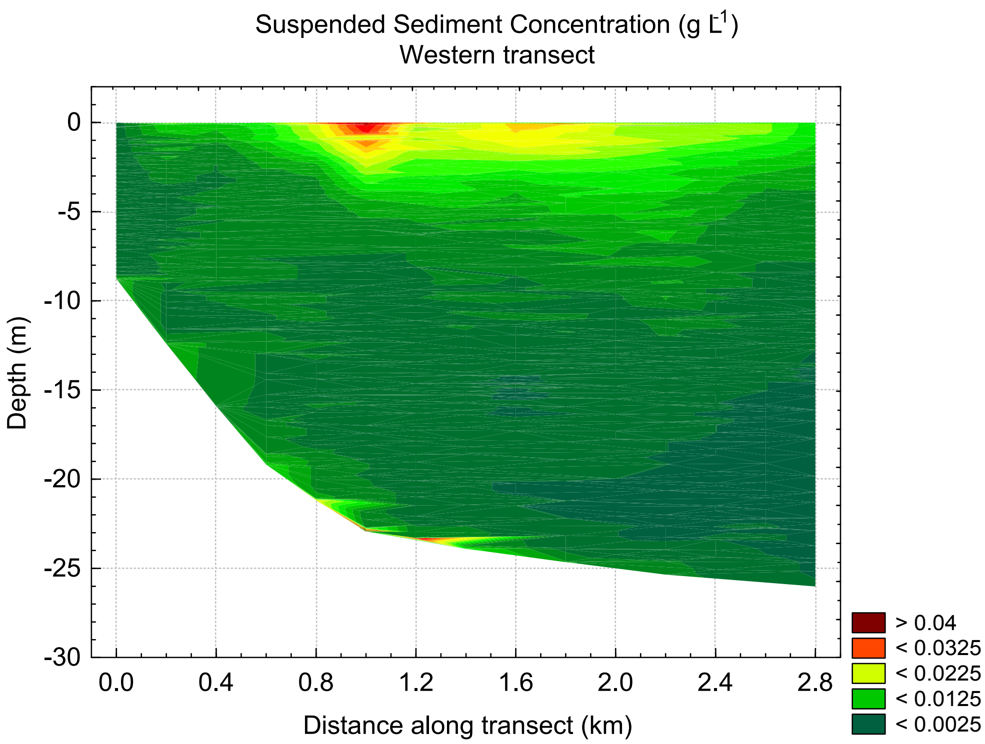
Proposal for monitoring sedimentation in the Te Whanganui-a-Hei Marine Reserve



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Proposal for monitoring sedimentation in the Te Whanganui-a-Hei Marine Reserve

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Prepared for

Department of Conservation

Waikato Conservancy

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1. Introduction

Coastal ecosystems worldwide are affected by a decline in water quality due to increased supply with terrigenous (land-derived) sediment. Terrigenous sediment enters coastal habitats as suspended particles via waterways, and/or directly by landslides. The rate of such supply can be high where land-based activities including vegetation removal and coastal urbanisation lead to large-scale mobilisation of soil, and where steep topography supports rapid transport. The suspended particles will eventually settle at some distance to the shore smothering the seafloor and its organisms. The effect of such deposition on the functioning of coastal ecosystems is of global concern; the underlying mechanisms, however, are still not well known.

The Department of Conservation identified sedimentation of fine-grained particles within the Te Whanganui-a-Hei (Hahei) Marine Reserve as an issue of concern. This reserve is influenced by estuaries and rivers flowing into Mercury Bay, to the west of the reserve. Since the reserve was gazetted in 1993, several biological monitoring programs have been undertaken within the area of which some provided evidence for increased deposition of fine-grained sediment. For example, during the May–June 2009 benthic and lobster monitoring programme, Haggitt and Mead (2009) noticed that the levels of fine sediment on reefal habitats had increased since 2006. Carballo (2006) noted that an increase in sedimentation of fine-grained particles may reduce species diversity and influence the structure of species assemblages, transforming relatively stable assemblages into unstable assemblages. Steger (2006) conducted a comprehensive study of the impact of sedimentation upon benthic community structure and demonstrated negative effects of increased sedimentation on four species, a macroalga, a sponge, a mussel, and a crab. Steger and Gardner (2007) demonstrated that high concentrations of suspended sediment can negatively affect suspension feeding species. In addition to affecting benthic communities, suspended particles reduce the amount of light penetrating the water column and so alter the primary production in the water column and the visual range of visual piscivore predators. For example, Utne-Palm (2001) demonstrated that seawater turbidity can affect the structure of the fish community by decreasing the success of visual predators.

These observations and the lack of quantitative data prompted the Department of Conservation to initiate long term monitoring of suspended particle concentrations and sedimentation in Te Whanganui-a-Hei Marine Reserve. The Department of Conservation approached the School of Applied Sciences, Auckland University of Technology, to develop such program. Four questions were identified to guide this development:

- What is the level of water column turbidity across the marine reserve?
- To what degree is the visibility in the water column affected?
- How much sediment is settling on the seafloor?
- Where do suspended particles come from?

Following discussions with the Department of Conservation we have inspected the water column and seafloor at current monitoring locations in the Te Whanganui-a-Hei Marine Reserve to gain an understanding of the local conditions. We then explored the suitability of methods for monitoring suspended particles and sedimentation to propose a cost-effective monitoring program. Finally, we conducted a trial monitoring run to assess the feasibility of the proposed programs.

2. Monitoring proposal

The issue of increased sedimentation in coastal environments has been monitored in a number of ways. Some programs monitor the quality and/or quantity of suspended particles in the water column; others determine the quantity of particles that settle out of the water column onto the seafloor. We propose to measure two variables *in situ* that are related to the quantity of suspended particles; Secchi depth and turbidity. The Secchi depth measurement is slow but simple whereas the turbidity measurement is fast but involves the deployment of a turbidity sensor. The rapid sensor response allows turbidity to be measured at high spatial and temporal resolution. The turbidity readings (unit NTU, Nephelometric Turbidity Units) of the sensor can be converted into suspended sediment concentrations (SSC, unit g L^{-1}) after a correlation between turbidity and SSC has been established for this particular environment. We also propose to monitor the rate at which particles settle out of the water column and the quality of the settling particles. To do so, sediment traps have to be deployed in the reserve.

Seawater turbidity

Turbidity is a property commonly used to describe water clarity in both marine and freshwater environments. It provides a gross assessment of light attenuation due to the presence of suspended material. Turbidity is not a direct measure of the quantity of suspended particles but a measure of the effect of these particles on the optical properties of the water.

A commonly used measure of turbidity in water uses the scattering of light by particles. This approach uses an instrument called a nephelometer with the detector setup to the side of the light beam (Figure 1). More light reaches the detector if there are lots of small particles scattering the source beam than if there are few. The units of turbidity from a calibrated nephelometer are Nephelometric Turbidity Units (NTU).

The measurement of turbidity is affected by the size distribution and composition of the suspended particles (Boss *et al.* 2009). Other water constituents contribute to turbidity, for example, water molecules, salts and other dissolved materials, and bubbles. For the simple case where there is only one kind of scattering material in water, the measured backscattering, less the known backscattering contribution by pure water, is linearly proportional to the concentration of this material. This is the basis of using optical instruments to provide proxies for suspended matter concentration.

The International Organization for Standardization (ISO) has defined turbidity as “the reduction of transparency of a liquid caused by the presence of undissolved matter” (ISO 1999). ISO approved several optical techniques for turbidity measurements: the measurement of light transmission, side-scattering, and backscattering (ISO 1999). Although these standards and definitions were created to be both technically and legally specific, they still suffer from fundamental deficiencies in their ability to create an absolute standard that covers both different natural water types and different instrument designs. Despite these limitations, a variety of *in situ* turbidity sensors are successfully used in many research and monitoring programs.

Optical turbidity sensors are usually calibrated with standards based on either formazin or AMCO-AEPA styrene divinylbenzene beads. Boss *et al.* (2009) recommend that the use of such turbidity standards for calibration purposes be stopped and that efforts be focused on calibrating sensors with particulate matter (see also Gibbs 1974, Zaneveld *et al.* 1979, Downing 2006). Different instruments calibrated with the same turbidity standard in the lab may not give the same results in the field and the differences may be very large (Gibbs 1974; Downing 2006). Turbidity standards could continue to be used to monitor instrument drift, and, if their optical properties are known, to calibrate sensors to absolute physical units.

