Ecological impacts of sea couch and saltwater paspalum in Bay of Plenty estuaries

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W.B. Shaw and R.B. Allen

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W.B. Shaw[1] and R.B. Allen[2]

[1] Wildland Consultants Ltd, P.O. Box 7137, Te Ngae, Rotorua, New Zealand
[2] Wildland Consultants Ltd, 764 Cumberland Street, Dunedin, New Zealand

ABSTRACT

The ecological impacts of sea couch (*Elytrigia pycnantha*) and saltwater paspalum (*Paspalum vaginatum*) on the marine ecosystems and wildlife habitats of harbours in the Bay of Plenty region of New Zealand are described. These are among several salt-tolerant grass species that have been introduced to New Zealand and have naturalised in coastal environments, some such as cord grasses (*Spartina* spp.), marram (*Ammophila arenaria*) and Mercer grass (*P. distichum*) becoming weeds, whereas others have not. Sea couch is widespread in the Bay of Plenty and likely to form dense swards on sand dunes, especially where marram is not predominant, and at the landward edges of salt marshes, where it has potential to have serious detrimental effects on the structure and function of the saltmarsh ecosystem. Because sea couch is widely established at numerous sites, there is little or no justification for its control in Bay of Plenty estuaries. Saltwater paspalum, which is near its southern distribution limit in the Bay of Plenty, has ecological effects similar to cord grasses in New Zealand estuaries, although on a much smaller scale: it alters the composition of the indigenous vegetation, reduces habitat for shorebirds and fish, and changes sediment accumulation and estuarine hydrology. There is a substantial amount of information about the control of cord grass in New Zealand estuaries, and it is probably applicable to saltwater paspalum in this environment. For both sea couch and saltwater paspalum, mechanical control, including grazing, is not an option, as plants will resprout from fragments, there is a high risk of spreading them from such fragments, and other components of the ecosystem might be damaged. It is recommended that, before control is reconsidered, some permanent plots be established to monitor vegetation development at sites where these species are dominant.

Keywords: sea couch, *Elytrigia pycnantha*, saltwater paspalum, *Paspalum vaginatum*, weed ecology, weed control, estuaries, Bay of Plenty, New Zealand.

1. Introduction

Several salt-tolerant grass species have been deliberately introduced to New Zealand for agricultural, recreational (e.g. lawns, sports turf), or other uses (e.g. sand stabilisation), and others have arrived accidentally. They have naturalised in coastal environments with varying degrees of detrimental effect on the structure and function of the indigenous ecosystems. Two such grasses are sea couch (*Elytrigia pycnantha*) and saltwater paspalum (*Paspalum vaginatum*).

This project was to report on the ecological impacts of sea couch and saltwater paspalum on the marine ecosystems and wildlife habitats of harbours in the Bay of Plenty region of New Zealand. It includes information on the ecology of these species and their distribution in New Zealand and, in particular, the Bay of Plenty, the impacts of other invasive grasses, recommendations on whether or not sea couch and saltwater paspalum should be treated as threatening ecological weeds, and control programmes that could be undertaken by the Department of Conservation (DOC).

2. Sea couch: background information

2.1 TAXONOMY OF SEA COUCH

The common name sea couch has been applied to several botanical entities, and their taxonomy seems to be variable. For example, a Dutch botanical website (www.nioo.knaw.nl/cemo/isled/speciesn.htm) lists the synonyms *Elymus pungens*, *Agropyron pungens*, *Elytrigia atherica*, *Elymus pycnanthus*, *Agropyron littorale* and *Elymus athericus* for sea couch. Two British Sites of Special Scientific Interest (SSSI) on the Dee Estuary note the presence of sea couch as *Elytrigia atherica* and *Agropyron pungens*, respectively (see the website for the Wirral Council: www.wirral.gov.uk/er/deesssi.htm, and www.wirral.gov.uk.er/RedSSSi.htm). Weiller et al. (1995) refer to sea couch in Victoria, Australia, as *Elytrigia pungens* subsp. *pungens*.

Edgar & Connor (2000) use the scientific name *Elytrigia pycnantha* for sea couch in New Zealand.

2.2 DISTRIBUTION IN NEW ZEALAND

Sea couch occupies waste land on the foreshore, stable sand behind beaches, and intertidal mud flats. It has been recorded in North Auckland, the Bay of Plenty, Gisborne, Hawke's Bay, and near Wellington, with one South Island record at Christchurch (Edgar & Connor 2000).

