scope to address the management of cumulative pressures such as catchment nutrient and sediment loads. However, the success of any restoration actions largely depends on the effective management of such primary drivers of ecological degradation.

Before addressing the specific on-site restoration options, the following section provides general background on setting up a restoration programme.

# 2. SETTING UP A RESTORATION PROGRAMME

## 2.1 THINGS TO CONSIDER

Historically the term ‘restoration’ referred to the return of an ecosystem to its pre-disturbed condition. However, today ‘restoration’ more commonly encompasses “any form of human intervention with the intent of improving upon the existing condition of an ecosystem or habitat” (Thom & Borde 2016).

While government agencies such as Environment Southland and the Department of Conservation tend to manage large-scale restoration projects directly, they also contribute to many highly successful community-based projects by providing funding, information, technical support, and “boots on the ground”.

To help guide restoration efforts, Rush (2003) and Rush & Ritchie (2003) developed a Toolkit and guide for community-based projects for the Department of Conservation. The guidance highlights essential components that are needed to achieve success in conservation-based projects as follows:

- Planning: well-planned project based on inclusive planning and decision making.
- Partnership: uphold Treaty of Waitangi principles and place high value on co-operation, trust and respect between project members.
- Learning: opportunity for learning and participation to achieve lasting results.

The key project components to be considered before beginning a restoration project are described briefly below. Additional detail is available from Rush (2003) and Rush and Ritchie (2003), and in the links provided in the information panel at the bottom of page 3.

### 2.1.1 What is the goal of restoration?

Having a clear restoration goal is essential to a successful restoration programme because it will help define the restoration plan, milestones for ongoing monitoring and guide adaptive management plans. A goal should describe the intended end point, objectives and actions, and describe what needs to be achieved to progress towards to the goal.

For example, the goal might be to increase the number of native birds in dune habitat. To achieve the goal the objective is to reduce predator numbers over the next 10 years and the action is to set and maintain bait stations and traps within 1 year. Multiple objectives and actions may be required to achieve the desired restoration goal throughout the project.

An important consideration when setting the restoration goal, objectives and actions is to understand current threats to the target habitat and why restoration is required because threats may need to be managed as part of or prior to the project starting (see Table 1 for a list of common threats and actions to consider when designing a restoration project for macroalgae, salt marsh and dune habitat).

### 2.1.2 Partnerships

Partnerships are an important component of an effective restoration project to ensure everyone involved is invested in achieving the common project goal. Partnerships will include shared decision-making, responsibility, trust and cooperation (Rush 2003). It is important to identify potential partners early in the process to ensure the project is inclusive in the planning and decision-making phase. Specific details on how to facilitate partnerships are outlined in Rush & Ritchie (2003).

A preliminary list of potential partners include:

- Environment Southland
- The appropriate Rūnanga (https://ngaitahu.iwi.nz/te-runanga-o-ngai-tahu/papatipu-runanga/)
- Department of Conservation
- The relevant district or city council
- Fish & Game
- Conservation groups. (https://www.doc.govt.nz/get-involved/volunteer/groups/southland/)
- Southland catchment groups (https://www.thrivingsouthland.co.nz/catchment-groups/)
- Southern Institute of Technology
- Southland community nursery
- Community

COMMUNITY PROJECT RESOURCES:

- Department of Conservation: Community Project Guidelines
  https://www.doc.govt.nz/get-involved/run-a-project/community-project-guidelines/
- New Zealand Landcare Trust: Community urban restoration and education guide
  https://www.landcare.org.nz/file/community-urban-restoration-ed-guide/open
- Community Net Aotearoa: Community Resource Kit
  https://community.net.nz/resources/community-resource-kit/

FUNDING OPTIONS:

- Department of Conservation: funding
  https://www.doc.govt.nz/get-involved/funding/

MONITORING TECHNIQUES:

- Environment Southland: Community environmental monitoring
  https://www.es.govt.nz/environment/community-monitoring
- Coastal Restoration Trust's Coastal Monitoring Database (Dunes)
  https://monitoring.coastalrestorationtrust.org.nz/

### 2.1.3 Permissions and stakeholders

It is important to consider any legal requirements, consents or permits that might be required to carry out a restoration project. This could include council or government agencies, hapū and landowners in addition to consultation with the local community. The following list provides an example of potential contacts for permissions, the list is not exhaustive:

- Environment Southland
- The appropriate Rūnanga
- Department of Conservation
- The relevant district or city council
- Fish & Game
- Landowners
- The relevant heritage authorities

### 2.1.4 Budget and fundraising

When partnerships have been established and the restoration project planned, the goal, objectives and actions will make funding requirements clearer. There are several funding options available including, but not limited to;

- Contestable funds/ grants
- Sponsorship
- Donations
- Crowd funding
- Membership fees
- Traditional fundraising methods

Prioritisation of action plans or scaling back the project may be required if adequate funding is not available. It is also important to consider sustained funding to maintain the project over time. Information on funding options is provided in the panel on pg. 3.

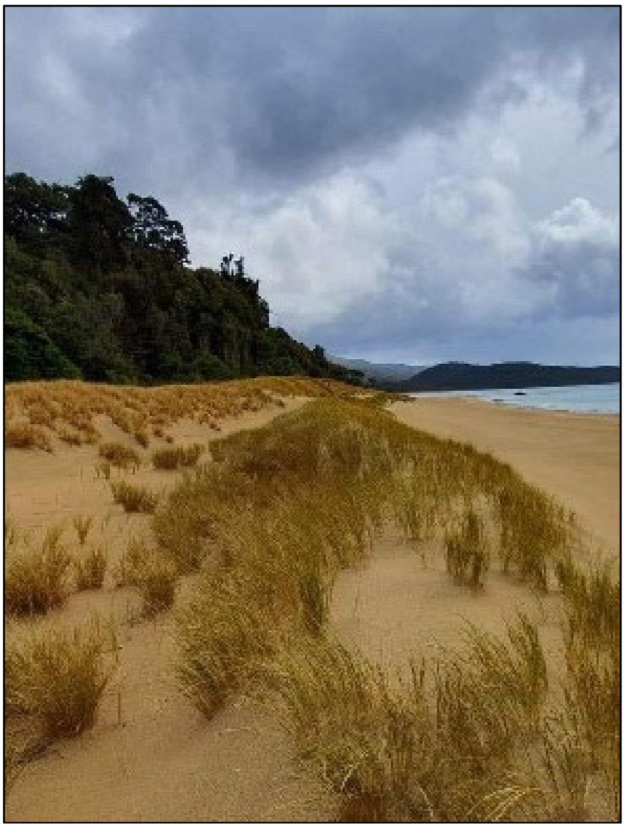
### 2.1.5 Monitoring and evaluation

Examples of monitoring tools used to monitor project progress for the three habitat types (macroalgae, salt marsh and dunes) are provided in Table 1. In general, monitoring and evaluation is essential to identify issues, measure success, guide adaptive management and communicate project progress with partners and the community. Monitoring and evaluation will be specific to the project goal, however there are some useful examples and resources for community monitoring projects on the Environment Southland website (see information panel).

### 2.1.6 Celebrate successes!

Restoration projects can last years to decades and therefore it is important to maintain project momentum. Celebrating and sharing successes with partners and the community is important to recognise peoples efforts and maintain motivation to continue the project (Rush 2003).

Eroding salt marsh and nuisance macroalgal beds, New River Estuary



Foredunes on Stewart Island

Table 1. Threats to coastal habitats and associated management, monitoring and evaluation.

| Threat | Description | Manage before planting? | Control method | Monitoring & evaluation |
|---|---|---|---|---|
| Rabbits, Hares, Possums | Native seedlings and young plants are preferentially browsed limiting the plants' ability to respond to a changing environment. Larger plants are less prone to browsing with only new growth targeted. | Yes | Control operations should aim for a minimum kill of 90%. Effective control initially will make ongoing maintenance more straight forward. Long-term sustained treatment is required to prevent the destruction of plant material (Unsworth 2005). Contact Environment Southland Biosecurity for pest management advice. | Monitor rabbit and hare populations. |
| Stock | Stock trampling damages the structural integrity of dune and salt marsh habitat with dunes prone to erosion and blowouts. Stock can also feed on vegetation limiting growth. | Yes | Keep stock in fenced areas so they cannot access dune or salt marsh habitat. Regularly check and maintain fences to prevent accidental access. Notify landowner and council if regular breaches are observed. | Compliance required. Check and maintain fences regularly. |
| Vehicles, Domestic Animals and People | Physical impact of vehicles and trampling from people leads to loss of vegetation through the crushing of underground roots leading to lower vegetation cover and erosion.<br>Loss of fauna including, birds and invertebrates through the above, and predation and disturbance.<br>In addition, there is the potential for introduction of exotic animal and plant species. | Yes | Public access to beaches is a matter of national importance and needs to be maintained, however environmental effects should be minimised.<br>Vehicle access is managed in Environment Southlands' Regional Coastal Plan. Restricted or designated areas of access for vehicles, people and domestic animal can minimise damage to dune and salt marsh areas.<br>Access can be limited in localised areas of regenerating habitat, bird nesting or of other value using temporary fencing and/or signage. Council approval is required to construct any structure in the coastal marine area.<br>Educate the community on the importance of coastal habitats including signage in high value areas to prevent vehicle, people and domestic animal access through community stewardship. | Compliance required to ensure Coastal Plan rules are observed.<br>Check and maintain temporary fencing and signage regularly.<br>Assess vehicle numbers and carry out community surveys.<br>Monitor coastal habitat and signs of impacts from vehicle, domestic animals, and people. |
| Exotic species | Exotic species can displace native vegetation and habitat for native species. | Dependent on goal of restoration. | Manage margins of exotic vegetation expansion and areas of low-density cover through hand removal or spraying.<br>Re-purpose areas previously cleared through native plantings and weed control. | Dependent on goal of restoration. |
| Land Development | Coastal land development has historically led to significant loss of dune and salt marsh habitat, exposing infrastructure to coastal hazards and limiting the area for natural dune and salt marsh migration. | NA | Managed through the Resource Management Act which is enacted through Environment Southlands Regional Coastal Plan and various district and city council plans in the region. | Compliance required to ensure RMA obligations are observed. |

Table 1 cont... Threats to coastal habitats and associated management, monitoring and evaluation.

| Threat | Description | Manage before planting? | Control method | Monitoring & evaluation |
|---|---|---|---|---|
| Shoreline hardening | Hard structures are built to protect infrastructure from coastal hazards, however it can lead to beach erosion and loss of salt marsh habitat. | Where appropriate remove hard structures and reshape shoreline before planting. | Requires council approval and consent. Site specific plan required (e.g. earthworks, planting, maintenance etc). | Beach or salt marsh shoreline profiles (erosion, accretion and tide heights)<br>Establishment of native species. |
| Climate Change | Climate change induced sea level rise is expected to be between 0.65 to 1.85m by 2150 (MfE, 2017). Coastal environments will be affected by increased storm surges, winds and the frequency and intensity of storms, promoting coastal flooding and erosion (MfE, 2017). While dunes and salt marsh provide some buffer against coastal hazards, erosion threatens these habitats. Furthermore, the migration of dunes and salt marsh landward in Southland is often limited by adjacent land use. | Need to consider site selection carefully to ensure it is resilient against the impacts of climate change. | Climate change and coastal hazard management predominantly focuses on protecting land use, infrastructure and human life, secondarily to the natural environment. Dunes and salt marsh can provide natural buffers against storm surge and sea level rise. Restoring dunes and salt marsh and allowing for landward migration with increasing sea level rise may be required. Larger scale management of coastal hazards is managed through the Resource Management Act and New Zealand Coastal Policy Statement (2010) which is enacted through Environment Southlands Regional Coastal Plan (under review) and various district and city council plans in the region. | NA |
| Nuisance macroalgal blooms<br>(macroalgae) | When nutrients inputs exceed the assimilative capacity of an estuary, macroalgae can grow to nuisance levels. At nuisance levels these species can smother and deprive ecologically valuable seagrass (*Zostera muelleri)* of light, causing its eventual decline. Decaying macroalgae can also accumulate on shorelines causing localised depletion of sediment oxygen, and nuisance odours. When high macroalgal cover is associated with soft, muddy sediments, conditions for animal life in the sediments are generally very poor. | NA | Reduce catchment sediment and nutrients loads to limit macroalgal growth.<br>Remove excessive macroalgae to minimise the expansion of beds and and associated degradation of sediments and/or target overwintering biomass to reduce growth in the following season. | Marine metre squared is an easy way to survey plants and animals in an area using a 1m$^2$ quadrat (https://www.mm2.net.nz/).<br>Broad scale methods described in the National Estuary Monitoring Protocol.<br>Environment Southland SoE monitoring. |

Table 1 cont... Threats to coastal habitats and associated management, monitoring and evaluation.

| Threat | Description | Manage before planting? | Control method | Monitoring & evaluation |
|---|---|---|---|---|
| Marram grass (*Ammophila arenaria*) (Section 7: Dunes) | Marram stablises dune systems and minimises natural sand movement and migration which can lead to significant erosion losses over time. Marram grass is persistent, disperses readily and quickly outcompetes native species. It is difficult to remove because it can re-establish from root fragments or seed banks stored in the sand. Hilton et al. (2006) concluded from studies within the Southland region that pīngao and marram grass cannot co-exist, with marram outcompeting pīngao when present. | Unless the site has been prioritised as a high value site for restoration, management should focus on protecting high value areas of native habitat from the incursion of marram grass rather than removal and planting. Marram eradication is costly, resource intensive and requires ongoing management. | Manage margins of marram expansion and areas of low density cover through spraying. Persistent and ongoing management is required, particularly in the initial years after spraying. Widespread established marram will likely require mechanical removal (e.g. with a digger) or repeated and intensive treatment with a grass-specific herbicide. The Department of Conservation use the herbicides Gallant or Hurricane (helicopter and knapsack spraying). Management of marram is site-based and targeted toward high values areas with established pīngao (Hilton & Konlechner 2010). Spraying occurs >2 months prior to planting. | Dependent on goal of restoration.<br>- Number of marram plants per $m^2$ monitoring decrease in plants over time.<br>- Re-establishment of native species.<br>- Dune geomorphology (shape and movement) |
| Lupin (*Lupinus aboreus*) (Section 7: Dunes) | Lupin was planted alongside marram in sand dune stabilisation efforts, providing a nitrogen source for marram grass. It was successful because it was able to survive harsh dune environments, outcompetes pīngao through shading and was not palatable to browsing animals. There was extensive dieback of Lupin in 1980's due to a fungus, however it remains widespread. | Management should focus on protecting high value areas of native habitat from the incursion of lupin rather than removal and planting. Lupin eradication is costly, resource intensive and requires ongoing management. | Manage margins of lupin expansion and areas of low-density cover through hand removal or spraying. In established areas repeated and intensive treatment with plant specific herbicide (e.g. Versatil™) that has little effect on native vegetation (Konlechner et al., 2016). Depending on the area, initial helicopter spraying followed by land-based spraying to remove remaining plants and any re-growth can be initially effective. Long term management needed because lupin seed bank allows for rapid re-establishment. Very costly, resource intensive and requires ongoing management. | Dependent on goal of restoration.<br>- Number of lupin plants per $m^2$ monitoring decrease in number of plants over time.<br>- Re-establishment of native species.<br>- Dune geomorphology (shape and movement) |

# 3. NUISANCE MACROALGAE (SEAWEED)

## 3.1 OVERVIEW

Environment Southland has requested guidance on the removal of excessive nuisance macroalgal growth as an option to halt the ongoing decline of estuary habitat, or to ideally improve estuary health. It is important to acknowledge that this extreme action is being considered because of the unprecedented expansion of nuisance macroalgae in several Southland estuaries over the past 10-15 years.