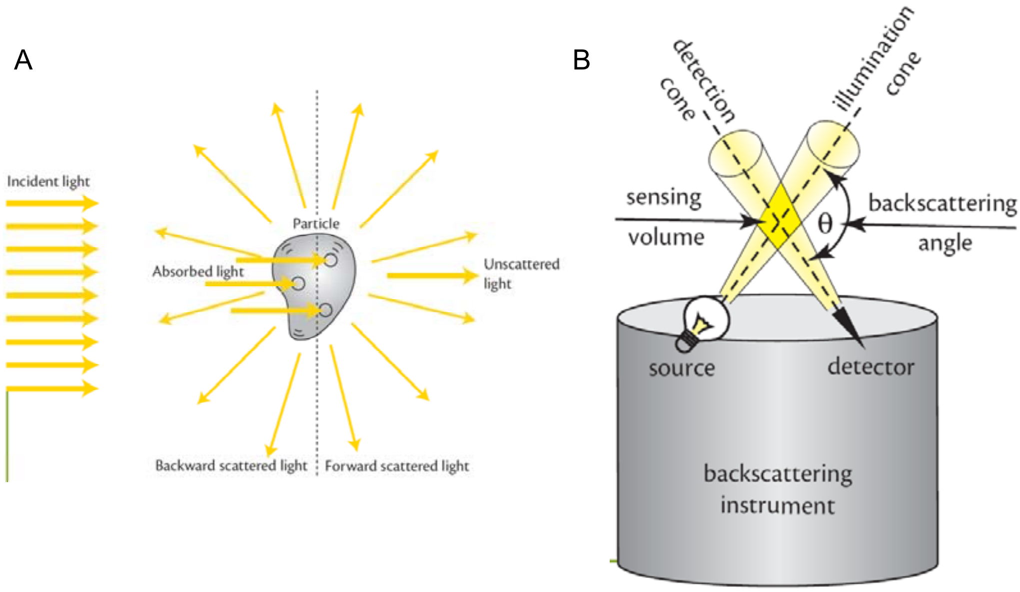


Figure 1. (A) Diagram showing how attenuation of light occurs through absorption and scattering. Scattered light is divided into the light scattered in the backward and forward directions relative to the direction of the un-attenuated beam. The measurement of backscattering provides information on the abundance and distribution of suspended particles. (B) Schematic of a single-angle backscattering sensor with detector and source embedded within a flat-faced instrument. The light backscattered near the angle, θ, emanates from the volume created by the intersection of the illumination and detection cones. Adopted from Boss *et al.* (2004).

Secchi depth

The Secchi disk was the first instrument used for providing a measure of the water transparency. The disk is named after Professor Pietro Angelo Secchi (1818–1878) who was among the first to use it. The white or black-and-white disc, which is normally 20 cm in diameter, is attached to a marked line and lowered. The depth at which it disappears from sight provides the measured transparency. Larger discs (75–100 cm) are used in deployments from the deck of high vessels. In small boats, however, the size of the disc has little effect on the recorded depth of disappearance.

The simplicity of the use of a Secchi disk and its durability make it possible to involve interested laypersons in monitoring. Involving private citizens and organisations in the collection of data encourages interest in the functioning of coastal systems, and through them the wider public is educated. The Secchi depth is a valuable measurement for broadly characterising the transparency of individual aquatic systems over a series of years, and for making broad comparisons among groups of systems. It should not, however, be used to estimate light extinction coefficients, or the thickness of the euphotic zone because their relationship with the Secchi depth is nonlinear and changing.

There is no standard protocol for the measurement of the Secchi depth. LaBounty (2008) adopted a protocol developed by Smith (2001) who advised the use of a viewer box. This box removes the negative effects of glare and glitter at the water surface on the precision of the observation. Whatever protocol is adopted for monitoring it is imperative that the procedure is set at the beginning of a monitoring program and is not altered thereafter so that results are comparable over time.

Sedimentation

Measuring the vertical flux, quantity, and quality of suspended particles is imperative to the proposed monitoring program. The ideal device for this task is a trap that once released, drifts with the current (drifting trap) because the particle collection efficiency of such trap is less biased by the flow speed of the surrounding seawater than that of a moored trap. The deployment of a drifting trap, however, is often impractical. Here, we recommend the deployment of moored sediment traps as shown in Figure 2. The traps are available from KC Denmark and consist of four collecting tubes. Each collecting tube has an inner diameter of 72 mm and a length of 450 mm. Please note that the collection efficiency of this trap will depend on the horizontal current speed at the trap mouth and the fall velocity of the suspended particles (Butman 1986, Baker *et al.* 1988).

The effect of flow speed on the trap efficiency may be negligible when flow is slow. Baker *et al.* (1988) demonstrated that the mass flux and the distribution of particle size and density collected at flow speeds <12 cm s^{-1} was indistinguishable from that collected in drifting traps deployed in an essentially identical particle and hydrographic environment. In contrast, at higher speeds, mass flux into moored traps decreased sharply, declining by a factor of 70 at flow speeds >50 cm s^{-1} (Baker *et al.* 1988).

To estimate the rate of particle settlement (g m^{-2} h^{-1}) and the organic matter content of the settled particles (% dry weight) the content of the collection tubes should be analysed for suspended solids, SS (filtration, drying at 60°C) and volatile suspended solids, VSS (filtration, drying at 60°C, then ashing at 400°C).

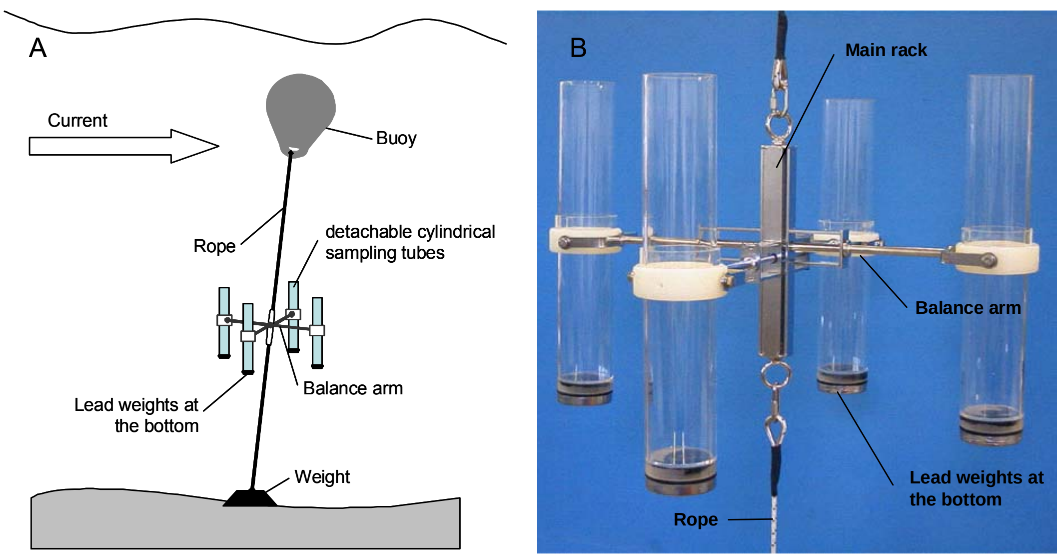


Figure 2. (A) Schematic of a trap deployment (not to scale). A subsurface buoy holds the trap upright at about 1 m above the seafloor. (B) Close-up of the KC Denmark sediment trap in (A) showing the main rack (centre), four arms with pivot joints, and 4 detachable cylindrical sampling tubes mounted with lead weights at the bottom. The construction of the sediment trap array ensures a permanently vertical position of the sampling tubes during deployment. Photograph in (B) was copied from www.kc-denmark.dk and modified.