2.3 ECOLOGY OF SEA COUCH

Sea couch is a rhizomatous perennial grass that occurs naturally along the coasts of the British Isles and western and southern Europe (Hubbard 1984), and that has been introduced to north-eastern America, Australia, and New Zealand. In its natural range it is found at the landward margins of salt marshes and brackish creeks, in sandy or gravelly muds, and on shingle and consolidated sand dunes, often over large areas. In the Netherlands it is a common successor to marram (*Ammophila arenaria*) on sand dunes (www.fgillings.freeserve.co.uk/marram.html), and in Victoria, Australia, it forms dense patches on low sand dunes, in marshes, and at lake margins (Weiller et al. 1995).

In New Zealand sea couch is recognised as a problem in some places because it reduces the area of habitat suitable for estuarine birds (Owen 1993, 1994).

3. Saltwater paspalum: background information

3.1 TAXONOMY OF SALTWATER PASPALUM

Saltwater paspalum is classified as *Paspalum vaginatum*. It is superficially similar in appearance to Mercer grass (*Paspalum distichum*), which is, however, distinguished by its soft leaf blade, and its intolerance of saline soil conditions (Edgar & Connor 2000). Graeme & Kendal (unpubl. 2001) note that there are morphological similarities between saltwater paspalum and the two native grasses *Zoysia minima* and *Z. pauciflora*, which are also found in coastal situations, though others consider them to be quite distinctive (S.M. Beadel pers. comm.).

3.2 DISTRIBUTION IN NEW ZEALAND

Edgar & Connor (2000) record the New Zealand distribution of saltwater paspalum as in coastal, often brackish, environments of North and South Auckland and Gisborne. Graeme & Kendal (unpubl. 2001) cite records from the Coromandel Peninsula, northern Waikato, and outlying islands, but confirm that it is mostly confined to subtropical latitudes. It is also known from the Kawhia Harbour (S.M. Beadel pers. comm.).

3.3 ECOLOGY OF SALTWATER PASPALUM

Saltwater paspalum is a stoloniferous grass native to tropical and subtropical North and South America, and possibly Europe. It has been introduced to South Africa, Australia, Hawaii and several other Pacific islands, and New Zealand, primarily as a turf grass for coastal golf courses.

In New Zealand, it forms swards near the edge of mud flats or on sandy and shingly shores, occasionally spreading into nearby pasture (Edgar and Connor 2000). Graeme & Kendal (unpubl. 2001) note that it is semi-aquatic, growing as dense swards on open mudflats and along creek banks above the mid-tide level, and as a spreading mat over mud, shingle, and sand, or amongst boulders, in the salt spray zone near the high tide mark. It is able to establish in coastal vegetation including mangroves, shrubland, and salt marsh, and on dunes with spinifex (*Spinifex sericeus*) and pingao (*Desmoschoenus spiralis*). However, it is unlikely to survive competition from other plant species out of a saline environment.

4. Indigenous coastal grasses

The indigenous herbaceous floras of coastal dune and estuarine ecosystems in New Zealand are dominated by small dicotyledonous herbaceous plants and monocotyledonous plants of the rush (Juncaceae), sedge (Cyperaceae), and restiad (Restionaceae) families.

Very few indigenous grass species are adapted to withstand a particularly saline environment: spinifex, which is now restricted to the northern South Island and the North Island, where it can be the sole sand binding plant of foredunes; sand tussock (*Austrofestuca littoralis*), which is scattered throughout New Zealand on sand dunes, but is rare in places; sand wind grass (*Lachnagrostis billardierei)*, which found throughout the North Island and in the northern South Island on coastal cliffs, sandy flats, and dunes; and the salt grasses *Puccinellia stricta* and *P. walkeri*, which are both salt marsh inhabitants, the latter of quite restricted distribution (Edgar & Connor 2000).

Edgar & Connor (2000) list other indigenous grass species that are found in coastal dune or estuarine environments, but that have more restricted distributions. These are *Austrostipa stipoides* (coastal rocks and mudflats, Bay of Plenty and Taranaki northwards, Wellington, Nelson), *Lachnagrostis ammobia* (coastal damp sand and wetlands, Fiordland, Catlins to Bluff), *L. littoralis* ssp. *salaria* (salt meadow, east coast from north Canterbury to Bluff, Stewart Island), *L. tenuis* (salt marsh and tidal ground on the coast near Christchurch, from the Otago Peninsula to Bluff, and on Stewart Island), and *Cortaderia splendens* (sand hills, rocks, and cliffs, North Cape to Marakopa-Opotiki, Three Kings, eastern offshore islands).

