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New River Estuary

Macroalgal Monitoring 2012/13

Prepared for

Environment Southland

July 2013

Cover Photo: *Gracilaria* and excessive soft mud deposition on intertidal flats in the Waihopai Arm.

Extensive growths of *Ulva (Enteromorpha)* and *Gracilaria* on intertidal flats near the Oreti River mouth.

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By

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Rotting *Gracilaria* and sulphide rich sediment in the Waihopai Arm.

1. INTRODUCTION AND METHODS

INTRODUCTION

Macroalgae is an important feature of estuaries, contributing to their high productivity and biodiversity. However, when high nutrient inputs combine with suitable growing conditions, nuisance blooms of rapidly growing algae e.g. *Ulva* (sea lettuce), *Gracilaria*, can occur. At nuisance levels such growths can deprive seagrass of light causing its eventual decline, while decaying macroalgae can accumulate on shorelines causing localised depletion of sediment oxygen, and nuisance odours. When high macroalgal cover coincides with soft muddy sediments, conditions for animal life in the sediments are generally very poor due to toxic sulphides, elevated nutrients, and depleted oxygen.

For short residence time estuaries like New River, highly eutrophic conditions only occur when sediments from large areas of the estuary exhibit all of the following symptoms; high macroalgal growth (>50% cover), are soft and muddy, have a shallow RPD, elevated nutrient and TOC concentrations, and very high invertebrate organic enrichment tolerance ratings [fine scale indicators].

This brief report summarises the sixth year of annual macroalgal monitoring in the New River Estuary, one of the key estuaries in the Environment Southland's long term estuary monitoring programme. The report describes intertidal macroalgal cover - a key broad scale indicator of estuary eutrophication - using macroalgal condition ratings developed for Southland's estuaries to rate the condition of the estuary, and recommend monitoring and management actions. Fine scale indicators of eutrophication (grain size, RPD boundary, sediment organic matter, nitrogen and phosphorus concentrations, and the community structure of certain sediment-dwelling animals) are reported in Robertson and Stevens (2010, 2011, 2012, 2013).

METHODS

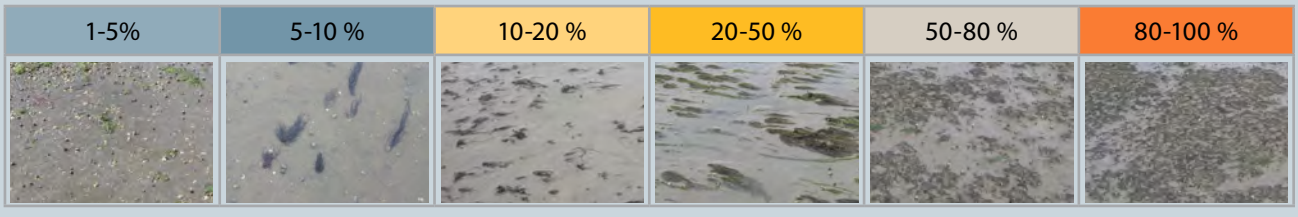
Broad scale mapping of the percentage cover of macroalgae throughout all the intertidal habitat of New River Estuary was undertaken in February 2013 using a combination of aerial photography, ground-truthing, and ArcMap 9.3 GIS-based digital mapping. The procedure, originally described for use in NZ estuaries by Robertson et al. (2002), has subsequently been modified and successfully applied to various estuaries to develop a separate GIS macroalgal layer (e.g. Stevens and Robertson 2008, 2010, 2012).

Rectified aerial photographs of the estuary (2011 Invercargill City Council ~10cm/pixel images supplied by ES) were used as base maps. Experienced coastal scientists then recorded the percentage cover of macroalgae directly onto laminated photos during field assessment of macroalgal cover. The field maps were then used to create a GIS layer from which the percentage cover information was subsequently calculated.

When present, macroalgae was mapped spatially using a 7 category percent cover rating scale (see Figure 1) to describe density.

The report outputs are used to both identify and classify macroalgal cover, and to show changes in macroalgal cover over time by comparisons with previous surveys (annually if a problem estuary, or 5 yearly if not). The current report presents the 2013 percentage cover of macroalgae within the estuary as a GIS-based map (Figure 4), and a summary table of the dominant species and percentage cover classes (Table 1). Changes with previous surveys are summarised in Table 2.

Figure 1. Visual rating scale for percentage cover estimates of macroalgae.



1. Introduction and Methods (Cont.)

CONDITION RATINGS

A series of interim fine scale estuary "condition ratings" have been proposed based on ratings developed for Southland's estuaries (e.g. Robertson & Stevens 2006) and subsequent extensions (e.g. Stevens and Robertson 2013). They are based on a review of NZ estuary monitoring data, guideline criteria, and expert opinion, and are designed to be used in combination with each other, and other important condition indices (particularly mud), when evaluating overall estuary condition and deciding on appropriate management.