One goal of the future monitoring program is to understand where particles settling onto the seafloor of the Te Whanganui-a-Hei (Hahei) Marine Reserve derive from. The origin of the particles can be inferred from the carbon and nitrogen isotope ratio; a ratio commonly used to discriminate between marine and terrestrial based organic matter (Rogers 2003). A higher ratio indicates a greater proportion of terrigenous material whereas a lower ratio indicates a larger proportion of marine material. Sediment that has a predominantly marine input (phytoplankton and zooplankton) has a C:N ratio of approximately 6. Freshly deposited marine organic matter ranges around 10 and predominantly terrigenous organic matter has a C:N ratio of >20 (Schulz and Zabel 2006). For example, Mishima *et al.* (1999) were able to trace the deposition of terrestrial sediment into Osaka Bay from the Yodo River and Schubert and Calvert (2001) were able to estimate the terrestrial contribution of the organic matter to the sediments of the central Arctic Ocean. Steger (2006) monitored the sedimentation within the Te Whanganui-a-Hei Marine Reserve and found that the C:N ratio was always highest at sites within the reserve compared to sites outside of the reserve.

3. Monitoring design and techniques

Monitoring design

We propose to monitor a series of 15 sites located along each of two three-kilometres long transect lines. One transect line reaches from the eastern region of Te Whanganui-a-Hei Marine Reserve. The second transect line reaches from the western region of the reserve. Each line begins inside the reserve close to land and runs perpendicular to the shore line. The 15 sites per transect line are equally spaced 200 m apart (Figure 3).

The transect lines are positioned along a gradient of water turbidity; high turbidity in close proximity to Whitianga estuary, lower turbidity in the eastern region of the reserve. The transect lines also reach across habitat types from shallow waters inside the reserve to deep water outside the reserve. This sampling layout was selected to achieve high resolution while allowing the measurements to be completed within one day.

We propose that the water column at each sampling site is investigated using two devices. A Secchi disk will be used to measure the Secchi depth and a multi-parameter sonde will be lowered through the water column to record a depth-profile of turbidity. To convert the turbidity readings from the sonde

(NTU) into suspended sediment concentration (g L^{-1}, see Figure 7), water samples need to be taken at the same time as profiling is conducted and later analysed for suspended sediment concentration. Secchi depth is a simple measurement of water clarity but it does not give information about the vertical distribution of particles and this is where the multi-parameter sonde is a real benefit to a study such as this.

We propose that each monitoring campaign lasts 4 days. The first day involves multiparameter sonde profiling, collection of water samples, Secchi disk measurements and sediment trap deployment. The sediment traps should remain deployed until recovery on the forth day. During our trial monitoring, we deployed the sediment traps for only 24 hours and found that they had collected only little sediment. A longer trap deployment will ensure that enough sediment is available for the laboratory analyses of suspended solids (SS), volatile suspended solids (VSS) and C:N ratios. Barcellos *et al.* (1997) used a similar deployment period. They deployed their sediment traps for 4 days and collected between 5 to 50 mg cm^{-2} day^{-1}. We recommend either monthly or bi-monthly monitoring.

The three components of the proposed monitoring programme complement each other. If resources became limiting, the sampling frequency for individual components could be altered. The deployment of sediment traps is probably the most resource demanding component and therefore could be conducted less frequently.

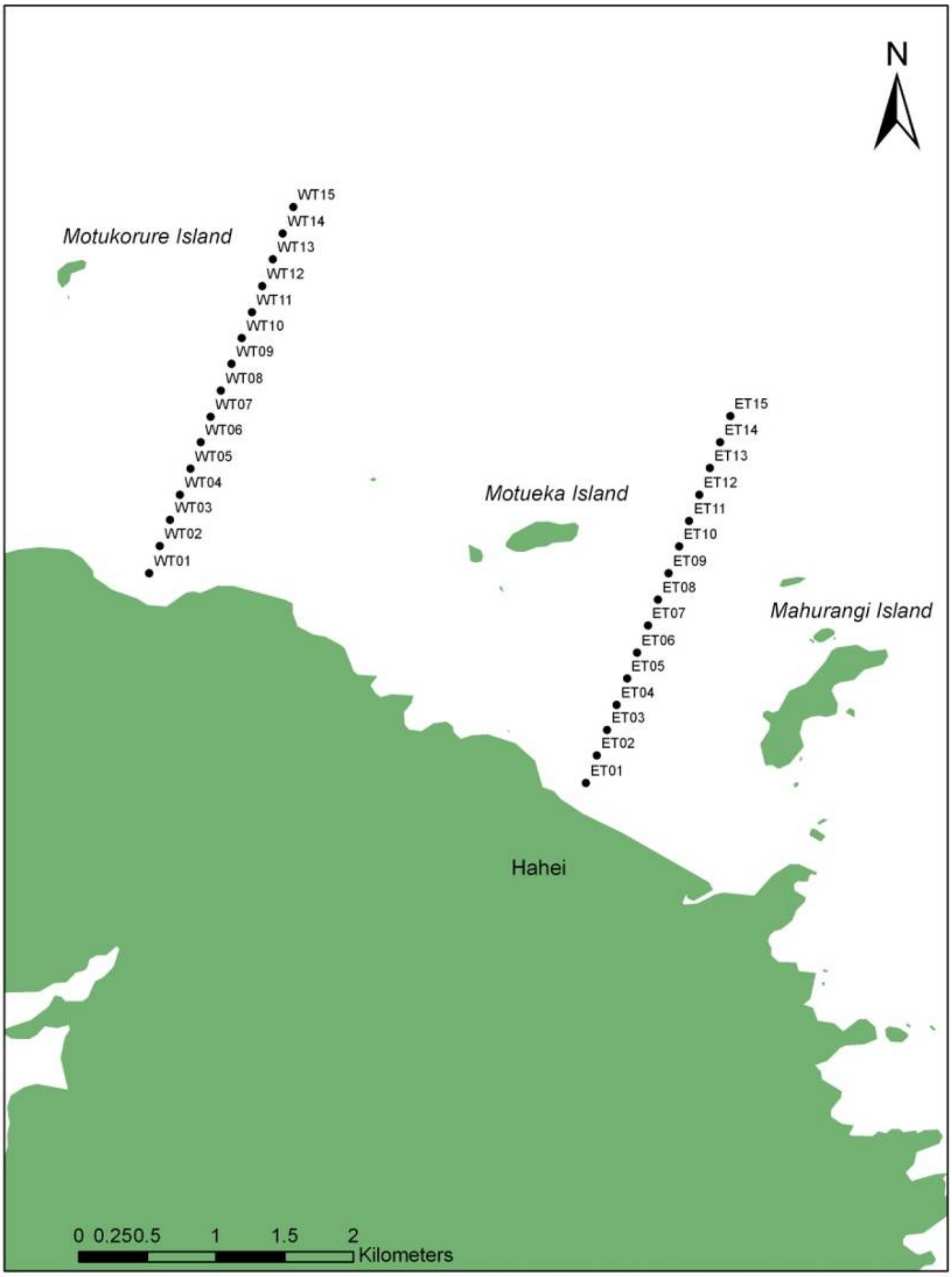


Figure 3. The location of two transects in the Te Whanganui-a-Hei Marine Reserve, Whitianga. Each circle marks the location of one sampling sites. There are 15 sites along each of the western (WT01–WT15) and eastern (ET01–ET15) transect lines.

Turbidity

At each of the sampling sites a multi-parameter sonde should be deployed. The sonde will need to record at least water turbidity, depth, temperature and salinity (Figure 4). A protocol for deploying the sonde is also included in this report. Profiling the water column along the two transect lines will allow us to describe the water column distribution of suspended particles. At the beginning, middle, and end of each transect line, it is advised to obtain a water sample from mid-water. The suspended sediment concentrations (g L^{-1}) in these water samples can then be correlated with the mid-water turbidity readings of the sonde to convert the series of turbidity profiles into more meaningful profiles of suspended sediment concentration.

Figure 4. Photograph showing a YSI 6600V2 multiparameter sonde with four self-cleaning optical sensors (wiper) capable of measuring dissolved oxygen, turbidity, chlorophyll and blue-green algae. This sonde also records temperature, conductivity (salinity), pressure (depth), pH, and oxidation–reduction potential (ORP).

Secchi depth

We propose to conduct Secchi depth measurements at each of the 15 sampling sites along both of the transect lines. Two measurements will be recorded whilst using a viewing box and following the Secchi depth protocol (see below). To save time, we advise that two people carry out the water-column measurements along the two transect lines; one to deploy the sonde and the other to record Secchi depth measurements.

Sedimentation

We propose to deploy two sediment traps for at least 2 days in 15 meter water depth. One trap on the western transect and the other on the eastern. Traps should be deployed and retrieved by SCUBA divers following the sediment trap protocol (see below). Each trap will collect four sediment samples. Three samples should be analysed for SS and VSS. The fourth sample should be used to measure the C:N ratio.