Swamp millet (*Isachne globosa*) is most common in the northern half of the North Island, where it grows as a semi-aquatic plant of coastal lowland swamps

and lake margins (Johnson & Brook 1989, Edgar & Connor 2000). It occurs in freshwater wetlands only, but is often found in freshwater sites on the margins of estuaries or coastal inlets.

There is a general paucity of vigorous, fast-growing, rhizomatous or stoloniferous herbaceous plants in the indigenous flora of these saline coastal ecosystems, so a 'functional gap' exists that can be filled readily by introduced salt-tolerant grasses such as sea couch and saltwater paspalum.

5. Other introduced weed grasses of coastal environments

Sea couch and saltwater paspalum are two of several grasses that can naturalise in and cause detriment to ecosystems near the coast in New Zealand. Surveys of the distribution of these two species could usefully note the presence of other potential weed species, with a view to future monitoring and control.

Cord grasses

Cord grass, *Spartina anglica* and *Spartina* × *townsendii*, and smooth cord grass, *Spartina alterniflora*, are historically the most prominent and problematic invasive species. Introduced as a tool primarily for reclaiming land from estuaries, cord grasses have invaded the intertidal zone of several estuaries throughout New Zealand (Partridge 1987), acting as a silt trap to build up the substrate level with a consequent loss of intertidal habitat.

Cord grasses have been the subject of much research (e.g. Bascand 1968, 1970; Hubbard & Partridge 1981; Lee & Partridge 1983; Partridge 1987; Turner & Hewitt 1997; Shaw 1999) and control efforts have been directed at many infestations. They have been eradicated from Ohiwa Harbour (Shaw & Gosling 1997), although a new infestation has been found on the eastern side of the harbour and ongoing monitoring of the original infestation site has detected some regrowth (which has been treated with herbicide and removed).

Marram grass

Marram grass (*Ammophila arenaria*) is the dominant plant on sand dunes around most of New Zealand's coast, where it has almost completely replaced the indigenous spinifex and pingao. It grows on mobile dunes, but does not survive long after the sand surface is stabilised, when it gives way to other plants such as the introduced tree lupin (*Lupinus arboreus*). Marram grass has been the subject of control efforts in several locations where the re-establishment of pingao is being attempted or it is a major competitor with pingao (cf. Owen 1998).

Manchurian wild rice

Growing as dense clumps up to 3 m tall, Manchurian wild rice (*Zizania latifolia*) invades waterways and displaces native wetland vegetation such as raupo reedland. It has been recorded from lagoons, river banks, tidal flats, roadside ditches, and damp paddocks, mainly in the northern North Island, but also at Waikanae, near Wellington (Edgar & Connor 2000).

Reed

Reed (*Phragmites australis*) grows as extensive clumps 3 m or more tall. It has been recorded in drains and adjacent ground throughout New Zealand, and is locally troublesome in areas such as Napier, Murchison, and Christchurch (Johnson & Brook 1989).

Sweetgrass

Reed sweetgrass (*Glyceria maxima*) and floating sweetgrass (*G. fluitans*) are found throughout New Zealand, at the silty margins of pools, ponds, and lowland lakes, and in slow rivers and drains. Glaucous sweetgrass (*G. declinata*) is widespread in a broad range of wet muddy habitats. Plicate sweetgrass (*G. plicata*) is widespread but scattered, at river and pond margins (Johnson & Brook 1989).

Mercer grass

Mercer grass (*Paspalum distichum*) is locally common in the North Island, and scattered southwards to Nelson and Lincoln. It is found in wet ground and at the margins of water bodies (Johnson & Brook 1989), and can form swards that exclude indigenous species.

Barley grass

Salt barley grass (*Critesion marinum*) has been recorded in Marlborough and Canterbury on low-lying moist coastal flats. Mediterranean barley grass (*C. hystrix*) occupies similar habitat but is more widespread, in South Auckland, Hawke's Bay, Wellington, Marlborough, Canterbury, Otago and Southland (Edgar & Connor 2000).

Foxtails

Orange foxtail (*Alopecurus aequalis*) has been recorded at Pukekohe and near Gisborne in coastal swampy ground (Edgar & Connor 2000). Marsh or kneed foxtail (*A. geniculatus*) is found throughout New Zealand in wet muds or gravels at the margins of water bodies including brackish lagoons. Meadow foxtail (*A. pratensis*) also occurs throughout, but is more common in the north, in moist pasture, beside drains, and at swamp margins.