Macroalgal ratings (see below) have been developed for both low and high density macroalgal cover, and temporal change. An "early warning trigger" highlights rapid or unexpected change, and each rating has a recommended monitoring and management response. In most cases initial management is to further assess an issue and consider what response actions may be appropriate (e.g. develop an Evaluation and Response Plan - ERP).

LOW DENSITY MACROALGAL COVER

A two part macroalgae condition rating has been developed: 1. for low density (<50%) macroalgal cover throughout the estuary, and 2. a warning indicator for hotspots of high density (>50%) cover (see following rating). Low density macroalgal condition is rated using a continuous index (the macroalgae coefficient - MC) based on the percentage cover of macroalgae in defined categories in the estuary where cover is <50%. The equation used is: ***MC=((0 x %macroalgal cover <1%)+(0.5 x %cover 1-5%)+(1.5 x %cover 5-10%)+(4.5 x %cover 10-20%)+(7.5 x %cover 20-50%))/100.***

LOW DENSITY MACROALGAL COVER CONDITION RATING

CONDITION RATING	DEFINITION	MC	RECOMMENDED RESPONSE
Very Low	Very Low	0.0 - 0.2	Monitor at 5 year intervals after baseline established
Low	Low	0.2 - 0.8	Monitor at 5 year intervals after baseline established
	Low Low-Moderate	0.8 - 1.5	Monitor at 5 year intervals after baseline established
Moderate	Low-Moderate	1.5 - 2.2	Monitor yearly. Initiate ERP
	Moderate	2.2 - 4.5	Monitor yearly. Initiate ERP
High	High	4.5 - 7.0	Monitor yearly. Initiate ERP
	Very High	>7.0	Monitor yearly. Initiate ERP
Early Warning Trigger	Trend of increasing Macroalgae Coefficient		Initiate ERP (Evaluation and Response Plan)

HIGH DENSITY MACROALGAL COVER

The high density macroalgae condition rating targets areas of high density growth and is applied to the percentage of the estuary where the cover of intertidal macroalgal exceeds 50%. While this may not necessarily be combined with the presence of nuisance conditions, dense growths are an early warning of the estuary potentially exceeding its assimilative capacity and developing gross eutrophic conditions. A trend of an increasing dense macroalgal cover, or an increasing Macroalgal Coefficient for low density cover, provides an "early warning trigger" for initiating management action.

HIGH DENSITY MACROALGAL COVER CONDITION RATING

CONDITION RATING	>50% MACROALGAL COVER OVER:	RECOMMENDED RESPONSE
Very Low	<1% of estuary	Monitor at 5 year intervals after baseline established
Low	1-5% of estuary	Post baseline, monitor 5 yearly. Initiate ERP
Moderate	6-10% of estuary	Monitor yearly. Initiate Evaluation & Response Plan
High	11-30% of estuary	Monitor yearly. Initiate Evaluation & Response Plan
Very High	>30% of estuary	Monitor yearly. Initiate Evaluation & Response Plan

HIGH DENSITY MACROALGAL COVER (CHANGE IN AREA)

Increases in the area of dense macroalgal cover indicate changes in catchment land use management are likely to be needed. Because extensive cover of dense macroalgae is commonly associated with gross eutrophic conditions that can be very difficult to reverse, even relatively small changes from baseline conditions should be evaluated as a priority.

HIGH DENSITY MACROALGAE AREA CHANGE RATING

CHANGE RATING	DEFINITION	RECOMMENDED RESPONSE
No increase	Area of cover (ha) not increasing, or is decreasing	Monitor at 5 year intervals after baseline established
Small Increase	Increase in area of cover (ha) <5% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Moderate Increase	Increase in area of cover (ha) 5-15% from baseline	Post baseline, monitor annually. Initiate ERP
Large Increase	Increase in area of cover (ha) 16-50% from baseline	Post baseline, monitor annually. Initiate ERP
Very Large Increase	Increase in area of cover (ha) >50% from baseline	Post baseline, monitor annually. Initiate ERP

2. RESULTS AND DISCUSSION

Table 1. Summary of macroalgal cover results, New River Estuary, February 2013.