We tested a KC Denmark sediment trap and found that it meets the requirements for this monitoring. This sediment trap has four collecting tubes which sit vertically in a steel frame (Figure 2). The tubes are weighted at the lower end so that they are always vertical. Once a trap has been secured to a mooring, an underwater float will hold the trap upright. The use of underwater floats is preferred to a surface float as there will be less drag due to wind and waves and it will create less interest from divers and boat users alike.

Sediment traps are to be deployed in 15 m water depth at the below locations following the sediment trap protocol (Figure 5).

Western site	S36˚49'03.3	E175˚46'42.6
Eastern site	S36˚49'46.0	E175˚48'25.7

During our monitoring trial we used temporary 50 kg moorings to secure the sediment traps on the seafloor. These moorings were constructed out of 100 mm thick steel plate. We recommend that permanent moorings weighing no less than 50 kg are placed into the sites. The moorings should have a low profile to minimise drag, and they should have a large solid loop on the top to secure the rope which will hold the trap in place.

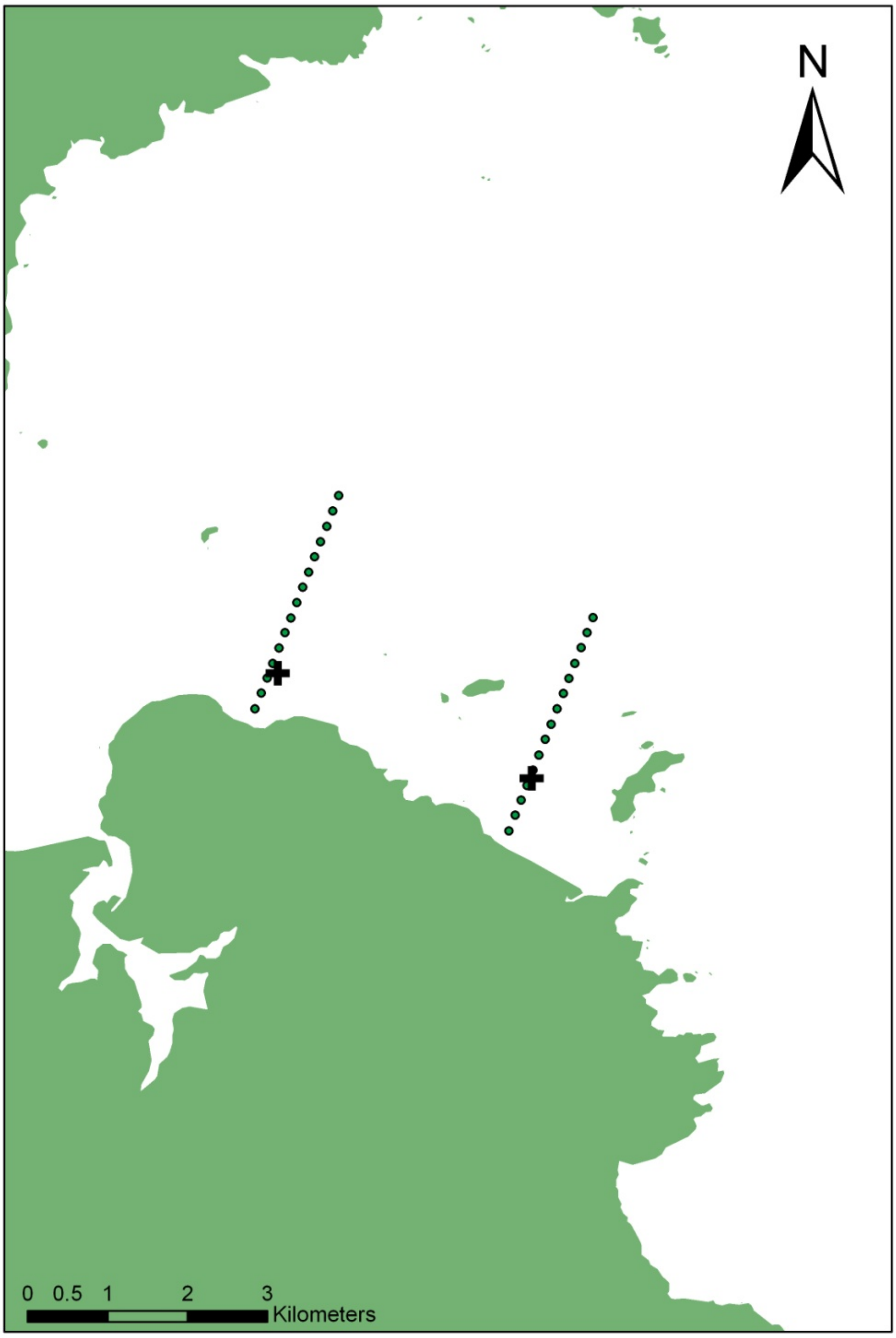


Figure 5. Location of the two sediment traps (black crosses) in relation to the sampling sites of the western and eastern transect lines.

4. Trial monitoring results

On the 2nd and 3rd of June 2010 we conducted a monitoring trial within the reserve following the above described program.

Secchi depth

Secchi depths along the eastern transect line remained fairly constant being 3–4 m (Figure 6). The western transect line began with a Secchi depth similar to that of the eastern transect line, however, after about 0.8 km along the transect line, the Secchi depth was reduced to 1–2 m.

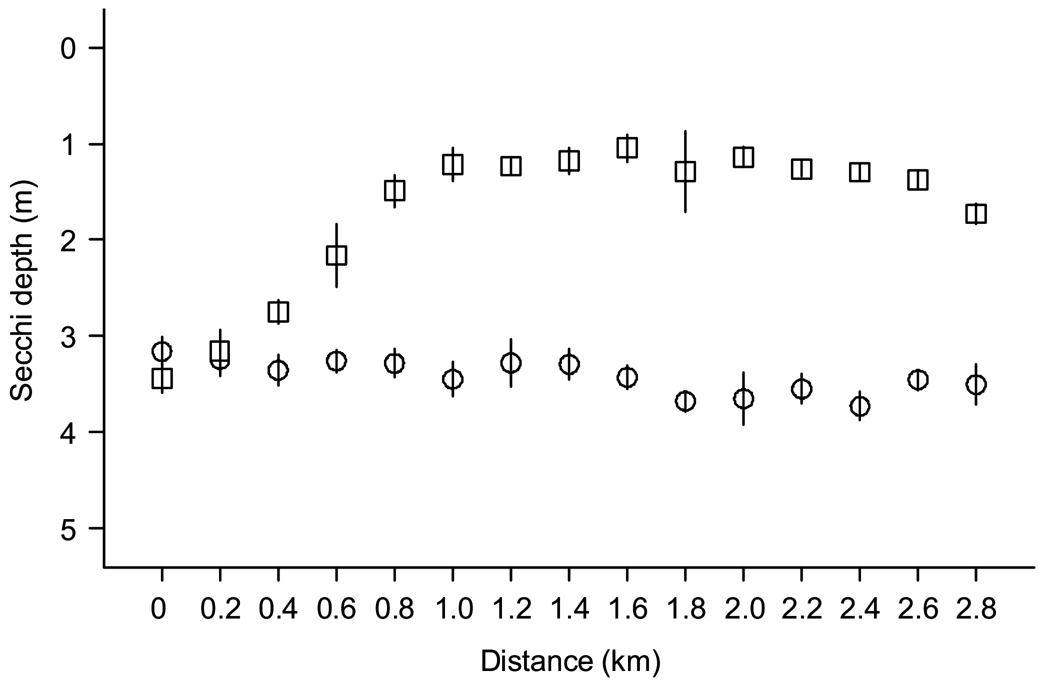


Figure 6. Mean Secchi depth (n = 4) at 15 sites along two transect lines. The square symbols indicate sampling sites along the western transect line and the circle symbols indicate sampling sites along the eastern transect line. Distance starts at the first sampling site closest to the shore. Error bars indicate one standard deviation.

Turbidity, salinity, dissolved oxygen

We used the linear correlation (Figure 7) between the concentration of suspended sediment in the water samples collected at the beginning, middle and end of each transect line and the turbidity readings at the depth from which the water samples were taken (Table 1) to convert the profile of turbidity into profiles of suspended sediment concentrations shown in Figure 8.