The benefits of physical removal of macroalgae are to reduce smothering of benthic habitat, improve sediment health, remove noxious odour, reduce seed sources for further growths, remove nutrients and improve estuary amenity. Zeldis et al. (2019) concluded that the routine removal of all nuisance macroalgae from heavily eutrophic estuaries (i.e. New River Estuary and Jacobs River Estuary) was likely unfeasible because of the enormous spatial extents and tonnages of growths, combined with the high likelihood of regrowth under current catchment nutrient loads. However, they considered it feasible to target selected areas, removing overwintering young plants that provide the nursery for the following summer growths, or established beds in otherwise healthy parts of the estuary, before they develop into persistent eutrophic areas.

While such macroalgae harvesting may temporarily slow down the expansion of nuisance blooms and minimise the ecological damage that would otherwise occur, harvesting in itself is very unlikely to remove enough nitrogen to resolve eutrophic symptoms in estuaries (Braun 2020; Kim et al. 2014; Zeldis et al. 2019). This highlights that reducing contaminant loads remains essential for improving overall estuary health long term.

## 3.2 BACKGROUND ON NUISANCE MACROALGAE

Macroalgae is an important and natural feature of estuaries and contributes to their high productivity and biodiversity. However, when high nutrient inputs combine with suitable growing conditions, nuisance blooms of rapidly growing species can occur (Sutula 2011), disrupting the natural ecological balance. Nuisance blooms generally arise where 'opportunistic' species respond to surplus nutrients and reach levels that are detrimental to estuary functioning. The most common estuary species in Southland are the native red seaweed *Agarophyton chilense* (previously named *Gracilaria chilensis*) and the bright green seaweed *Ulva* spp. (commonly known as 'sea lettuce'). *Agarophyton* is the most problematic seaweed in Southland, commonly establishing in the protected upper estuary mudflats where deposition of nutrient rich sediments is greatest.

When high macroalgal cover is associated with soft, muddy sediments, conditions for animal life in the sediments are generally poor due to elevated organic matter, depleted oxygen, and an accumulation of toxic sulphides. Decaying macroalgae can also accumulate on shorelines causing localised depletion of sediment oxygen, and nuisance odours. Macroalgae can also smother and deprive ecologically valuable seagrass (*Zostera muelleri*) of light, causing its eventual decline, although this often occurs after beds have been compromised by the excessive deposition of fine sediment.

There is a strong correlation between nutrient loads and the proliferation of macroalgae in estuaries (WFD-UK 2014, Sutula et al. 2014, Robertson et al. 2017, Plew et al. 2020). Under eutrophic conditions nuisance blooms of macroalgae expand in spatial extent, have high biomass, and become entrained in (grow directly within) sediment, leading to persistent and difficult to reverse ecological problems.

Environment Southland has been carrying out State of Environment (SoE) monitoring in estuaries since 2001. Over this relatively short timeframe, estuary health across Southland has drastically deteriorated with symptoms of eutrophication (e.g. nuisance macroalgae, muddy sediments, poor oxygenation in sediments) now widespread, particularly in New River Estuary, Jacobs River Estuary and Fortrose Estuary (Stevens & Forest 2020c-d; Stevens et al. 2020).

## 3.3 STAGES OF MACROALGAE ESTABLISHMENT

There are several stages to the development of persistent nuisance blooms of macroalgae. In healthy ecosystems, *Agarophyton* is commonly only evident growing attached to hard substrate or attached to shellfish living in the sediment (see following photo, Fig. 2 - top photo, Luxton 1981). In intertidal areas the seaweed is suspended on the incoming tide and is exposed to water column nutrients for the period that it is inundated. At low tide it is generally not exposed to nutrient sources and growth is seldom seen at nuisance levels in healthy intertidal areas.

With increased cover and biomass, seaweed can promote the settling of sediment particles, which in developed catchments are also often associated with elevated nutrients. Where seaweed is able to grow directly in the sediment, it is able to draw on this secondary source of nutrients when it is not inundated by tidal waters, increasing the period when it can grow.

Red seaweed (*Agrophyton*) attached to a cockle

As *Agarophyton* can grow readily from fragments or thalli (similar to roots) that break off plants, increasing seaweed densities lead to a greater potential for beds expanding where they are transported around the estuary via wind and currents (Stevens & Robertson 2011; Luxton 1981; Guillemin et al. 2008). Guillemin et al. (2008) found growth from fragments (asexual reproduction) in *Agarophyton chilense* was more common than sexual reproduction in farmed populations because the unstable soft estuarine mud of the farms decreased normal spore settlement and germination. Soft estuarine mud environments with *Agarophyton* growths are common in most Southland estuaries.

Further establishment of *Agarophyton* leads to entrained patches were the macroalgae thalli are anchored in the sediment, leading to relatively stable algal beds (Luxton 1981). Trapping of fine nutrient-rich sediments in these areas can result in the formation of mounds covered in thick *Agarophyton* and *Ulva* spp. (Fig. 2 - middle photo). The process becomes self-reinforcing, with more algae trapping more sediments leading to more algae. These dense beds can also trap seawater, bathing the algae in nutrient-rich waters for much of the tidal cycle, fueling growth. Further, when growths lead to sediment anoxia, the anoxic conditions release sediment-bound nutrients further fueling growths.

In Southland estuaries, high cover and biomass has led to conditions so degraded that the macroalgae can no longer survive leading to die back and poor sediment quality (see Fig. 2 – lower photo).

Macroalgae attached to a hard substrate in the sediment

Raised mounds of macroalgae in Jacobs River Estuary

100% cover, high biomass macroalgae decaying with sulfur bacteria (white) at the surface, New River Estuary

Fig. 2 Examples of different stages of macroalgal cover.

Active removal of macroalgae in the early stages of establishment (before entrainment leading to significant sediment degradation) could minimise further expansion of these degraded areas.

## 3.4 EFFECTS OF MACROALGAE REMOVAL

All harvesting techniques (e.g. hand-removal, mechanical harvester, drag nets, vacuum devices etc.) require environmental consideration before they can be applied (Nelson et al. 2015). The disturbance of sediments, particularly soft sediments, can lead to the release of nutrient-rich porewater and the suspension of fine particles that reduce light availability and can further contribute to water quality problems.

Van Alstyne et al. (2011) demonstrated that the disturbance of sediments for clam harvesting released nutrient-rich sediment porewater which enhanced macroalgal growth. Schiel & Nelson (1990) also noted the potential deleterious effects on benthic infauna and shellfish with sediment disturbance during mechanical harvesting of *Agarophyton*. In addition to effects on water and sediment quality, disturbance of macroalgae can lead to the dispersal of spores or fragments that can re-establish in other parts of the estuary (Moore et al. 2006).

In trials from New Zealand estuaries Luxton (1981) recorded the effectiveness of hand removal and trawling of *Agarophyton*, noting that hand raking during low tide was not practical and led to excessive substrate disturbance and erosion. Boat removal was the preferred collection method. However, in that study *Agarophyton* regenerated from residual fragments similar to pre-harvest levels after ~3 months. Further understanding of macroalgae re-establishment after removal, removal techniques and potential dispersal to other areas is clearly needed to understand the full effects of harvesting.

Natural removal of macroalgae (likely due to a combination of wind driven waves and flood scouring) has been recorded in recent years from Jacobs River, New River and Toetoes (Fortrose) estuaries (Stevens 2018, Stevens & Forrest 2020c, Stevens & Forrest 2020d). Removal of both the smothering surface macroalgae, as well as entrained algae growing in the sediments, resulted in underlying soft mud, and muds trapped within the algae, being flushed from these parts of the estuary. The sediments in exposed areas were scoured back down to firm muddy sand, the dominant substrate prior to macroalgal establishment.

No significant adverse environmental effects were observed from this natural large-scale removal (most algae appeared to have been washed out to sea), but there was an anecdotal improvement in estuary sediment quality with reduced muddiness, improved sediment oxygenation and decreased organic content. These events, recorded as part of regular SoE monitoring, highlight that sediment accumulation and degradation are strongly coupled to macroalgae and there may be dual benefits to macroalgae removal (e.g. removal of both macroalgae and fine sediment, including sediment-bound nutrients).

Removal of dense macroalgae and potentially sediment can decrease the bed height of the intertidal flats, changing the hydrodynamic regime of the estuary. At present, the extensive macroalgae growths restrict tidal drainage and provide ideal growing conditions for macroalgae in shallow nutrient-saturated porewater over much of the tidal cycle (Zeldis et al. 2019). However, while the removal of macroalgae and sediment through natural processes can result in local improvements, if the macroalgae is simply deposited elsewhere in the estuary, problems may arise in new areas.

Environmental effects should be assessed on a site-by-site basis before removal of macroalgae occurs, particularly large-scale removal. Where mechanical removal is being considered, an assessment of environmental effects should be undertaken which should include the implications of doing nothing.

**Dense beds of macroalgae in New River Estuary. Removal would influence the hydrological regime of the estuary**

## 3.5 DO I NEED PERMISSION TO REMOVE MACROALGAE?

Small scale harvest – non-commercial

Fisheries does not restrict the removal of seaweed from estuaries for non-commercial purposes. However, the 'removal of live vegetation from the coastal marine area' under rule 10.5.3 is a discretionary activity in Environment Southland's Coastal Plan (2013). As such resource consent is likely required to remove seaweed from Southland estuaries. Small scale harvest, particularly by hand is unlikely to have any adverse environmental effects.

Large scale removal – non-commercial

As stated above permissions will be required to remove seaweed from Southland estuaries. Large scale removal of seaweed including mechanical harvesting could lead to potential adverse environmental effects on estuary health. An assessment of environmental effects, in addition to permission from Environment Southland, will be needed before project commencement.

Commercial harvesting

Any commercial harvesting of aquatic life including seaweed must be carried out under a commercial fishing permit (section (s)89, The Fisheries Act 1996; White & White 2020). At present there is moratorium (Schedule 4C of The Fisheries Act 1996) on new permits for the commercial harvest of seaweeds including *Gracilaria chilensis* (now known as *Agarophyton chilense*) and *Ulva* spp. (White & White 2020).

## 3.6 PRIORITISATION OF SITES FOR MACROALGAE REMOVAL

As discussed previously, Environment Southland carry out monitoring in the main estuaries within developed catchments across the region. The monitoring includes mapping macroalgae cover and biomass in estuaries either annually or on a ~5-year cycle depending on the extent of the problem (see monitoring reports at www.es.govt.nz). This information should be reviewed to assess areas of potential gain. Obvious candidate estuaries include New River Estuary, Jacobs River Estuary and Toetoes (Fortrose) Estuary where macroalgal problems are already well established and documented. However, macroalgal removal may also be useful in estuaries where problems are not yet widespread, targeting localised areas of nuisance growth before establishment.

Existing information can be utilised to select sites that would address macroalgal expansion (see Section 4). For example, macroalgal cover, biomass and substrate condition are spatially mapped and therefore areas of increasing cover and deteriorating sediment quality can be easily identified through a desktop assessment.

We recommend Environment Southland review existing information collected in SoE monitoring and prioritise sites for potential macroalgal removal, particularly in areas of expansion or new areas of nuisance macroalgae growth in healthy estuaries.

## 3.7 WHAT CAN BE DONE?

Section 2 describes how to initiate, plan and start a community-based project. This section describes some potential options that could be considered to manage macroalgae depending on the project timeframe (short-term, mid-term, long-term).

It does not preclude the need for reductions in current contaminant loads, particularly nutrient inputs. This is because without removing the root cause of the problem, no significant change in overall estuary health will be observed.

### 3.7.1 Short-term options

Target new areas of establishment or areas of expansion

A selective approach to the removal of macroalgae from key areas could minimise further expansion of problem areas and, in estuaries where nuisance macroalgae is not yet established, prevent a persistent problem from developing.

In general, macroalgae in areas of expansion (i.e. on the margins of dense beds) will be attached to a hard substrate (e.g. cockle or rock) or be in the very early stages of entrainment (i.e. loosely attached to the sediment) and therefore removal by hand at low tide is relatively easy. Macroalgae in these expansion areas has also generally not led to significant trapping of fine sediment or degradation of the underlying sediments through organic enrichment or sediment anoxia, therefore early removal of excessive algae protects the resident biota from damage. Because macroalgae can grow from fragments it is important when collecting macroalgae that the majority of the plant is removed to minimise the potential for re-growth in future (see Section 3.3).

While there are a number of commercial uses for macroalgae (e.g. agar) it can also be utilised as a fertiliser adding nutrients directly to the garden or be included in compost. However, because macroalgae can absorb pollutants, particularly around stormwater and sewage outflows, it should only be used as a fertiliser for consumable plants (e.g. vegetable garden) where it is collected from unpolluted waters.

Macroalgae attached to hard substrate in firm sands with reasonably high cover

Bushy Point, New River Estuary, dense cover in the background with developing cover in the foreground

Small mounds of *Gracilaria* forming in seagrass beds, New River Estuary

Localised area of seaweed around a freshwater water input, Waikawa Estuary

New River Estuary, increasing cover on the margin of dense cover in the background

### 3.7.2 Mid-term options

Target areas of overwintering biomass

While targeting key areas of expansion will minimise the further spread of macroalgal beds it does not manage the extensive areas of high biomass cover currently present in the estuary.

In a study of Avon-Heathcote Estuary, Hawes and O'Brien (2000) concluded that the overwintering *Ulva* biomass was an important determinant of macroalgal biomass in the subsequent growing season. Reproductive growth of *Agarophyton* occurs in summer (Guilleman et al. 2008) and therefore removing winter biomass will likely suppress the reproductive source and subsequent growth in the following season as observed in Hawes and O'Brien (2000).

In Southland estuaries, high biomass macroalgae is generally associated with poor sediment conditions (e.g. soft anoxic muds) so harvesting on foot at low tide, while possible, is unlikely to be feasible for large scale removal. Such harvesting will also disturb sediments which can lead to reduced water clarity and sediment dispersal (Luxton 1981). Established areas in Southland estuaries also have very high biomass areas that can be up to 40kg/m$^2$ making removal of large volumes by foot difficult (Stevens & Forrest 2020c; see photos on following page).

Zeldis et al. (2019) concluded the physical removal of macroalgae from Southland estuaries could control its biomass minimising negative effects. However, that study considered that large scale removal (e.g. estimated 12,900 tonne for New River Estuary and 4,900 tonne for Jacobs River Estuary) was considered likely to achieve only a marginal improvement in trophic state. This is primarily because the degradation in Southland estuaries is severe and represents some of the worst examples in New Zealand. As such, while local benefits will accrue, it will require significant effort to improve overall trophic state combining contaminant load reductions with active restoration methods, like large scale macroalgal biomass removal.

Harvest by boat (e.g. hand raking or cutting) at high tide or mechanical weed harvest from a boat are the most feasible options for large scale removal. Luxton (1981) trialled experimental harvesting of *Agarophyton* from soft sediments in the Manukau Harbour, New Zealand and found mechanical raking and netting of free-floating seaweed was the most effective method of collection and caused less sediment disturbance than mechanical harvesting.