Percentage Cover	Ha	%	Dominant species
<1%	957	32.1	-
1-5%	898	30.1	*Gracilaria, Ulva lactuca, Ulva intestinalis*
5-10%	432	14.5	*Gracilaria, Ulva lactuca, Ulva intestinalis*
10-20%	144	4.8	*Gracilaria, Ulva lactuca, Ulva intestinalis*
20-50%	156	5.2	*Gracilaria, Ulva intestinalis, Ulva lactuca*
50-80%	145	4.9	*Gracilaria, Ulva intestinalis, Ulva lactuca*
>80%	248	8.3	*Gracilaria, Ulva intestinalis*
TOTAL	**2,980**	**100**	

* Note, *Ulva intestinalis* is synonymous with *Enteromorpha intestinalis* (reported as *Enteromorpha* previously).

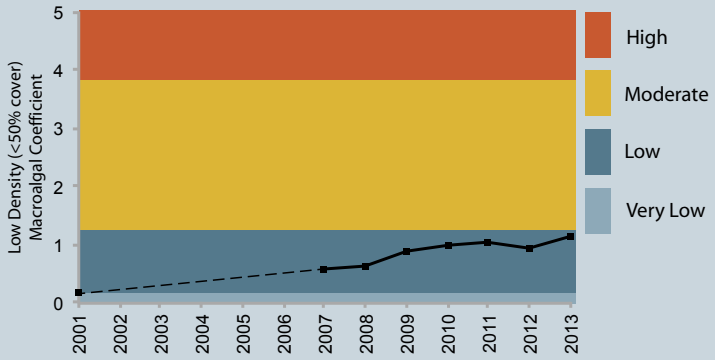


Figure 2. Low density macroalgal cover (Macroalgal Coefficient), New River Estuary, 2001-2013 (dashed line indicates predicted trend).

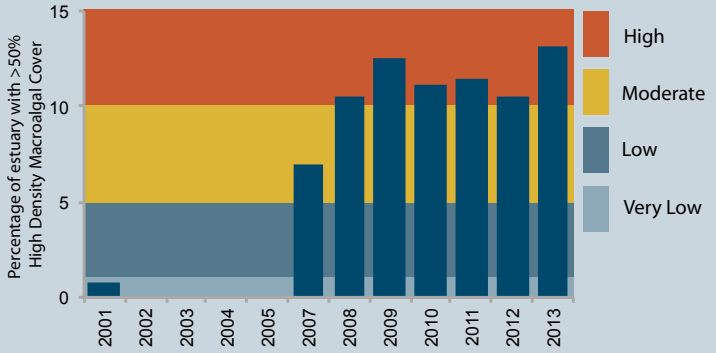


Figure 3. Percentage of estuary with high density (>50%) macroalgal cover, New River Estuary, 2001-2013.

Broad scale mapping results are presented in Figure 4 with 2013 results for the low density (<50% cover) Macroalgal Coefficient (MC) and the high density (>50%) macroalgal cover presented in Table 1, and results for the 2001-2013 period summarised in Table 2 and in Figures 2 and 3.

Overall, the red alga *Gracilaria* was the dominant species in the estuary in 2013, followed by the green alga *Ulva (Enteromorpha) intestinalis* which was most common along channel margins and on the root systems of decaying *Spartina* beds. *Ulva lactuca* (sea lettuce) was less common but present on sandy flats throughout the estuary, particularly near Bushy Point and Omaui.

The condition ratings for macroalgal cover were revised in 2013 following a review of the extensive data set compiled for Southland since 2007. The revised ratings better characterise the distribution of low density macroalgal growths in the estuary (which generally do not cause significant nuisance conditions), and distinguish these from areas of high density macroalgal growths that are commonly associated with nuisance conditions and sediment deterioration, particularly when they combine with excessive soft muds.

In 2013, the low density MC (LDMC) was 1.13, a condition rating of "low", the same as for the 2007-2013 period, but up from the "very low" rating in 2001 (Figure 2). Since 2001, the LDMC has shown a clear trend of increase (initiating the "trigger warning") indicating low density growth has increased throughout the estuary.

The percentage of the estuary with a high density (>50%) macroalgal cover in 2013 was 13% (393ha), a condition rating of "high" (Figure 3). Dense cover had increased by 80ha over the previous 12 months, by over 200ha since 2007, and by over 350ha since 2001, a condition rating of "very large increase". In a relative context, high density macroalgal cover within New River is now nearly double the entire size of Haldane Estuary or four times the size of Waiau Lagoon.

This reflects the dramatic expansion of extensive macroalgae growth in soft sediment areas primarily on the western side of the Waihopai Arm, in Daffodil Bay, and at Bushy Point; e.g. compare Figure 4a (2007) and 4b (2013). These are the same parts of the estuary that have undergone a rapid shift to persistent gross nuisance conditions (the area covered by both high macroalgal cover and soft muddy sediments with degraded sediment conditions - see Stevens and Robertson 2012).

