OLD BAR BEACH SAND TRACING STUDY: ILLUMINATING THE PATHWAYS

P Lawless[1], **M Griffith**[2], J Marsh[3], P Evans[4], G Blumberg[1]

[1]Royal HaskoningDHV, Sydney
[2]Greater Taree City Council, Taree
[3]ETS (Worldwide), Helensburgh (UK)
[4]NSW Office of Environment and Heritage, Newcastle

Introduction

There is a long history of erosion/recession at Old Bar Beach, with some of the highest recession rates on the NSW coast. With significant threats to coastal properties at Old Bar, Greater Taree City Council (Council) partnered with the NSW Office of Environment and Heritage (OEH) to investigate structural options available to protect development. While a rock revetment could feasibly protect property, this would inevitably detract from beach amenity. A possible solution to preserve beach amenity would be to undertake targeted beach nourishment. A better understanding of the complex sediment transport processes in the region is required to fully assess the feasibility of any beach nourishment strategy. Understanding the sediment transport pathways and loss mechanisms also assists in assessing the feasibility of other possible coastal management strategies.

Working with OEH and MidCoast Water, Council carried out a sand tracing study aimed at improving the understanding of sediment transport processes at Old Bar Beach (Royal HaskoningDHV, 2015). Sand tracers provide unequivocal and tangible data on actual sediment transport on a site-specific basis for the study period.

The first step involved the deployment of various coloured fluorescent sand tracer material at three locations on Old Bar Beach. Over the following 10 months, four (4) sampling exercises were undertaken within both the onshore and offshore environments. The sampling region extended from the southern side of Wallabi Point to the southern end of Manning Point Beach, including the Farquhar Inlet entrance area. The sampling region and tracer deployment locations are depicted on Figure 1.

The collected samples were subsequently analysed to assess the transport directions of the tracer material under the prevailing coastal processes. The analysis clearly identified longshore and cross-shore sediment transport pathways. This provided an improved conceptual understanding of sediment transport processes at Old Bar Beach for a range of wave conditions including low energy, significant storm activity, and post-storm beach recovery. The results from the sand tracing study will provide more certainty to Council and the local community regarding the selection and design of possible coastal management options at Old Bar Beach.

Sand tracing is starting to gain traction in Australia as an innovative and valuable tool for determining the effectiveness of coastal management strategies.

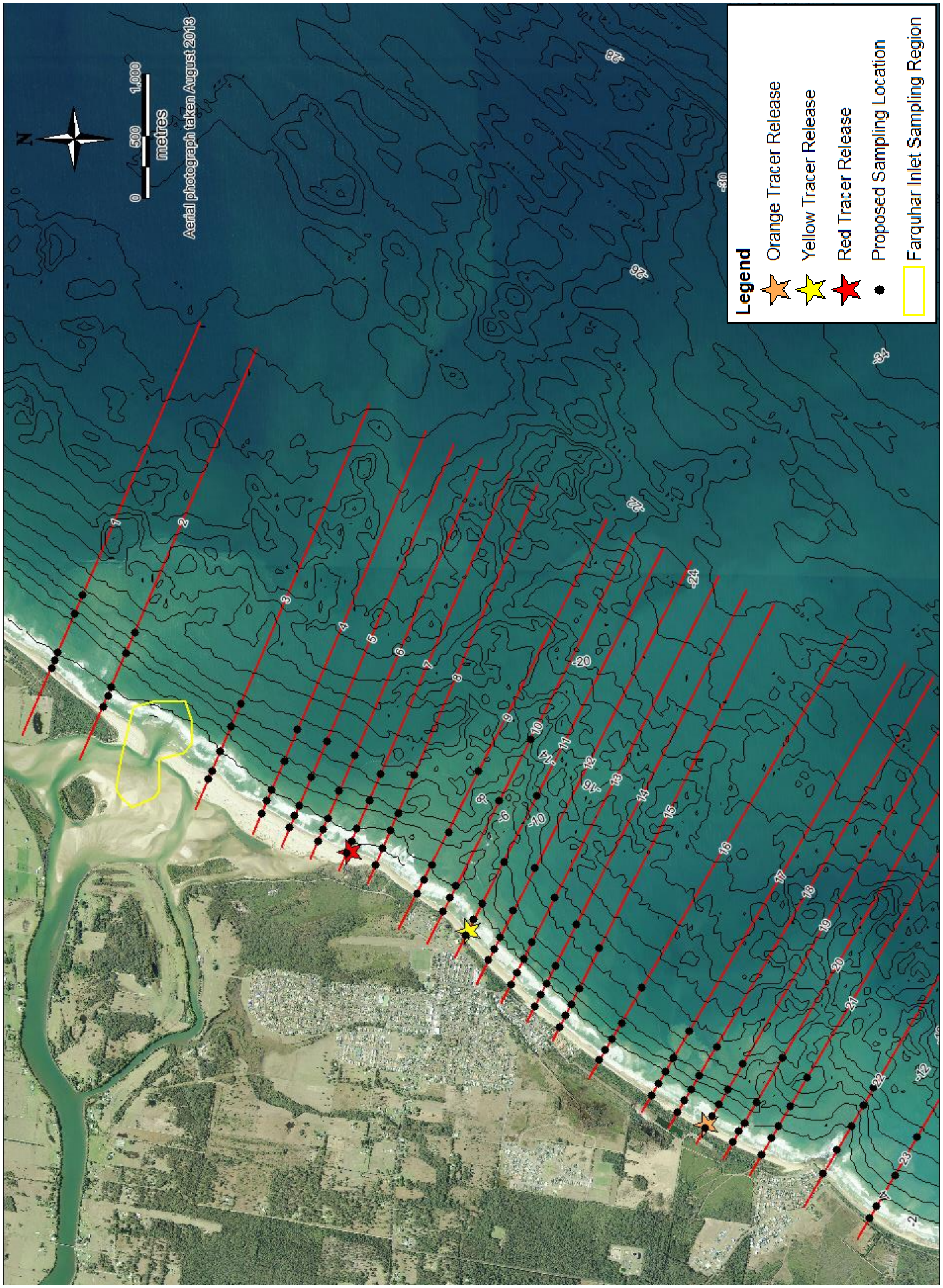

Figure 1: Sampling region and tracer release locations, with 23 transects depicted (seabed contours at 2 m intervals and to AHD)

Background Sampling and Analysis

Background sampling and analysis was carried out prior to the deployment of the tracer material in order to determine whether there was any background fluorescent material present in the natural sediment that may interfere with analysis of the introduced tracer. The background samples were collected before any tracer mixing or release took place.

Background samples were collected along the beach and offshore at each transect in the proposed sampling region (Figure 1). A total of 46 background samples were collected.

From the analysis of the background samples, it was observed that there was no natural fluorescence in the samples which could interfere with the analysis of the introduced fluorescent tracer particles used in this study.

Tracer Manufacture and Deployment

Tracer Manufacture

ETS' EcoTrace fluorescent sediment particle tracers were utilised in this study. The environmentally benign tracers are designed to be transported like natural sediment, thus assimilating the processes of tidal currents, wind and waves to give an integrated assessment of sediment transport. The tracers are a solid solution of fluorescent dyes in a thermoplastic polymer base.

Fluorescent tracer particles have emerged as a preferred form of environmental tracing technology in comparison to other methods. For example, radioactive tracers are generally not favoured due to environmental concerns, while the effectiveness of dyeing native sediments can be limited by abrasion of the dye material. Similarly, the use of rare earth metals to make a (fluorescent) particle magnetic is not considered to be effective due to significant concerns over particle charge, while radiometric detection is significantly less detectable and therefore less informative than the fluorescent tracer particles, even as a towed array system. In comparison, the EcoTrace particles have been shown to remain highly detectable in high energy environments over study periods spanning several years.

While it is acknowledged that certain forms of microplastics in the marine environment are known to cause environmental harm, ETS' EcoTrace particles are non-toxic and are considered inert. For example, ecotoxicology testing on Pacific Oysters was undertaken by the Centre for Environmental Fisheries & Aquaculture Science (CEFAS) for bacterial-sized EcoTrace particles, which demonstrated that the oysters eliminated all of the particles as pseudofaeces.