**Harvesting seaweed using a rake in Canada (left image source Monagail et al. 2017) and harvesting seaweed by hand in Brazil (right; image source Rebours et al. 2014)**

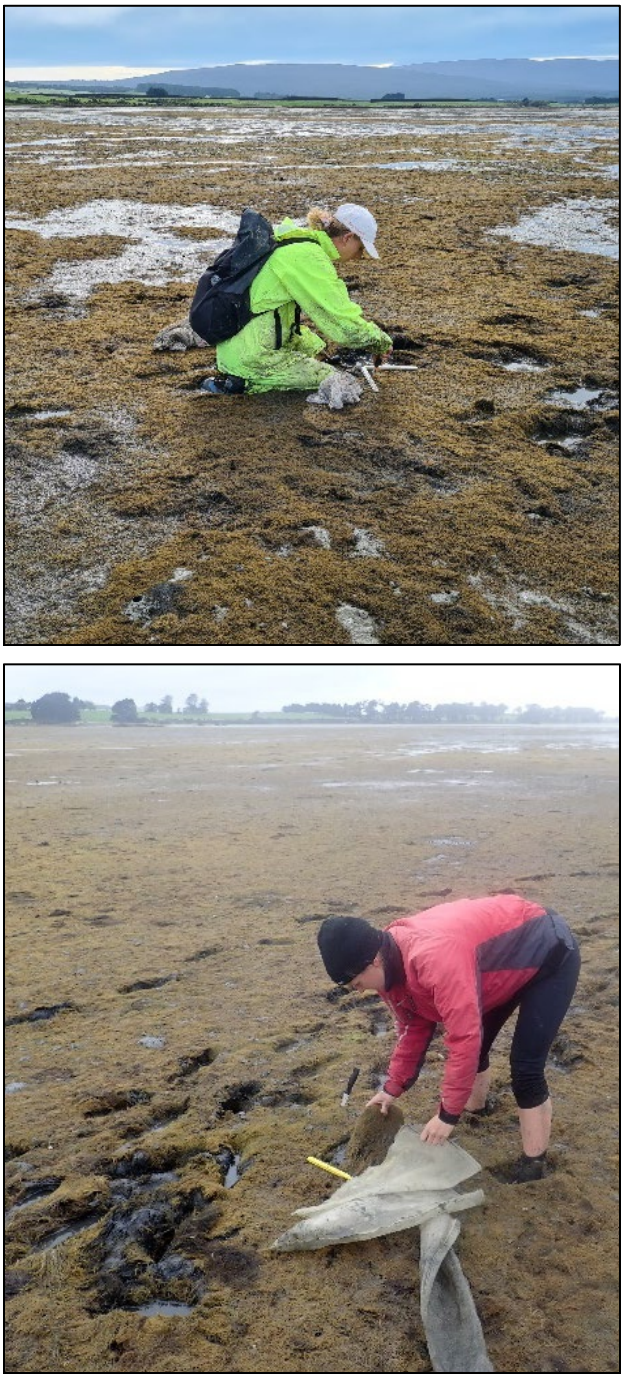
It should be acknowledged that while these harvesting methods will reduce overall biomass, seaweed fragments (i.e. thalli) will remain and grow back. Luxton (1981) saw a rapid return of biomass ~3 months after harvesting. However, as the initial harvest occurred just prior to the reproductive season, earlier harvesting of the overwintering biomass could minimise the rapid regrowth of algae. This may also have other benefits such as reducing the amount of fine sediment accrual that would otherwise be trapped in macroalgal fronds, and could expose sediments underlying previous algal cover allowing it to be flushed from the site through natural processes such as wind driven waves or flood flows, e.g. Jacobs River Estuary (Stevens 2018).

Continuous removal pressure has been shown to be effective at reducing biomass. Commercial over-harvesting of wild stocks resulted in the collapse of *Agarophyton* in Chile (Santelices & Ugarte 1987; Guilleman et al. 2014), which indicates removal is an effective method of suppressing *Agarophyton* growth.

Large-scale removal could also have unintended consequences on estuary health (e.g. release of nutrients, dispersal of sediment, poor water clarity, removal of biota and shifts in community structure) and seaweed that is removed will require a method of disposal or re-use that does not impact on the environment.

As discussed previously, permissions should be sought and an assessment of environment effects should be carried out prior to removal, which should include the implications of doing nothing.

Sites can be selected using existing information collected in Environment Southland's SoE monitoring programme which includes spatial maps of macroalgal cover and biomass in addition to substrate type (e.g. soft mud; see section 3.6).



**Dense beds of *Agarophyton* in Southland associated with muddy sediments**

Dense macroalgae beds over soft muds in New River Estuary

### 3.7.3 Long-term options

Explore commercial harvesting of wild macroalgae

New Zealand has a large coastline in comparison to its land area and over 1000 known algal species (White & White 2020; Shiel & Nelson 1990). Harvesting seaweed biomass has occurred on a local scale (e,g, *Ulva* in Tauranga and Christchurch; Nelson et al. 2015), beach cast seaweeds (Schiel & Nelson 1990) and experimental harvesting of nuisance *Agarophyton* in Manukau Harbour (Luxton 1981).

Dense beds of *Agarophyton* in Jacobs River Estuary

There is a potential commercial value of *Agarophyton* for agar, fertilisers and other products however methods for economically viable, large-scale harvest over soft sediments have not yet been identified for nuisance seaweeds (Nelson et al. 2015).

*Agarophyton chilense*, a native species to New Zealand, colonised the Chilean coast and since the 1970s it has been commercially harvested in the wild or cultivated for agar production (Guilleman et al. 2014). At present, in New Zealand there is a moratorium on the commercial harvest of seaweeds including *Agarophyton chilense* and *Ulva* spp. as stated in section 3.5.

More research is required to determine whether there is a potential local market for *Agarophyton* in New Zealand (or an export market), and to explore methods of harvesting at a local scale to minimise effort and associated environmental effects. If the commercial harvest of *Agarophyton* was feasible it could potentially offset costs of active removal of macroalgae from the estuary.

While *Ulva* is present in Southland estuaries it is currently not the key nuisance macroalgae species and its cover varies year-to-year therefore exploring commercial harvesting options for *Ulva* is not considered viable.

## 3.8 SUMMARY

The need for active management of nuisance macroalgal growths highlights the unprecedented expansion of nuisance macroalgae in several Southland estuaries over the past 10-15 years. While the above options provide guidance to minimise the impacts of macroalgae they do not remove the fundamental problem of nutrient and sediment loads exceeding the estuaries assimilative capacity. Until these loads are reduced, no significant changes in estuary state will be observed. However, macroalgal removal, in combination with contaminant load reductions could lead to positive outcomes for estuary health.

If Environment Southland choose to implement macroalgal removal as a non-regulatory management option we strongly recommend the council first prioritise sites based on needs, values, impact and amenity.

The case study to follow is intended as an example of how to implement a macroalgal removal project on the ground the site has not been selected through a council prioritisation process.

# 4. CASE STUDY – MACROALGAL REMOVAL, NEW RIVER ESTUARY

## 4.1 BACKGROUND

New River Estuary is a large (4,600ha) estuary situated at the confluence of the Ōreti and Waihopai Rivers near Invercargill and which discharges to the sea at the eastern end of Ōreti Beach. The estuary drains a large 4,314km$^2$ catchment comprising ~60% intensive pasture, 17% low producing pasture, 13% native forest, and 8% exotic forest (Stevens 2018).

In 2001, ~43ha of the estuary had a >50% cover of *Agarophyton* but nuisance conditions were not reported (Robertson et al. 2002). Since that time, *Agarophyton* growth has significantly expanded across the estuary at a rate and to levels that are unprecedented in New Zealand (Stevens & Forrest 2020). Extensive seagrass beds in the Waihopai Arm in 2001 (58ha) also significantly declined after 2007 and are now almost completely lost with only 1.8ha remaining due to increasing sediment deposition and subsequent macroalgal smothering (Stevens & Forrest 2020, Robertson et al. 2017).

In 2020, macroalgae >50% covered an area of 486ha or 16.5% of the intertidal area (see Fig 3). In Waihopai Arm (north) and Daffodil Bay (west), where nuisance macroalgal growths have established most strongly, macroalgal biomass was classified as 'high' (1-3kg/m$^2$) to 'very high' (>3kg/m$^2$) and is at levels where adverse impacts to estuary biota are known to occur (Robertson et al. 2016). In 2020, these areas of nuisance macroalgae were associated with poor sediment conditions including mud-dominated sediments (>50% mud) and poor sediment oxygenation at 82% of the sites monitored.

In some areas, sediment conditions have become so degraded from persistent blooms of nuisance macroalgae that the macroalgae itself has not been able to survive. The result has been extensive decomposing beds of *Agarophyton* covered in white mats of sulfur oxidising bacteria on top of a black anoxic sediment slurry over 0.5m deep. These areas are now largely azoic with the animals commonly present in an estuary unable to survive in the degraded condition present (see photo on following page).

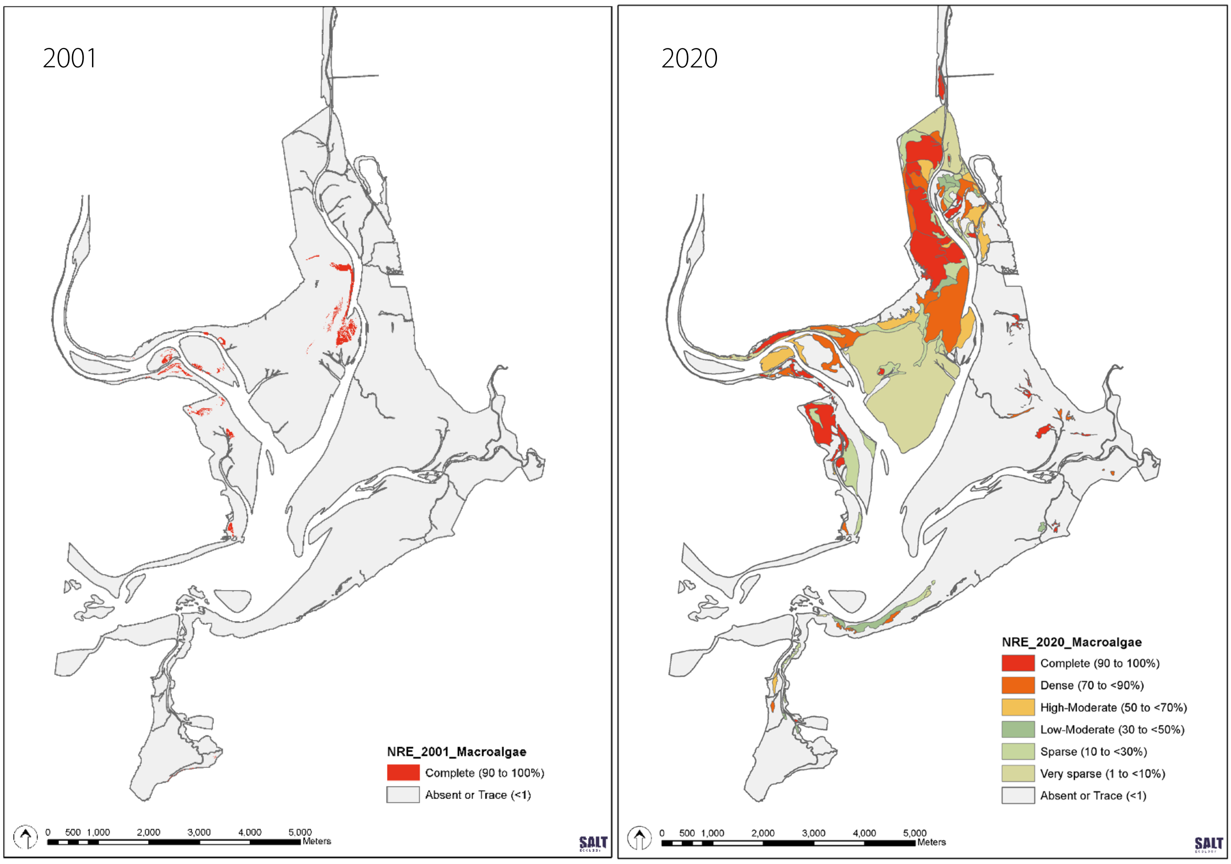



Fig. 3. Macroalgal cover in New River Estuary 2001 and 2020, total estuary area 4,600ha (Stevens & Forrest 2020).

100% cover, high biomass macroalgae decaying with sulfur bacteria (white) at the surface and anoxic sediment slurry below, Daffodil Bay

Mounds of macroalgae in Waihopai Arm, New River Estuary showing evidence of flood scouring

## 4.2 CURRENT MANAGEMENT

Environment Southland's People, Water and Land Programme is working toward setting objectives and limits on contaminants such as nutrients and sediments. This programme will implement the National Policy Statement for Freshwater Management (NPSFM) requirement to set state objectives for waterbodies and limits to resource use, requiring current state be maintained or improved.

At present the estuary and discharges to coast are managed under Environment Southland's Regional Coastal Plan (2013) and activities in the catchment are managed under the proposed Southland Water and Land Plan (2020).

The Department of Conservation manage the invasive cordgrass (*Spartina*) that was introduced into the estuary in the 1930's to facilitate reclamation of the tidal flats. It has since been almost completely eradicated but still requires regular monitoring to prevent re-incursion.

Invercargill City Council manage the Invercargill waste transfer station, wastewater treatment plant and park land on the estuary margins.

The connection between estuaries and rivers is recognised in the Ngāi Tahu ki Murihiku Iwi Management Plan and New River Estuary is included in the Statutory Acknowledgements of Rakiura/Te Ara a Kiwa (Rakiura/Foveaux Strait CMA) (Schedule 104), as well through the Ōreti River Statutory Acknowledgement.

At present, to our knowledge, there are no active restoration projects occurring in New River Estuary.

## 4.3 MINIMISING FURTHER EXPANSION OF MACROALGAE

As stated previously, reducing the cover of macroalgae at the margins of existing macroalgal beds reduces the likelihood of established beds expanding and creating further areas with poor sediment conditions. Small-scale macroalgae removal will not change the overall health of the estuary but could slow down the rate of deterioration as an interim measure whilst contaminant loads are reduced. The project will require ongoing macroalgal removal due to the extent of macroalgae already present in the estuary.

### 4.3.1 Site selection

In February 2020, macroalgal cover and biomass was mapped in New River Estuary. Areas of combined macroalgal cover (>50%), muddy sediments (>50% mud) and poor oxygenation were also recorded. Key characteristics to select sites for the removal of macroalgae are:

- Sediment mud content <50% and sediment well oxygenated.
- Macroalgae is not entrained (e.g. not rooted more than 3cm within underlying sediment)

- The area of macroalgal cover is either newly established, or in previously established areas that border expanding beds.
- The biomass in the area of cover is on the margins of 'high' (1-3kg/m$^2$) to 'very high' (>3kg/m$^2$) biomass.
- Areas with extensive entrained beds with thalli (roots) deep in the sediment should be avoided as rapid re-establishment is likely in these areas.
- Areas associated with very soft muds would ideally be avoided due to access and working difficulties.

Fig. 4 shows three potential sites based on the criteria presented above. Google Earth and Beacon, Environment Southland's mapping platform (https://maps.es.govt.nz/), are a source of aerial imagery that can be useful for further assessing site access and target areas in combination with the information e.g. Fig. 5. Health and safety, and ease of access should be considered when selecting a site, particularly if untrained personnel will be participating.

Macroalgae can absorb pollutants. When selecting a site, particularly for community-based removal, avoid areas around stormwater drains, sewage outfalls and landfill waste.


Fig. 4. Aerial view of the Bushy Point and a recommended area of recent macroalgal expansion to target for removal.

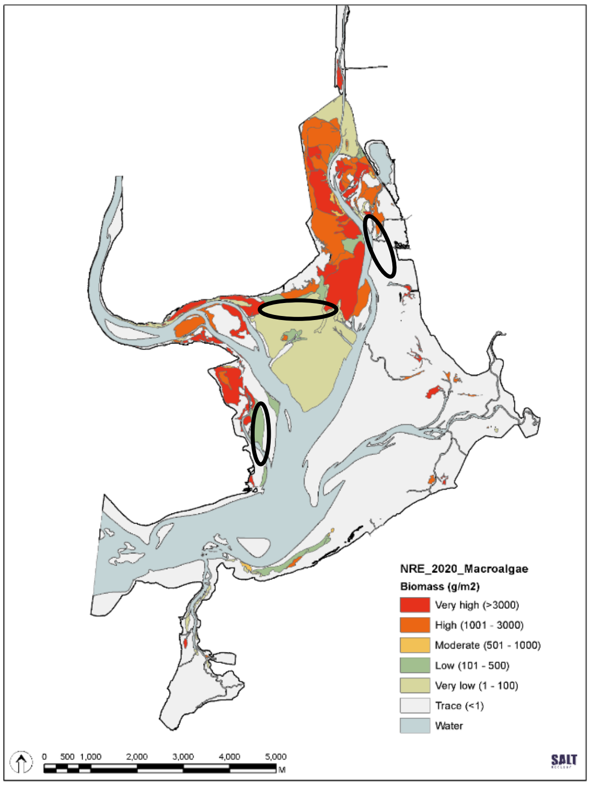



Fig. 5. Site selection to target areas of macroalgal expansion or potentially new problem areas.