Table 1. Turbidity (NTU) and suspended solid concentration (SSC, g L⁻1) at mid-water depth at site 1, 7, and 15 along the western and eastern transects.

Distance (km)	Western transect		Eastern transect	
	Turbidity (NTU)	SSC (g L^{-1})	Turbidity (NTU)	SSC (g L^{-1})
0	4.3	-	4.3	0.0038
1.2	4.2	0.0032	3.8	0.0017
1.8	3.9	0.0022	3.8	0.0017

The seawater along the eastern transect was less turbid than that along the western transect line (Figure 8). In the western region there appears to be a more turbid body of surface water located around 0.8 km from the start of the transect line. The salinity wafer plots indicate that this water has a lower salinity and is therefore from freshwater origins (Figure 9). Seawater oxygen concentrations were higher in shallow water near to the shore throughout the reserve (Figure 10).

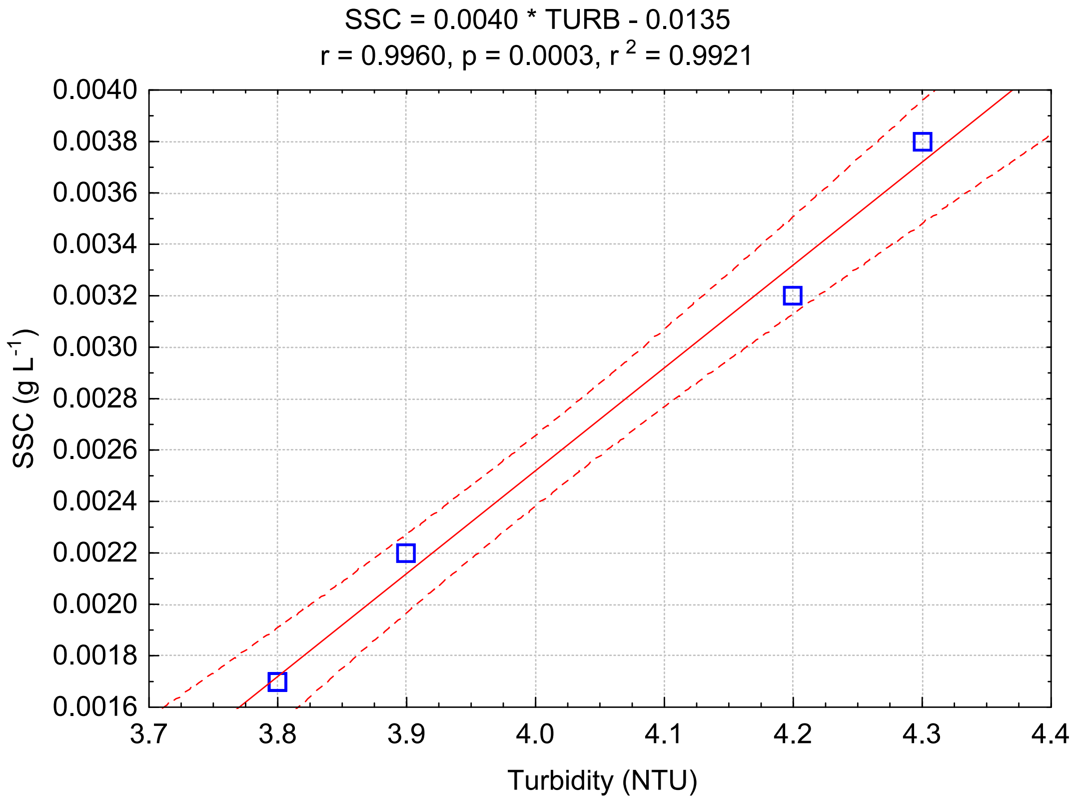


Figure 7. Relationship between suspended sediment concentration (SSC, g L^{-1}) and turbidity (NTU). Solid line indicates linear fit of data points (open symbols) and dashed lines indicate 95% confidence limits.

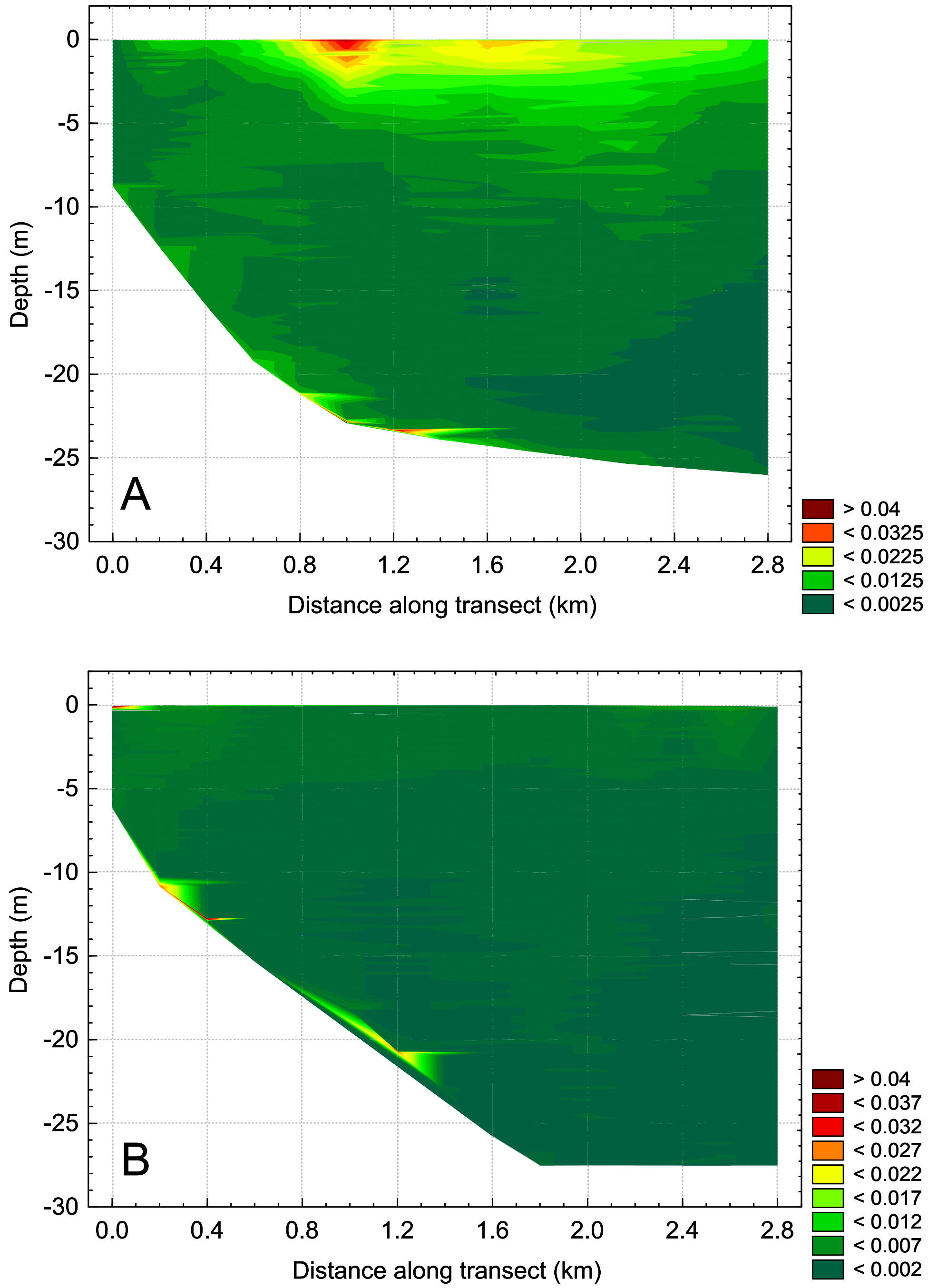
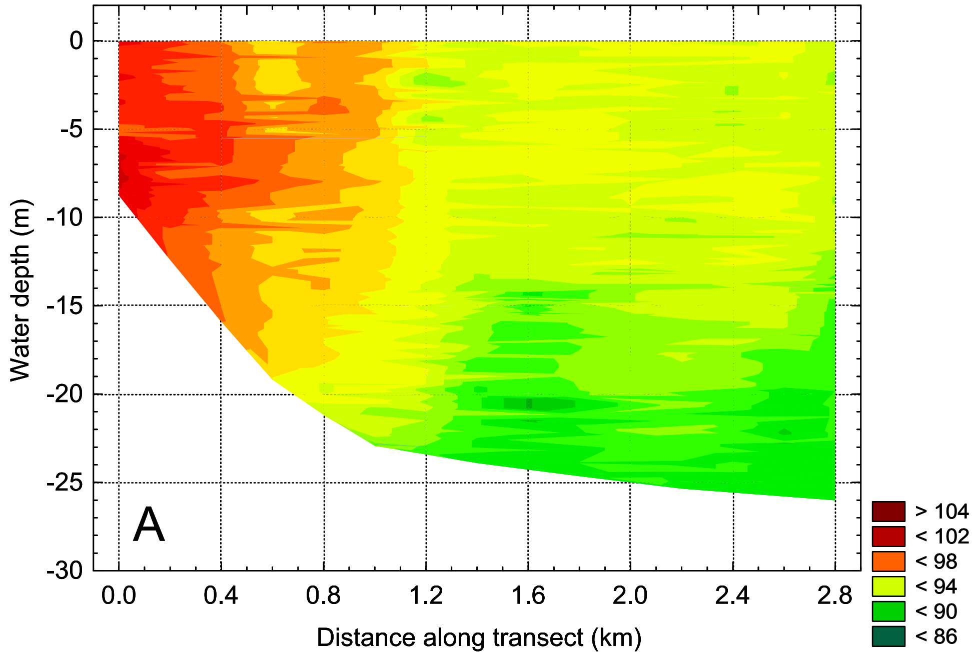