In terms of structure, the EcoTrace particles are 15% by weight polymer, with the vast bulk of the structure comprising the naturally occurring mineral barium sulphate. The polymer is interspersed in thin veneers around and between the barium sulphate particle, which therefore does not present a large volume of internal cavities to absorb contaminants such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). Other forms of microplastics, such as polyethylene, are known to be a source and sink for such contaminants (Rochman et al, 2013).

Furthermore, the relatively small quantity of material used in the study means that the scale of any adverse environmental impact would be negligible. Moreover, the benefits of the study (e.g. improving the level of understanding of the local coastal processes) are considered to far outweigh any unlikely minor environmental impacts.

ETS used a generic sediment particle density of 2.65 g/cm^3, equivalent to the density of silica, to provide comparable results of transport of the sediment tracers to natural sediment under typical conditions. Fall velocity tests were also undertaken for the sand tracers which indicated that the sand-sized tracer particles had similar fall velocities to natural sand grains.

In order for the sediment tracers to behave in the same way as the target sediment, it was important to ensure that the tracer particles had similar physical characteristics to the target sediment. Beach sampling and analysis for particle size distribution (PSD) was therefore undertaken prior to the manufacture of tracer material.

Based on the assessment of particle size results for the native beach material, fine to medium sand-sized tracers (125 to 500 µm) were manufactured and utilised for this study.

Tracer Deployment

Tracer material was placed at three locations along Old Bar Beach (refer Figure 1), namely:

- yellow tracer (350 kg) at Taree-Old Bar Surf Life Saving Club (SLSC);
- red tracer (250 kg) at the northern end of the beach, south of Farquhar Inlet; and,
- orange tracer (250 kg) at the MidCoast Water Exfiltration Ponds.

The yellow and red tracer material was deployed in May 2014, while the orange tracer material was deployed in July 2014.

At each site, the tracer material was released into two alongshore trenches, each about 50-70 m long (alongshore), 0.5 m wide (cross-shore) and 0.3 m deep. These trenches were located at around mean low water (MLW) at each site. This was necessary to ensure that the tracer material would be subjected to swash, wave and tidal processes immediately following deployment. Placement was therefore undertaken around low tide to enable access to the placement locations.

Prior to release, the tracer particles were wetted and mixed with sand from the site to ensure they adsorbed the same electro-chemical charge as natural sand particles. This also prevented the tracer material from being blown away from the placement location by wind action.

Photographs taken during each tracer deployment are provided in Figure 2.

Figure 2: Photographs of tracer deployments

Prevailing Conditions

Manly Hydraulics Laboratory (MHL), which is part of NSW Public Works, operates a network of Waverider buoys in deep water along the NSW coast. Hourly wave data from the Crowdy Head Waverider buoy, located approximately 35 km north-east of Old Bar Beach, was analysed for the following dates:

- between yellow/red tracer deployment and Sampling Exercise 1, i.e. 15 May 2014 to 16 July 2014;
- between Sampling Exercise 1/orange tracer deployment and Sampling Exercise 2, i.e. 17 July 2014 to 11 September 2014[1];
- between Sampling Exercise 2 and Sampling Exercise 3, i.e. 12 September 2014 to 10 December 2014;
- between Sampling Exercise 3 and Sampling Exercise 4, i.e. 11 December 2014 to 12 March 2015; and
- over the entire study period, i.e. 15 May 2014 to 12 March 2015.

Statistics for significant wave height (H_s), peak spectral wave period (T_p) and wave direction for each period are summarised in Table 1. The long-term mean and 10% exceedance H_s and T_p values for the Crowdy Head data record are also provided in Table 1 to give an indication of wave conditions during the study period relative to long-term conditions.

[1] The Crowdy Head Waverider buoy did not collect data between 2/9/14 and 12/9/14.

Table 1: Crowdy Head offshore wave statistics

Period	Statistic	H_s (m)	T_p (s)	Wave Direction (deg TN)
Between yellow/red tracer deployment and Sampling Exercise 1 (15/5/14 to 16/7/14)	Minimum	0.5	3.5	-
	Maximum	3.0	16.0	-
	Mean	1.3	10.1	145
	Median	1.2	9.8	151
	10% Exceedance	1.9	12.9	-
Between Sampling Exercise 1 / orange tracer deployment and Sampling Exercise 2 (17/7/14 to 11/9/14[1])	Minimum	0.4	3.3	-
	Maximum	4.8	17.4	-
	Mean	1.9	11.1	145
	Median	1.8	10.8	150
	10% Exceedance	3.4	13.8	-
Between Sampling Exercise 2 and Sampling Exercise 3 (12/9/14 to 10/12/14)	Minimum	0.6	4.1	-
	Maximum	3.3	17.4	-
	Mean	1.5	9.4	123
	Median	1.3	9.3	133
	10% Exceedance	2.1	12.1	-
Between Sampling Exercise 3 and Sampling Exercise 4 (11/12/14 to 12/3/14)	Minimum	0.6	4.0	-
	Maximum	5.3	13.8	-
	Mean	1.6	9.6	113
	Median	1.5	9.8	109
	10% Exceedance	2.3	11.5	-
Entire study period (15/5/14 to 12/3/14)	Minimum	0.4	3.3	-
	Maximum	5.3	17.4	-
	Mean	1.5	9.9	128
	Median	1.4	9.8	134
	10% Exceedance	2.3	12.9	-
Long-term (October 1985 to December 2009) After Shand et al (2011)	**Mean**	**1.6**	**9.7**	**Not reported**
	10% Exceedance	**2.5**	**12.2**	

Overall, it is evident that offshore wave conditions during the study period were relatively mild in comparison to long-term average conditions. Neutral or slightly accretionary conditions would be expected to prevail throughout the majority of this period, with the exception of discrete and infrequent storm events, with the most notable event occurring towards the end of August 2014. This storm was characterised by significant wave heights above 3.0 m for around four days, and a maximum H_s of 4.8 m. The average recurrence interval (ARI) for this storm was estimated to be around 4 years[2].

A larger wave event than the August 2014 event was recorded on 12/12/14, with a maximum H_s of 5.3 m at 11.5 s T_p and a wave direction of 207° TN. However, this storm occurred over a much shorter duration than the August 2014 event, with significant wave heights above 2.5 m for around two days. The estimated ARI for these conditions is less than 0.2 years (or five times per year)[2], which highlights the minor nature of this event.

[2] This estimation was based on ARI versus duration exceedance plots provided in Shand et al (2011) for the Crowdy Head Waverider Buoy data.

Visual observations of dunal sand profiles were also undertaken to provide a qualitative indication of beach change during the study period (Figure 3). Overall, it was considered that the study period was likely neutral or slightly accretionary in terms of dunal sand volumes. However, the period July to September 2014 appeared to be erosive in terms of dunal sand volumes, which can be primarily attributed to the August 2014 storm event.

Figure 3: Views of Old Bar Beach near Meridian Resort during study period

Furthermore, OEH carried out detailed surveys of Old Bar Beach in November 2013 and March 2015. Comparison of these surveys was undertaken to assess recent changes in dune positions and profiles at a number of locations along Old Bar Beach. This assessment found that:

- Slight accretion of dune profiles generally occurred along Old Bar Beach between the orange tracer release site and Old Bar Public School.

- Minor recession of dune profiles generally occurred between Old Bar Public School and Taree-Old Bar SLSC. While profile recession (at 4 m AHD) was measured near the yellow tracer release site, accretion of the lower beach face was also evident. This would generally increase the likelihood of yellow tracer material on the beach being buried during the study period.
- Analysis of profile change to the north of Urana Bombora, including the red tracer release site, could not be undertaken due to the limited spatial coverage of the November 2013 survey.