### 4.3.2 Planning the project

Once the site is selected follow the guidance and resources in Section 2 that describe in more detail how to set up a project and a community-based group. However, for the purposes of this case study the following is provided as an example:

Restoration Goal:

- Reduce the impacts of macroalgae in New River Estuary.

Restoration Objective:

- Target areas of macroalgal expansion, to prevent further degradation to sediments and key habitats (e.g. seagrass and sand flats) by nuisance macroalgae.

Action:

- Remove macroalgae by hand in late summer to early winter.
- Periodically revisit areas removing any new macroalgal shoots.

Budget:

- Removal of macroalgae by hand does not require any significant expense. Gumboots, a bucket or bag and a pair of gloves should be all that is needed.

### 4.3.3 Getting started

This section assumes health and safety protocols have been developed and appropriate permissions sought.

*Creating a site plan and collect baseline data*

1. Mark out the target area using a GPS or landmarks. Draw area onto aerial image.
2. Collect baseline data using either the marine metre squared method or the broad scale assessment of macroalgal cover (Table 1). Take photos of the site and record percent cover data and any other observations on the site (e.g. sandy, muddy, animals, sediment colour etc). There is some guidance on data collection for the marine metre squared method on the website, not all data will be relevant to assessing project progress.

### 4.3.4 Action on the ground

*Collecting macroalgae*

1. Wearing gloves, collect macroalgae by hand, shake the macroalgae or rinse in seawater to ensure no sea creatures have been collected.
2. Place the macroalgae into buckets or bags and remove from the site.
3. If using macroalgae as a fertiliser, rinse in freshwater to remove excess salts and apply it to the garden directly or add it to the compost.
4. Use macroalgae as fertiliser at home, at a local nursery or dispose of as per the council guidance.

### 4.3.5 Ongoing maintenance

As discussed previously, targeting areas of expansion is an interim measure and macroalgae will likely re-establish due to the large amount of macroalgae already present in the estuary. Therefore, monitoring percent cover will provide an indication of how quickly it re-establishes and how frequently it needs to be removed to prevent it from persisting in the area. Following the steps above for monitoring:

1. Revisit the site 6-months after the initial removal to monitor the percent cover and assess any change, remove any new macroalgae.
2. Based on the 6-month monitoring data determine whether the project plan needs to be modified (e.g. return in 3, 6 or 12 months).
3. Adapt the plan and follow the revised action steps.
4. After 12-18 months communicate project progress to project partners and the community. It is important to understand with this type of project re-incursions of macroalgae are highly likely and therefore maintaining project momentum over time may be difficult. As such, communication of project outcomes and revisiting the goal will be important
5. Re-evaluate the overall success of the removal. It may be that the scale of the problem is so large that the volume of material needs to be increased, or the efforts of volunteers redirected into other restoration options.

### 4.3.6 Summary

Removal of macroalgae in areas of expansion is reasonably straightforward, despite being labour intensive. However, it remains an extreme management action in response to excess catchment contaminant loads and eutrophication issues in the estuary.

As discussed previously the council should prioritise sites for macroalgal management if it is considered a feasible option. There are many suitable areas in New River Estuary, for example; Pleasure Bay, Whalers Bay, Mokomoko Inlet, upper and eastern Waihopai Arm, Duck Creek, and the banks of the lower Ōreti River.

# 5. SALT MARSH

## 5.1 BACKGROUND

Estuaries are dynamic ecosystems located at the interface between the land and the sea. They provide habitat for a wide variety of species including birds, fish, invertebrates and plants. Vegetated estuarine habitats (commonly referred to as salt marsh) are one of the most productive habitats on Earth. They support multiple food webs and play an important role in atmospheric gas regulation, with their prolific plant growth creating 'carbon sinks' where carbon dioxide is absorbed as part of plant photosynthesis, and terrestrial and estuarine-derived carbon is deposited and locked up in the estuary sediment. They also provide tremendous additional benefits for humans including flood and erosion control, maintenance of water quality, nutrient and sediment assimilation, and a wide variety of opportunities for recreation.

In general, salt marsh transitions across three zones of vegetation from terrestrial to supratidal to intertidal (Fig. 6). Terrestrial vegetation is subjected to salt spray but is not tidally inundated. It includes a mix of common coastal plants and ground covers. Supratidal vegetation is subjected to salt spray and periodic inundation by spring tides, waves or storm surges. Intertidal vegetation is regularly inundated by seawater. The species present are all salt tolerant with the dominant cover in the upper reaches commonly comprising salt marsh ribbonwood, occasional shore tussocks and smaller soft rushes and, in the lower reaches, extensive beds of rushes, e.g. searush, jointed wire rush, three-square and low-growing herbfields including glasswort, remuremu and primrose. Seagrass is also found in the intertidal zone.

Salt marsh habitat; ribbonwood, rushes and herbfield Awarua Bay, Southland

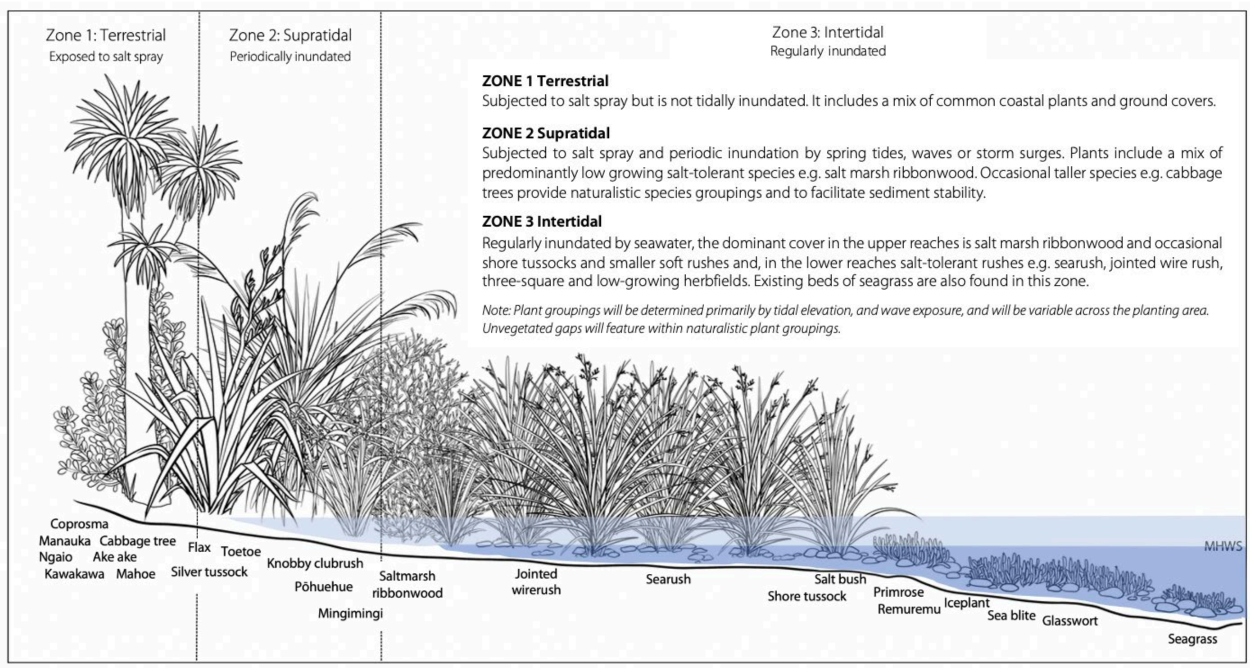



Fig. 6. Conceptual diagram of a salt marsh habitat with three zones of vegetation; herbfield, rushes and estuarine shrubs.

## 5.2 THREATS TO SALT MARSH HABITAT

Worldwide, and in New Zealand, there has been extensive loss of salt marsh habitat, primarily through direct displacement from roading and urban developments, or conversion to farmland. There has also been a significant reduction in the extent or quality of salt marsh through species losses or fragmentation, alterations to drainage and flow paths, terrestrial weed invasions and disconnection from adjacent terrestrial ecosystems, in particular coastal wetlands and forests.

Estuaries and salt marshes have, to date, generally been able to respond to, or assimilate, natural physical changes in sea level, tidal inundation and/or sediment supply. However, where changes are significantly above natural rates (e.g. accelerating Sea Level Rise (SLR), increased flood intensity and frequency, or land development causing excessive sediment inputs), then this dynamic balance can be disrupted. This is compounded by infrastructure developments commonly associated with coastal defences (e.g. flap gates, seawalls, bunds) that seek to reduce tidal inundation and shoreline erosion.

**Roading infrastructure disconnecting salt marsh habitat from the estuary, Haldane Estuary, Southland**

The capacity of salt marsh to respond to SLR relies to a large extent on salt marsh being able to migrate landward to maintain suitable growing conditions. The presence of hard barriers around the upper margins of estuaries prevents this migration and creates what is commonly referred to as 'coastal squeeze' resulting in the loss of both salt marsh and intertidal estuary flats.

## 5.3 PRIORITISATION OF SALT MARSH RESTORATION SITES

Many factors need to be considered for successful restoration, and site prioritisation has to consider not only the physical characteristics of a site, but a wide range of associated social, cultural and economic variables such as those outlined in Section 2.

To assist in prioritisation it is common to apply screening criteria to help guide decision-making. An example of salt marsh restoration scoring criteria are presented in Table 3. These reflect a mix of high level screening criteria to determine the likely ease of undertaking a restoration project (e.g. selecting areas without high value infrastructure on council land that will result in high biodiversity benefits), as well as habitat and implementation criteria. Scoring can be weighted to emphasise local priorities or time frames, but are intented to stimulate thinking about the types of benefits and potential barriers to implementation that may exist at specific sites.

It is also important to consider the value of demonstration sites which may not necessarily provide optimal ecological outcomes, but can be used to promote the benefits of restoration actions, or to trial different methods at small scales before embarking on more ambitious projects. In most cases, the best outcomes result when there is a high level of community support for an initiative where local project champions are personally invested in the outcomes.

## 5.4 WHAT CAN BE DONE?

Section 2 describes how to initiate, plan and start a community-based project. This section describes what options could be considered depending on the project timeframe with more detail provided on threats, control methods and monitoring.

While one of the most obvious methods of salt marsh restoration is to simply plant more salt marsh, there are a wide variety of other ways in which salt marsh restoration can also be achieved as outlined in Table 2 below and illustrated in Fig.7.

Table 2. Options for salt marsh restoration.

| |
|---|
| Shoreline recontouring |
| Beach nourishment |
| Chenier ridges / islands |
| Reinstatement of tidal flows |
| Armour removal |
| Flap gate removal |
| Dike or berm removal |
| Physical exclusion |
| Weed control |
| Pest control |
| New salt marsh planting |
| Infill salt marsh planting |

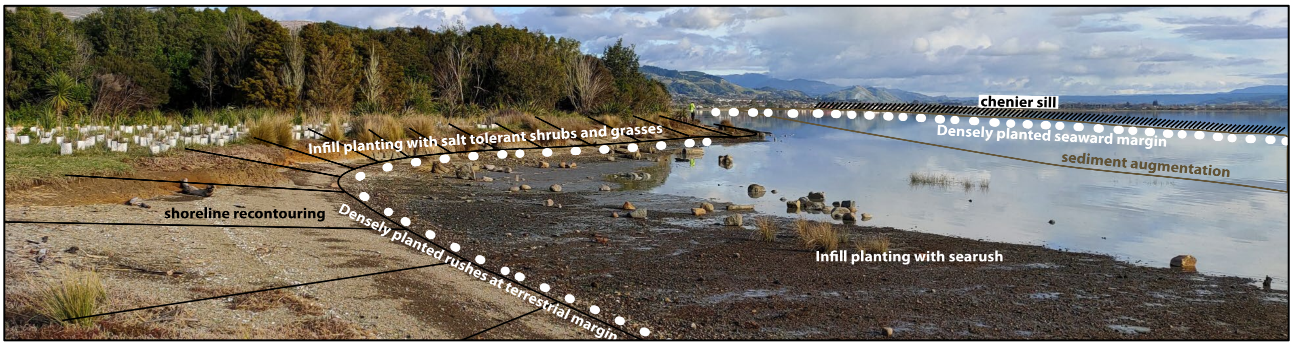



Fig. 7. Example of various options for salt marsh restoration at the margin of an estuary.

Table 1. Potential criteria for determining estuary restoration priorities.

| | Proposed criteria for prioritising salt marsh restoration | Low (1) | Moderate (3) | High (5) |
|---|---|---|---|---|
| PRELIMINARY HIGH LEVEL SCREENING | | | | 5 |
| 1 | Land ownership | Private | Conservation ownership | Council owned |
| 2 | Tidal inundation | Terrestrial | Within current tidal range | Within 100yr SLR range |
| 3 | Extent of historic degradation | Largely intact | Modified | Heavily degraded |
| 4 | Biodiversity benefit | No change | Some benefits | Large improvements |
| 5 | Proximity to existing restoration initiative | Unconnected (>500m) | Nearby (within 500m) | Adjoining |
| 6 | Proximity to ecologically important vegetated area | Unconnected (>500m) | Nearby (within 500m) | Adjoining |
| 7 | Value of infrastructure assets potentially affected within restoration | >$100k | $10-$100k | <$10k |
| HABITAT CRITERIA | | | | |
| 1 | Area available at site | <1ha | 1-5ha | >5ha |
| 2 | Mean width of intertidal area | 0-50m | 50-500m | >500m |
| 3 | Protection from currents/waves | Unprotected | Partially protected | Mostly protected |
| 4 | Extent of shoreline armouring | 75-100% | 25-75% | <25% |
| 5 | Width of riparian buffer | Absent | 0-10m | >10m |
| 6 | Adjacent land suitable for coastal retreat in response to SLR | No | Yes (with changes) | Yes (without changes) |
| 7 | Degree of local habitat connectivity/diversity | Degraded | Significantly modified | Largely intact |
| 8 | Likely benefit to birds compared to current state | Small | Moderate | Large |
| 9 | Likely benefit to fish compared to current state | Small | Moderate | Large |
| IMPLEMENTATION CRITERIA | | | | |
| 1 | Proven restoration methodology | Unproven | Demonstrated | Well established |
| 2 | Likely risk of failure (e.g. erosion, plant desiccation) | High | Moderate | Low |
| 3 | Likely cost of initial restoration | High (>$50k/ha) | Moderate ($10-50k/ha) | Low (<10k/ha) |
| 4 | Likely cost of ongoing site maintenance | High (>$10k pa) | Moderate ($5-10k pa) | Low (<$5k pa) |
| 5 | Site accessibility | Difficult | Moderate | Easy |
| 6 | Extent of physical site preparation required | High | Moderate | Low |
| 7 | Is resource consent likely to be required? | Notified consent | Non-notified consent | Permitted |
| 8 | Potential adverse impact from restoration works | Significant | Moderate | Slight |
| 9 | Likely human amenity value | Low | Moderate | High |
| 10 | Time frame for establishing desired changes | Slow | Moderate | Fast |