Figure 8. Wafer plots showing water column profiles of suspended sediment concentrations (SSC, g L^{-1}) along (A) the western and (B) the eastern transect lines measured on the 2nd of June 2010.



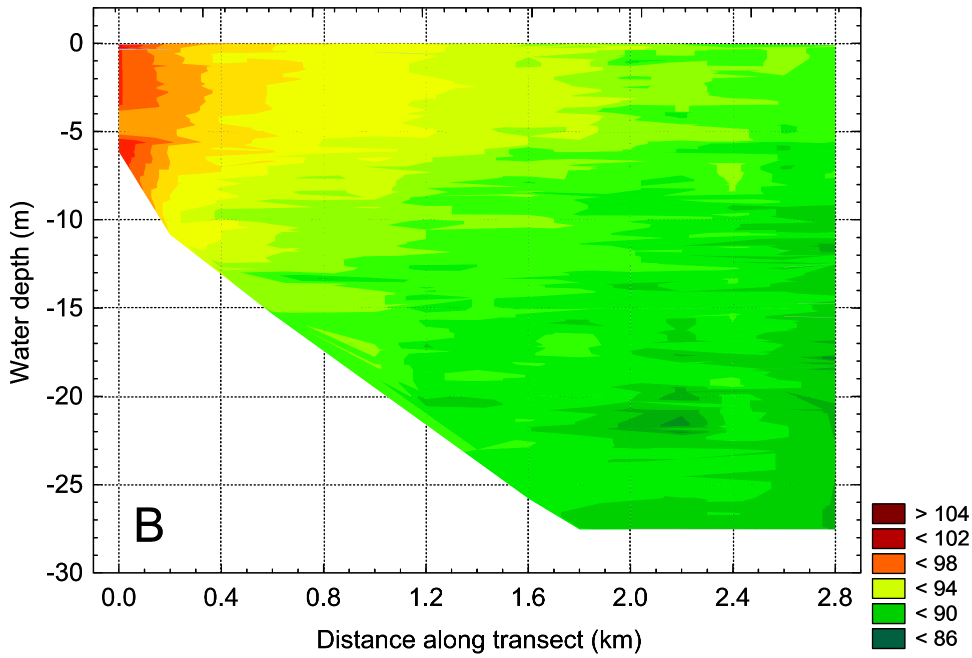


Figure 9. Wafer plots showing water column profiles of dissolved oxygen concentration (% saturation) along (A) the western and (B) the eastern transect line measured on the 2nd of June 2010.

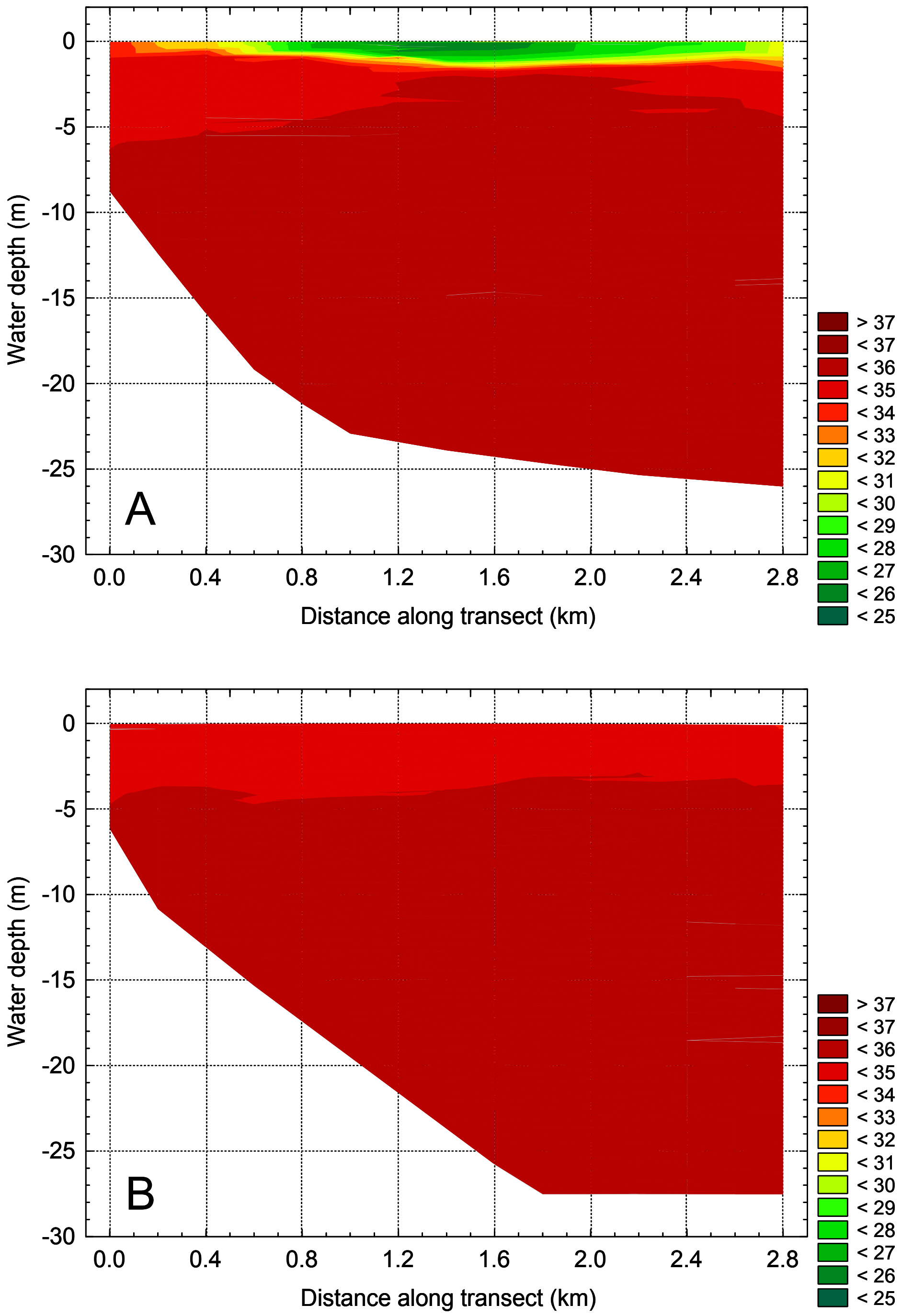


Figure 10. Wafer plots showing water column profiles of salinity (PSU) along (A) the western and (B) the eastern transect lines measured on the 2nd of June 2010.

Sediment trap

After a 24 hour deployment a thin layer of sediment was collected in the tubes from both sites (Figure 11).