It was also noted that the entrance to Farquhar Inlet migrated southwards by a distance of around 100 m between September 2014 and March 2015, i.e. between Sampling Exercise 2 and Sampling Exercise 4. The total southwards migration between August 2013 and March 2015 was around 450 m. Southwards migration is indicative of a closing entrance state (WorleyParsons, 2010).

Sample Collection and Analysis

Sample Collection

Following the deployment of tracer material, a total of four sampling exercises were undertaken from July 2014 to March 2015 to ascertain the transport of the tracers under natural processes. The timing of these sampling exercises was as follows:

- Sampling Exercise 1 – July 2014;
- Sampling Exercise 2 – September 2014;
- Sampling Exercise 3 – November-December 2014; and,
- Sampling Exercise 4 – March 2015.

It should be noted that a fifth sampling exercise was undertaken in September 2015. However, since the sample analysis results for this sampling exercise were not available at the time of writing this paper, it has not been discussed herein.

The selection of sample locations for each sampling exercise required a flexible approach that considered the expected sediment transport pathways and extents during the preceding period. This was based on recorded offshore wave data, observed erosion or accretion, and results from any preceding sampling exercises. Site conditions at the time of sampling also influenced adopted sample locations. The timing of each sampling exercise was influenced by boat availability and weather conditions.

Samples were generally collected from within a sampling region which comprised numerous shore-normal transects located within an area extending from near Wallabi Point in the south to the northern side of Farquhar Inlet in the north (refer Figure 1). Spacing between adjacent transects varied from 125 m to 500 m. For each transect, up to eight (8) samples were collected at the following approximate positions:

- Mean High Water (MHW, at about 0.5 m AHD);
- Mean Sea Level (MSL, at about 0 m AHD);
- MLW (at about -0.5 m AHD);
- -2 m AHD;

- -4 m AHD;
- -7 m AHD;
- -11 m AHD; and,
- -14 m AHD.

Several samples were also taken within the entrance of Farquhar Inlet during Sampling Exercises 2, 3 and 4.

Collection of the MHW, MSL, MLW and Farquhar Inlet surface samples involved transferring sand from the upper 5-10 cm of the beach surface into plastic containers using a stainless steel spoon. The spoon was rinsed in seawater following collection of each sample to minimise the risk of cross-contamination between sites.

Depth-averaged beach samples (MHW, MSL and MLW) were also collected along nine (9) additional transects at each tracer release site during Sampling Exercise 4 to determine any vertical mixing or burial of the tracer material on the beach to more accurately quantify tracer results on the beach. The Farquhar Inlet samples collected during Sampling Exercise 4 were also depth-averaged.

The depth-averaged samples collected during Sampling Exercise 4 were obtained by digging a small pit approximately 0.3-0.5 m deep and 0.3 m wide, then transferring sand from the side of the pit into plastic containers using a stainless steel spoon. Care was taken to ensure that equal amounts of sediment were sampled along the entire vertical cross-section of the pit. The sediment in the plastic container was also homogenised to ensure that the sample was representative of depth-averaged conditions.

Offshore samples were collected using a stainless steel *Shipek* grab sampler with bucket attachment. Sampling was undertaken from a fibreglass fishing vessel. The grab sampler was lowered to the sea bed at each sampling location where the bucket attachment was triggered to close and penetrate the sediment.

Prior to sampling, the grab sampler bucket was thoroughly rinsed in seawater. This process was repeated between sampling locations to avoid any potential contamination between sites. Samples were transferred from the grab sampler bucket into plastic containers using a stainless steel spoon. The spoon was rinsed in seawater following collection of each sample to minimise the risk of cross-contamination between sites.

Each sample container was clearly labelled and stored in a plastic zip-lock bag to preserve the sample in the event that the plastic container was damaged prior to analysis (e.g. during transit to the analytical laboratory).

Photographs of the beach and offshore sampling are provided in Figure 4.

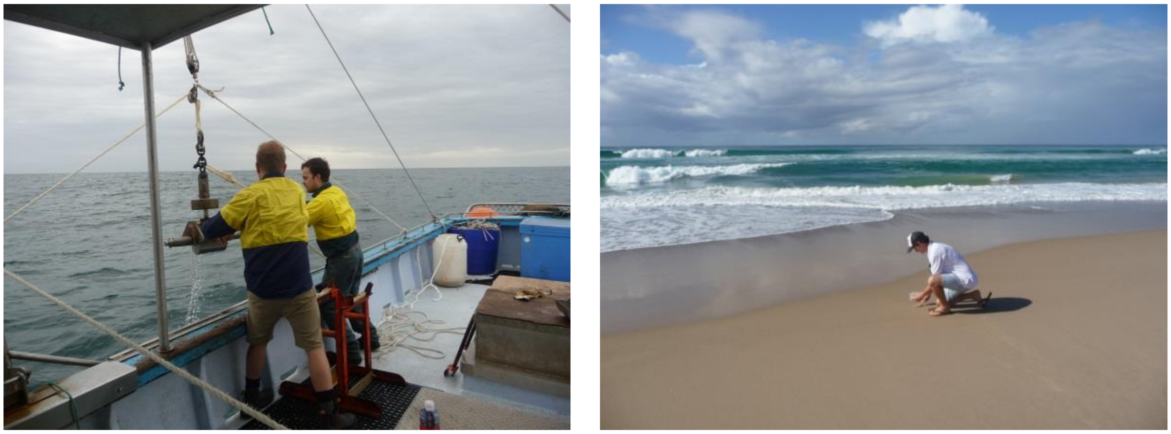

Figure 4: Offshore sampling (left) and beach sampling (right)

Sample Analysis

All the collected samples were shipped to ETS's ISO 9001 certified laboratory in the UK. All samples were analysed for tracer particle counts using a magnifying ultra-violet (UV) stereo inspection microscope, which were then converted into particle counts per square metre of the sample area, e.g. cross-sectional area of the grab sampler bucket attachment for the offshore samples.

Particle sizing of tracer particles covered the following size bands:

- 'fine': 125-250 µm, i.e. equivalent to fine sand (Wentworth grain size classification);
- 'medium': 250-375 µm, i.e. finer fraction of medium sand (Wentworth grain size classification); and,
- 'coarse': 375-500 µm, i.e. coarser fraction of medium sand (Wentworth grain size classification).

Results

Tracer counts for each of the sampling exercises are plotted in Figure 5 (yellow tracer), Figure 6 (red tracer) and Figure 7 (orange tracer; with the exception of Sampling Exercise 1[3]).

Particle size analysis results for each of the sampling exercises are plotted in Figure 8 (yellow tracer), Figure 9 (red tracer) and Figure 10 (orange tracer; with the exception of Sampling Exercise 1[3]).

These results are discussed in the following sections.

[3] The orange tracer material was deployed after the first sampling exercise was completed, and was therefore assessed based on results obtained from subsequent sampling exercises.