An expanded scoring narrative is included on the following page

Table 3 cont…Expanded scoring narrative

| PRELIMINARY HIGH LEVEL SCREENING | | 1 | 3 | 5 |
|---|---|---|---|---|
| 1 | Land ownership | Land with private ownership and site governance | Crown or covenanted land with defined site management objectives or approvals required. eg. Scenic reserve, QE2 covenant | Council owned and managed land |
| 2 | Tidal inundation | Terrestrial land with no predicted tidal inundation | Land within currently defined MHWS | Land within predicted 100yr SLR scenario |
| 3 | Extent of historic degradation | Natural habitat is largely intact, but can be improved | Natural habitat is modified, but most key features remain | Natural habitat is significantly degraded or absent, but was historically present |
| 4 | Biodiversity benefit | No significant change to current state | Some benefits through enhancement of existing values | Large improvements through combined enhancement of existing state and restoring lost biodiversity |
| 5 | Proximity to existing restoration initiative | Unconnected to existing or proposed restoration project | Within 500m of existing or proposed restoration project | Directly adjoining existing or proposed restoration project |
| 6 | Proximity to ecologically important vegetated area | Unconnected to existing important vegetated area (e.g. seagrass, salt marsh, wetland, indigenous forest) | Within 500m of important vegetated area (e.g. seagrass, salt marsh, wetland, indigenous forest) | Adjoining important vegetated area (e.g. seagrass, salt marsh, wetland, indigenous forest) |
| 7 | Value of infrastructure assets potentially affected within restoration | Value of infrastructure assets in footprint potentially affected >$100k | Value of infrastructure assets in footprint potentially affected is $10-$100k | Value of infrastructure assets in footprint potentially affected <$10k |
| HABITAT CRITERIA | | 1 | 3 | 5 |
| 1 | Area available at site | Site small (<1ha) | Site moderate (1-5ha) | Site large (>5ha) |
| 2 | Mean width of intertidal area | Intertidal width <50m | Intertidal width 50-500m | Intertidal width >500m |
| 3 | Protection from currents/waves | Site un-protected from prevailing wave energy | Site partially protected from prevailing wave energy | Site mostly protected from prevailing wave energy |
| 4 | Extent of shoreline armouring | 75-100% armouring | 25-75% armouring | <25% armouring |
| 5 | Width of riparian buffer | No riparian vegetation present | Riparian vegetation 0-10m wide | Riparian vegetation >10m wide |
| 6 | Adjacent land suitable for coastal retreat in response to SLR | No adjacent land suitable for coastal retreat | Adjacent land suitable for coastal retreat with land changes needed | Adjacent land suitable for coastal retreat without land changes needed |
| 7 | Degree of local habitat connectivity/diversity | Monoculture or isolated habitat areas significantly degraded from natural state | Mixed species assemblages but with limited diversity and connectivity compared to natural state | Species assemblages are relatively diverse and in close proximity |
| 8 | Likely benefit to birds compared to current state | No change or small increase in habitat area or quality | Moderate increase in habitat area or quality | Large increase in habitat area or quality |
| 9 | Likely benefit to fish compared to current state | No change or small increase in habitat area or quality | Moderate increase in habitat area or quality | Large increase in habitat area or quality |
| IMPLEMENTATION CRITERIA | | 1 | 3 | 5 |
| 1 | Proven restoration methodology | Novel method | Method used successfully elsewhere | Many examples of sucessful use, including within NZ |
| 2 | Likely risk of failure (e.g. erosion, plant desiccation) | Physical conditions at the edge of tolerances of key habitat forming species | Physical conditions mostly within tolerances of key habitat forming species | Physical conditions well within of tolerances of key habitat forming species |
| 3 | Likely cost of initial restoration | High (>$50k/ha) | Moderate ($10-50k/ha) | Low (<$10k/ha) |
| 4 | Likely cost of ongoing site maintenance | High maintenance costs (>$10kpa), e.g. labour intensive, high plant losses, extensive weed control) | Moderate maintenance costs ($5-10kpa),e.g. Limited labour, low plant losses, annual weed spraying) | Very little ongoing maintenance required (<$5kpa) |
| 5 | Site accessibility | Access difficult e.g., no vehicle access to site or traffic management required | Access constraints manageable e.g., fence removal, 4wd access | No access constraints |
| 6 | Extent of physical site preparation required | Extensive works needed over >50% of site using machinery | Works needed over 10-50% of site with some machinery | Works needed over <10% of site without using machinery |
| 7 | Is resource consent likely to be required? | Notified consent required | Non-notified consent | Permitted activity with no consent required |
| 8 | Potential adverse impact from restoration works | Significant adverse impacts that may persist or which can not be readily mitigated through appropriate management | Some short-duration adverse impacts that can be mitigated through appropriate management | No significant adverse impacts |
| 9 | Likely human amenity value | No current or future recreational opportunities | Indirect and limited use (e.g. walkway/cycleway, remore view-point) | Direct and frequent use (e.g. park with multiple passive and active uses) |
| 10 | Time frame for establishing desired changes | Desired changes occur over a long timeframe (>10 years) | Desired changes occur over a moderate timeframe (5-10 years) | Desired changes occur over a rapid timeframe (<5 years) |

### 5.4.1 Short-term options

Short-term measures should be aimed toward minimising existing threats, supporting current restoration programmes and/or educating the community on the importance of protecting salt marsh habitats.

<u>Protect existing salt marsh</u>

In most cases protecting existing salt marsh from loss is the single most efficient way of maximising salt marsh extent. This is because it is generally more difficult and expensive to recreate the natural biodiversity of lost habitat than it is to retain it. Protection can come indirectly, for example via regulatory means, education, or enforcement. It can also be achieved directly through physical exclusion of stock and vehicles, weed control or protection from erosion. The latter may include shoreline reshaping or the construction of chenier ridges to dampen wave energy in the intertidal zone.

<u>Exclusion of stock</u>

Environment Southland's Regional Coastal Plan (2013) restricts grazing and keeping of stock in the coastal marine area and prohibits it on Crown Land in the coastal marine area. Educating landowners on the importance of salt marsh habitat and monitoring compliance would ensure the plan rules are effective and salt marsh habitat in these areas is maintained.

Salt marsh present on the left where stock are excluded and absent on the right where stock has access, Waikawa Estuary

<u>Weed control – Threatened areas</u>

Minimising the expansion of weeds and grasses is essential. Protecting areas without invasive species is paramount, as is controlling any new incursions swiftly. The management of pest species (mammal and vegetation) can be expensive, ongoing and is unavoidable where pests are established.

<u>Exclusion of vehicles, domestic animals and people</u>

Vehicle use on Southland beaches is widespread (Robertson & Stevens 2008), and there is substantial evidence of vehicle damage to seagrass beds and salt marsh in Southland estuaries (see photos).

Fencing, bollards and/or signage, where appropriate, can be used to minimise damage to vulnerable salt marsh habitats (e.g. herbfields). In Southland, signage is described under rule 5.3.1 and 5.3.2 of the Regional Coastal Plan. Furthermore, any structure in the Coastal Marine Area will likely require consent under the Regional Coastal Plan and therefore, as discussed previously, it is important to contact the council before considering this option.

Vehicle tracks in herbfields at Sandy Point

Vehicles tracks in New River Estuary through seagrass beds adjacent to salt marsh habitat

### 5.4.2 Medium to long-term options

<u>Restore natural tidal connections and infill planting</u>

Over medium to long-term time frames, new or infill planting is recommended alongside the restoration of natural tidal and freshwater connections.

Ecosystem connections can also be enhanced by linking fragmented areas of salt marsh through infill planting, or by planting vegetation corridors to connect with adjacent wetlands, terrestrial forests or riparian areas.

While it can be relatively easy to physically reconnect or improve tidal flows to low-lying land on estuary margins through the removal of tidal flapgates, more effort is needed where it requires the removal of shoreline armouring, lowering of culverts, or reversal of past salt marsh channelisation and drainage. However, as changes such as these can be in direct conflict with existing land use activities, or the wishes of landowners, they require appropriate consultation and a shared vision to be effectively implemented.

<u>Restoring salt marsh habitat</u>

Restoring areas of previously damaged of lost salt marsh require careful consideration of prior disturbance (e.g. wave erosion) to identify whether areas would be suitable for salt marsh restoration. Features such as chenier sills, sediment augmentation and shoreline recontouring can suppress wave energy and increase the area of available salt marsh habitat for planting. Appendix 1: "Salt Marsh Planting Guide" provides guidance on plant types and planting guidance.

Environment Southland Regional Coastal Plan (2013) contains rules applicable to planting below mean high water spring (rule 5.4.2.3 and 5.4.2.4). Seek council advice when planning salt marsh restoration projects.

Before restoring previously lost areas of salt marsh, careful consideration should be given to whether modifying the estuary margin and reinstating salt marsh will improve the ecological condition and community value of the estuary.

Furthermore, where any active replanting is proposed it is critical to consider the likely long-term success of any restoration plantings including the effects of predicted SLR.

## 5.5 OVERARCHING SALT MARSH PLANTING OBJECTIVES

The following general objectives should be used to guide salt marsh planting:

- Use indigenous coastal species to stabilise sediments and mitigate coastal erosion.
- Reinstate salt marsh habitat previously lost through historical reclamation.
- Plant from a species palette naturally found at the coastal edge.
- Plant hardy species to maximise planting success.
- Plant in naturalistic groupings of species, appropriate to their natural densities and distribution on the shore.
- Include species that enhance biodiversity and facilitate natural salt marsh expansion.
- Minimise required maintenance through species selection and positioning.
- Visually integrate planting as much as possible across the identified planting zones (terrestrial, supratidal, intertidal).

**Upper Waihopai Arm showing remnant salt marsh within flood banks. The areas of green pasture either side of the channel is reclaimed estuary.**

# 6. CASE STUDY – SALT MARSH RESTORATION SANDY POINT, NEW RIVER ESTUARY

## 6.1 BACKGROUND

New River Estuary is a large (4,600ha) estuary situated at the confluence of the Ōreti and Waihopai Rivers near Invercargill and which discharges to the sea at the eastern end of Ōreti Beach. The estuary drains a large 4,314km$^2$ catchment comprising ~60% intensive pasture, 17% low producing pasture, 13% native forest, and 8% exotic forest (Stevens 2020).

Salt marsh, last mapped in 2012 (Fig. 8, Stevens & Robertson 2012) comprised ~464ha or 10% of the estuary. While this is a relatively large total area, it is significantly reduced from the likely historic salt marsh extent, with the total estuary area likely to have been reduced by over 1200ha by reclamation and subsequent flood protection work, and industrial, urban and agricultural developments along the estuary margins which have all displaced historical salt marsh habitat.

Ongoing margin development was evident on private land adjacent to the estuary in 2012 with drainage and reclamation removing many of the low-lying margins favoured by salt marsh and flanking wetlands e.g. west Waihopai Arm, east Mokomoko Inlet. Such areas buffer the estuary from sediment and nutrients, provide high value wildlife habitat, and will be very important in the future if predicted sea level rise forces salt marsh inland (Stevens & Robertson 2012).

Natural salt marsh losses have also occurred with erosion of the seaward edge of salt marsh beds evident in the east of the estuary near Woodend, and on the true left of the Ōreti River near Bushy Point.

**Eroding salt marsh in the east of New River Estuary near Woodend**

## 6.2 RESTORATION OF SALT MARSH

Salt marsh restoration efforts in New Zealand have to date primarily focused on riparian plantings with a strong emphasis on terrestrial species revegetation of estuary margins. However, there have recently been successful attempts to replant intertidal and supratidal salt marsh in tidally inundated areas (authors unpublished data).

However, as stated previously, reducing the loss of existing salt marsh is usually the cheapest and easiest way of protecting salt marsh. A primary focus should therefore be to identify where salt marsh is present which may be vulnerable to loss from either land conversion, grazing, weed invasion, drainage or damage. This could be done as a desktop exercise using aerial photos and local knowledge. Priority areas could then be identified, and information provided to landowners regarding the regulatory status of any high value habitat areas, combined with education about their ecological value.

The same process could be used to identify areas of previous salt marsh growth which could become potential sites for future restoration.

### 6.2.1 Site selection

Existing data on sea level, coastal structures and habitat features can be used to identify areas that could be suitable for restoration based on their potential for inundation as a consequence of predicted SLR. These areas often provide the greatest restoration benefits for the lowest relative cost but may require significant lead-in time or stakeholder engagement to be realised.

Geographic Information System (GIS) spatial mapping approaches are well suited to identifying areas for potential protection or restoration at a region-wide scale to optimise priority setting. The spatial framework is also ideal for mapping and recording data on restoration work already initiated or proposed.

GIS data layers are often readily available showing land ownership, salt marsh features, barriers to coastal retreat (e.g. seawalls), existing restoration projects, and low-lying land where tidal inundation is predicted to occur within the next 10-20 years or where land may be inundated if existing barriers were removed.

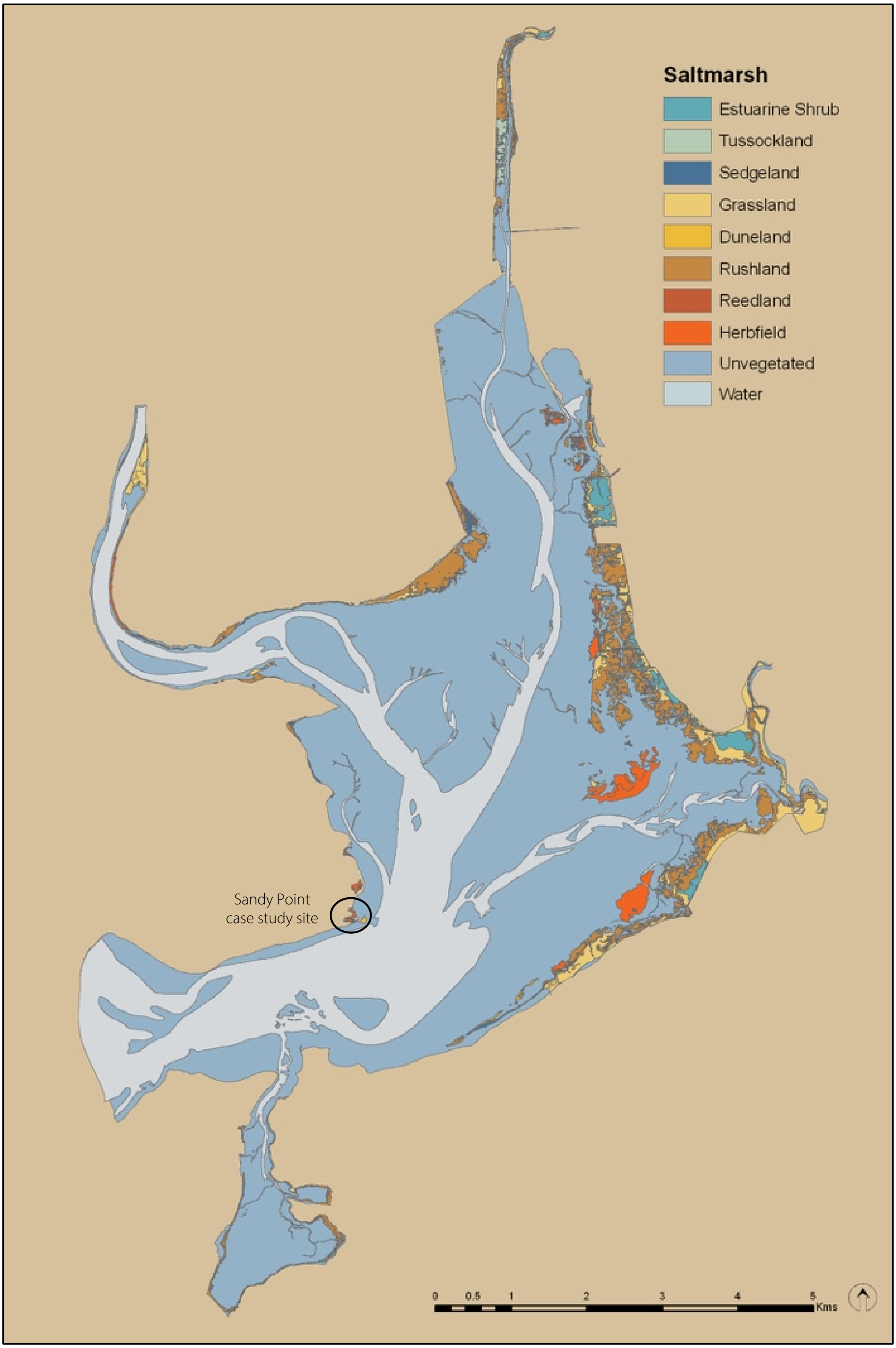



Fig. 8. Map showing location of dominant salt marsh habitat in New River Estuary, 2012. Source: Stevens and Robertson (2012).

Broad scale habitat mapping has identified the spatial location of salt marsh throughout New River Estuary, including areas of adjoining native terrestrial vegetation. While virtually all areas could be enhanced by weed and pest control, removal of constructed margins, or exclusion of vehicles and animals, it is suggested that Sandy Point be considered as a suitable candidate for initial restoration (Fig. 9).

Sandy Point has large patches of fragile herbfields that are currently severely impacted by vehicle damage. Site access is good, there is excellent scope for salt marsh migration in response to sea level rise, terrestrial margin areas can be replanted in a mix of estuarine and coastal forest species (exotic pine forest has recently been harvested), and invasive weeds (e.g. marram grass) are a locally manageable scale. The site is ~5ha so is relatively manageable.

The site would also be suitable for dune restoration on the seaward side (see following section for examples of the type of dune restoration that could be undertaken), and there is a nearby patch of nuisance macroalgae that could be potentially removed as a trial if Environment Southland wanted to use the location as a trial site for different restoration options.

### 6.2.2 Planning the project

Follow the guidance and resources in Section 2 that describe in detail how to set up a project and a community-based group. However, for the purposes of this case study the following is provided as an example:


Fig. 9. Sandy Point showing location of salt marsh habitat and suggested restoration options.

Restoration goal:

- Reduce the loss of existing salt marsh in New River Estuary

Restoration Objective:

- Prevent direct damage to existing salt marsh by vehicles.
- Increase community awareness of salt marsh value.
- Control weeds and re-establish native salt marsh and margin plants.

Action:

- Restrict vehicle access to existing saltmarsh e.g. post and rail, bollards, rock, gates.
- Use signage to increase awareness of current issues and proposed solutions.
- Develop a pest and weed management strategy.
- Plant selected salt marsh species as appropriate (see Appendix 1: "Salt Marsh Planting Guide" for further detail).

Budget:

- Cost will depend on the site boundary and exclusion methods chosen, but are expected to be relatively modest. Pest and weed control and planting are suitable for volunteer labour.
- Funding will be required for initial plants, fencing, signage and pest/weed management (e.g. herbicides and personnel) in addition to ongoing maintenance costs.
- If expert consultation is required in the site design this may incur additional costs.
- Account for any consenting costs that may be incurred through the process.
- The costs associated with the project will likely require funding support. Funding options are discussed in Section 2.1.3.

### 6.2.3 Getting started

This section assumes health and safety protocols have been developed and appropriate permissions sought.

*Creating a site plan and collect baseline data*

- Mark out the target area using a GPS or landmarks. Draw area onto aerial image.
- Take photos of the site and record percent cover data of key species and other relevant site observations (e.g. substrate type and current impacts such as vehicles, animal browsing, weeds). Ideally map the site using established broad scale mapping methods (e.g. Robertson et al. 2002).
- From the information collected, draw a site plan and determine works needed (e.g. fencing, number of plants etc).

### 6.2.4 Action on the ground

*Site protection*

- Install measures to exclude vehicles from existing herbfield areas. It may also be a consideration to install security cameras if damage is ongoing.
- Concurrent with vehicle exclusion from sensitive areas, install signage explaining the reason for the exclusion and information panels describing the plants being protected.

*Planting*

- Determine suitable coastal and estuarine species, and relative proportion of plants, using the guide in Appendix 1. The cost should be based on the local nursery where plants will be sourced and reflect the recommended spacings. Example costs are ~$2.50 for root trainer plants and $8 for larger potted specimens.
- Order eco-sourced plants well in advance of the planting date (at least 6-12 months) so that they are available as needed at the scheduled time of planting. Guidance on plants and planting is provided in Appendix 1: "Salt Marsh Planting Guide".
- Allow for additional costs for plant protectors and stakes (~$2 per plant), and slow release NPK fertiliser pellets to increase the success of plant establishment and enhance growth (~$0.50/plant).
- If the estimated planting budget exceeds what is available, the planting area can be reduced, or planting staggered over time.
- Within damaged areas, undertake infill planting as required. Strategically plant for shelter and physical exclusion as needed.

*Weed control*

Undertake weed management where necessary around the site margins. Because of the relatively small area involved, weed spraying using a knapsack is recommended. Further guidance is provided in Appendix 1.

*Pest control*

Once the site is defined, an assessment of the area should be carried out to determine whether animal browsing is likely a significant issue. If browsing is expected, bait stations or traps will need to be deployed on site and routinely monitored. More information can be provided by the Environment Southland Biosecurity team.

*Fencing and signage*

Depending on its purpose fencing and signage can be relatively low cost. For example, wooden stakes and rope are often sufficient to dissuade foot-traffic and can be easily relocated, installed, and maintained by volunteers. Exclusion fencing (e.g. for vehicles or pests) is best installed by professional contractors. Basic signage can be relatively low cost however information panels are more expensive and require specialist input.

*Monitor*

Monitor the site after planting as per the methods in Table 1. For example, take photos of the site and record the area planted on aerial imagery and with a GPS, record coverage of key species across the project area. More complex monitoring techniques are provided in the National Estuary Monitoring Protocol (Robertson et al. 2002).

Routinely monitor fencing, weed and pest control methods (e.g. traps should be checked every 2-4 weeks and fencing condition should be checked particularly after large storm events).

### 6.2.5 Ongoing maintenance

*Weed control*

Six-monthly or annual knapsack spraying will be needed to suppress weed growth.

*Replacement planting*

Plant as per the project plan. Accounting for some plant losses, plant replacements or carry out infill planting to ensure good coverage of plants across the site for at least the first 3 years.

*Evaluate*

Based on the monitoring discussed previously determine whether the project plan needs to be modified (e.g. more frequent weed control, plant replacement, reducing pest control as plants become established, etc). Adapt the plan using the information collected from monitoring.

After 12-18 months communicate project progress to the project partners and the community. It is important maintain project momentum by sharing project successes.

### 6.2.6 Summary

Small scale salt marsh restoration projects that are targeted toward community education and enhancement of a localised area, such as the case study presented, are readily achievable. However, there are a large number of different restoration opportunities which could be undertaken depending on the specific priorities of Council and the wider community. Examples include reconnecting tidal flows to coastal margin areas cut-off by flap gates or bunds, constructing chenier sills to minimise erosion, or simply ensuring that terrestrial plantings along the estuary margin include salt-tolerant species. Higher level priorities include accounting for SLR in planning documents and ensuring rules on salt marsh drainage and clearance are appropriate and enforced.

As discussed previously the council should prioritise protecting and enhancing existing salt marsh sites ahead of attempting to establish new areas of salt marsh. These efforts should first focus on identifying vulnerable areas of existing high value habitat using desktop approaches like GIS inundation mapping, aerial photography, and existing knowledge.

Salt marsh habitat, Awarua Bay Southland

# 7. DUNES

## 7.1 BACKGROUND ON DUNES

Sand dunes are ridges or hills of sand commonly found landward of a beach. Windblown sand is deposited against an obstruction (e.g. vegetation, rocks, logs) and the dune grows perpendicular to the direction of the wind. Naturally, coastal dune systems are dynamic with erosion and accretion patterns constantly changing. Despite this they provide an important habitat for native vegetation, nesting birds (e.g. New Zealand dotterel) and insects (e.g. moths and butterflies).

While dunes are an important habitat for native species, they also provide a supply of sand to beaches during periods of erosion, and trap sand in periods of accretion. Thus, they provide a natural buffer against coastal hazards such as storm surges, wave action, erosion and coastal flooding.

In general, a natural dune has three sections: foredune, mid dune and back dune (Fig. 10). The foredune is a relatively active dune ridge where sand is trapped in sand-binding vegetation such as Pīngao (or Pīkao) or golden sand sedge (*Ficinia spiralis*). The plant has long runners that extend across the sand surface accruing sand which forms a gently sloping dune (see photo below).

Sand-binding plant pīngao, Fortrose Spit. Note the gentle slopes and open areas of sand indicating active dunes.

The mid-dune is the landward side of the foredune and is more sheltered (Fig. 10). In the mid-dune there can be sparse areas of sands and on occasion wetlands where the sand has eroded down to the water table. Mid-dune vegetation is dominated by low growing shrubs, sedges, and herbaceous plants such as sand coprosma (*Coprosma acerosa*), shore spurge (*Euphorbia glauca*), vegetable sheep (*Raoulia* spp), and the nationally threatened sand iris (*Libertia peregrinans*).

Back dunes are stable dunes that are protected from the direct impacts of the coast by the fore and mid-dunes. Vegetation on these dunes is more established with trees and shrubs dominating, including totara (*Podocarpus totara*), flax (*Phormium tenax*), manuka (*Leptospermum scoparium*), kanuka (*Kunzea ericoides*) and cabbage tree (*Cordyline australis*).

Throughout New Zealand native species like pīngao have been commonly displaced by marram grass (*Ammophila arenaria*), an invasive sand-binding grass introduced from Europe.

Steep-faced introduced marram grass dunes at Ōreti Beach (source: ES). Note the dune height and large volume of trapped sand.

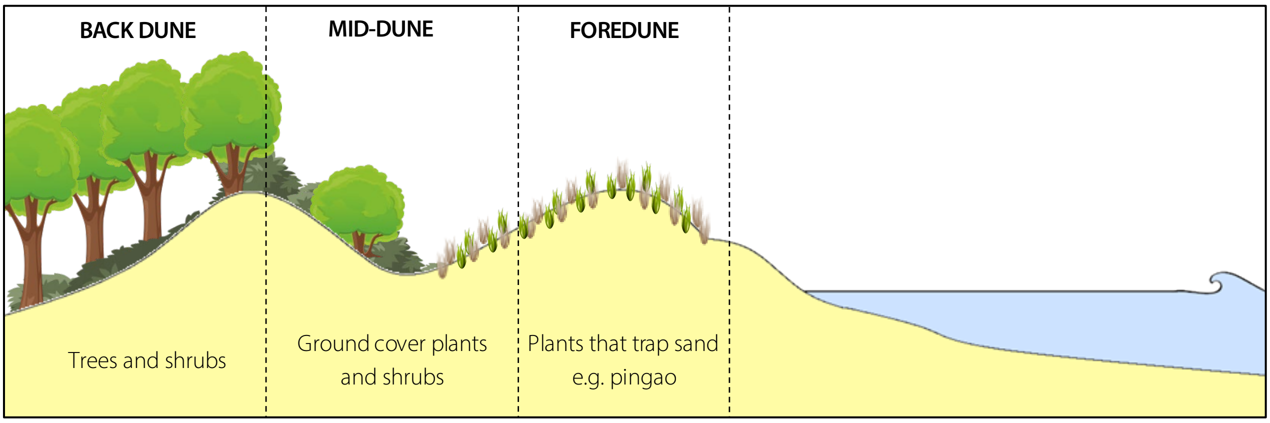



Fig. 10. Conceptual diagram of a dune system denoting three common zones.

Marram grass decreases dune activity by stabilising the foredune with dense vegetation cover, making them more susceptible to extreme erosion events where large volumes of sand are mobilised. Large erosion events can leave steep dune faces that poorly dissipate wave energy and are prone to wind and wave blow-outs, resulting in large volumes of sand being lost. Active dunes release sand to beaches slowly over time mitigating the effects of beach erosion. In contrast, marram dunes are stabilised by vegetation and therefore the natural release of sand to the beach over time is reduced.

In Southland, marram grass was planted in the 1940's to stabilise dune habitat and prevent sand deposition on productive land (Hilton et al. 2000a; McLachlan 2014; Esler 2017). By 2008, only a few isolated sites remained with active dune systems dominated by pīngao (e.g. Toetoes Spit, Three Sisters near Omaui and Waipapa Point; Robertson & Stevens 2008).

Elsewhere, most dune systems were dominated by marram grass comprising a stablised foredune, flanked by intensive land use where the mid and back dunes were heavily developed. Consequently, there has been significant a loss of biodiversity and natural character (Robertson & Stevens 2008), with the natural progression of dune vegetation (i.e. foredune, mid-dune and backdune; Fig. 10) severely disrupted and very little capacity for natural dune migration.

## 7.2 THREATS TO DUNE SYSTEMS

The New Zealand Coastal Policy Statement (2010) recognises the national importance of dunes with the objective to safeguard the integrity, form, function and resilience of dunes. Since the early 1900's there has been more than a 70% loss of active dune systems in New Zealand (Hilton 2006). Losses can be attributed to significant development in the coastal area and the introduction of invasive species with European settlement and ongoing development since then (Bergin et al. 2011; Konlechner et al. 2014). Ongoing threats to dune systems in Southland (see Table 1) and across New Zealand include;

- Displacement of native vegetation by exotic species
- Grazing and disturbance by stock and smaller animals (e.g. rabbits)
- Vehicles use, domestic animals and human disturbance of nesting habitats and vegetation
- Development in coastal areas; settlements, agriculture, silviculture
- Shoreline hardening
- Natural hazards such as sea level rise and storm surges.

## 7.3 PRIORITISATION OF SITES FOR RESTORATION

There is a significant amount of existing guidance on dune restoration in New Zealand (Bergin et al. 2011; DOC 2021; ACC 2021, Jamieson 2010). The purpose of this report is to summarise the guidance and apply it to a Southland case study. The purpose of the case study is to provide an example of how to approach restoration, and the Ōreti Beach dune system was selected by ES. This case study has not been through a specific site prioritisation process.

Several dunes have been prioritised nationally for protection and restoration in the Southland region. Many are in Fiordland and Stewart Island where conservation management is under the jurisdiction of the Department of Conservation (Hilton et al., 2000a). Other dunes on the south coast include Toetoes (Fortose) Beach, for example. Konlechner (2016) provides further guidance on dunes that should be prioritised for management in the Southland region. While these dune systems have been prioritised for the Department of Conservation, other criteria specific to council goals may also be considered in prioritising dune systems for restoration.

In 2008, Southland's coastline was mapped to assess the state and vulnerability of coastal habitats across the region, in that study several dune systems were identified along with their current values and threats (Robertson & Stevens 2008). We recommend Environment Southland review existing information on dunes to assess where restoration and protection efforts would be most valuable. Considering community and iwi values in addition to stressors (weeds, pests, coastal hazards) and adequate space for dune management including landward movement with predicted sea level rise.

**A small patch of pīngao within marram grass at Three Sisters near Omaui in 2008**

Pīngao and cushion plant (*Raoulia beauverdii*), Fortrose Spit

## 7.4 WHAT CAN BE DONE?

Section 2 describes how to initiate, plan and start a community-based project. This section describes what options could be considered depending on the project timeframe with more detail provided on threats, control methods and monitoring in Table 1. The threats outlined in Table 1 can stretch across all timeframes (short-term, mid-term and long term). A plant list including guidance is also supplied in Appendix 2 "Sand dune planting guide" which includes planning before planting, how and where to plant (e.g. foredune, mid-dune and back dune) and considerations after planting.

### 7.4.1 Short-term options

Short-term measures should be aimed toward minimising threats, supporting current programmes and/or educating the community on the importance of protecting dune habitats. Protection of existing high value dune habitat is an important short-term step in maintaining ecosystem services and minimising the need for restoration efforts in future. These measures are also relevant to mid- and long-term restoration.

Education & community

Beach user attitudes and behaviours (e.g. vehicle access) are particularly important for effective and sustainable dune restoration (Bergin et al. 2011). Bergin et al. (2011) highlighted the importance of community-based partnerships (e.g. Coastcare groups) in improving dune education and developing an understanding within the community for the importance of natural dune systems and the management required to maintain them. There are several educational resources available that can be used in community groups and schools to educate beach users on the importance of dune habitats (see information box).

Exclusion of stock

Environment Southland's Regional Coastal Plan (2013) restricts grazing and keeping of stock in the coastal marine area and prohibits it on Crown Land in the coastal marine area. Educating landowners on the importance of dune habitat and monitoring compliance would ensure the plan rules are effective and dune habitat in these areas is maintained.

Cattle grazing in the coastal marine area, Southland

EDUCATIONAL RESOURCES:

- Department of Conservation: Our Golden Coast
  https://www.doc.govt.nz/get-involved/conservation-education/resources/our-own-gold-coast/
- Bay of Plenty's: Life's a Beach Dune Community
  https://www.boprc.govt.nz/living-in-the-bay/education/teacher-resources/lifes-a-beach-dune-community
- The Nature Education: Knowledge Project (Coastal Dunes: Geomorphology)
  https://www.nature.com/scitable/knowledge/library/coastal-dunes-geomorphology-25822000/

Weed and pest control – Threatened areas

Pests including rabbits and hares are known to damage coastal sand dune vegetation through browsing. Native seedlings and young native plants are browsed preferentially limiting the plants' ability to respond to a changing environment. Pest management is an expensive and ongoing measure with >90% reduction in rabbit populations required to reduce browsing pressure and increase the success of native plant establishment (Unsworth 2005). Larger plants are less prone to browsing with only new growth and runners targeted. Exclusion or pest baiting, and trapping is an important measure to maintain existing habitat and to consider before re-planting where pest browsing is an issue (Table 1).

Minimising the expansion of invasive vegetation is also essential (Table 1). Protecting areas without invasive species is paramount, controlling any new incursions swiftly. The management of pest species (mammal and vegetation) can be expensive, ongoing and is often unavoidable where pests are established if restoration projects are to be successful.

Exclusion of vehicles, domestic animals and people

Vehicle use on Southland beaches and dunes is widespread (Robertson & Stevens 2008). Environment Southland's Regional Coastal Plan (2013) highlighted intensive recreational activities on dune lands and vehicle access threaten dune habitat. However, beach access is also an important priority for the community and dune habitats cross over a number of councils, government and iwi jurisdictions.

To minimise damage to vulnerable parts of dune systems (e.g. foredune vegetation), fencing and signage can provide a chance for the dunes to recover (Bergin et al. 2011). Guidance on fencing options and designing accessways is provided in Article 9.1 and 9.2 in the Restoration of Coastal Sand Dunes Using Native Plants (Technical Handbook) prepared by the New Zealand Coastal Restoration Trust (Bergin et al. 2011). Seek advice from the council before fencing in the coastal environment.


Signage relating to vehicle access on a Southland beach

Vehicle damage to marram dunes in Southland

### 7.4.2 Mid-to long-term options

Short-term measures remain applicable and are often a pre-requisite to mid- and long-term options (e.g. removing threats such as pest control).

Re-planting and re-shaping dune habitat

A planting guide for dune habitat restoration is provided in Appendix 2, however it is critical to consider current (e.g. weed and pest control) and future (e.g. climate change) threats before embarking on a re-planting project.

Furthermore, the ongoing cost and goal of restoration needs to be considered. For example, restoring native plants to promote the re-establishment of active dunes may not align with community values due to the impacts of sand movement onto adjacent land. In a survey of existing dune restoration groups in New Zealand, erosion control and foreshore stabilisation were the main priority (i.e. dunes were historically stabilised with marram) and native vegetation, and fauna were secondary (Jamieson 2010).

This section considers three main dune re-planting objectives using case studies as examples:

1. Improving degraded dunes as an alternative to hard structures
2. Removal of marram grass and re-planting foredunes in natives
3. Re-planting mid and back dune habitat

### *Improving degraded dunes as an alternative to hard structures*

In some areas where there is sufficient space for dune management, dunes can provide an important buffer to protect against coastal hazards, reducing the need for hard structures. Dahm et al. (2005) presented a case study on Papamoa East, Bay of Plenty, where a subdivision close to the sea was prone to coastal hazards (e.g. storm surges and erosion) and the ongoing effects of climate change. Historically the dune protecting the properties was bulldozed to create greater areas of flat space. In 1994, the local Coast Care Group re-planted native sand binding vegetation in the degraded dune face, without mechanical reshaping. The dunes were allowed to re-establish their natural form and migrate seaward creating a larger buffer between the properties and coastal hazards. Since then, large areas of coastal foredunes have been restored (~20km length) and the focus has shifted toward mid and back dune planting to increase biodiversity values (Dahm et al. 2005).

### *Removal of marram grass and re-planting foredunes in natives*

Mainland dunes in Southland are predominantly covered in the introduced marram grass. It can be removed through two main mechanisms;

- Mechanical: physical removal of plants and roots with a digger and reshaping the dune (Dahm et al. 2005; Konlchner et al. 2014).
- Herbicides: widespread aerial spraying followed by targeted hand spraying. Root systems decay and dunes erode slowly over time. Reshaping can take years to decades (Konlchner et al. 2014)

Regardless of the method of control, a single intervention is insufficient to prevent re-colonisation of marram grass and maintain long term sand mobility (Konlchner et al., 2014). Both approaches require annual ongoing management of vegetation. Small or isolated areas of dune habitat will have more success than restoration within a long stretch of marram grass dunes because the likelihood of recolonisation is increased.

On Stewart Island/Rakiura successful dune restoration has been carried out in a localised area (Doughboy Bay) by the Department of Conservation, with support from the University of Otago, since 1999. The programme goal was to restore dunes to a more natural condition. Activities included spraying marram grass, re-planting sand-binding natives supported by ongoing maintenance and monitoring (Konlchner et al. 2014). No mechanical methods were used. It took 3-years to achieve zero-density of marram grass, after which active dune formations started to develop (Konlchner et al. 2014). Over decades the project has restored ~4km of foredunes to a native vegetation dominated active dune system. The project has required significant resourcing and ongoing maintenance to prevent the re-establishment of marram grass.

### *Re-planting mid and back dune habitat*

In Southland, many areas of back dunes have been developed and converted to pasture or exotic forest. Reclamation of these back dune areas means only narrow foredunes remain (e.g. Ōreti Beach) and these have a limited ability for landward migration.

A complete sequence of mid and back dune habitat and vegetation not only provides for ecological values such as increased biodiversity, but it also provides a natural buffer against coastal hazards. Environment Southland should prioritise high value sites to minimise further losses and restore areas of back dune habitat where needed (e.g. Three Sisters and Long Beach).

ES should focus effort where remnant back dune habitat remains or there are opportunities for restoring a natural sequence of dune vegetation, e.g. retiring back dune grazing areas.

Photos of Sandy Point at the entrance of New River Estuary highlight the changes in dune habitat across a small area since the 1940’s. The scenario is observed for most dune systems across the Southland and wider New Zealand.

Changes to Sandy Point and Ōreti Beach (west) over time (1947, 1969 and 2020) including development in backdunes and stabilisation of active dunes (source: Retrolens and Google Earth)

## Climate change resilience

Sand dunes provide a natural buffer mitigating the impacts of coastal hazards such as storm surges, winds, waves, coastal flooding, and erosion. Climate change is expected to increase the intensity and frequency these events (MfE, 2017). While dunes provide a buffer against coastal hazards, ongoing sediment loss and reduced progradation (i.e. foredune builds out toward the sea creating a wide dune) particularly in narrow stable dunes (e.g. marram grass dominated dunes) will likely lead to net loss of sand from beaches. Furthermore, the migration of dunes landward in Southland is limited by land use directly adjacent to dunes.

Climate change induced sea level rise is expected to increase sea levels by between 0.65 to 1.85m by 2150 (MfE, 2017). As sea levels rise beaches will retreat forming a new shoreline further inland. Coupled with increased storm events this will lead to more frequent coastal inundation events potentially impacting infrastructure such as coastal roads.

Naturally formed dunes will migrate with sea level rise and self-repair after erosion events. Therefore, it is important to consider restoring wide dune buffers as a potential option to mitigate coastal hazards (Dahm et al. 2005). This is also acknowledged by the Ministry for Environment where the protection and use of natural buffers such as sand dunes is considered as an adaptation option to the impact of increased coastal hazards with climate change (MfE, 2017).

Dahm et al. (2005) highlighted that coastal dune restoration could be used as an adaptive approach to help mitigate the effects of sea level rise in a changing climate, and resultant coastal hazards in addition to being an effective educational tool to raise awareness in the community about the impacts of coastal hazards and climate change.

A local assessment of climate change impacts and mitigation options should include dune restoration and protection.

Erosion events in marram dunes, Southland coast

## 7.5 SUMMARY

Dune management should focus on protecting and enhancing existing areas of native habitat through protection measures (e.g. stock exclusion, pest and weed control, fencing etc) and in fill planting where needed. These areas provide a natural buffer against coastal hazards and are important ecological habitats along the Southlands coast. Reverting areas of dune habitat back to native vegetation in Southland will be expensive and require an ongoing commitment to management for two reasons (1) large areas of back dune habitat have been cleared and converted to farming and (2) marram grass is established across most dunes in Southland.

When planning a dune restoration project it is essential to consider the goal of restoration because if foreshore stabilisation is the main priority, native vegetation may not be suitable for this at all locations.

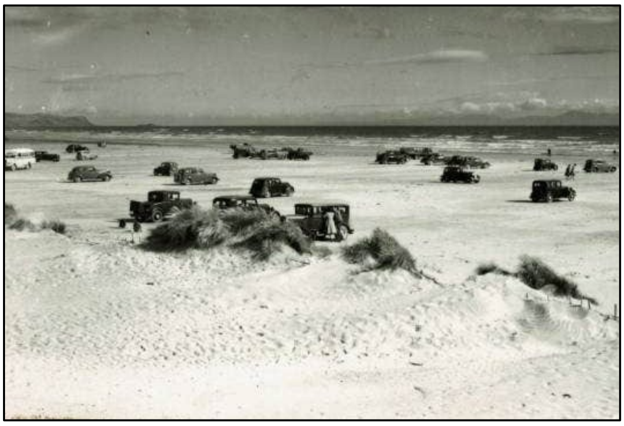
If Environment Southland choose to manage dunes actively through protection and restoration, we strongly recommend the council first prioritises sites based on needs, values, impact and amenity.

The case study to follow is intended as an example of how to implement a dune restoration project to support community education and enhancement of a localised area the case study site has not been selected through a council prioritisation process.

# 8. CASE STUDY – DUNE RESTORATION ŌRETI BEACH

## 8.1 BACKGROUND

Ōreti Beach extends from Sandy Point to Riverton with a narrow sand dune system dominated by an almost homogenous cover of invasive species including introduced marram grass (*Ammophila arenaria* and yellow tree lupin (*Lupinus arboreus*) (McLachlan 2014). The modified back dunes are now largely in pasture and exotic forest (Robertson & Stevens, 2008) with few remaining remnants of unimpacted native back dune vegetation (see photos).



Marram grass planted along a manuka fence tapping sand, Ōreti Beach in the 1940s (source: Esler 2017).

Marram dominated dunes, Ōreti Beach Southland

Eroding sand dunes at the Waimatuku Estuary entrance

Historically the dunes were grazed and, along with rabbits introduced in the mid 1800's, this led to a decrease in native vegetation cover and dune erosion (Robertson & Stevens, 2008; Hilton et al. 2000a). In the mid 1940's marram grass was planted for erosion control at the foredune (see photo below) to protect farmland, leading to relatively immobile dunes (Hilton et al. 2000a; McLachlan 2014; Esler 2017).

## 8.2 CURRENT MANAGEMENT

There is an existing memorandum of understanding (MoU) for the management of Ōreti Beach extending from Sandy Point (south-east) to Taunamau Stream (north-west Waimatuku). The document outlines roles and responsibilities of each of the parties:

- Department of Conservation (DOC)
- Environment Southland
- Invercargill City Council
- Ministry for Primary industries
- New Zealand Police
- Southland District Council
- Waihōpai Rūnaka

The MoU highlights the impact that human activity is having on the beach including disturbance of toheroa beds, sand dunes and littering. The listed parties are responsible for promoting conservation on the sand dunes and enforcing rules within the area (e.g. vehicle access, littering, fishing, RMA obligations etc).

## 8.3 RESTORATION OF DUNES

Dune restoration efforts at Mason Bay, Stewart Island have demonstrated that it is possible to effectively remove marram grass and maintain native species through ongoing maintenance (Konlchner et al. 2014). However, the persistent recurrence of marram is likely after active removal due to the presence of extensive seed banks requiring a clear long-term management vision (McLachlan 2014).

### 8.3.1 Site selection

Hilton (2000b) carried out an assessment for the Department of Conservation of the Kawakaputa Bay and Haldane Bay dune systems in Southland to determine whether marram control and pīngao restoration were an option. The recommendations from that study were to focus on areas of higher value first including Fortrose Spit, Three Sisters, Long Beach, Dummies Beach, Doughboy Bay and Mason Bay before attempting to eradicate marram in other areas across the region.

While such sites may be priorities for restoration based on ecological considerations, Environment Southland directed Salt Ecology to choose a small case study site on Ōreti Beach as a representative example of where the specific restoration goal was focused primarily on community education and enhancement of a localised area.

As marram dunes are well established along the length of Ōreti beach, a small trial site for marram removal was selected on the coastal sand dunes west of the Waimatuku Estuary entrance (Fig. 11). The site was selected based on the following factors:

- The Waimatuku Estuary mouth has migrated from west to east over the past 20 years and dune regrowth in this area is reasonably new (5-10 years), the cover of marram is not complete, and the seed bank is likely less established than other parts of Ōreti Beach.
- The dunes are currently active with visible sand erosion and accretion.
- The site can be accessed by vehicle along the beach.
- Dune recontouring is not necessary.
- The area west of the estuary entrance has minimal vehicle traffic, with the main area of use to the east of the estuary entrance.
- Re-establishing native vegetated dunes in this area will minimise erosion of the beach.

It is noted that the site was selected from a desktop assessment using:

- Aerial imagery (current & historic; Fig. 12)
- SoE monitoring reports

Ideally, a field assessment would also be carried out to check suitability of the site although this was outside the scope of the current report.

### 8.3.2 Planning the project

Section 2 describes in general terms how to set up a project and a community-based group and plan a project. However, for the purposes of this case study the following is provided as an example;

Restoration Goal:

**Fig. 11 Aerial imagery of the Waimatuku Estuary entrance with proposed restoration site.**

- Re-establish native foredune vegetation in the area west of the Waimatuku Estuary entrance.

Restoration Objective:

- Remove exotic species (e.g. marram grass).
- Control browsing species.
- Establish native sand binding pīngao on the foredunes.

- Control weeds and re-incursion of marram grass.

Action:

There are two options for marram eradication:

1. *Mechanical removal:* using earthworks machinery and a skilled operator remove marram grass, restore substrate to loose sand and re-shape the dune. Re-plant within 1-2 weeks of reshaping to minimise windblown sand.
2. *Chemical removal:* initially spray entire area with herbicide (see Table 1). Wait at least 2 months prior to planting to ensure complete dieback of marram grass and dissipation of the herbicide.