In these areas macroalgae was causing gross nuisance conditions which had worsened over the past year. Sediment oxygenation beneath thick macroalgae was very poor with sediments anoxic from the surface to >15cm, and sulphur bacterial mats growing at the surface.

2. Results and Discussion (Continued)

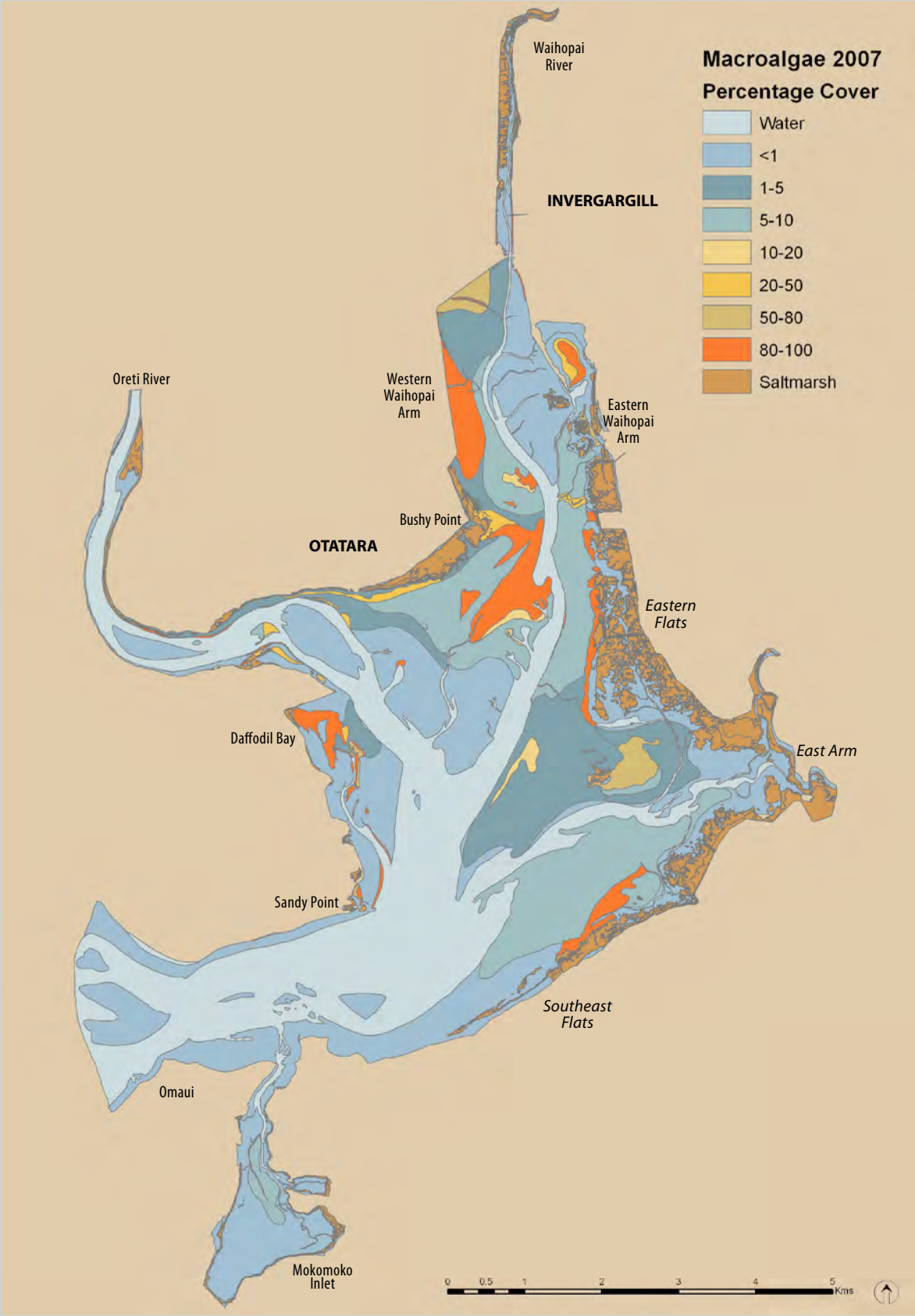


Figure 4a. Map of macroalgal cover - New River Estuary, February 2007

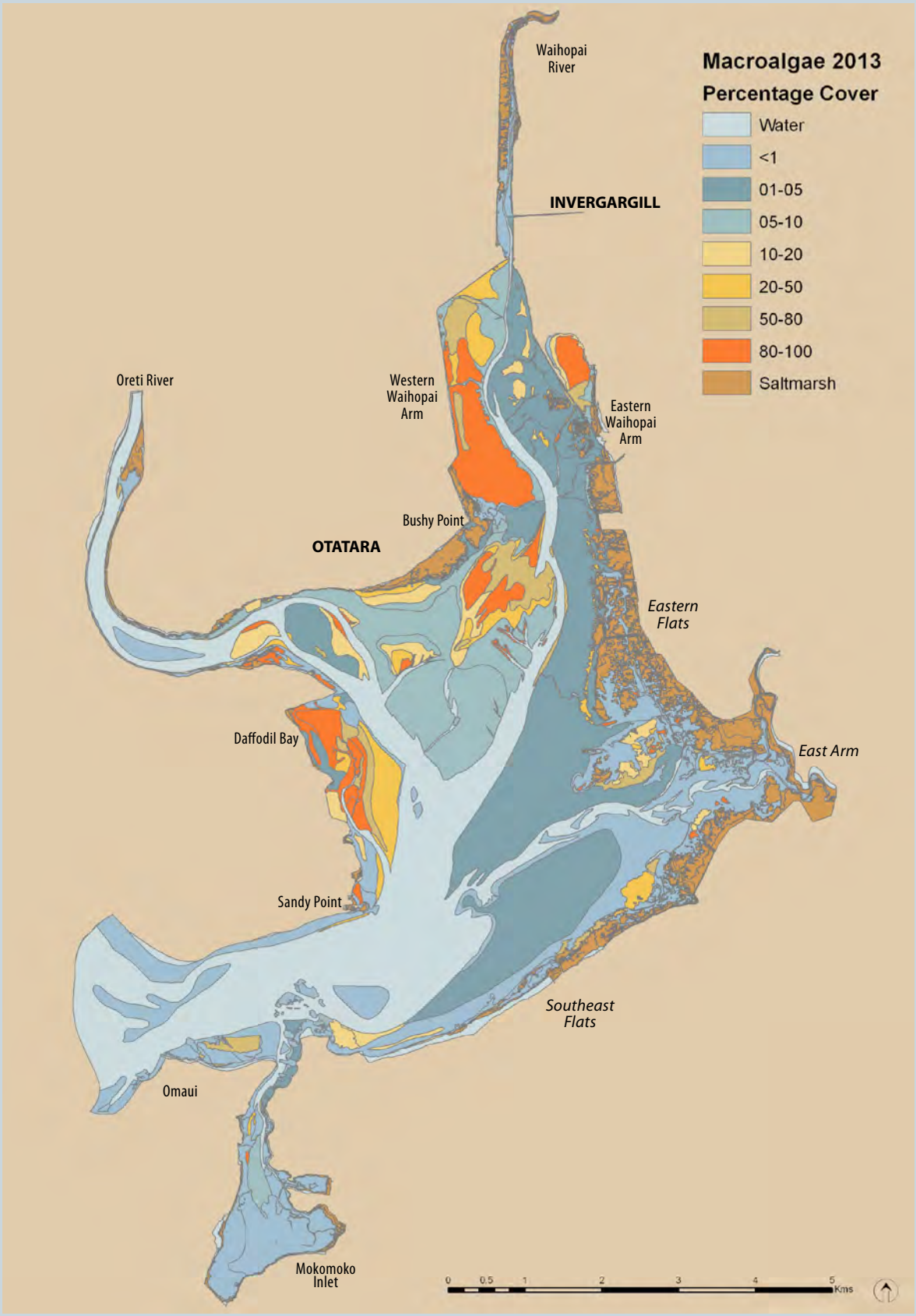


Figure 4b. Map of macroalgal cover - New River Estuary, February 2013

2. Results and Discussion (Continued)

LOW DENSITY MACROALGAL CONDITION RATING
2013 LOW

LOW DENSITY COVER CHANGE RATING
2013 TRIGGER WARNING (TREND OF INCREASE)

HIGH DENSITY MACROALGAL CONDITION RATING
2013 HIGH

HIGH DENSITY COVER CHANGE RATING
2001-2013 VERY LARGE INCREASE

Because persistent and extensive areas of gross nuisance conditions should not be present in short residence time estuaries like New River Estuary, their presence (estimated at >240ha) provides a clear signal that the assimilative capacity of the estuary is being exceeded.

These gross eutrophic conditions will kill or displace most estuarine animals and shellfish, and also release nutrients previously bound in the sediments. As these nutrients will predominantly be released in the form of ammonia, which is readily available to fuel macroalgal growth, a cycle of increasing habitat deterioration will establish that is likely to be difficult to reverse. Because this is occurring predominantly in the relatively rare sheltered tidal flats of the estuary most favourable for the growth of high value seagrass habitat (which is very susceptible to reduced oxygen levels and smothering by fine sediments and macroalgal growths), the ecological cost of such extensive growths is significant.

In the western side of the Waihopai Arm there was an 85% loss of seagrass (a reduction from 46ha to 7ha) from 2001 to 2012 (Stevens and Robertson 2012), with the remaining seagrass beds in a state of stress from smothering with fine muds and dense macroalgae. Changes in seagrass cover from 2012 to 2013 were assessed directly in the field using an ipad showing digital boundaries of the seagrass beds mapped in 2012, and real-time GPS tracking to highlight where change had occurred. This clearly showed the extent of losses, and that smothering of seagrass with fine muds and dense macroalgae was likely to be the primary cause of loss. Losses from 2012 to 2013, assessed in representative areas, were estimated at 50% (~3.5ha), with a typical change indicated in Figure 5 below.

In most areas where macroalgal cover exceeded 80%, underlying seagrass was dead or highly stressed, while mud deposition had completely buried many beds. Consequently, unless macroalgal and sediment deposition rapidly declines in the upper Waihopai Arm, the remaining seagrass beds, previously the most extensive in the estuary, are likely to be lost in the very near future.

Figure 5. Representative example of seagrass bed smothered by macroalgal growth and soft mud, Waihopai Arm, Feb. 2013. The 2012 seagrass boundary is indicated by the red line and the 2013 seagrass boundary indicated by yellow lines, indicating ~50% loss from smothering by macroalgae or soft mud.

2. Results and Discussion (Continued)

Table 2. Summary of condition rating and results, New River Estuary, 2001-2013.

Year	Low Density MC Rating	High Density % Rating	Result
2001	**VERY LOW** 0.20*	**VERY LOW** (<1%)	High cover (>50% cover) over <1% of the estuary (based on both personal observation and limited broad scale mapping (e.g. Robertson et al. 2002). *estimated value
2007	**LOW** 0.58	**MOD** (7%)	Low cover across most of estuary. Rating driven by patches of high cover near the Oreti River mouth and west of the Waihopai channel by Bushy Point.
2008	**LOW** 0.66	**HIGH** (11%)	A large increase in cover and nuisance conditions on the west side of the northern arm from 2007. Low cover across most of the central and lower estuary.
2009	**LOW** 0.91	**HIGH** (12%)	A large increase in cover and nuisance conditions on the west side of the northern arm and Bushy Point since 2008. Low cover across central and lower estuary.
2010	**LOW** 1.00	**HIGH** (11%)	Rapid deterioration of sediment quality on the northwest flats. Extensive growths at Bushy Point and Daffodil Bay. Low cover across central and lower estuary.
2011	**LOW** 1.05	**HIGH** (11%)	Extensive areas of poor sediment quality on the northwest flats. Heavy growths at Bushy Point and Daffodil Bay. Low cover across central and lower estuary.
2012	**LOW** 0.96	**HIGH** (11%)	Extensive areas of poor sediment quality on the northwest flats. Heavy growths at Bushy Point and Daffodil Bay. Low cover across central and lower estuary.
2013	**LOW** 1.13	**HIGH** (13%)	Increased heavy growths at already degraded Waihopai and Daffodil Bay areas. Increase in sediment degradation at Bushy Point. Large increase in low density cover by Oreti River mouth. Low cover across central and lower estuary.

Figure 6. Bushy Point showing muds trapped in macroalgae, and poor sediment conditions.

The worst impacted area in the estuary is on the northwestern flats between Bushy Point and the Waihopai River channel (Figures 8 and 9), but there are two other areas in the estuary where *Gracilaria*-dominated macroalgal growth is also excessive - Daffodil Bay and Bushy Point. Degraded sediment conditions in Daffodil Bay, while not as extensive as in the Waihopai Arm, show low oxygen levels, elevated organic enrichment, high and increasing dense macroalgal cover, and the presence of soft muds - a clear indication of deteriorating conditions.

In 2011, Bushy Point had extensive macroalgal beds of mostly 50-80% cover with underlying sediments still mostly sandy and relatively well oxygenated. In 2012, there was increased deposition of muds over ~27ha, providing a clear early warning of deteriorating conditions in this previously healthy part of the estuary. In 2013, conditions had continued to worsen with smothering macroalgal growths trapping fine muds at a rapid rate, and a widespread reduction in sediment oxygenation evident, including several areas with anoxic muds at the surface (see Figure 6). The dense macroalgal cover limits the removal of mud from the exposed flats by reducing the re-suspension of sediment by wind-generated waves. As a consequence, the sediments in this previously sandy area are becoming deeper, softer, and muddier.

The majority of the areas in the estuary where dense macroalgal cover and soft muds are present remain in very poor condition. Other indicators of increasing eutrophication of the estuary since 2007 are also evident. These, reported on in Robertson and Stevens (2012, 2013), include:

- A reduction in sediment oxygenation (RPD depth).
- Increased sediment nutrient concentrations (nitrogen and phosphorus).
- Increased organic content (measured as total organic carbon).
- Excessive rates of sedimentation (e.g. average of 34mm/year since 2007 in the middle of the northwestern flats).
- A severely degraded sediment invertebrate community.

Extensive parts (72%) of the estuary also had a low (<5%) macroalgal cover with no nuisance conditions. These areas were located predominantly in the well-flushed lower estuary and central basin, and the northeastern and eastern flats. However, it was notable in 2013 that the growths were often long (>1m) indicating very favourable growing conditions (Figure 7).

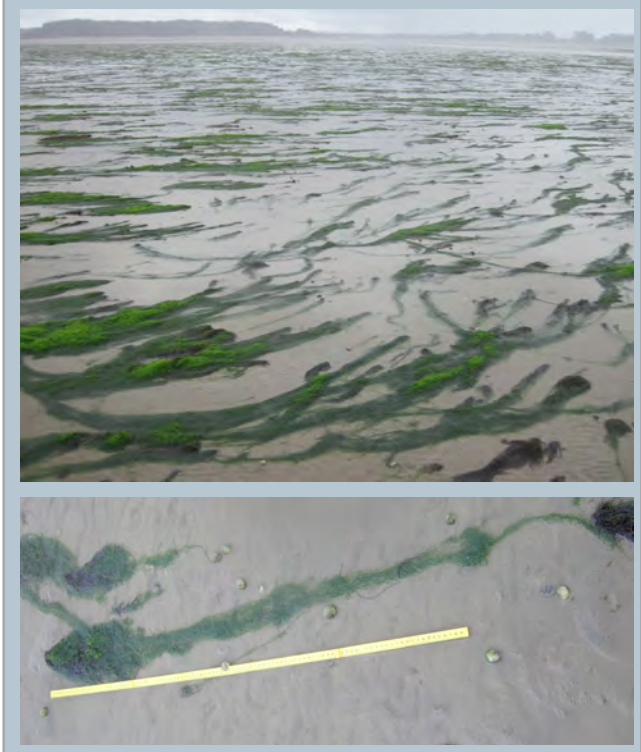
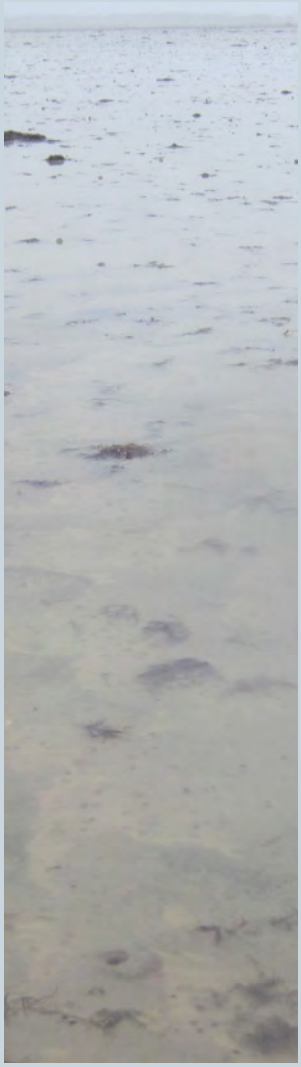


Figure 7. *Ulva* and *Gracilaria* growth near the Oreti River mouth (1m ruler shown).

Figure 8. Examples of anoxic sediment and extensive macroalgal cover in the Waihopai Arm in 2013.

Figure 9. *Gracilaria* beds in the Waihopai Arm, 2013. Seagrass beds dominated this area in 2001.

2. Results and Discussion (Continued)



Bushy Point showing recent deposition of muds.

Overall, gross nuisance conditions occupy 8% of the estuary with the majority located on the western side of the Waihopai Arm and a smaller area in Daffodil Bay (Stevens and Robertson 2012). This compares unfavourably with 1-2% in 2007 (Robertson and Stevens 2007) and <1% in 2001 (Robertson et al. 2002).

Results from broad scale habitat mapping, fine scale monitoring, sedimentation rate monitoring, and annual macroalgal monitoring (e.g. Robertson et al. 2002, Robertson and Stevens 2007, 2008, 2010, 2011, 2012, Stevens and Robertson 2008, 2009, 2010, 2011, 2012) have previously identified eutrophication and sedimentation problems in New River Estuary. These reports triggered recommendations for nutrient source identification (Stevens and Robertson 2008), and an immediate reduction in nutrient and sediment loads from the catchment (Stevens and Robertson 2009, 2010) as follows:

The increase in macroalgal cover from 2007, combined with the presence of nuisance conditions, and declining sediment quality, means macroalgae should continue to be monitored annually. In addition, the following management is recommended:

Set Limits on Nutrient Inputs

- *Because nutrient inputs to New River Estuary are high and strongly related to the eutrophication symptoms (Robertson and Stevens 2008), it is recommended that catchment nutrient inputs be reduced. A Total Daily Maximum Load to the New River Estuary of 2.0-2.5 tonnes N/day (as opposed to the current input of 3.6 tonnes/day) is suggested as a preliminary guide to maintain the mesotrophic state in the lower estuary and achieve less enriched conditions in the upper estuary areas near the Oreti and Waihopai River inputs. Further work is needed before a definitive limit can be set.*

Identify and Manage Major Nutrient Sources

- *The identification of nutrient sources to the estuary is seen as a priority given the very significant nature of both point and non-point discharges. Once identified, a plan should be developed to priortise and reduce the key inputs.*

In response to the extensive estuary degradation that has been reported on since 2007, ES has commissioned work in 2013/14 to identify nutrient sources, and to establish guidelines for nutrient inputs. These vital components will underpin the basis for future management, but as ongoing impacts are expected to continue for some time, further recommendations for monitoring and management are put forward in Sections 3 and 4.

CONCLUSION

The 2013 macroalgal cover in New River Estuary had an overall condition rating of "POOR". Gross nuisance conditions of rotting macroalgae and poorly oxygenated and sulphide rich sediments are causing significant problems in the northwestern Waihopai Arm, and in sheltered areas in the western flats near Daffodil Bay and at Bushy Point. These areas require targeted management action. Macroalgae in the well flushed central basin and lower estuary is not currently causing significant problems, although a large increase in growths near the Oreti River mouth serves as a clear warning that problems may develop in the lower estuary if management action is not taken.

3. MONITORING

Daffodil Bay.

New River Estuary has been identified by Environment Southland as a high priority for monitoring, and is a key part of their coastal monitoring programme being undertaken in a staged manner throughout the Southland region. The future monitoring recommendations are outlined as follows:

Macroalgal and Seagrass Monitoring

- Continue with the programme of annual broad scale mapping of macroalgae. Next monitoring due in February 2014. In addition, in order to assess changes in seagrass cover (particularly in the Waihopai Arm), it is recommended that seagrass cover in key locations be monitored annually in tandem with the macroalgal monitoring.

Broad Scale Habitat Mapping

- Continue with the programme of 5 yearly broad scale habitat mapping. Next monitoring due in February/March 2017. Note this will include seagrass mapping of the whole estuary.

Fine Scale Monitoring

- Fine scale monitoring sites have been increased to include two additional sites that are representative of more vulnerable poorly flushed areas in the estuary. Monitor the two new sites in February 2013, and again in February 2015 when the 5 yearly fine scale trend monitoring at three existing sites falls due.

Sedimentation Rate Monitoring

- Because sedimentation is a priority issue in the estuary it is recommended that all sediment plate depths be measured annually. These plates will also be used to gauge the success of actions taken to reduce sediment inputs.

4. MANAGEMENT

Waihopai Arm.

Eutrophication and sedimentation have been identified as a major issue in New River Estuary since at least 2007-8 (Robertson and Stevens 2007, Stevens and Robertson 2008), as has been the case for several other Southland estuaries (e.g. Jacobs River, Waimatuku and Waituna Lagoon).

To address these issues, it is recommended that appropriate catchment nutrient and sediment guideline criteria be developed for each estuary type in Southland and that these guideline criteria are then used to assess the extent to which catchment loads meet these guidelines. Estuaries where guidelines are exceeded are prioritised for more extensive investigations, monitoring and management. The key steps in such an approach are as follows:

- Assign catchment nutrient and sediment load guideline criteria to each Southland estuary (using criteria appropriate to each type of estuary). Guideline criteria should be based on available catchment load/estuary response information from other relevant estuaries.
- Estimate catchment nutrient and suspended sediment loads to each estuary using available catchment models and stream monitoring data.
- Determine the extent to which each estuary meets guideline catchment load criteria.
- Rank estuaries according to exceedance of recommended guideline criteria.
- Assess the potential for requiring more detailed assessments of priority estuaries (e.g. estuary response modelling, stream and tributary monitoring, catchment load modelling).
- Develop plans for restoration of priority estuaries.

Overall, if the approach is followed, and the estuary and its surroundings are managed to ensure that the assimilative capacity is not breached, then the estuary will flourish and provide sustainable human use and ecological values in the long term.

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6. ACKNOWLEDGEMENT

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