Beard grass

Beard grass (*Polypogon monspeliensis*) has been recorded throughout New Zealand, mainly in coastal situations on the damp margins of salt marshes,

lagoons, and estuaries, and in brackish pasture (Johnson & Brook 1989). It is present in Ohiwa Harbour (Owen 1998).

Creeping bent

Creeping bent (*Agrostis stolonifera*) is widespread throughout New Zealand, fringing salt marshes, estuaries, and damp coastal banks (Johnson & Brook 1989). It is common on estuarine margins in the Bay of Plenty.

Salt grasses

Salt grass (*Puccinellia fasciculata*) has been recorded on mud flats and salt marshes at Gisborne and Wairoa, and scattered from Christchurch to Invercargill at the salty or brackish margins of coastal lagoons and estuaries (Johnson & Brook 1989; Edgar & Connor 2000). Reflexed salt grass (*P. distans*) is found in salt marshes at Auckland, in Ohiwa Harbour, at Porangahau, around Nelson, in north Canterbury, at Banks Peninsula, and near Dunedin (Edgar & Connor 2000).

Sickle grasses

Parapholis incurva is a small annual grass of sand dunes, saline flats, the margins of coastal swamps, salt marshes, and coastal banks, from Auckland to Otago ((Johnson & Brook 1989; Edgar & Connor 2000). *Paraopholis strigosa* is found in salt marshes and mud flats around North Auckland and on the eastern Coromandel Peninsula (Edgar & Connor 2000).

Pyp grass

Pyp grass (*Ehrharta villosa*) is a South African rhizomatous grass that is established on sand dunes at Wanganui and in Hawke's Bay (Edgar & Connor 2000). Originally planted as a sand binder, it has been reported to show a tendency to increase. Its close relatives *E. calycina* and velt grass (*E. erecta*) are also naturalised. The former is found on Auckland, Manawatu and Wairarapa dunes, and the latter is abundant and spreading rapidly on sandy areas throughout Auckland province, Taranaki, Wellington province, Abel Tasman National Park, and the Canterbury coast (Edgar & Connor 2000).

Kikuyu grass

Kikuyu grass (*Pennisetum clandestinum*) is a stoloniferous and rhizomatous perennial that occupies coastal sandy or rocky foreshore in much of the North Island, the Marlborough Sounds, Nelson, Westland, and Canterbury. It forms a dense sward that excludes other plant species, is shade tolerant, and is difficult to eradicate (Edgar & Connor 2000). It is common on estuarine margins throughout the Bay of Plenty.

6. Introduced non-weed grasses

Other introduced grasses can establish on coastal sands and mudflats, but have not become weeds (Edgar & Connor 2000).

- Harestail (*Lagurus ovatus*), annual, throughout, commonly found on sand dunes
- Large quaking grass (*Briza maxima*), annual, scattered in NI, Nelson, Christchurch, Westland, Dunedin. Coastal roadsides and sandy/shingly waste ground.
- Shivery grass (*B. minor*), annual, scattered throughout, sandhills and swamp margins.
- Hard grass (*Catapodium rigidum*), annual, scattered on east coast of North and South Islands, sandy/gravelly beaches.
- Barb grass (*Hainardia cylindrica*), annual, salt flats, Auckland city, near Kawhia, Tauranga, north Canterbury, Banks Peninsula.
- Perennial beard grass (× *Agropogon littoralis*), salt flats and damp sandy or silty ground near coast. Hybrid between *Polypogon monspeliensis* and *Agrostis stolonifera*. Buller, Canterbury.
- Lyme grass (*Leymus arenarius*), perennial tufts, sand dunes on central Canterbury coast. Siberian lyme grass *L. racemosus*, sand dunes on central Canterbury coast and at Bluff.
- Sand couch (*Thinopyrum junceiforme* = *Agropyron junceum*), rhizomatous, forms colonies on sand dunes and sandy ground, North Canterbury to Christchurch.
- Rhodes grass (*Chloris gayana*), perennial, Auckland province, scattered, behind dunes in grassy flats.
- Indian doab (*Cynodon dactylon*), mat-forming rhizomatous and stoloniferous perennial, throughout North Island and to mid-South Island, coastal, often between dunes.
- Japanese millet (*Echinochloa esculenta*), scattered throughout North Island, Nelson, Blenheim, Christchurch, coastal sands.
- Chinese pennisetum (*Pennisetum alopecuroides*), limited distribution near Warkworth, lower Wanganui River, Nelson, Marlborough, coastal sand, wet ground.

7. Ecological impacts of sea couch and saltwater paspalum in New Zealand

7.1 SEA COUCH

Little appears to have been documented of the potential or actual ecological impact of sea couch in New Zealand. However, given its ability to form dense swards both in the northern temperate countries of its natural range and in Australian coastal situations (Weiller et al. 1995), it is likely to be able to do the same on New Zealand sand dunes, especially where marram is not predominant, and at the landward edges of salt marshes. Beadel (unpubl. 1993) and Owen (1994) recorded sea couch at Ohiwa Harbour on sand dunes, in saltmarsh, on estuary margins, and on tidal river margins. In the saltmarsh environment, especially, there is potential for sea couch to have serious detrimental effects on the structure and function of the saltmarsh ecosystem. These range from sediment accumulation and displacement of the indigenous flora to destruction of roosting and feeding grounds of shore birds. Owen (1994) notes the concern in DOC about the effects of sea couch in Ohiwa Harbour, and recorded it at 27 (64%) of marshbird sites. He also noted that the species 'is tolerant to estuarine environments, providing the site is predominantly sand or is subject to salt spray influences'.

7.2 SALTWATER PASPALUM

A review of the impacts of saltwater paspalum by Graeme & Kendal (2001) noted that it has ecological effects similar to cord grasses (*Spartina* spp.) in New Zealand estuaries: it changes the composition and structure of indigenous vegetation, excludes burrowing fauna, reduces access to feeding and roosting sites of shore birds, alters fish spawning and feeding grounds, and changes estuarine hydrology by accumulating sediment. Graeme & Kendal (2001) also pointed out that saltwater paspalum can grow amongst mangroves, in rushland, in salt meadow, and in upper salt marsh shrubland communities, and has the potential to overtop and displace lower-statured vegetation here.

8. Status of sea couch and saltwater paspalum in the Bay of Plenty

8.1 SEA COUCH

Ohiwa

Sea couch has been recorded widely and is particularly abundant on the margins of Ohiwa Harbour.

Daniel (1984) listed sea couch (as *Agropyron pungens*) as one of a suite of dominant species in manuka communities on the harbour margins, in vegetation gradations above salt marsh. He also noted that it is 'common' in the high-tide salt meadow zone. Clarkson & Regnier (1989) recorded 'dense swards of sea couch' in pohutukawa/manuka–olearia–marsh ribbonwood scrub in the Motuotu Island Nature Reserve. They also recorded it in sea rush–oioi–sea couch–three-square sedge–rushland in the Pataua Island Scientific Reserve, where it was common at or above mean high water.

Beadel (unpubl. 1992) mapped the vegetation of the harbour and its margins in 1992 and found sea couch to be a dominant component in some marginal sand dune vegetation types (e.g. sea couch–*Muehlenbeckia complexa* grassland, sea couch–lupin–blackberry–bracken–*M. complexa*–Yorkshire fog grassland), and very common in narrow strips of estuary margin vegetation. These sites tend to contain mixtures of indigenous and exotic species. Scrutiny of Beadel's 1992 vegetation map for Ohiwa revealed that sea couch may be present at c. 130 sites (or more) on the harbour margins.

The sites where it is present have often been disturbed by grazing or drainage (Beadel unpubl. 1992). It does, however, also occur in estuarine sedgeland, tussockland, and shrubland; in the following vegetation types mapped by Beadel (unpubl. 1992): *Stipa* (= *Austrostipa*) *stipoides/Selliera radicans*–sea couch tussockland, and sea rush–*Baumea juncea*–sea couch–oioi grass–sedge–tussockland. At Ohiwa, sea couch also establishes on recently deposited sandy substrates at about high-tide level, where it may be the first species to establish on new substrates. On these sites it provides relatively open cover, which would trap further sediment and also enhance opportunities for the establishment of a range of species.

Little Waihi Estuary

Sea couch has been recorded in Little Waihi Estuary, in the following vegetation types mapped by Beadel (unpubl. 1991): marsh ribbonwood shrubland; oioi–sea rush sedgeland; marsh ribbonwood/sea couch–sea rush–*Baumea juncea*–oioi sedgeland. Owen (1994) noted that it was a 'major coloniser' of similar habitats to those in Ohiwa Harbour.

Waiotahi Estuary

Clarkson & Regnier (1989) recorded sea couch as a prominent component of bracken–sea couch–ripgut brome fern–grassland on the Waiotahi Spit, immediately adjacent to the Waiotahi Estuary.

Tauranga

There is only limited information recorded on sea couch in Tauranga, where it is known to occur in scattered locations, e.g. the Jess Road inlet (Beadel unpubl. 1996; S.M. Beadel pers. comm.).

8.2 SALTWATER PASPALUM

Graeme & Kendal (2001) listed a herbarium specimen of saltwater paspalum from Tauranga Harbour (Waikareao Estuary salt marsh; WELT SP016003; 1920). They also cited recent collections from the eastern side of the Coromandel Peninsula. Saltwater paspalum requires a subtropical environment, and the Bay of Plenty lies near its present southern distribution limit, apart from an anomalous record from Kapiti Island. However, with climate warming, Bay of Plenty estuaries will become increasingly suitable habitat. Saltwater paspalum has the potential to become a serious weed in this environment.

Beadel (unpubl. 1994a) recorded saltwater paspalum in the Waimapu Estuary, and also in the Waikareao Estuary (Beadel unpubl. 1994b). Saltwater paspalum is also known to be present at the following sites in Tauranga Harbour (S.M. Beadel pers. comm.): Te Maunga Estuary; northern side of Wairoa River; on an island in Wairoa River; Matakana Island (Bowentown end – Wetland 2 in Beadel 1990); Tuapiro Spit; and also at Rangataua Bay (P. Cashmore pers. comm.).

9. Control of sea couch in the Bay of Plenty

9.1 JUSTIFICATION FOR CONTROL

There is little or no justification for the control of sea couch in Bay of Plenty estuaries. The species is widely established at numerous sites, and is an integral part of many variable vegetation types on dunelands, in saltmarsh, and on harbour margins. Effective control would be a huge task, even in selected sites.

9.2 MONITORING

It would be useful to establish permanent vegetation plots at a selection of sites where sea couch is prominent, to monitor vegetation development and succession over time.

9.3 CONTROL METHODS

There are no documented accounts of control of sea couch in New Zealand, though it is likely to be relatively easy to control on a local basis using grass-selective herbicides.

Mechanical control, including grazing, is not an option, as plants will resprout from fragments of rhizomes, and there is a high risk of spreading fragments carried on machinery, by stock, or by water. There is also the likelihood of unacceptable levels of damage to fragile habitats by grazing or the use of machinery.

10. Control of saltwater paspalum in the Bay of Plenty

10.1 JUSTIFICATION FOR CONTROL

Before any control programme can be considered, it is essential to determine the distribution of saltwater paspalum by surveying all suitable habitat. The potential sources of infestations should also be located, e.g. coastal golf courses and roadsides. All infestations should be mapped and located by GPS.

10.2 MONITORING

A regular, preferably annual, monitoring programme should be established, both to record changes in the distribution of the plants and to assess the effects of any control programmes undertaken.

10.3 CONTROL METHODS

Graeme & Kendal (2001) noted that there has been no documented control of saltwater paspalum in New Zealand.

Mechanical control, including grazing, is not an option: plants will resprout from fragments of stolons, and there is a high risk of spreading them from plant fragments carried on machinery, by stock, or by water. Moreover, their habitat is fragile, and the use of machinery is likely to have detrimental effects on other components of the ecosystem.

Haloxyfop and clethodim have been tested for control of Mercer grass (*Paspalum distichum*), a relative of saltwater paspalum, but caused damage to non-target indigenous plants, including species of *Carex*, C*rassula*, *Isolepis*, *Juncus*, and *Plantago* (Champion 1998).

There is a substantial amount of information about the control of cord grass (*Spartina* spp.) in New Zealand estuaries, and it is probably applicable to saltwater paspalum (and sea couch) in this environment. For example, Shaw & Gosling (1997) recorded the successful and selective elimination of *Spartina alterniflora* from part of Ohiwa Harbour by the use of Gallant (haloxyfop) herbicide, but noted that shellfish can accumulate this chemical in the short term.

11. Conclusions

Both saltwater paspalum and sea couch are strongly invasive exotic species in estuarine and estuarine margin environments. Both species are early colonisers of fresh or bare surfaces and, once established, can exclude indigenous species for many years. There is a good case to establish some permanent vegetation plots to monitor vegetation development at sites where these species are dominant. The justification for control should be reconsidered, subject to results of monitoring of vegetation development and plant succession, say in five years' time. In the meantime these species, particularly sea couch, are so widespread in the Bay of Plenty that control is not feasible except at selected sites.

There is also a need for field trials of chemical control methods for sea couch and saltwater paspalum, including assessments of effects on other estuarine organisms.

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