For this case study chemical spraying is recommended primarily because the area is not yet covered in high density marram grass, stabilised dunes are not well-formed (meaning re-shaping is not needed) and spraying should be an effective eradication method. Ongoing marram control will be required annually after the initial spraying.

**Start of dune establishment with marram grass growth in sands, Waimatuku Estuary**

At least 2 months after chemical spraying plant pīngao and other foredune species in Autumn or Spring to allow it to establish before summer when temperatures increase. See Appendix 2 for sand dune plant list and planting guidance.

Other actions include:

- Pest control, minimise the impact of browsing animals by using bait stations and traps (more information can be provided by Environment Southlands Biosecurity team).
- Sign and temporarily fence planted area of revegetation to prevent human disturbance.
- Periodically revisit the site removing any weeds or marram grass by hand or by spraying.

Budget:

- Funding will be required for plants, fencing, signage and pest and weed management (e.g. herbicides and personnel) initially in addition to ongoing maintenance costs.
- If expert consultation is required in the site design this may incur additional costs.
- Account for any consenting costs that may be incurred through the process.
- The costs associated with the project will likely require funding support. Funding options are discussed in Section 2.1.3.

### 8.3.3 Getting started

This section describes the general steps to develop a site plan for the restoration project following the guidance in the previous section and Section 2.

*Creating a site plan and baseline data*

1. Carry out a site visit and mark out the target area using a GPS or landmarks.
2. Collect baseline data by taking photos from fixed points and draw the project area on aerial imagery or use more detailed monitoring methods provided in Table 1 and the information panel in Section 1.
3. From the information collected in the site visit identify the work area, draw a site plan and determine works needed (e.g. dune reshaping, number of plants etc).

For the purposes of this case study the area of interest is ~3.5ha, marram eradication will occur over the whole area and planting will take place over a smaller area of ~200m length by 25m width section of foredune habitat (~5000$m^2$).

With the site plan established the cost of marram eradication, planting, pest control and fencing can be determined in addition to seeking appropriate permissions.

*Marram eradication budget*

Chemical removal of marram can occur by helicopter or knapsack. Depending on the density of marram at the site, helicopter spraying over the entire 3.5ha area may be more efficient. Relative costs will need to be determined.

Ongoing annual spraying using a knapsack will be required to minimise marram regrowth. Costs will depend on the area to be sprayed.

*Planting budget*

The planting area at the case study site is ~5000m$^2$. To determine the type and relative proportion of plants the Sand Dune Planting Guide in Appendix 2 was used. The cost and number of plants was calculated using the "planting calculator" on the New Zealand Coastal Restoration Trust website (see Fig. 13). Prices should be included from the local nursery where plants will be sourced.

When planting sand-binders the guidance from the Coastal Restoration Trust is to include a NPK fertiliser pellet with each plant to increase the success of plant establishment and enhance growth. The number and cost of fertiliser pellets can also be included in the "planting calculator" (see Fig. 13).

Order eco-sourced plants well in advance of the planting date (at least 6-12 months) so that they are available as needed at the scheduled time of planting. Guidance on plants and planting is provided in Appendix 2.

If the estimated planting budget exceeds what is available, the planting area can be reduced or planting staggered. For example, plant the key sand binding species (pīngao) first and when funding is available plant remaining species. Planting will not be successful is marram is not eradicated before planting natives.

*Pest control budget*

Once the site is defined, an assessment of the area should be carried out to determine whether animal browsing is likely a significant issue. If browsing is expected, bait stations or traps will need to be deployed on site and routinely monitored. More information can be provided by the Environment Southland Biosecurity team.

*Fencing and signage*

Fencing in foredune habitat is prone to wind and wave erosion and therefore fencing with minimal materials that is relatively low cost is recommended (Bergin et al. 2011). For example, waratah posts and wire or cord would be sufficient temporary fencing for newly planted foredune habitat. The fences can be relocated easily with the movement of the dune front through erosion and accretion processes. The cost of waratah fencing around the designated area of 5000m$^2$ would be ~$500 to $1000 and can easily be constructed by volunteers. Signage can be prepared for the site a low cost ~$100.

The estimated budget does not include paid personnel, project administration, equipment hire or consenting. Table 4 provides a high-level estimate for demonstration purposes only to illustrate the costs associated with a planting project. Pricing should be done at the project planning stage based on up-to-date costs from local suppliers. The estimated budget includes:

- Removal of marram via knapsack spraying over a 3.5ha area, targeting the planting area as priority.
- Planting a 5000m$^2$ area of foredune in pīngao in year 1, followed by other species in year 2 including an allowance of ~10% pīngao replacements in the second year and replacements and plant infilling in year 3.
- Fencing assumes no additional maintenance is required in the proceeding years.
- Pest control is limited to $1000 for illustrative purposes, costs may increase or decrease depending on the extent of the browsing problem in the area.

**Table 4. Estimated cost of a dune planting project.**

| | Year 1 | Year 2 | Year 3 |
|---|---|---|---|
| Marram removal | $5000 | $1500 | $1500 |
| Plants | $50,000 | $10,000 | $5000 |
| Pest Control | $1000 | $1000 | ~$1000 |
| Fencing/ signage | $1000 | - | - |
| **Total** | $57,000 | $12,500 | $7,500 |

Establishment of marram grass starting to trap sand near Waimatuku Estuary

*Estimate of minimum operating costs*

Fig. 12. The area of proposed dune restoration. Area of proposed initial planting highlighted in yellow (~5000m$^2$). Succession planting can occur after the establishment of the foredune plantings.

### 8.3.4 Action on the ground

This section describes the steps to carry out a dune restoration project following the actions in the project plan. This section assumes health and safety protocols have been developed and appropriate permissions sought (e.g. consents, rūnaka, landowners etc).

*Marram eradication*

Seek advice from Environment Southland prior to spraying and ensure spray does not drift into the adjacent Waimatuku Estuary. The Department of Conservation use the herbicides Gallant or Hurricane for spraying marram grass. Prioritise the area of proposed planting, with good coverage of the planting area. Spray northward of the foredune to remove marram across the target project area. Spraying should occur 2-3 months prior to planting following the manufacturers guidelines.

*Planting*

Plant in Autumn or Spring following the guidance in Appendix 2 "Sand dune planting guide".

*Pests*

Install traps or bait stations as per Environment Southland Biosecurity advice.

*Fencing and signage*

Install waratah posts at no greater than 5m intervals with wire or coloured cord in between posts around the newly planted foredune habitat. The temporary fencing can be moved with the migration of the sand dune. Install signage on the fencing.

*Monitor*

Monitor the site after planting as per the methods in Table 1. For example, take photos of the site and record the area planted on aerial imagery and with a GPS, record coverage of marram and pīngao across the project area. More complex monitoring techniques are provided on the Coastal Restoration Trust's Coastal Monitoring Database website.

Routinely monitor fencing, weed and pest control methods (e.g. traps should be checked every 2-4 weeks and fencing condition should be checked particularly after large storm events).

Established dunes in the foreground and developing dunes in the background, Waimatuku Estuary

## Planting Calculator

Area: 5000 $m^2$ | Project/Site: Waimatuku Estuary - west of entrance

### PLANTING

| Species | Proportion | Spacing | No. of plants to use |
|---|---|---|---|
| Ficinia spiralis (pingao) | 80 % | 0.5 m | 18335 |
| Carex pumila (sand sedge) | 5 % | 0.5 m | 1146 |
| Pimelea arenaria (sand daphne) | 5 % | 1.5 m | 127 |
| Calystegia soldanella (shore bindweed) | 10 % | 0.5 m | 2292 |
| | % | m | |
| | % | m | |
| | % | m | |
| | % | m | |
| | % | m | |
| | % | m | |
| Totals | 100 % | | 21900 |

### BUDGETING

| Species | Cost per plant | Total cost of plants | Tablets per plant | Tablet cost (ea) | No. of tablets | Total cost of tablets |
|---|---|---|---|---|---|---|
| Ficinia spiralis (pingao) | $ 2.45 | $ 44920.75 | 2 | $ 0.1 | 36670 | $ 3667.C |
| Carex pumila (sand sedge) | $ 2.30 | $ 2635.80 | 2 | $ 0.1 | 2292 | $ 229.2C |
| Pimelea arenaria (sand daphne) | $ 4.25 | $ 539.75 | 2 | $ 0.1 | 254 | $ 25.40 |
| Calystegia soldanella (shore bindweed) | $ 2.50 | $ 5730.00 | 2 | $ 0.1 | 4584 | $ 458.4C |
| | $ | $ 0.00 | | $ | 0 | $ 0.00 |
| | $ | $ 0.00 | | $ | 0 | $ 0.00 |
| | $ | $ 0.00 | | $ | 0 | $ 0.00 |
| | $ | $ 0.00 | | $ | 0 | $ 0.00 |
| | $ | $ 0.00 | | $ | 0 | $ 0.00 |
| | $ | $ 0.00 | | $ | 0 | $ 0.00 |
| Totals | | $ 53826.30 | | | 4380 | $ 4380.00 |

Total Budget $ 58206.30

Fig. 13. Example of planting calculator available on the New Zealand Coastal Restoration Trust website. Estimated costs to plant the front of the foredune estimated area ~5000$m^2$.

### 8.3.5 Ongoing maintenance

*Marram control*

Annual knapsack spraying will be needed to suppress marram growth particularly in the foredune area and across the wider project area if budget allows.

*Replacement planting*

Plant as per the project plan. Accounting for some plant losses, plant replacements or carry out infill planting to ensure good coverage of plants across the site for at least the first 3 years.

*Evaluate*

Based on the monitoring discussed previously determine whether the project plan needs to be modified (e.g. more frequent marram control, plant survival, reducing pest control as plants become established, etc). Adapt the plan using the information collected from monitoring.

After 12-18 months communicate project progress to the project partners and the community. It is important maintain project momentum by sharing project successes.

### 8.3.6 Summary

Small scale dune restoration projects that are targeted toward community education and enhancement of a localised area, such as the case study presented, are achievable. However, large scale marram eradication and restoration of native vegetation such as in Mason Bay, Stewart Island require a significant ongoing commitment from volunteers and funders and may not necessarily align with community values on mainland Southland.

As discussed previously the council should prioritise sites for dune management including both protection and restoration options. These efforts should first focus on areas of existing high value habitat for example;

- Fortrose Spit
- Three Sisters
- Long Beach
- Dummies Beach
- Kawakaputa Bay
- Haldane Bay
- Tahakopa Beach
- Tautuku Bay
- Waipapa Beach

Konlechner (2016) provides guidance on priorities for sand dune management in Southland.

# 9. SUMMARY

Restoration options, like those discussed above, are generally only considered when the existing environment has been severely degraded or has been previously lost. While options are available to improve degraded habitats (as discussed in this report), the most effective method of restoration remains protection (e.g. manage threats) and enhancement (e.g. infilling planting). This is because it is generally more difficult and expensive to recreate the natural biodiversity of lost habitat than it is to retain it.

# 10. RECOMMENDATIONS

The following recommendations provide some guidance on where Environment Southland should focus restoration efforts:

- Assess the feasibility and potential impact of small-scale nuisance macroalgal harvesting for mitigation of localised problems.
- Explore options for commercial macroalgal harvesting for larger-scale long-term benefits.
- Implement more active management to retain high value coastal habitats, including salt marsh and dunes.
- Focus on identifying vulnerable areas of existing high value habitat using desktop approaches like GIS inundation mapping, aerial photography, and existing knowledge. Prioritise protecting and enhancing existing sites ahead of attempting to create new habitat areas.
- Undertake relatively small-scale restorations where the major causes of degradation can be directly addressed e.g. vehicle damage, and where there are clear benefits from community engagement and education.
- Plan and undertake or facilitate more ambitious restoration which will result in long-term ecological gains e.g. reconnecting tidal flows to previous estuary areas likely to be inundated under predicted sea level rise scenarios.

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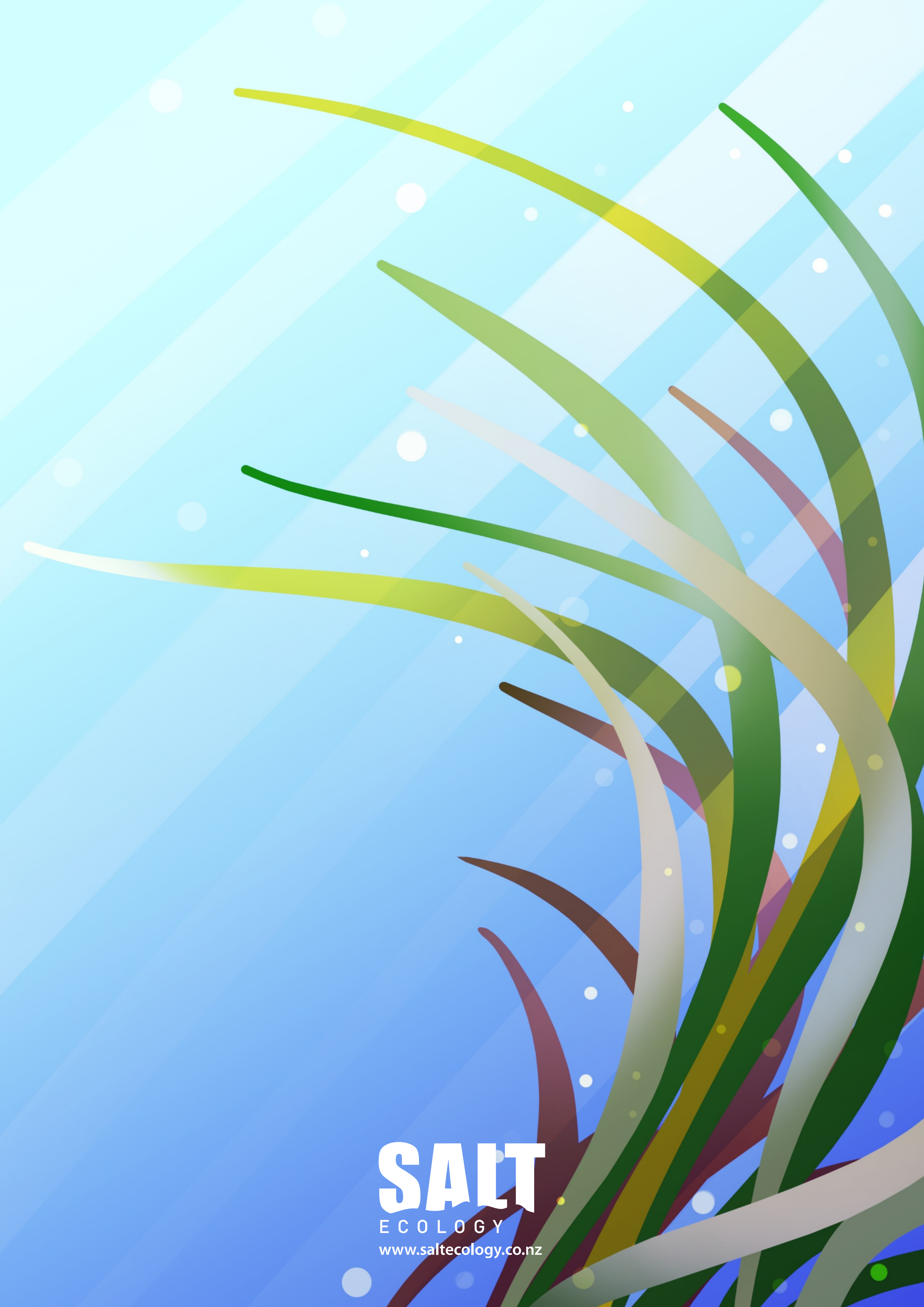
# APPENDICES

Appendix 1. Salt marsh Southland Planting Guide

Appendix 2 Sand dune Southland Planting Guide



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