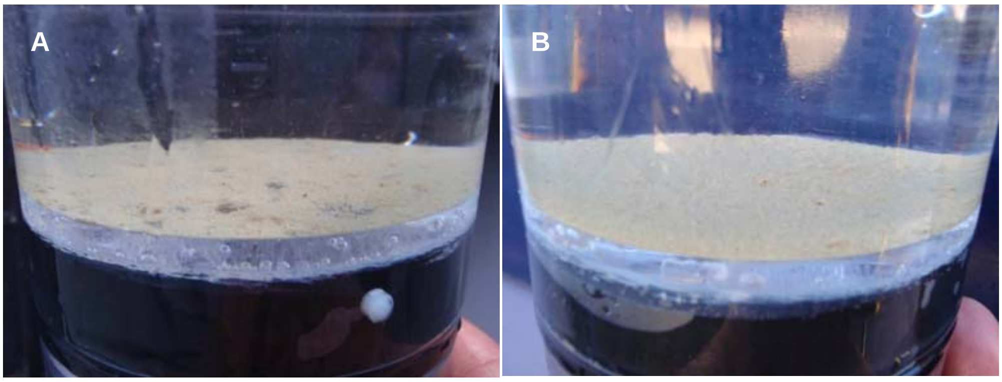


Figure 11. Photograph showing the amount of sediment collected during 24 hour deployment of the KC Denmark sediment traps at the (A) western and (B) eastern transect at 15 m water depth.

Analysis of the contents of the sediment traps revealed that the average sedimentation rate at the eastern site was not significantly different from that at the western site (Table 2).

Table 2. Organic matter content (% dry weight) and sedimentation rate (gram dry weight m^{-2} h^{-1}) of particles collected at the eastern and western boundary of the Te Whanganui-a-Hei (Hahei) Marine Reserve.

Replicate trap sample	Organic matter content (% dry weight)		Sedimentation rate (g m^{-2} h^{-1})	
	WT	ET	WT	ET
1	12.35	-	5.01	2.63
2	14.33	12.19	5.01	4.52
3	13.85	13.31	2.76	3.04
Average	13.51	-	4.26	3.40
SD	1.03	-	1.29	0.99

Sediment collected from the western sediment trap had a $\delta^{15}N$ value of 6.05 and $\delta^{13}C$ value of −18.7 whereas sediment from the eastern trap had a $\delta^{13}C$ value of −15.8 and $\delta^{13}N$ value of 6.56. The C:N ratio for the western site was 11.2 whereas for the eastern site the ratio was 12.5.

5. Summary

We were able to demonstrate that it is feasible to complete our proposed monitoring plan within the set time frame.

We found that the amount of suspended particles in the water column differed from one end of the reserve to the other. The water column in the western region of the reserve was stratified, with turbid brackish water overlying clearer marine water. A similar stratification was not evident in the eastern region of the reserve.

The oxygenation of the seawater in the eastern region was similar to that of the seawater in the western regions. Higher oxygen saturation was observed in shallower areas closer to shore.

The differences in seawater turbidity detected with the multiparameter sonde were confirmed by Secchi depth measurements.

The rate of particle sedimentation at the eastern end of the reserve did not differ significantly from that at the western end of the reserve. We recommend to conduct C:N analysis less frequently to allow an additional replicate trap sample to be included in the estimates of sedimentation rates.

The C:N ratios of the sediment collected at the eastern and western site were similar but higher than the sediment collected by Steger (2006) during 2003–2004. This finding suggests that the sediment collected during our monitoring trial contained more terrigenous material than that collected by Steger.

We included in this report protocols and data sheets for all monitoring activities. It is imperative that a protocol for collecting the data is established at the beginning of a monitoring program and this is closely followed for the entire duration of the program.

6. Protocols and data sheets

Protocol for Secchi disk measurements

Protocol for water samples

Protocol for multi parameter sonde measurements

Protocol for sediment traps

Secchi depth

The observer must have “normal” eye sight and not be wearing sunglasses. The same observer must record all the measurements at each site throughout each monitoring period. Measurements must be recorded from the sunny side of the boat when possible.

- Weather conditions during the time of measurements are recorded for each transect line.
- Whilst sitting on the sunny (in very cloudy conditions then the western) side of the boat, place the viewer box into the water so that the sealed end is immersed just a couple of centimetres.
- Allow 30 seconds for the observers’ eyes to acclimatise.
- Lower the Secchi disk slowly into the water. Measure and record the depths at which the disk disappears and reappears. (Secchi depth = distant from the bottom of the viewer box to the face of the Secchi disk.) Repeat the measurement.
- Repeat the above at each site.

Secchi Depth Data Sheet–Western Transect

Date:
Skipper:
Boat:
Observer:

Visual assessments

Wind direction		Full sun		Fine	
Wind speed		Partial sun		Raining	
Wave height		Cloudy		Showers	

Site	Waypoint	Time	Disap.	Reap.	Disap.	Reap.
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Comments:

Secchi Depth Data Sheet–Eastern Transect

Date:
Skipper:
Boat:
Observer:

Visual assessments

Wind direction		Full sun		Fine	
Wind speed		Partial sun		Raining	
Wave height		Cloudy		Showers	

Site	Waypoint	Time	Disap.	Reap.	Disap.	Reap.
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Comments:

Water sampling

Water samples are collected at sites **01**, **07** and **15** on both transect lines. Water samples are to be collected at the same time as the multi-parameter sonde is deployed.

- Using the boat's depth sounder, determine the depth of water at each of the three sites.
- Open the Niskin water sampler and secure each end of the lid tails into the catch.
- Whilst holding the weight in one hand, lower the sampler to mid water (half of the maximum depth).
- Record the time.
- Drop the weight down the line.
- Retrieve the sampler.
- Record the depth the sample was collect from.
- Undo the rubber tube and open the air valve.
- Pour out a little water from the tube line.
- Fill the 0.5 L bottle with the water sample.
- Label the bottle with date, transect line, and site number.
- Store the sample in a chilly bin with ice.
- Once all six samples are collected put into the freezer until the sediment samples have also been collected and send to NIWA Hamilton.

Water Sample Data Sheet

Date:
Skipper:
Boat:
Researcher:

Western Transect

Site	Waypoint	Depth	Time
1			
7			
15			

Eastern Transect

Site	Waypoint	Depth	Time
1			
7			
15			

Comments:

Water column profiling

- Calibrate all sensors of the multi-parameter sonde following the instructions in the instrument manual.
- Set the sonde to take readings continuously every two or four seconds starting in the morning of the monitoring day. The wiper of the turbidity sensor should be set to operate approximately every 5 minutes.
- When the boat approaches the first site, replace the sonde cap with the guard.
- Attach a rope securely to the top of the sonde. Tie the other end of the rope onto the boat.
- Record the time and a GPS waypoint at the beginning of each deployment.
- Place the sonde into the water and slowly lower it at a pace of 1 meter depth per 10 seconds.
- Once you feel that the sonde has touched the seafloor retrieve the sonde (data recorded on the way up are not used, so there is no time restriction when retrieving the sonde).
- Try to leave the sonde in the water between sampling sites. If this is not practical, allow the sonde to acclimatise in the surface water before each deployment for about 30 seconds.
- Once all the sites have been sampled wash the sonde and the sensors with fresh water and attach the cap.

Multi Parameter Sonde Data Sheet

Date:
Skipper:
Boat:
Researcher:

Western Transect

Site	Waypoint	Time
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Eastern Transect

Site	Waypoint	Time
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Sediment trap deployment

We recommend the use of a KC Denmark sediment trap with four collecting tubes. A similar trap may be used as long as this trap is used consistently throughout the entire monitoring program.

Traps are to be secured in place using permanent moorings and held upright by an underwater float. The trap is attached to the float and the mooring with 1-m ropes with strong “diver friendly” clips at each end. Traps are to be deployed and retrieved by two divers.

One trap is to be placed on the eastern transect line, the other on the western and both in 15 m water depth. Traps are to be left at the sites for 4 days. Should the weather be unsuitable for collection, both traps should be collected at the next available date and the length of their deployment should be recorded and data adjusted for accordingly.