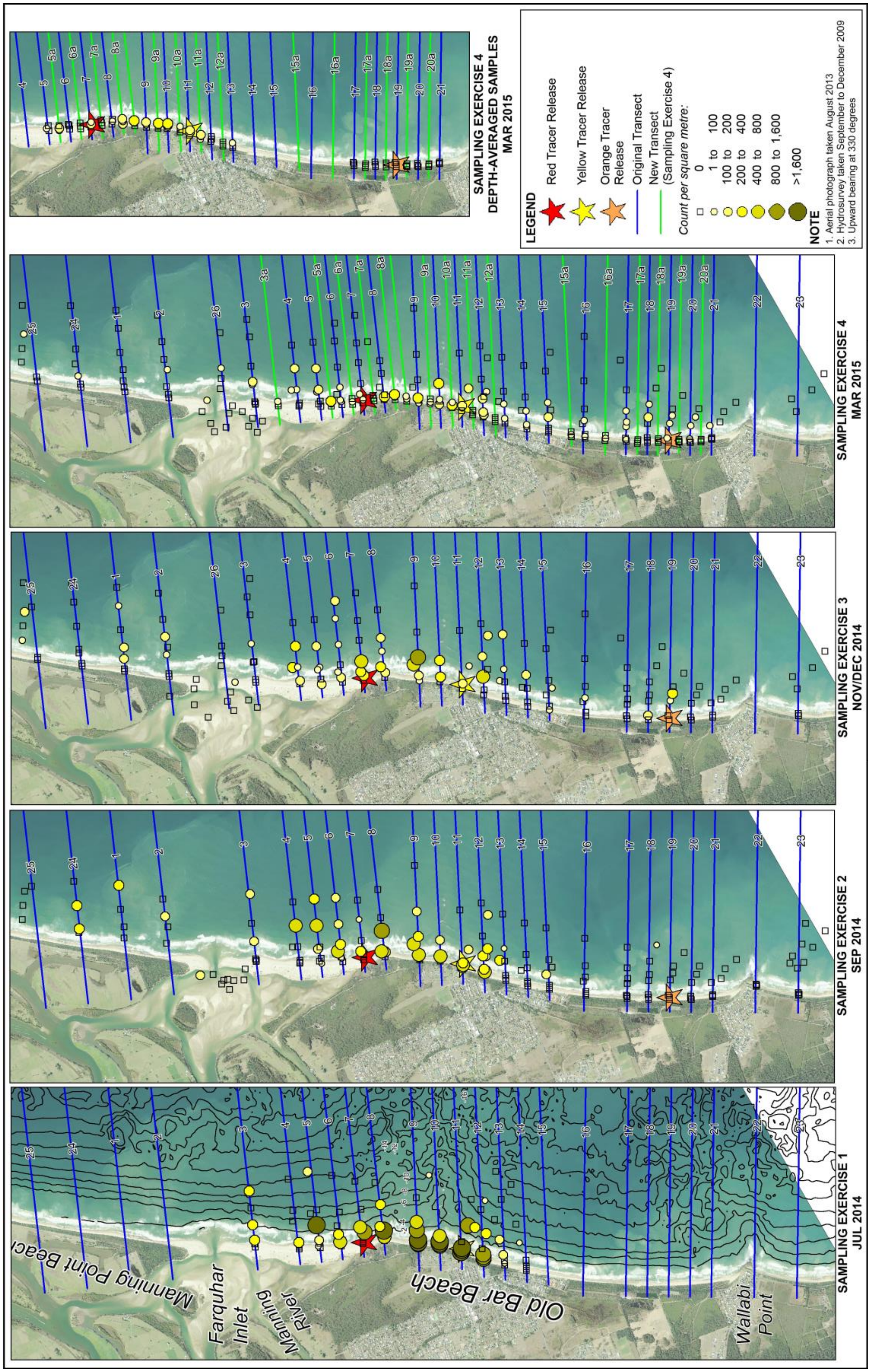

Figure 5: Yellow tracer results - counts per square metre

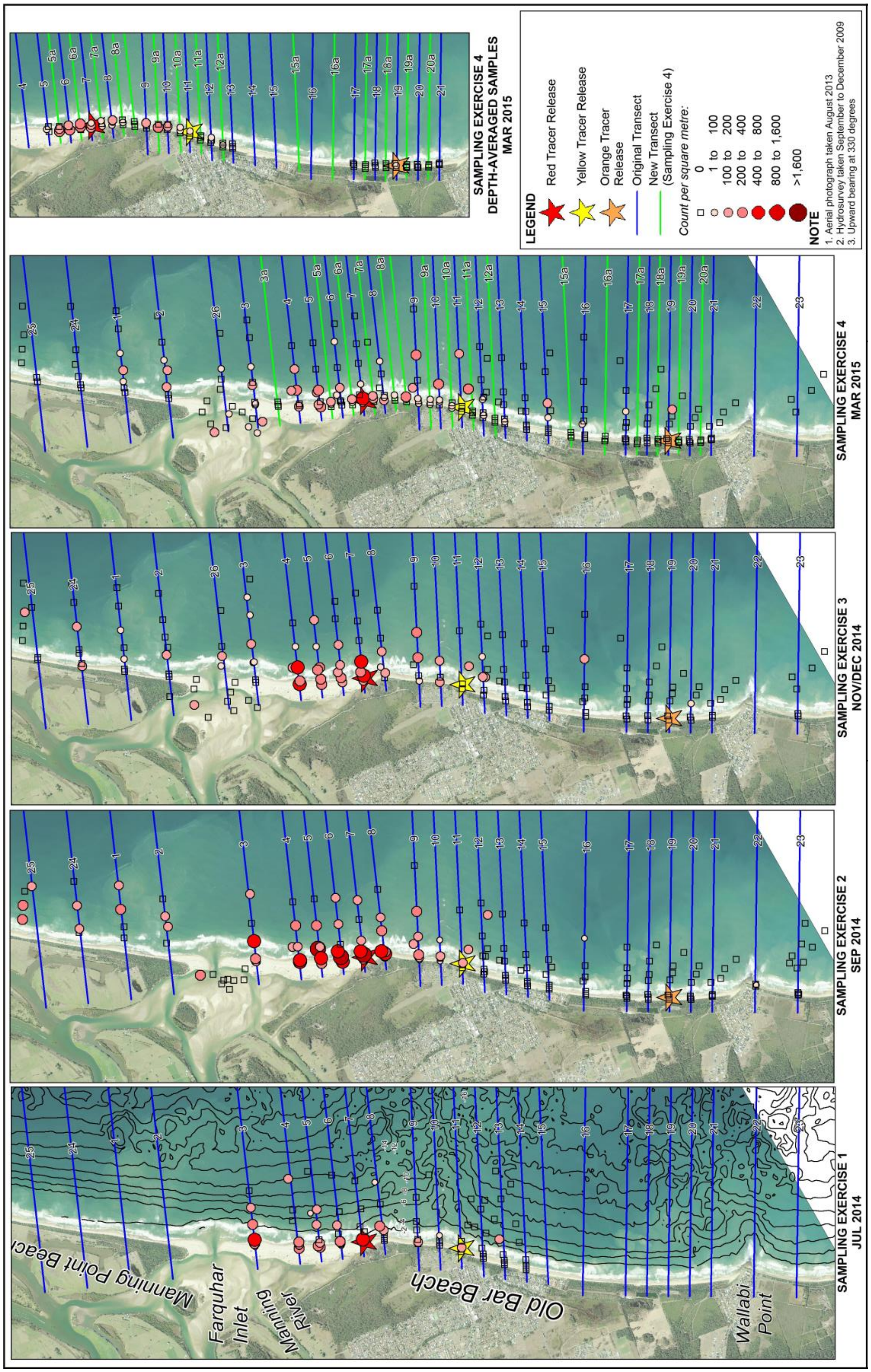

Figure 6: Red tracer results - counts per square metre

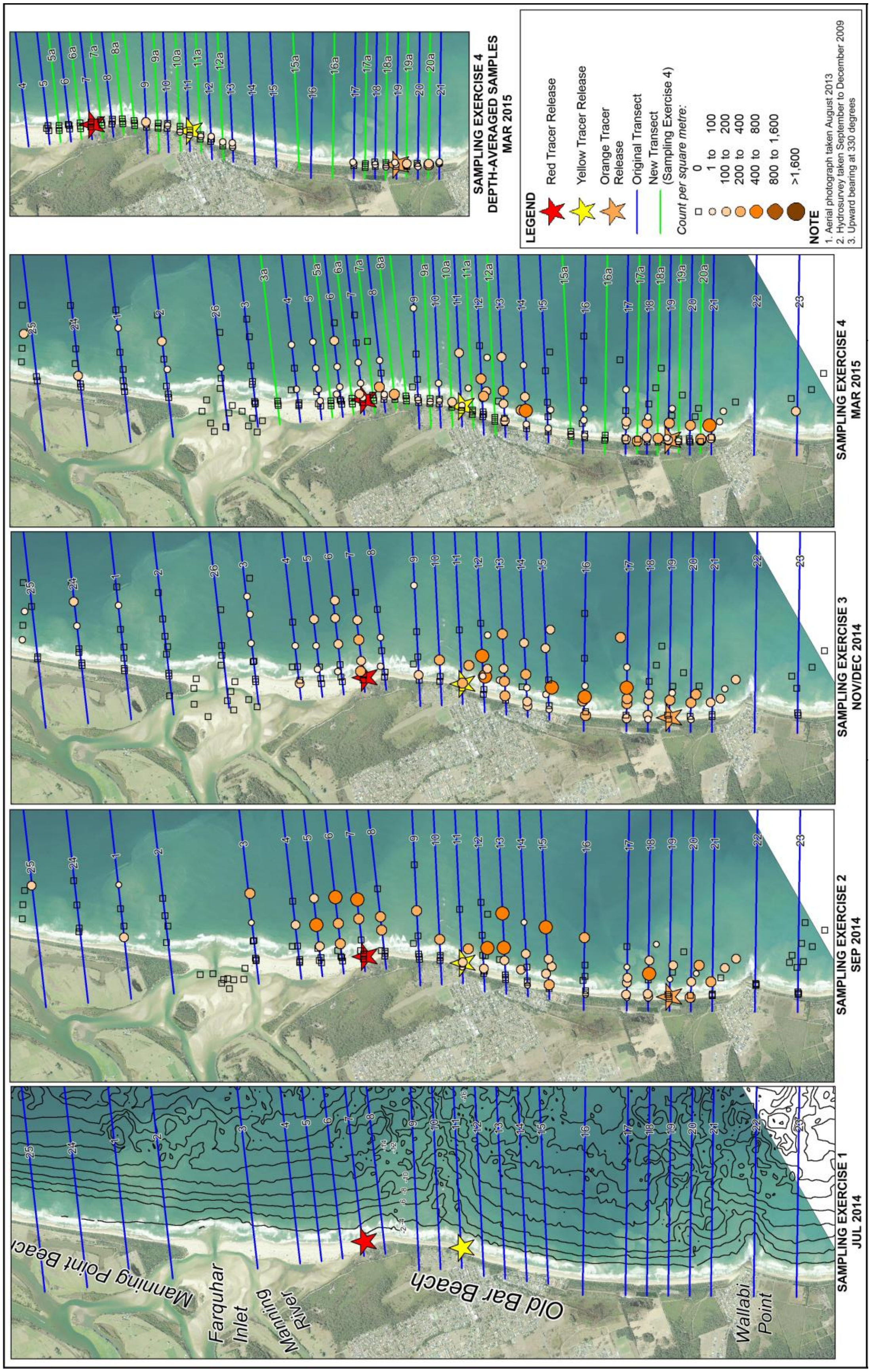

Figure 7: Orange tracer results - counts per square metre

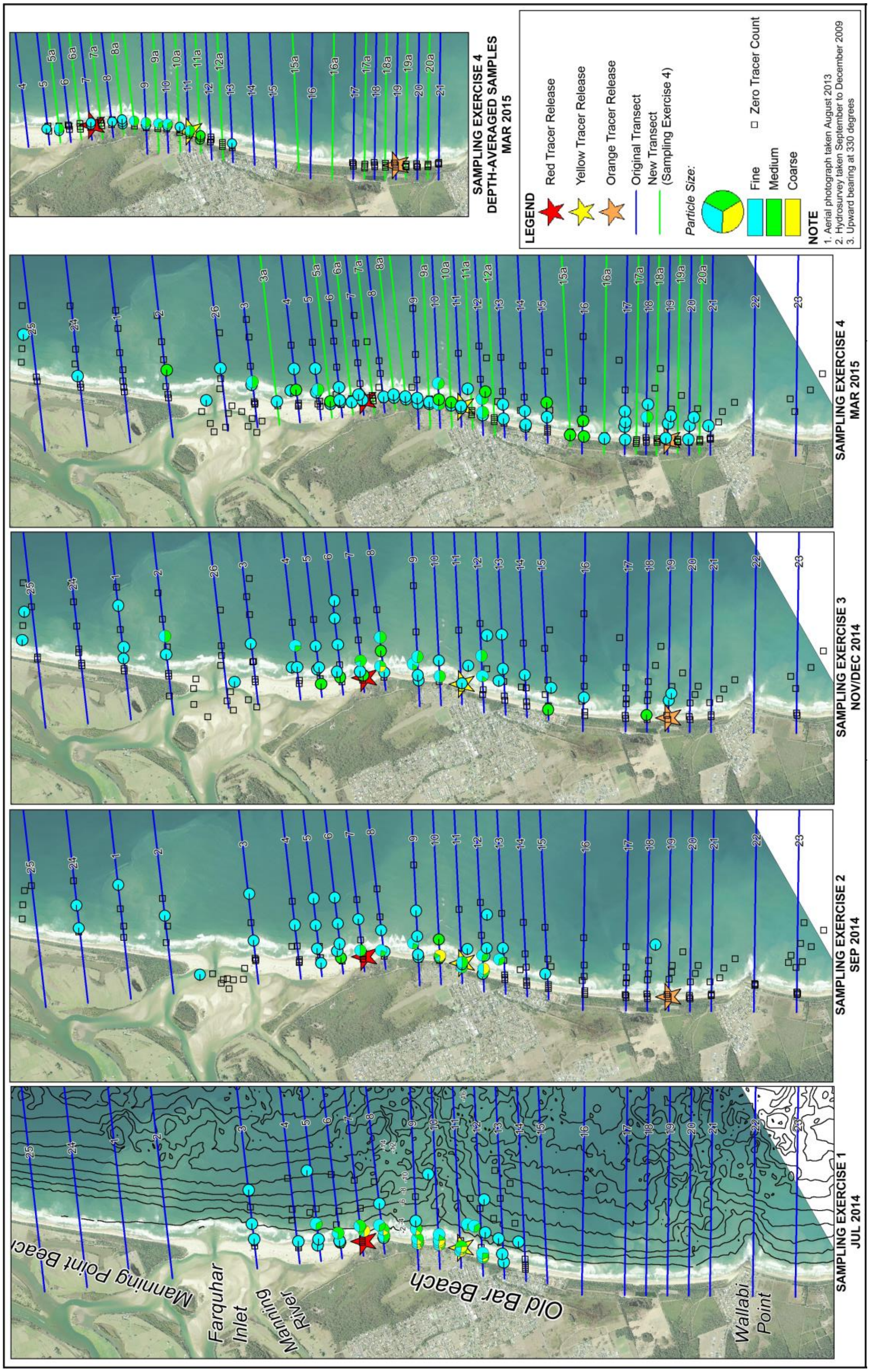

Figure 8: Particle size analysis results – yellow tracer

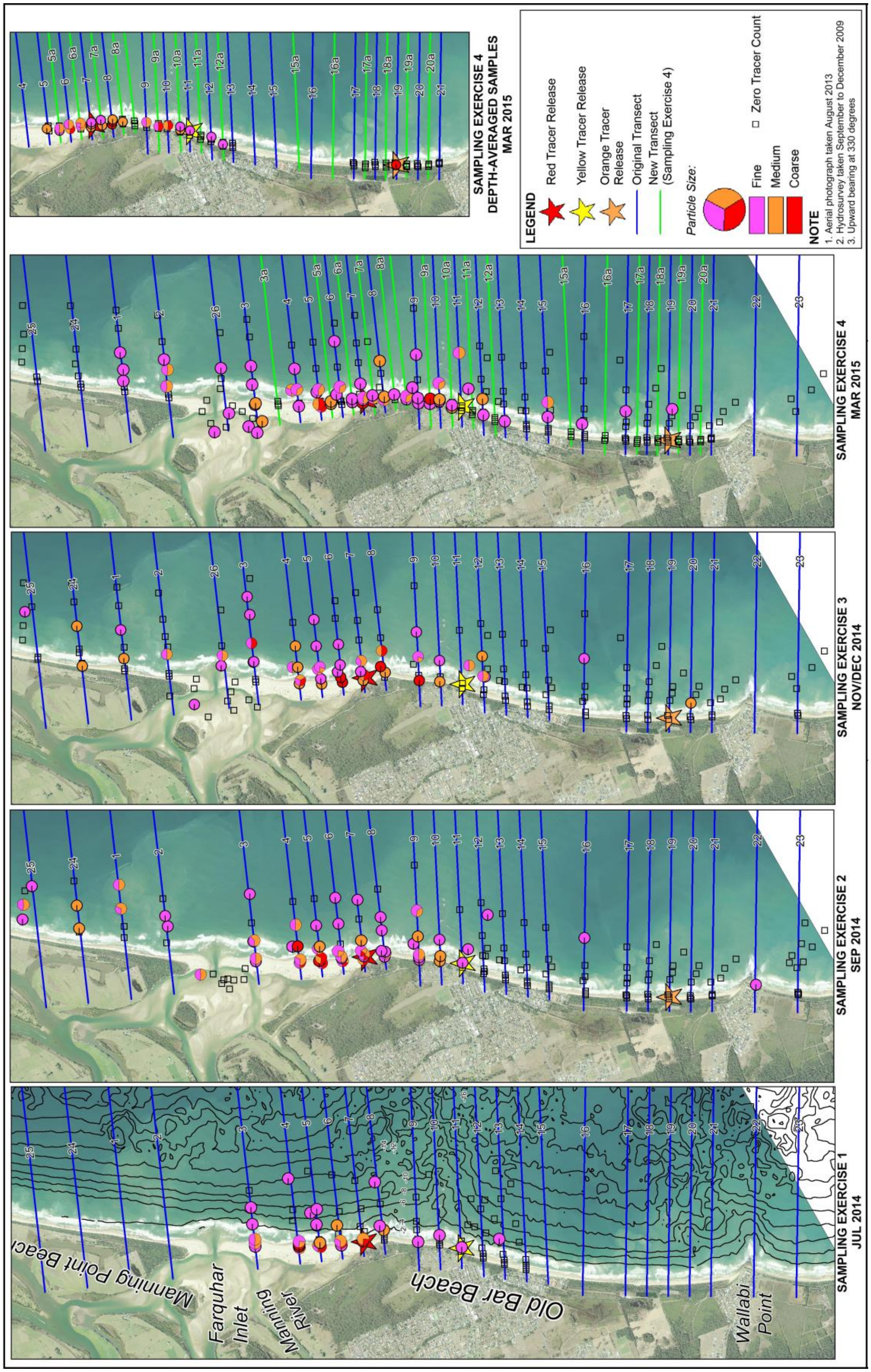

Figure 9: Particle size analysis results – red tracer

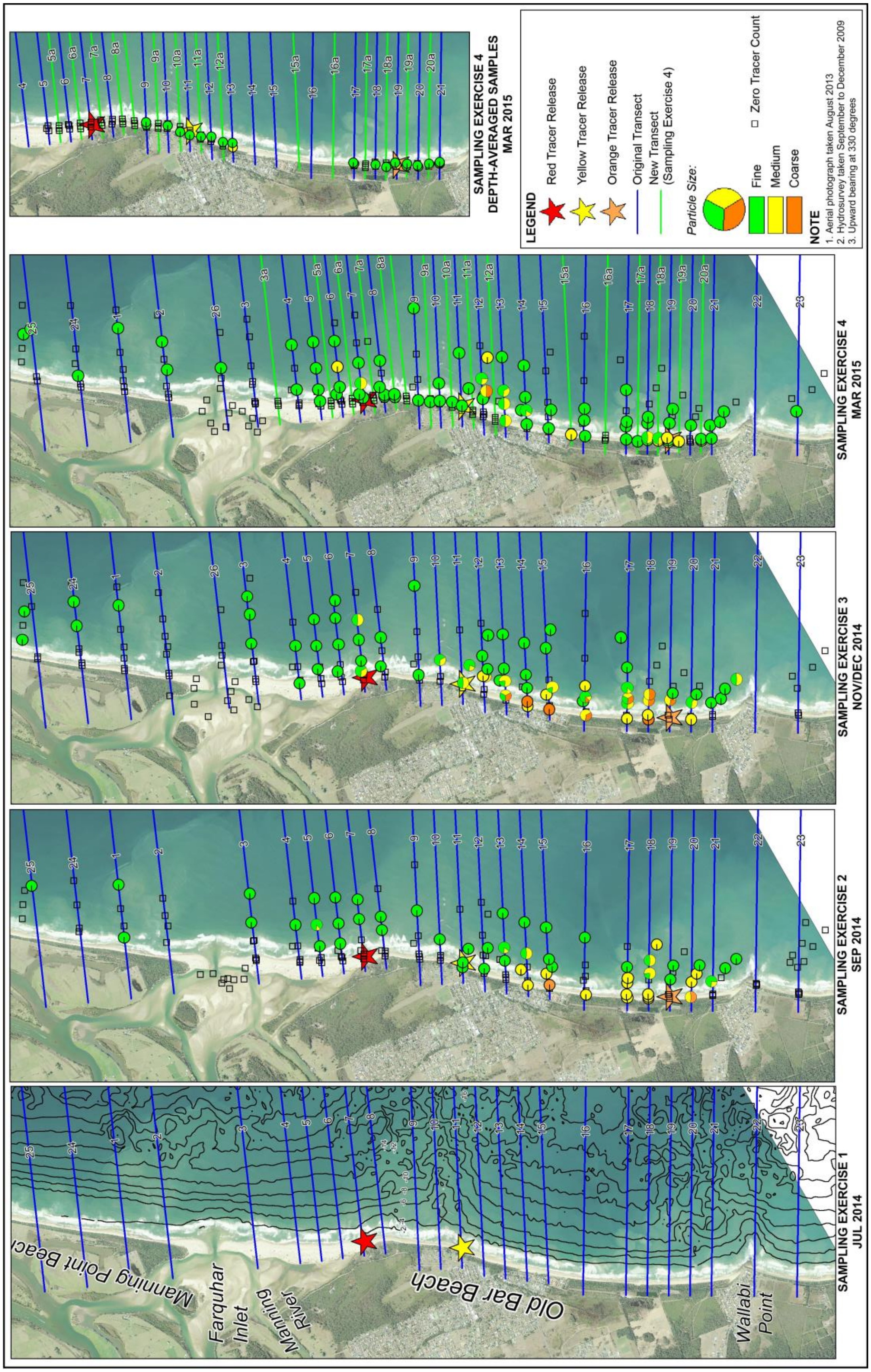

Figure 10: Particle size analysis results – orange tracer

Discussion

Inferred Sediment Transport Processes

The results from each sampling exercise demonstrated that the yellow, red and orange tracer material was transported very widely during the study period, with sediment transport occurring both alongshore and offshore from the tracer release sites. The spatial extent of the observed longshore transport was greater than expected for the relatively calm prevailing conditions during the first two months of the study, with northwards transport of at least 2.5 km for the yellow tracer material between May and July 2014 (refer Figure 5).

The results indicated that the entire length of Old Bar Beach has experienced erosion during the study period. Transport of the orange tracer was greater than the yellow and red tracer, which suggested that the most significant erosion occurred around the southern end of Old Bar Beach.

Predominantly northwards alongshore transport was consistently inferred from the results for each sampling exercise. This included inshore bypassing of Urana Bombora from the yellow, orange and red tracer release sites, which indicated that this feature was not a barrier to alongshore sediment transport in either direction over the study period. Furthermore, northwards transport of material from each release site continued at least 2 km past the entrance to Farquhar Inlet (to the limit of sampling), which indicated that northwards sediment transport at least partially bypassed the inlet during the study period.

Some longshore transport occurred to the south, and it is likely that this southwards transport can be related to more easterly wave directions during summer, including periods of ENE wave conditions. Overall, it appeared that the southwards transport occurred at a slower rate than the dominant northwards transport; that is, there was a net northwards alongshore transport over the study period.

Significant offshore transport and deposition occurred for each tracer, particularly as a result of the storm event in August 2014 which had an estimated ARI of 4 years. This was most notable from the orange release site near the MidCoast Water Exfiltration Ponds. It is likely that large rip cell(s) formed at the southern end of Old Bar Beach in the vicinity of the orange release site during the storm event, which carried sediment offshore to water depths of at least -11 m AHD.

Some onshore recovery of sand eroded from the beach and transported offshore during the August 2014 storm event could be inferred from the results of sampling exercises in November-December 2014 and March 2015. However, tracer material was recorded in samples collected around and offshore of the nearshore boundary of Hallermeier's shoal zone at -12 m AHD (Hallermeier, 1981; Royal HaskoningDHV, 2014), which suggests possible permanent offshore sand losses from Old Bar Beach due to storm activity. This is considered to be an important factor contributing to the observed high recession rates at Old Bar Beach.

The net northwards transport of material past Urana Bombora may also be contributing to the observed high recession rates at Old Bar Beach, if this transport is occurring at a higher rate than the alongshore supply of material entering the Old Bar Beach system past

Saltwater Point and Wallabi Point from the south. Indeed, the extensive reef extensions to those promontories would significantly limit (perhaps entirely) any net northwards littoral drift of sediment into the Old Bar Beach system (Figure 11). However, there is no clear evidence from the sediment tracing that the observed recession, particularly at the northern end of Old Bar Beach, would be caused by this process. The clearest evidence for the cause of recession at Old Bar Beach from the sediment tracing is that it is related to cross-shore processes which move sand well offshore to depths where it may never return (or it may take many years to return) to the sub-aerial beach.

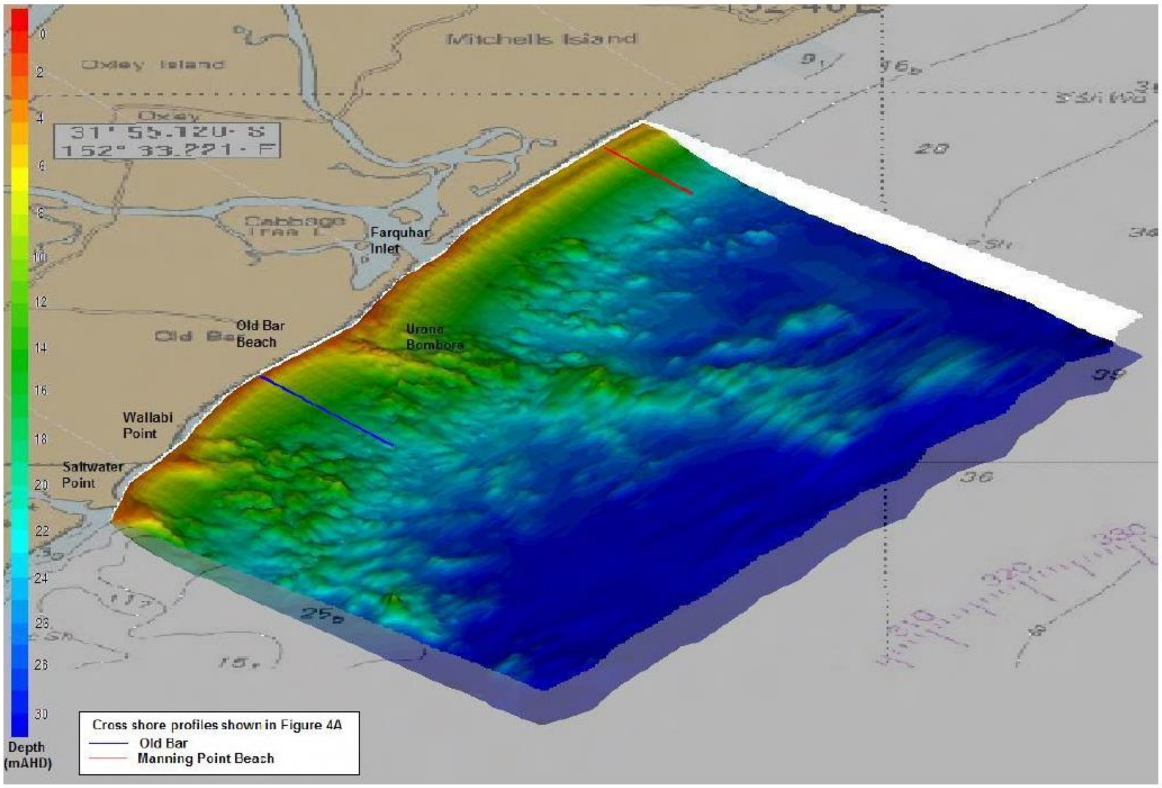

Figure 11: Shaded relief of the bathymetry in the study area indicating extensive nearshore reef formations (WorleyParsons, 2010)

Farquhar Inlet has remained open during the study period, although it has been observed to migrate in a southwards direction. The inlet is understood to be mostly open, closing on average perhaps once every five years (WorleyParsons, 2010). While negligible transport into the Farquhar Inlet entrance area was observed for the yellow and orange tracers for Sampling Exercise 4 (as per the preceding sampling exercises), transport of the red tracer material to this area could be inferred from the results. This suggested that sand eroded from Old Bar Beach migrated to the entrance area, perhaps over timescales in the order of several months to years. However, the rates at which this occurs suggests that the infilling of the Farquhar entrance is only a minor contributor to the observed recession of Old Bar Beach.

A conceptual description of the key sediment transport processes identified from the tracer study is presented in Figure 12.

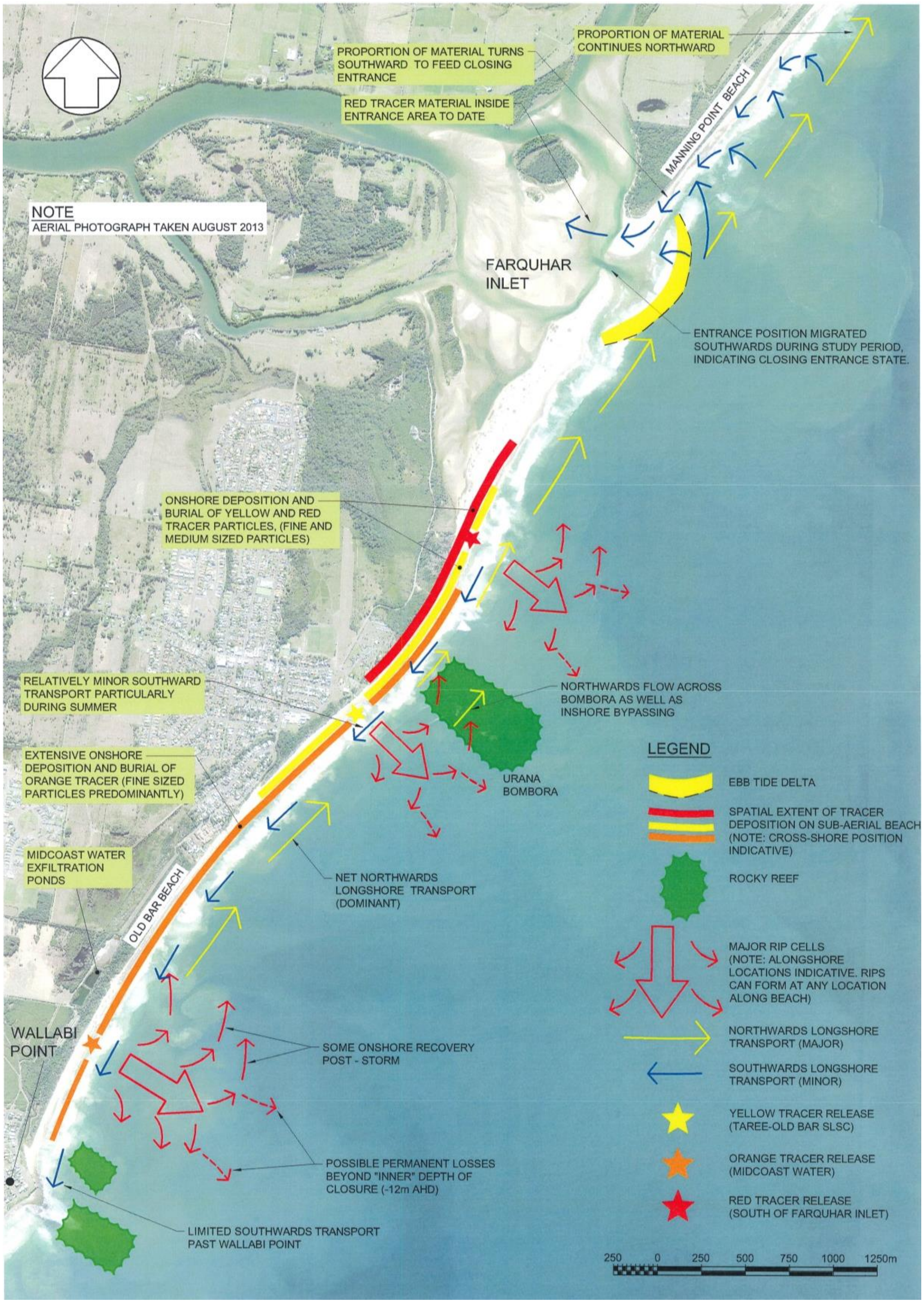

Figure 12: Conceptual description of sediment transport processes inferred from tracer results

Particle Size Results

Particle size analysis results for each tracer released indicate that under the conditions experienced during the study period, it was predominantly fine sediment that was transported alongshore and offshore from Old Bar Beach. Alongshore transport of the coarse tracer particles was minor and was typically confined to the active beach zone in the immediate vicinity of the tracer release sites.

Medium sized tracer particles were also transported relatively widely during the study period, albeit to a much lesser degree than the fine sized tracer. In particular, the red and orange tracers were observed to be transported up to several kilometres from the respective tracer release sites. The transport of medium tracer particles was typically confined to the intertidal beach, inshore zone and inner nearshore zone, with negligible transport further offshore.

Several samples, in particular multiple depth-averaged samples collected during Sampling Exercise 4 indicated both medium and coarse sized yellow and red tracer particles in the immediate vicinity of the respective tracer release sites. This suggests that a proportion of the yellow and red sand tracers did not erode after initial placement despite apparent erosion during winter months, and/or returned during the more accretionary spring/summer period and became buried.

In comparison, the beach samples (surface and depth-averaged) and nearshore/offshore samples demonstrate predominantly fine sized orange tracer particles being present almost throughout the sampling region, possibly suggesting deposition of predominantly fine sediment and burial of fine sediment during more quiescent summer months. The notable absence of medium and coarse sized orange tracer in the surface and depth-averaged beach samples indicates that this material did not remain on the intertidal beach following placement and has likely been buried in the nearshore zone.

Implications for Coastal Management at Old Bar Beach

A sound understanding of coastal processes and associated sediment dynamics is essential to inform assessment of the various coastal management options available for Old Bar Beach. Based on the information provided herein, it is clear that the sediment transport processes at Old Bar Beach are highly complex, with a range of processes influencing beach morphodynamics.

Overall, it is considered that significant sand losses can occur at Old Bar Beach in response to both longshore and cross-shore processes. In particular, cross-shore losses to water depths at or beyond a depth 12 m AHD were observed to occur in response to a storm event at the end of August 2014 with an estimated ARI of 4 years. This may represent a permanent loss of sand from the beach system.

It is also considered that sediment transport is significantly influenced by entrance dynamics associated with Farquhar Inlet (Gordon, 2013), although this was not clearly represented in the tracer results, possibly because these processes operate over longer timescales than those considered during the study period. The complex nearshore bathymetry also appears to influence sediment transport processes, particularly in the vicinity of Urana Bombora.

Effective coastal management options would need to consider the range of spatial and temporal scales over which sediment transport processes operate. It is fair to conclude that no single management solution would adequately address all of the sediment loss mechanisms occurring at Old Bar Beach.

The predominance of northwards longshore transport inferred from the tracer results is likely to be associated with material eroded from the local embayment rather than evidence of any strong net littoral drift. The entire region consists of complex reefs with only a thin veneer of sand making up the beach and nearshore zone (Coffey and Partners, 1981), while geomorphic evidence suggests that net littoral drift from the south would be significantly limited, perhaps negligible. As such groynes are unlikely to be effective in combatting recession within the embayment. Furthermore, groynes do not address the cross-shore sediment losses that are a dominant process at Old Bar Beach.

Similarly, the cross-shore sediment losses inferred from the tracer results could be reduced at localised sections of the beach with offshore reef(s) of suitable scale, crest level and construction material. However, the considerable complexities surrounding regional coastal processes at Old Bar Beach means that the ability to predict shoreline response to an artificial reef structure(s) at this location would be highly uncertain. Isolated structures would be ineffective.

The tracer results may have implications for any future beach nourishment implemented at Old Bar Beach. For example, if nourishment were to be undertaken in the vicinity of Taree-Old Bar SLSC or the MidCoast Water Exfiltration Ponds, in general it could be expected that the nourishment sand would be readily transported offshore and to the north during storm conditions, particularly for the finer sand fractions. Medium and coarse sized sand, if it could be sourced locally, could improve the longevity of nourished profile but would have implications for beach type and wave conditions.

Conclusions

A sediment tracing study was undertaken at Old Bar Beach to improve the understanding of sediment transport processes at this location. Analysis of the collected samples provided unequivocal and tangible data on actual sediment transport at Old Bar Beach during the study period. Key observations included:

- Predominantly northwards alongshore transport was consistently inferred from the results for each sampling exercise. This included inshore bypassing of Urana Bombora from each of the tracer release sites, which indicated that this feature was not a barrier to alongshore sediment transport in either direction during the study period.
- Northwards transport of material from each release site continued at least 2 km past the entrance to Farquhar Inlet (to the limit of sampling), which indicated that northwards sediment transport at least partially bypassed the inlet.
- Some alongshore transport appeared to occur to the south, most notably during summer and likely as a result of the more easterly wave direction during this period.
- Significant offshore transport and deposition occurred for each tracer, particularly as a result of a significant storm event in August 2014. This was most notable from the (southern) orange release site and was probably related to the development of large rip cell(s).

- In the sampling exercises undertaken following the August 2014 storm event, tracer material was recorded in samples collected around and offshore of the inner boundary of the shoal zone at -12 m AHD. This observation provides the clearest evidence for the cause of recession at Old Bar Beach from the sediment tracing; that is, it is related to cross-shore processes which move sand well offshore to depths where it may never return (or it may take many years to return) to the sub-aerial beach.
- The net northwards transport of material past Urana Bombora may also be contributing to the observed high recession rates at Old Bar Beach if this transport is representative of long term behaviour. Supply from the south around Saltwater Point is likely to be negligible.
- Some onshore recovery of sand eroded from the beach and transported offshore during the August 2014 storm event was inferred from the results of subsequent sampling exercises.
- While negligible transport into the Farquhar Inlet entrance area was observed for the yellow and orange tracers, transport of the red tracer material to this area could be inferred from the Sampling Exercise 4 results. This suggested that sand eroded from the beach migrated to the entrance area over timescales in the order of several months to years. However, at this stage it cannot be confirmed from the tracer results that Farquhar Inlet is a significant sink for sediment eroded from Old Bar Beach.

Particle size analysis results for each tracer released indicated that under the conditions experienced during the study period, it was predominantly fine sediment that was transported alongshore and offshore from Old Bar Beach. Medium sized tracer particles also dispersed relatively widely alongshore, albeit to a much lesser degree than the fine sized tracer and typically confined to the intertidal beach and inshore areas shallower than 5 m near the respective tracer release sites. Alongshore transport of the coarse tracer particles was minor and was typically confined to the intertidal beach in the immediate vicinity of the tracer release sites.

The tracer results will provide more certainty to Council and the local community regarding the selection and design of possible coastal management options at Old Bar Beach. For example, if any future beach nourishment is implemented at Old Bar Beach consideration could be given to sourcing medium and coarse sized sand for the nourishment material to increase the longevity of nourished profiles, potentially from Farquhar Inlet.

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