Protocol for trap deployment

1. The skipper locates the deployment site using GPS and anchors the boat.
2. One trap is assembled on board the anchored vessel.
3. The float should be attached to the top of the trap with a 1-m rope. A 30-m rope and a 1-m rope are attached to the bottom of the trap.
4. The trap is carefully lowered into the water and the tubes filled with seawater so that the trap is able to sink to a depth of about 1 m.
5. Two divers enter the water.
6. One diver holds the end of the rope which is attached to the bottom of the trap. The other diver carries a wreck reel or similar to aid in conducting an underwater search of the permanent mooring.
7. Both divers descend along the anchor line. The diver holding the rope lets out the rope as they descend so that there is little tension on the trap.
8. Once on the sea floor, the diver with the wreck reel starts a circular search whilst the other diver remains at the anchor and holds onto the end of the wreck reel.
9. Once the permanent mooring is located, both divers make their way to it.
10. The diver holding the rope threads the end of the rope through the ring/shackle of the mooring.
11. Both divers pull the trap down below the surface and connect the 1-m rope at the lower end of the trap to the shackle.
12. The 30-m rope can then be released and coiled up.
13. The divers check that the underwater float is holding the trap firmly upright and the mooring is holding it in place.
14. Divers ascend with a safety stop.

Protocol for retrieving the traps

1. The skipper locates the deployment site using GPS and anchors the boat.
2. Two divers enter the water.
3. One diver carries a 30-m rope and six latex non-powdered gloves. The other diver carries a wreck reel or similar to aid in conducting an underwater search.
4. The divers follow the anchor line while descending.
5. Once on the seafloor, the divers conduct a circular search to locate the sediment trap.
6. Once the trap is located, one diver seals the end of each collecting tube with one latex glove.
7. The diver ties the 30-m rope onto the bottom of the sediment trap and then detaches the 1-m rope from the mooring.
8. The diver gently releases the trap allowing the underwater float to carry the trap to the surface.
9. The divers ascend whilst still holding the other end of the 30-m rope and perform a safety stop.
10. Once on the surface, the divers tow the trap to the boat.
11. While one diver remains in the water, the other boards the vessel.
12. The diver in the water releases one tube at a time and passes this tube to the second diver on the boat.
13. Once all tubes are on board, the trap can be lifted out of the water.
14. The contents of the tubes are to be carefully poured into a 2 L bottle.
15. Each bottle is to be labelled and placed into a chilly bin containing ice.

Sample analysis

- Three of the four samples collected from each trap are to be analysed for TPM, POM and PCOM. These samples are to be couriered to the NIWA laboratory in Hamilton.
- One sample from each trap is to be analysed for C:N isotope ratios. This sample is to be sent to the Isotope Unit at The University of Waikato in Hamilton.
- All samples are to be kept on ice during transportation.
- Laboratories are to be notified before samples are sent.

7. References

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8. Appendix

Site locations

Geographic Coordinate System GCS_NZGD_2000

Western Transect Line

Site	East	South
WT 01	175°46'33.41	36°49'17.743
WT02	175°46'35.92	36°49'11.328
WT03	175°46'38.431	36°49'4.913
WT 04	175°46'40.941	36°48'59.335
WT 05	175°46'42.893	36°48'52.92
WT 06	175°46'44.845	36°48'46.505
WT 07	175°46'47.635	36°48'40.927
WT 08	175°46'50.424	36°48'35.07
WT 09	175°46'52.655	36°48'28.376
WT 10	175°46'55.165	36°48'22.24
WT 11	175°46'57.675	36°48'16.104
WT 12	175°46'59.628	36°48'9.968
WT 13	175°47'2.138	36°48'3.274
WT 14	175°47'4.927	36°47'57.696
WT 15	175°47'7.716	36°47'51.281

Eastern Transect Line

Site	East	South
ET01	175°48'16.607	36°50'7.389
ET02	175°48'18.839	36°50'0.974
ET03	175°48'21.349	36°49'54.838
ET04	175°48'23.58	36°49'48.981
ET05	175°48'26.09	36°49'42.009
ET06	175°48'28.322	36°49'36.43
ET07	175°48'30.832	36°49'29.736
ET08	175°48'33.621	36°49'23.879
ET09	175°48'35.573	36°49'17.743
ET10	175°48'38.083	36°49'11.886
ET11	175°48'40.594	36°49'5.471
ET12	175°48'43.104	36°48'59.056
ET13	175°48'45.893	36°48'52.641
ET14	175°48'48.124	36°48'46.505
ET15	175°48'50.634	36°48'40.648

Secchi Depth Data Sheet–Western Transect

Date: 02/06/2010
Skipper: Andy Wills (DOC)
Boat: Triplefin MSA number 121774
Observer: Severine Dewas (AUT)

Visual assessments

Wind direction	w/sw	Full sun		Fine	
Wind speed		Partial sun	x	Raining	
Wave height		Cloudy		Showers	x

Site	Waypoint	Time	Disap.	Reap.	Disap.	Reap.
1	WT01	11:07	3056	3.32	3.58	3.29
2	WT02	11:25	3.03	2.90	3.30	3.39
3	WT03	11:29	2.90	2.74	2.77	2.60
4	WT04	11:35	1.95	1.81	2.51	2.37
5	WT05	11:40	1.69	1.56	1.42	1.30
6	WT06	11:45	1.42	1.28	1.13	1.03
7	WT07	11:51	1.26	1.17	1.33	1.18
8	WT08	12:03	1.33	1.15	1.23	1.01
9	WT09	12:09	1.20	0.99	1.12	0.88
10	WT10	12:13	1.15	1.00	1.10	0.92
11	WT11	12:18	1.18	1.02	1.26	1.09
12	WT12	12:21	1.27	1.16	1.36	1.26
13	WT13	12:25	1.39	1.29	1.32	1.19
14	WT14	12:29	1.44	1.34	1.47	1.25
15	WT15	12:34	1.79	1.65	1.84	1.64

Comments:

Secchi Depth Data Sheet–Eastern Transect

Date: 02/06/2010
Skipper: Andy Wills (DOC)
Boat: Triplefin MSA number 121774
Observer: Severine Dewas (AUT)

Visual assessments

Wind direction	w/sw	Full sun		Fine	
Wind speed		Partial sun	x	Raining	
Wave height		Cloudy		Showers	x

Site	Waypoint	Time	Disap.	Reap.	Disap.	Reap.
1	ET01	12:49	3.30	3.12	3.25	2.97
2	ET02	12:57	3.28	3.03	3.44	3.22
3	ET03	13:00	3.43	3.18	3.54	3.28
4	ET04	13:03	3.40	3.18	3.31	3.15
5	ET05	13:06	3.28	3.11	3.47	3.28
6	ET06	13:10	3.47	3.26	3.68	3.39
7	ET07	13:13	3.56	3.33	3.26	2.97
8	ET08	13:21	3.25	3.13	3.52	3.28
9	ET09	13:26	3.42	3.37	3.61	3.32
10	ET10	13:30	3.76	3.55	3.76	3.64
11	ET11	13:37	3.50	3.28	3.91	3.62
12	ET12	13:41	3.70	3.40	3.66	3.44
13	ET13	13:46	3.92	3.67	3.76	3.57
14	ET14	13:52	3.55	3.35	3.54	3.38
15	ET15	13:58	3.80	3.50	3.32	3.39

Comments:

Multi Parameter Sonde Data Sheet

Date: 02/06/2010
Skipper: Andy Wills (DOC)
Boat: Triplefin MSA number 121774
Researcher: Sue Dodd (AUT)

Western Transect

Site	Waypoint	Time
1	WT01	11:05
2	WT02	11:20
3	WT03	11:26
4	WT04	11:31
5	WT05	11:36
6	WT06	11:41
7	WT07	11:48
8	WT08	12:00
9	WT09	12:05
10	WT10	12:10
11	WT11	12:13
12	WT12	12:17
13	WT13	12:23
14	WT14	12:25
15	WT15	12:30

Eastern Transect

Site	Waypoint	Time
1	ET01	12:48
2	ET02	12:54
3	ET03	12:56
4	ET04	13:00
5	ET05	13:03
6	ET06	13:06
7	ET07	13:10
8	ET08	13:18
9	ET09	13:22
10	ET10	13:27
11	ET11	13:34
12	ET12	13:38
13	ET13	13:43
14	ET14	13:148
15	ET15	13:55

Water Sample Data Sheet

Date: 02/06/2010
Skipper: Andy Wills (DOC)
Boat: Triplefin MSA number 121774
Researcher: Sue Dodd (AUT)

Western Transect

Site	Waypoint	Depth	Time
1	WT01	3.5	11:15
7	WT07	11.3	11:55
15	WT15	12.6	12:35

Eastern Transect

Site	Waypoint	Depth	Time
1	ET01	3.2	12:50
7	ET07	9.95	13:16
15	ET15	15.26	14:07

Comments: