Hanson Bay	120	286	12	10	12	1
Mount Drummond Beach	26	77	N	2	4	NS
Nene Valley	7	11	42	14	14	82
Number 1 and 2 Rocks	8680*	8210*	790*	300*	430*	300*
Pennington Bay	20	46	9	8	4	
Point Peter	1	3			1	1
Sandy River	73	146	NS	7	3	NS
Scott Bay	1	4	4	1	1	6
Sheringah Beach	4	40	NS	2	8	NS
Sleaford Bay	118	1478*	NS	13	43*	NS
St Mary Bay		6	71		1	19
St Mary Bay Sth	2	7			1	3
The Granites	2	32	NS	3	15	NS
Tractor Beach	2	5	8		0	8
Tyringa Beach	23	38	4	17	10	2
Waitpinga Beach	80	93	7	7	3	1
West Bay	45	181	133	13	10	29

NS = Not surveyed in that year
* Debris logged mostly or only for the catch point and therefore not representative of the whole beach

Note: Distribution of debris pieces varies along the shore. Some beaches are oriented to naturally catch debris (have concave sections) whereas others are straight. The above numbers are approximate only. Some beaches had debris logged only in catch points and the remaining length of beach had numbers that were considerably less.

Environmental observations

This type of metadata was not heavily utilised, but did include observations of birds and mammals, plus any interesting things seen in the water.

Regional data interpretation

In order to not bias the spatial analysis of the beach survey data, all collections of donated materials were removed from the data set as they were collected over an unknown period from unknown positions on selected beaches only. Inclusion of these data would have strongly biased the spatial analysis to Avoid Bay, as this was where the large collections donated by the beachcomber based in Coffin Bay (Stuart Valladares) were found during many trips to that beach. The donated samples were, however, geochemically characterized to aid interpretation of hydrocarbon families and this integrated geochemical data set is reported in the Part 3 – Geochemistry section. Other exclusions from the spatial data set also included unclassifiable and miscellaneous samples (e.g. peat). As such

the beach survey data set used below includes only asphaltites, tarballs and resinites/ambers. Total marine debris data are also included as comparators.

The total number of samples used in the spatial data interpretation were 511, (95 from 2014, 98 from 2015 and 318 from 2016, Table 8).

Table 8: Sample numbers collected per bitumen type and year.

Sample Type	2014	2015	2016
Asphaltite	10	14	19
Greasy Bitumen			2
Resinite/Amber	3	19	29
Sooty Bitumen	1	1	1
Waxy Bitumen	84	84	296

[The numbers above do not include donated samples]

Sample numbers and family

Based on results of whole-oil geochemical analysis, the vast majority of samples collected were classified as Type 1 waxy bitumens with high botryocccane contents (Figure 21), interpreted by various authors to indicate an Indonesian origin (McKirdy et al., 1986, 1994; Currie et al., 1992; Edwards et al., 2016, 2017). Other oil family sample collections were generally an order of magnitude lower than Type 1 oil family collections.

Over the course of the study the collections of materials increased in sequential years. This may partly be due to more optimal timing of collection, i.e. September and October in 2015 and 2016 respectively versus November in 2014. However, there are notable differences in the collections made in 2016 with several new unclassified families becoming apparent and larger collections across most families, which may be attributable to the very large storm that eroded many of the beaches just prior to the 2016 survey (Figure 21, Table 10). In addition there were also quite a number of very fresh bitumen samples collected during the Kangaroo Island and eastern leg in 2016.

A notable feature of the collections of samples throughout this project period is the low abundance of asphaltites (Figure 21) relative to historical observations and studies (Trewartha, 1850; Padley, 1990, 1992, 1995) with the reason for this difference being unknown.

Table 9: Cummulative total sample numbers by bitumen family for each beach visted.

Beach_Name	1&2 Rocks Soft Bitumen (Unknown)	Sandy River Soft Bitumen (Unknown)	Asphaltite	Sooty Bitumen	Type I waxy bitumen (high botryococcane)	Type II waxy bitumen (low botryococcane)	Type III waxy bitumen (no botryococcane, low wax)	Type IV waxy bitumen (no botryococcane, high wax)	Unclassified high wax bitumen	Unknown
28 Mile Crossing					3					
Avoid Bay					3		2			2
Bales Beach					6					2
Beachport Conservation Park					44	1	2		2	3
Cactus Beach			5		5		2		4	1
Dogfence Beach					32		6	1	14	8
Elliston			1		4			1	1	
Eves Cove				1	37		3		18	1
Eyre Well			2		2					
Fowlers Bay West			1							
Geltwood Beach				1	8	2	1			
Hanson Bay					2		4		1	
Mount Drummond Beach					5		4	1		1
Nene Valley					2					
Number 1 and 2 Rocks	8				67	9	11		6	1
Pennington Bay					2				1	
Sandy River		47			1		5		1	
Scott Bay					1					
Sheringah Beach			1		5		3		1	2
Sleaford Bay					1		2	1	2	
St Mary Bay Sth					2					
The Granites			2		24	1	1		1	
Tractor Beach			12							2
Tyringa Beach			1							
Waitpinga Beach			2		5		7	15	3	
West Bay			1	1	1					

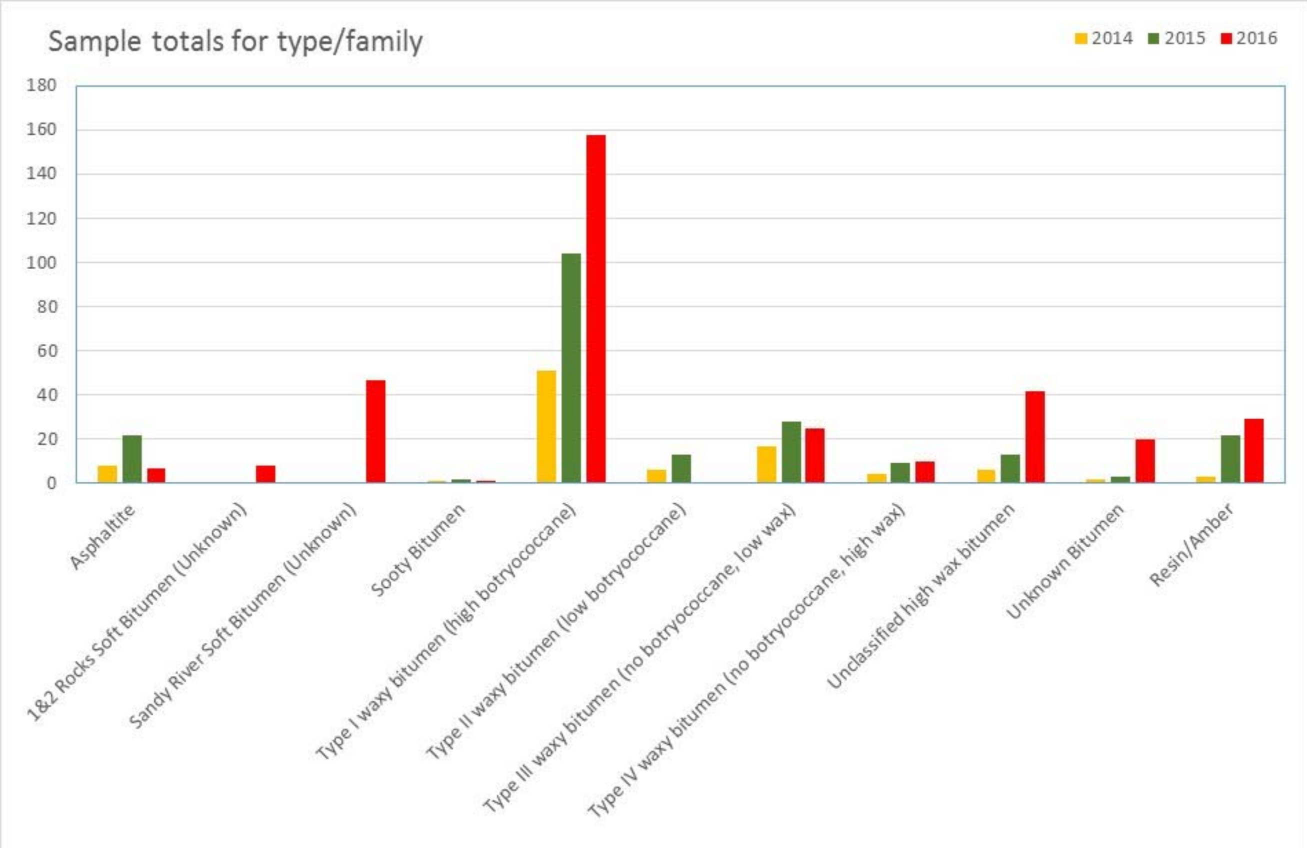


Figure 21: Sample numbers plotted against oil family (determined by whole oil GC-MS) by year after exclusion of donated samples plus unclassifiable and miscellaneous materials.

Table 10: Sample numbers collected on the beaches by bitumen type for each year.

	2014										2015										2016									
Beach_Name	1&2 Rocks Soft Bitumen (Unknown)	Sandy River Soft Bitumen (Unknown)	Asphaltite	Sooty Bitumen	Type I waxy bitumen (high botryococcane)	Type II waxy bitumen (low botryococcane)	Type III waxy bitumen (no botryococcane, low wax)	Type IV waxy bitumen (no botryococcane, high wax)	Unclassified high wax bitumen	Unknown	1&2 Rocks Soft Bitumen (Unknown)	Sandy River Soft Bitumen (Unknown)	Asphaltite	Sooty Bitumen	Type I waxy bitumen (high botryococcane)	Type II waxy bitumen (low botryococcane)	Type III waxy bitumen (no botryococcane, low wax)	Type IV waxy bitumen (no botryococcane, high wax)	Unclassified high wax bitumen	Unknown	1&2 Rocks Soft Bitumen (Unknown)	Sandy River Soft Bitumen (Unknown)	Asphaltite	Sooty Bitumen	Type I waxy bitumen (high botryococcane)	Type II waxy bitumen (low botryococcane)	Type III waxy bitumen (no botryococcane, low wax)	Type IV waxy bitumen (no botryococcane, high wax)	Unclassified high wax bitumen	Unknown
28 Mile Crossing																									3					
Avoid Bay																									3		2			2
Bales Beach										1					1										5					1
Beachport Conservation Park					3										6	1									35		2		2	3
Cactus Beach			2										1										2		5		2		4	1
Dogfence Beach					1										11		2	1	7	1					20		4		7	7
Elliston			1												1										3			1	1	
Eves Cove				1	3																				34		3		18	1
Eyre Well			1										1												2					
Fowlers Bay West			1																											
Geltwood Beach					3	1	1							1	2	1									3					
Hanson Bay					2		3										1												1	
Mount Drummond Beach																	1								5		3	1		1
Nene Valley															1										1					
Number 1 and 2 Rocks					37	4	6		5						14	5	2				8				16		3		1	1
Pennington Bay															1										1				1	
Sandy River																	3					47			1		2		1	
Scott Bay																									1					
Sheringah Beach										1					2								1		3		3		1	1
Sleaford Bay								1									1								1		1		2	
St Mary Bay Sth															1										1					
The Granites			1			1			1						13		1						1		11					
Tractor Beach													10										2							2
Tyringa Beach													1																	
Waitpinga Beach			1		2		7	3										4					1		3			8	3	
West Bay			1																					1	1					

Stranding locations

Understanding the stranding patterns in relation to beach morphologies and relative energies is important in ascertaining which beaches are more prone to retention of coastal bitumens. This stranding pattern can help establish how the metocean conditions within GAB influence the stranding of flotsam on the beaches of South Australia. These factors have implications not only for understanding the distributions and provenance of the tarballs and asphaltites found on those beaches, but also the possible behavior of petroleum on beaches in the unlikely event of an offshore hydrocarbon release.

Stranding position on beach

The stranding position of a tarball or asphaltite on the beach is an indicator of how long it may have been there. Prior authors have suggested that the arrival of tarballs and asphaltites is strongly correlated to storm events (Sprigg & Woolley, 1963; Padley, 1995; Edwards et al., 2016). As stranding is most likely at peak tide, it can reasonably be assumed that any materials found within the mid-tidal zone of the beach are likely to have arrived on the previous tide and represent either reworked materials or new arrivals. Conversely, samples found on the upper shore represent materials emplaced during major storm events. The upper-intertidal samples are therefore likely to have been emplaced during spring tides.

It is impossible to understand the degree of reworking of the collected samples since they may have been reworked on-and-off the beach many times before collection. It is also likely that some specimens may have been winnowed from the beaches between storm events and spring tides. Hence detailed geochemical interpretation is required to determine the least weathered samples (see Part 3 Geochemistry)

Figure 22 shows the relative stranding position on the beaches for the samples collected during the project and reveals that most samples were found on the upper intertidal and upper shoreline. Only minor numbers of samples were collected from the mid-intertidal zone (Figure 22). This distribution is not unexpected as the mid-intertidal zone is swept on each tide, whereas materials stranded within the upper-intertidal and upper shoreline zones are only infrequently winnowed. The materials arriving in these positions would therefore be retained.

The pattern of stranding in the upper-intertidal and upper shoreline zones does vary between years, with the former yielding the highest number of stranded materials in 2014 and 2016, whereas the upper shoreline was the stranding site of most samples in 2015. This stranding pattern may be, in part, due to when the beaches were sampled and the prevailing weather conditions prior to each visit.

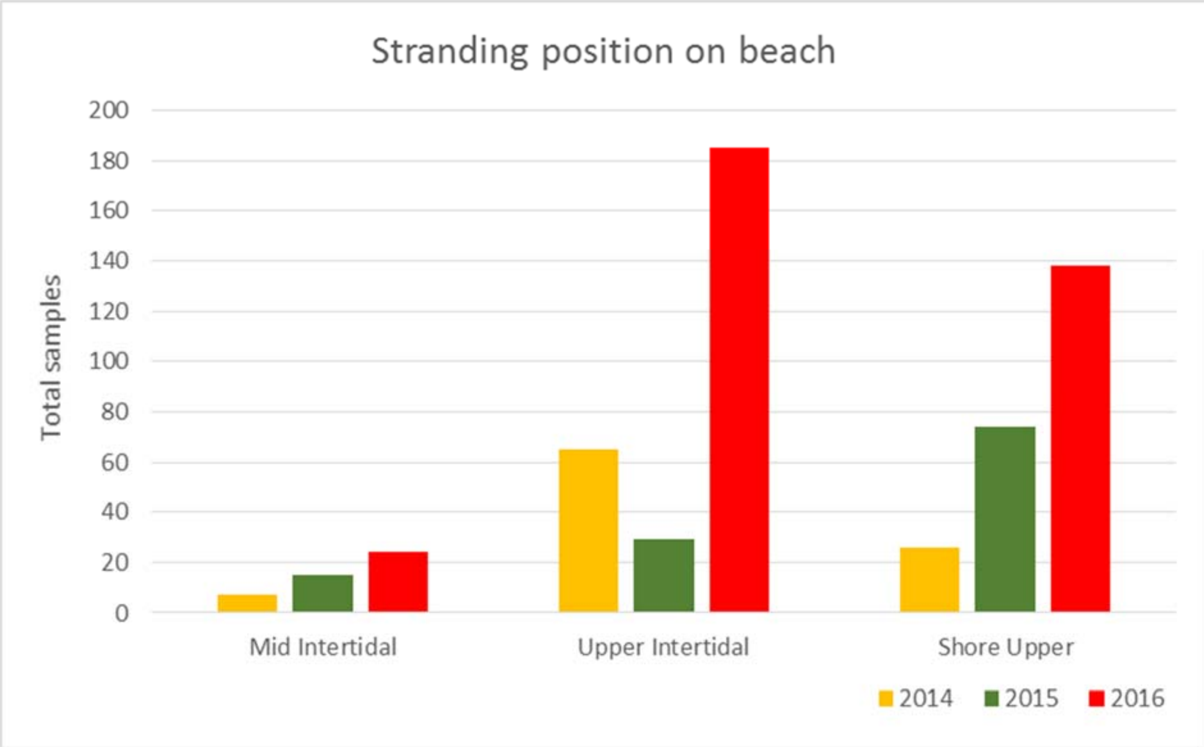


Figure 22: Stranding position on beach.

In 2014 two large spring tides were observed in the month preceding sample collection at Thevenard, South Australia (Figure 23) the first, and largest of the year, being associated with elevated onshore winds and possibly also waves (Figure 24). The second spring tide occurred just prior to visiting the site and this may explain the higher numbers of samples collected on the upper-intertidal section of the beach versus the upper shoreline (Figure 22).

In 2015 the tidal and wind conditions were more benign than those recorded during both 2014 and 2016. The largest spring tide of the year was observed in May (Figure 25) with a number of smaller spring tides of similar magnitude occurring throughout the winter before the survey. A period of higher winds was observed in July, although this was not accompanied by high tides (Figure 26). The similar magnitude spring tides between the large May tide and collection have likely had the effect of winnowing stranded tarballs and asphaltites from the intertidal zone of the beaches. However, materials stranded on the upper shoreline during the exceptional tide in May are conserved. This explains both the low numbers of samples collected in 2015 and their position on the beach (Figure 22).

The 2016 winter tidal conditions prior to the beach survey were dominated by a number of storm surges culminating in a once-in-50 year storm event on 28th of September, which was characterised by very high tides and high onshore winds (Figure 27 and Figure 28). This and a subsequent slightly smaller tidal event occurred just prior to the beach surveys which commenced on October 4th and explains the high numbers of samples collected from the beaches. The sample collections are biased toward the upper intertidal category, because, at many of the beaches visited, erosion had led to the complete removal of the upper shoreline leaving only the upper-intertidalzone intact in front of back beach dunes or cliffs.

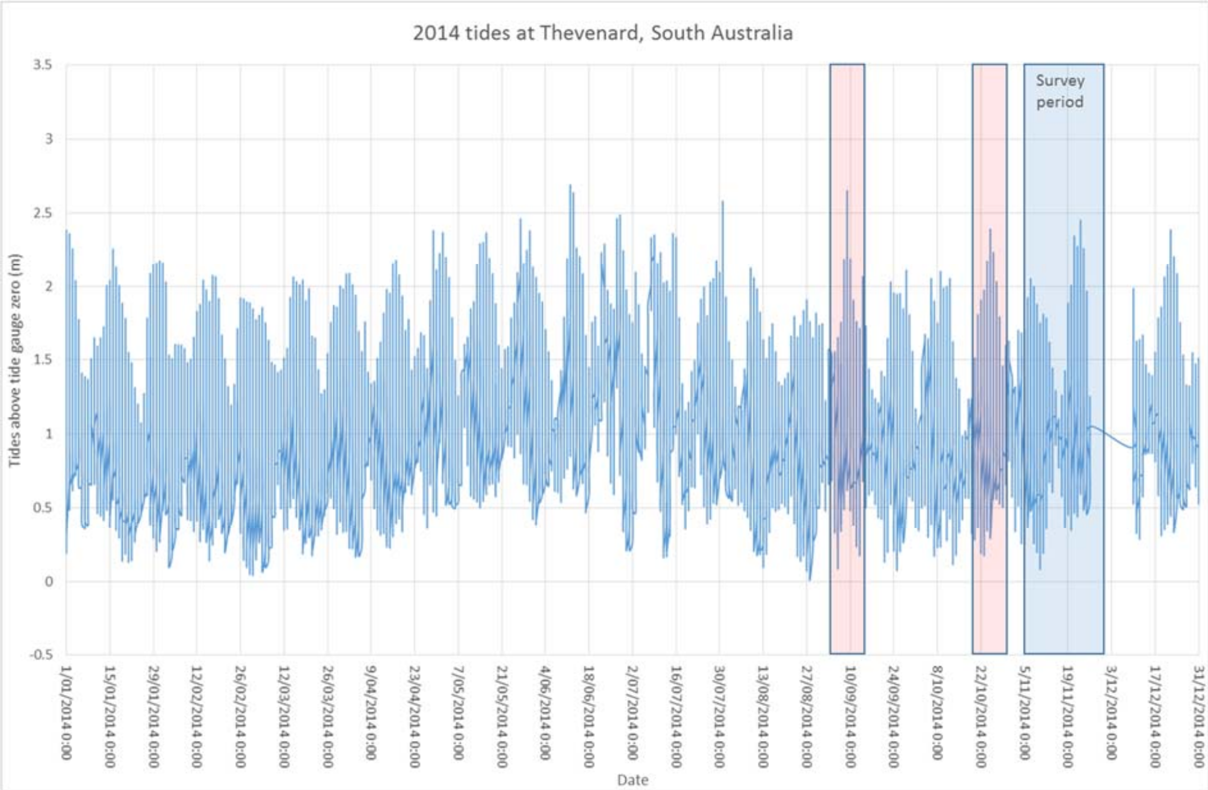


Figure 23: 2014 tides at Thevenard, South Australia.

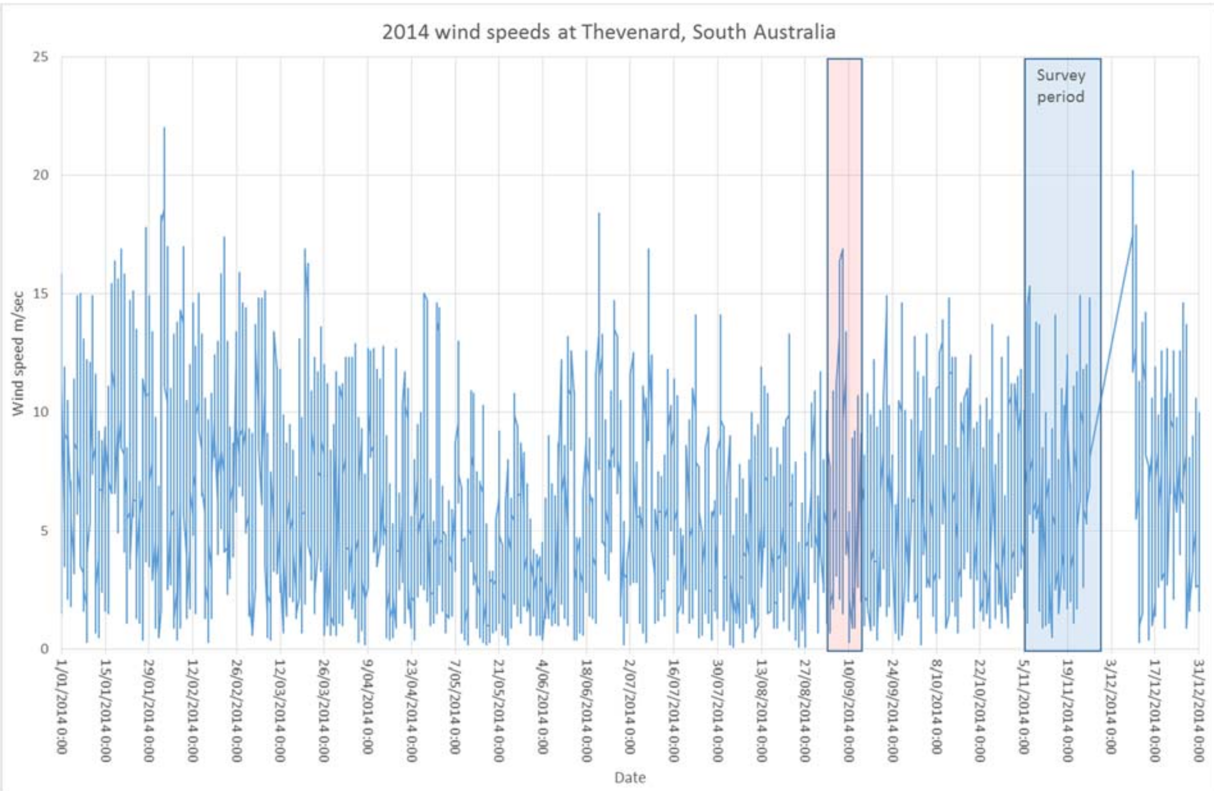


Figure 24: 2014 wind speeds at Thevenard, South Australia.

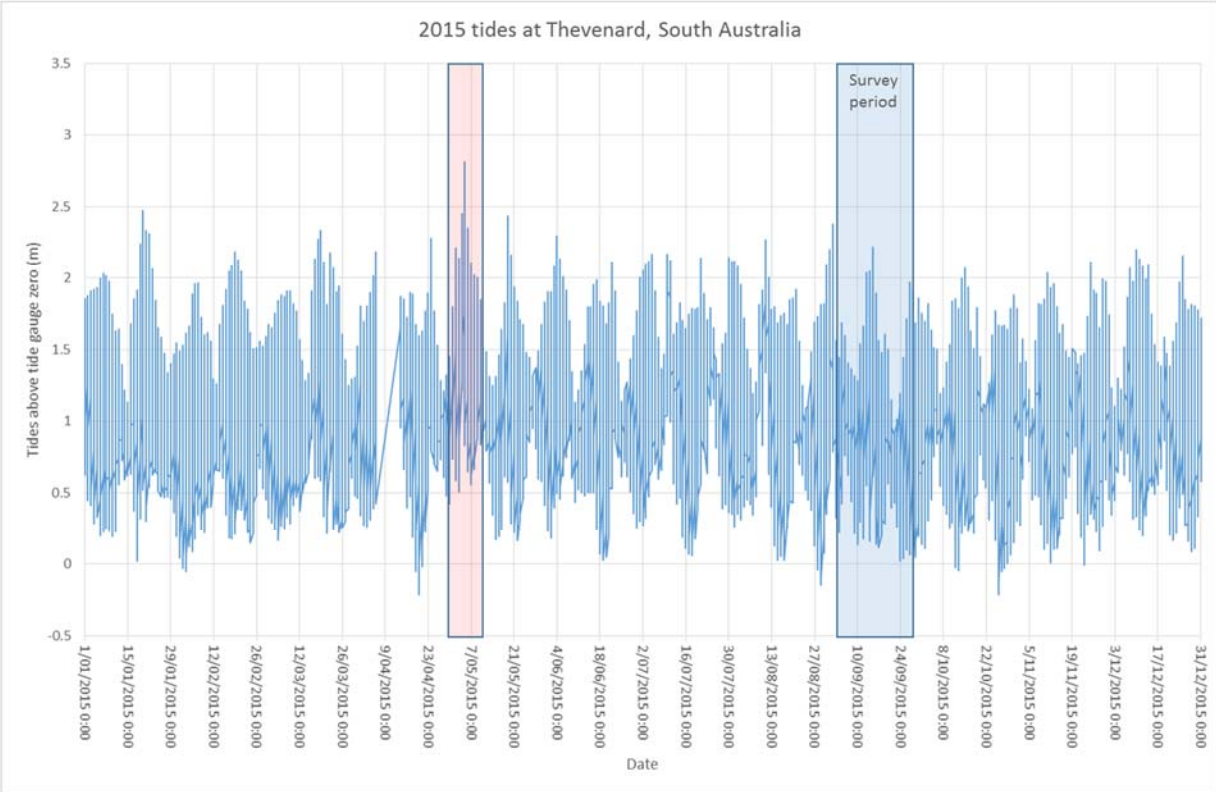


Figure 25: 2015 tides at Thevenard, South Australia.

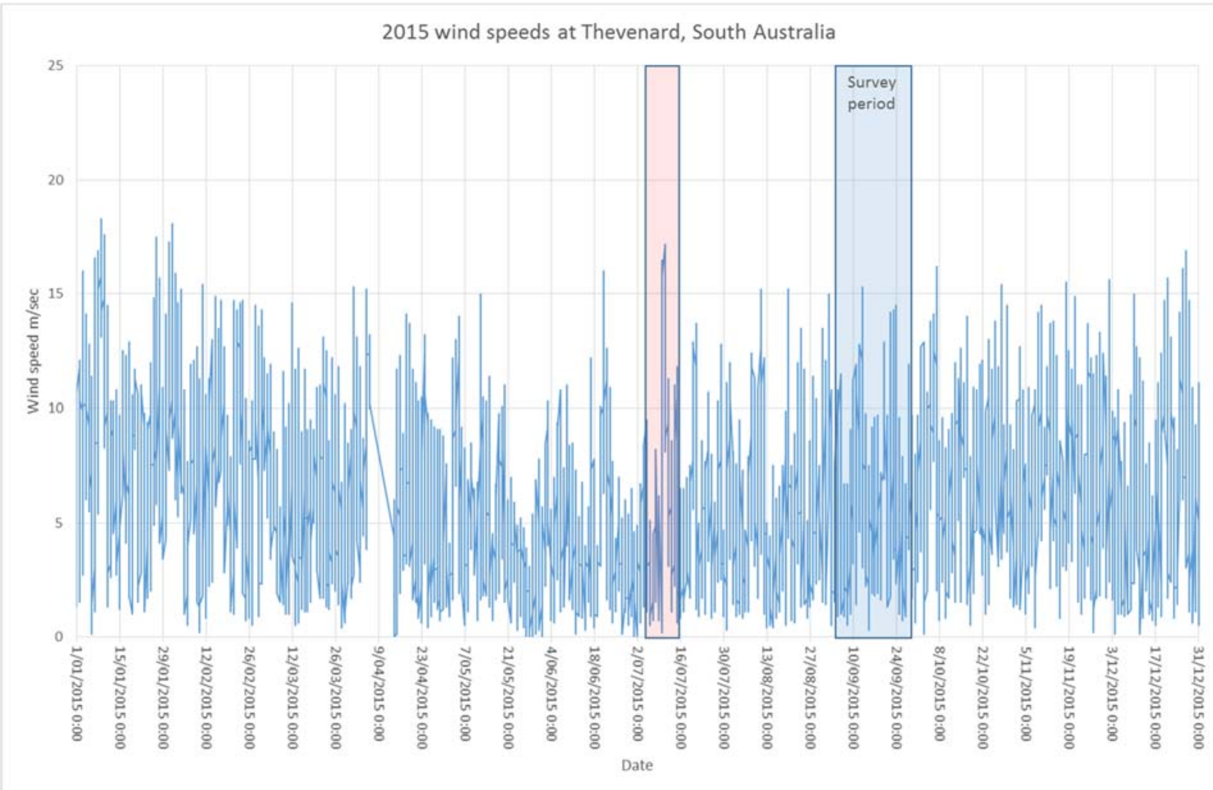


Figure 26: 2015 wind speeds at Thevenard, South Australia.

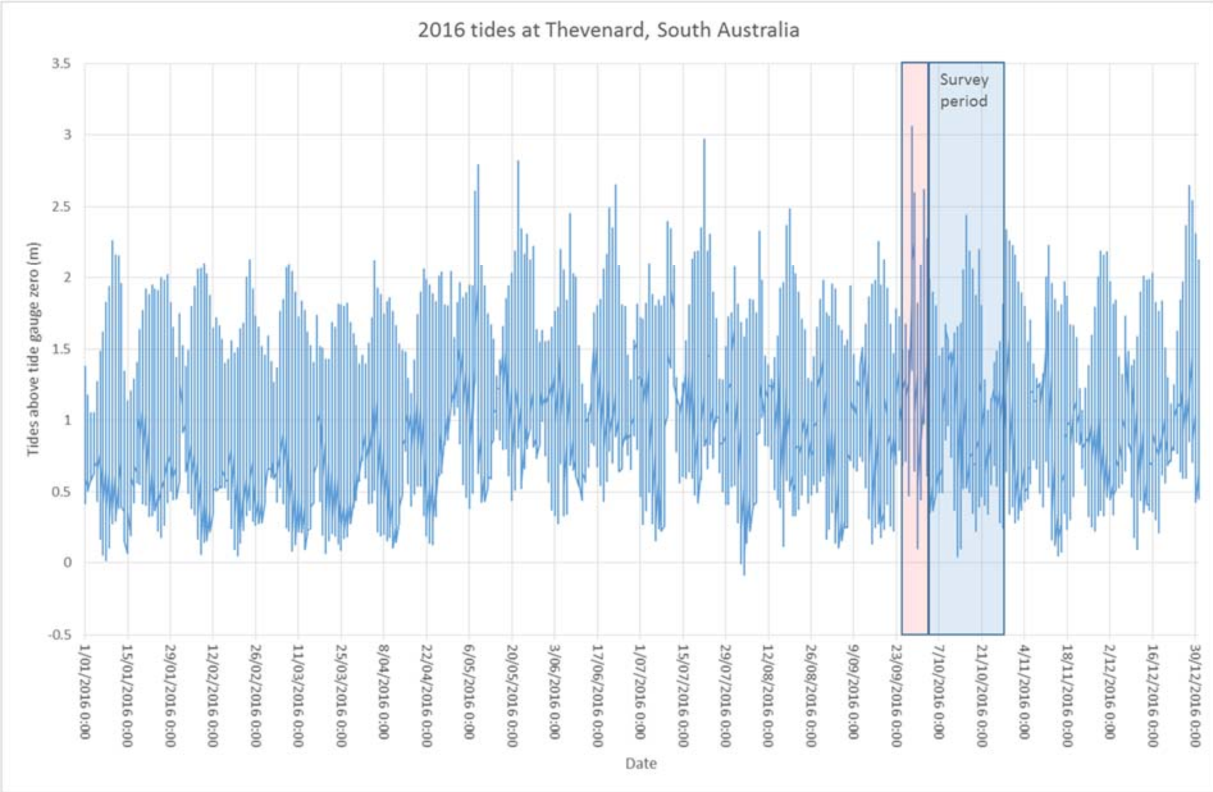


Figure 27: 2016 tides at Thevenard, South Australia.

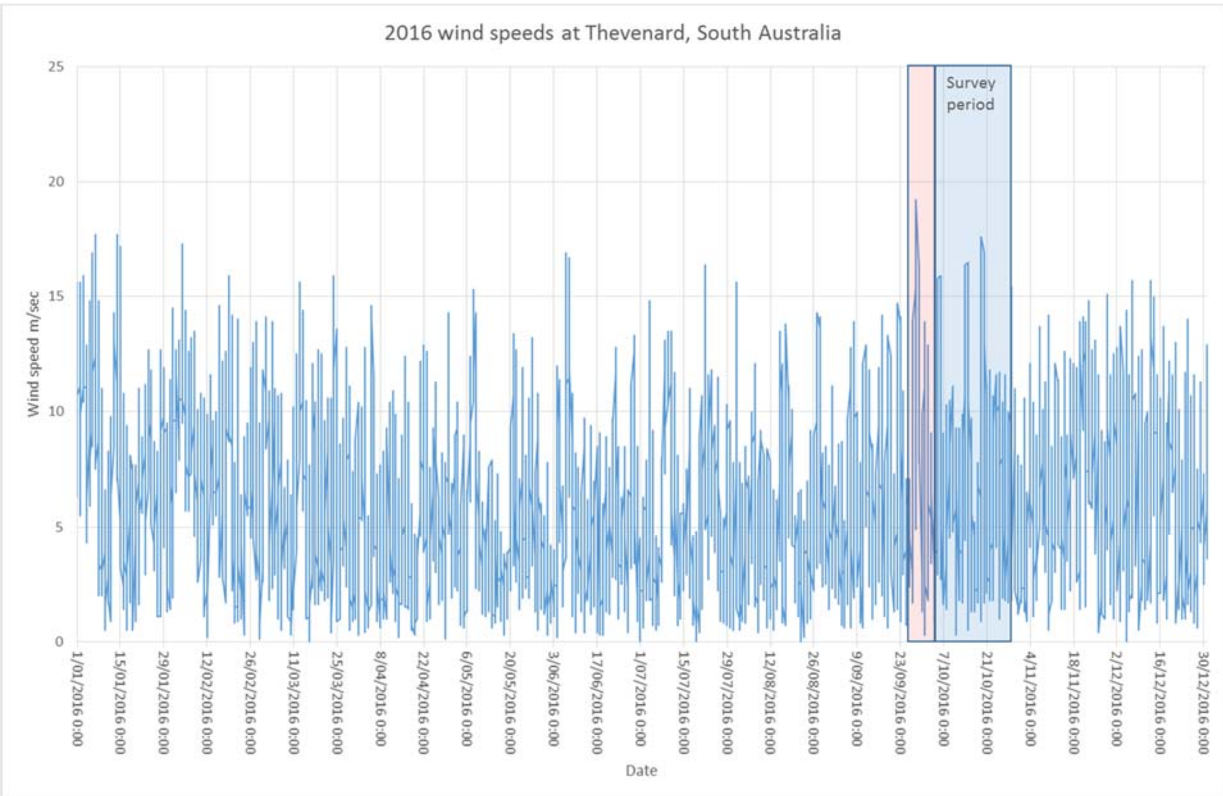


Figure 28: 2016 wind speeds at Thevenard, South Australia.

Stranding beach slope and width

To help understand the types of beaches on which tarballs and asphaltites become stranded the beach slope versus number of samples has been plotted in Figure 29. For 2014 and 2015 the highest number of samples were collected on beaches with low-angle slopes of between 1 and 4 degrees. These low-angle slopes have lower energy uprush (onshore flow) and backwash (offshore flow) allowing deposition of entrained materials. In 2016 high numbers of samples were also collected from beaches with slopes of up to 3 m, presumably due to the higher wave energies from recent storms permitting deposition of materials on higher angle slopes. For slopes greater than 4 degrees, few samples were collected suggesting that the high energy uprush (onshore flow) and backwash (offshore flow) are not conducive to the settling out of the tarballs and asphaltites. The exception being Eve's Cove in 2016 which had a high angle and many samples were collected.

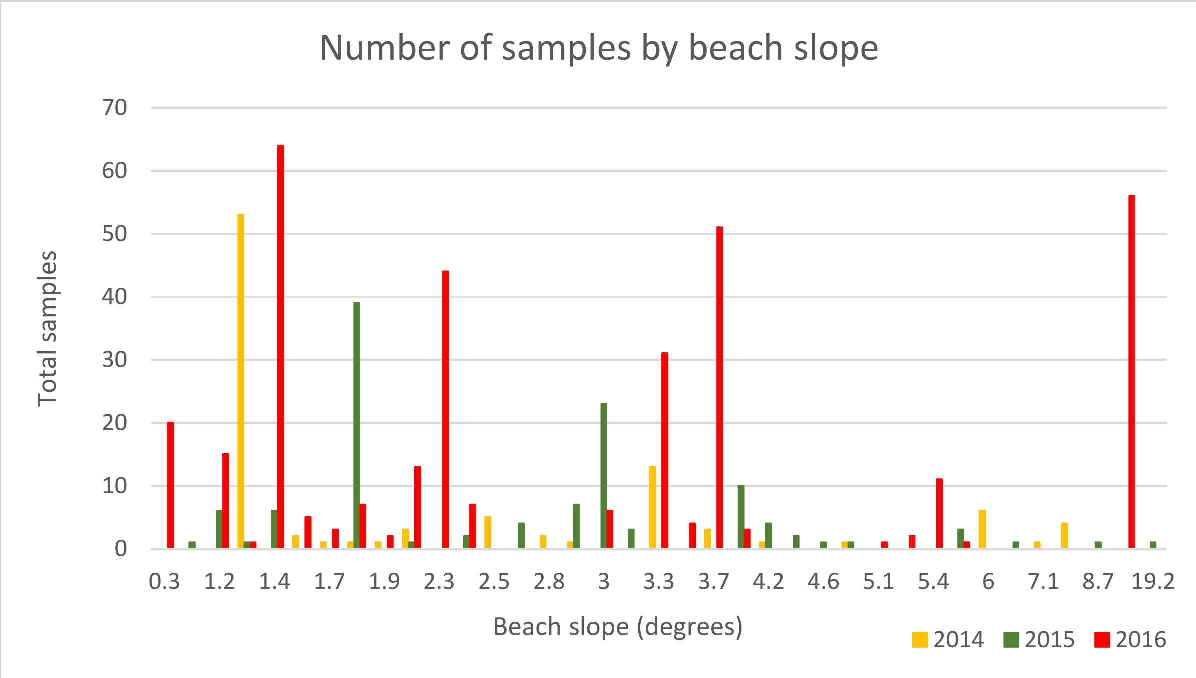


Figure 29: Stranding by beach slope.

When the sample collections are plotted against beach width (Figure 30) it is apparent that narrow beaches collect materials less frequently than do the wider beaches. This is likely due to narrow beaches generally having steeper slopes. Whilst there is no clear correlation with stranding position for beaches with widths greater than 25 m, it is notable that many of the stranding positions in 2016 were associated with narrower beaches. This is due to the reduced widths of beaches following the storm that affected the region just prior to the beach survey.

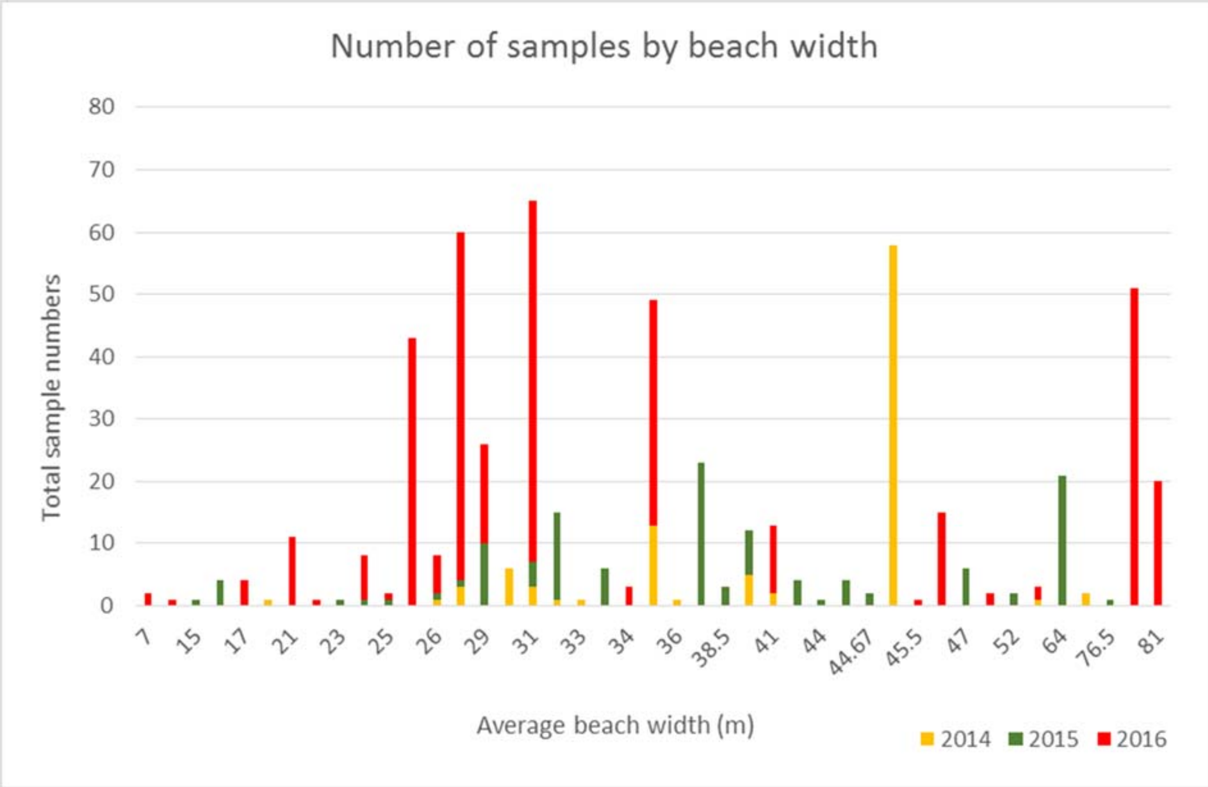


Figure 30: Beach widths.

Beach aspect

Although the locations chosen for the study were dominated by beaches with a south westerly aspect, they represent a range of beach aspects. As discussed above, the choice of a variety of beach aspects was deliberate in order to test if aspect had an influence on asphaltite and tarball stranding. The numbers of beaches visited and their aspect are plotted in Figure 31.

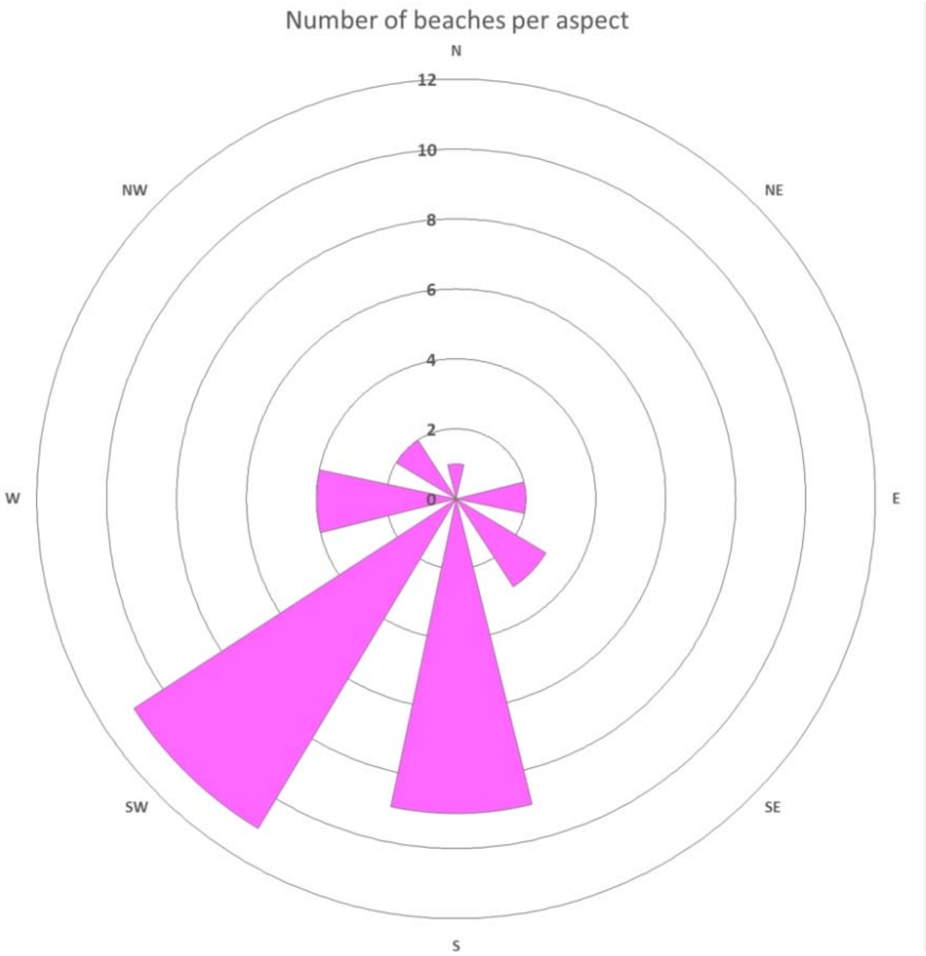


Figure 31: Beach aspect.

In order to help understand the influence (if any) of aspect on stranding, any bias toward one aspect direction in the data set has to be eliminated. To achieve this asphaltite and bitumen sample numbers and loadings (g/100 m) are normalized to beach aspect (number of beaches with particular aspect divided by number of samples collected). When done distinct differences in sample numbers and loadings for each given aspect become apparent (Figure 32, A and C).

The asphaltites show a predominantly NW beach stranding aspect whereas the bitumen's are predominantly stranded on beaches with a SW aspect. It is important to note the interannual variation of stranding aspect. For the asphaltites the predominant NW stranding aspect only occurs in 2015 and 2016, whereas the predominant stranding aspect of 2014 is to the south which likely reflects changes in release and oceanographic conditions at the time of stranding. The beach aspect for the bitumen sample numbers and loadings (g/100m) are consistent throughout the study period, with the predominant stranding aspect being to the southwest (Figure 32, C and D).

As also demonstrated by the gross and normalized numbers of samples by aspect in Rose diagrams of sample numbers (Figure 33), the majority of samples throughout the study years are encountered on south west facing beaches. The sample numbers are highly dominated by bitumens and the results are heavily weighted towards key beaches, such as Number 1 & 2 Rocks, where large

collections of bitumens were consistently collected (see Detailed interpretation of example beaches section below)

After the sample numbers are compared with the gross and normalized sample loadings (g/100m) the asphaltites are a larger component of the strandings reflecting the large sizes of asphaltites compared to the bitumens collected (Figure 34 Rose diagrams of sample loadings).

When normalized asphaltite loadings (g/100m) are considered (Figure 32, B and D) it becomes clear that whilst the sample numbers are low the asphaltites stranded on the southern aspect beaches constitute the larger samples collected in the study. This data is significantly biased by the collection in 2016 of the largest sample of the study (3.3 kg) on the south-facing Waitpinga Beach. If this sample is removed from the data set, the normalized sample loads are more balanced between south and southwest facing beaches. These stranding patterns could be useful in determining the provenance of the asphaltites, as prevailing wind and weather conditions at different times of the year could lead to more effective stranding on beaches with aspect facing these weather conditions. The stranding of higher numbers of smaller and more weathered asphaltites (see DEGRADATION OF OIL FAMILIES) on northwest-facing beaches situated on the Eyre Peninsula suggests that these materials may have been at sea for longer periods of time before stranding. The stranding of a low number of larger, less weathered asphaltites on south- and southwest-facing beaches mainly, but not exclusively, along the Limestone Coast suggests that these materials may have been at sea, or have been reworked on beaches, for less time before stranding occurred (see IMPLICATIONS OF METOCEAN CONDITIONS OF THE GAB ON ASPHALTITE AND TARBALL STRANDINGS).

When the aspect data are broken down into bitumen families by year for both the sample numbers and loadings (Figure 35) there is no clear pattern by year by stranding aspect by family. This shows that the individual bitumen families do not have different stranding behaviors nor or they are likely to have metocean conditions and origin points which determine a particular beach stranding aspect.

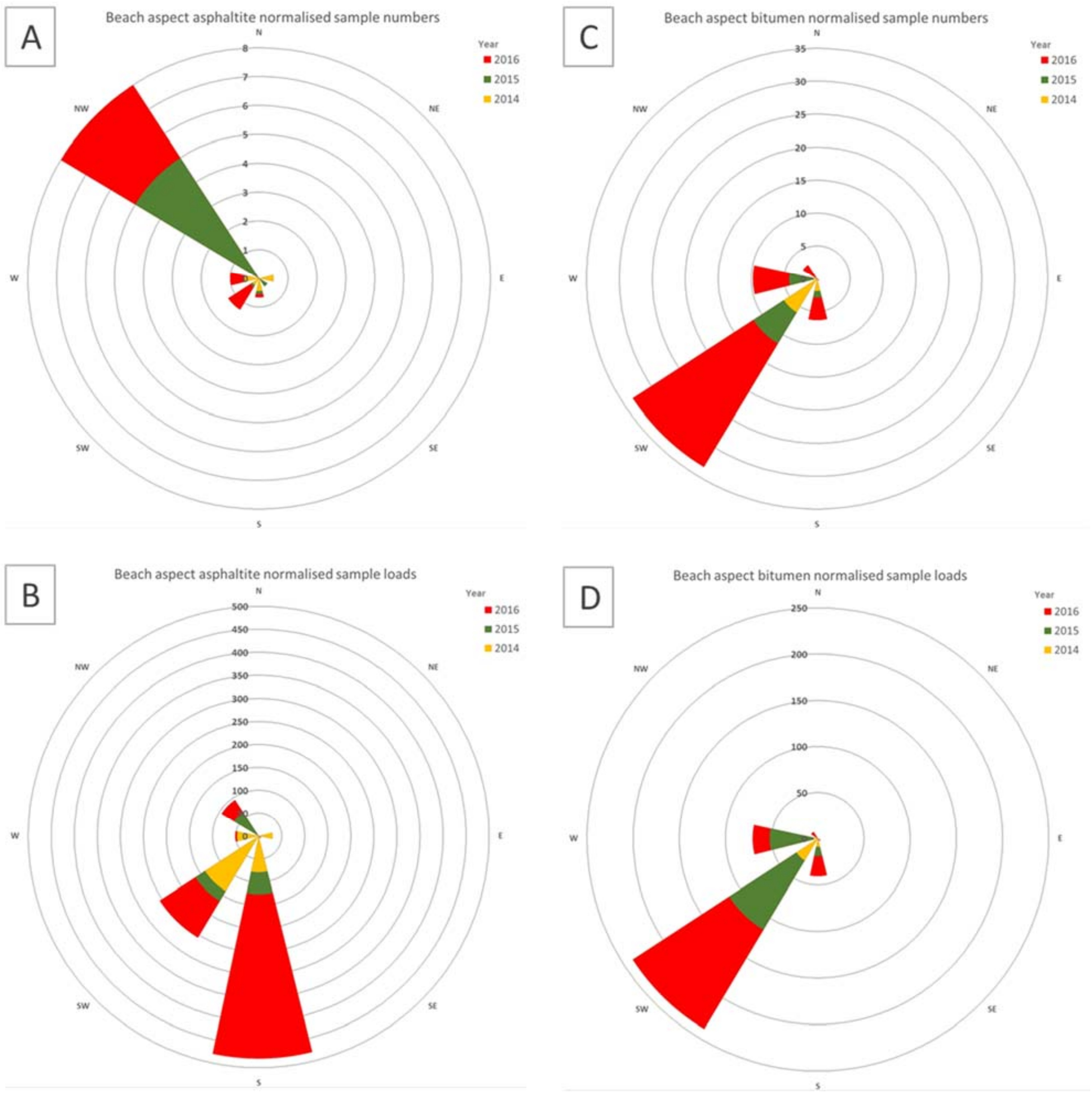


Figure 32: Beach aspect and sample numbers.

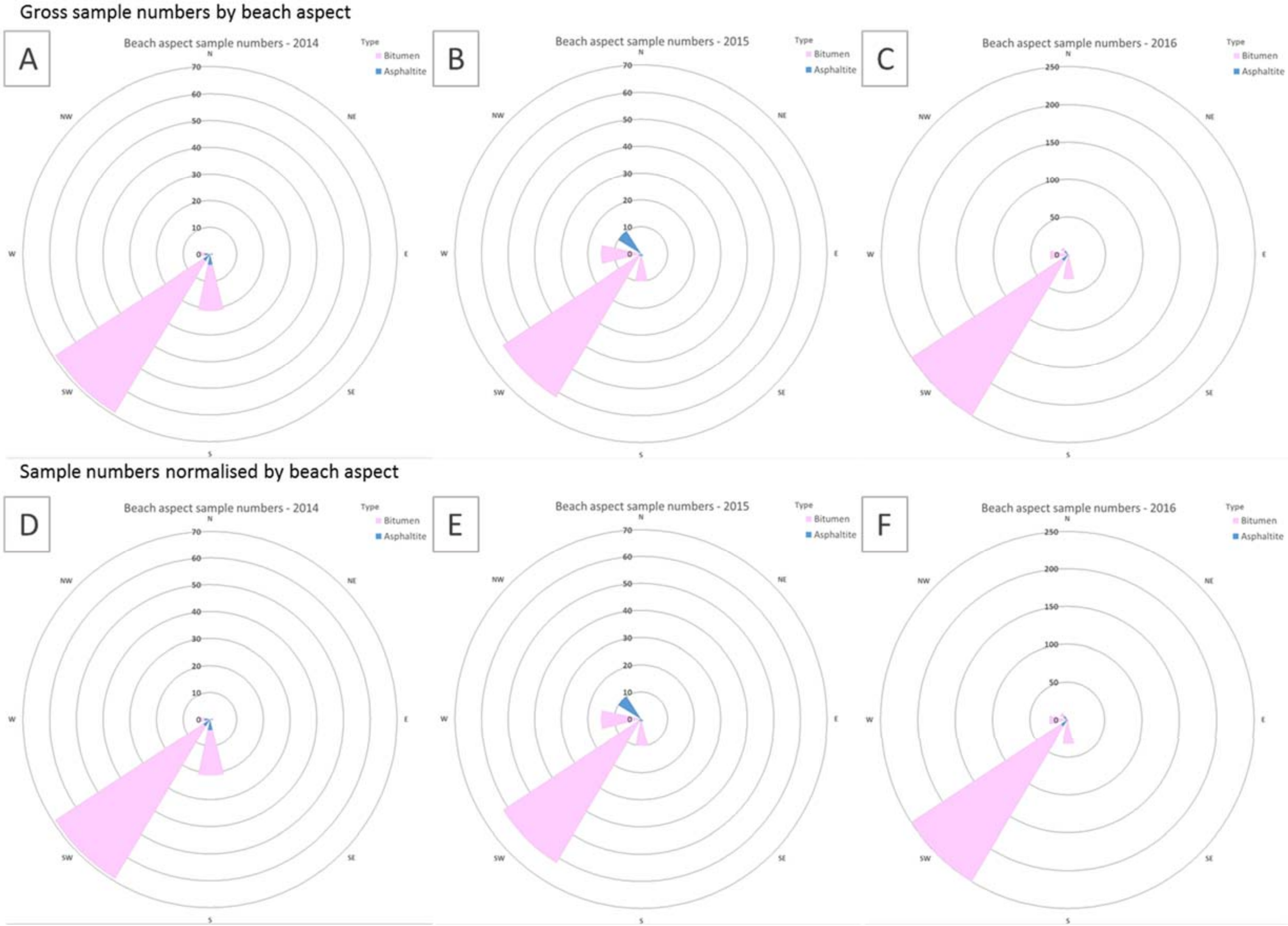


Figure 33: Rose diagrams of gross sample numbers by beach aspect (top row) and sample numers normalised by beach aspect (g/100m, bottom row) plotted by survey year for bitumen and asphaltites (donated samples and unclassifiable and miscellaneous materials excluded).

Figure 34: Rose diagrams of gross sample loadings by beach aspect (top row) and normalised sample loadings b beach aspect (g/100m, bottom row) by survey year for bitumen and asphaltites (donated samples and unclassifiable and miscellaneous materials excluded).

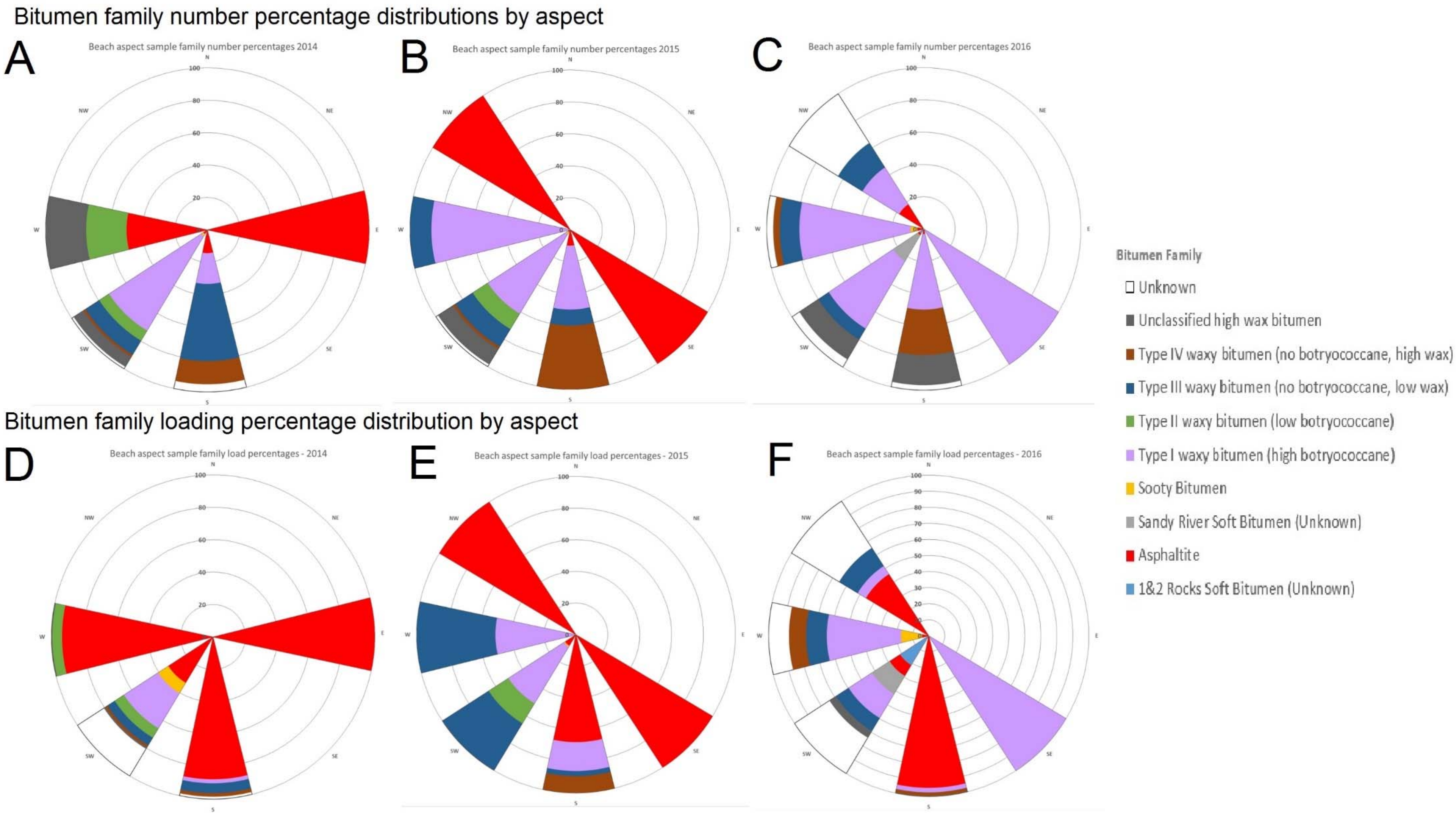


Figure 35: Rose diagrams of total numbers by percent (top row) and sample loadings by percentage (bottom row) plotted by aspect and by survey year for bitumen and asphaltites (donated samples and unclassifiable and miscellaneous materials excluded).

Detailed interpretation of example beaches

Australian beaches can be classified into 15 types (Short, 2007): six wave-dominated, three tide-modified, and four tide-dominated, which are a product of wave-tide and sediment conditions. There are also two types which are influenced by intertidal rocks and fringing reefs. The beach type has a significant influence on beach processes and geomorphology and as such it needs consideration when interpreting costal bitumen strandings.

According to Short (2007), most of the beaches of South Australia are wave dominated (65%) due to average breaking wave heights being similar to spring tide heights, whilst within the gulfs the beaches are either tidally modified (3%) or tidally dominated (32%). Of the beaches included in this study 30 (94%) are wave dominated and 2 (6%) are tidally modified. To help develop a detailed understanding of the nature of stranding on wave-dominated beaches which make up the majority of beaches in this study and across South Australia, summary data from a number of key beaches are presented below. These include two representative beaches from the Limestone Coast and two from the Eyre Peninsula.

Number 1 & 2 rocks

Number 1 & 2 rocks is located on the Limestone Coast and was one of the beaches previously visited by Padley (1995). It is classified as a high energy wave-dominated rhythmic bar and beach and as such is characterised by an outer bar on to which waves break with the broken wave and white water flowing shoreward as a wave bore (http://www.ozcoasts.gov.au; Short 2012). The southwest facing, straight 490 m section of beach surveyed (Figure 36) is near the northern headland of a ~2 km- long concave cove with a southwest to west aspect. Immediately offshore, at each end of the beach section surveyed, are rocky outcrops which funnel and modify the waves as they move toward and break on the beach (Figure 36). Shoreline photographs from each year show at the macro scale considerable variance in the amounts of stranded materials on the beach between years (Figure 37) with 2016 clearly showing the lowest quantity of materials for this beach.

The surveyed section of beach had a variable width of between 45 and 65 m (dependant on survey year) and a low slope of between 1.3 and 3.3 degrees (Figure 38). The beach is composed of fine yellow sand and the back beach character is primarily vegetated dunes.

This beach was the source of a large number of tarball samples collected throughout project across each of the years, especially during 2014 (Figure 38). There is no discernible preferred accumulation site on the stretch of beach (Figure 36) and the stranding locations on the beach profile (Figure 38) have similar distributions to those identified in the whole dataset above.

The location appears to be a natural collection point of a large amount of anthropogenic materials, including very high concentrations of plastics when compared to other beaches. This suggests that once trapped on the beach the materials cannot wash back out to sea nor be transported, via longshore drift, elsewhere. This is likely due the rocky outcrops acting as a natural groynes, preventing the movement of materials after arrival. Interestingly no asphaltite samples were found on this, albeit short, section of beach suggesting that the predominant wind and wave direction responsible for funnelling the tarballs and plastics onto this section of beach may not be the same as those that deposit asphaltites (i.e. the rocky outcrops may inhibit their deposition if the wind and wave fields are not from the southwest/west).

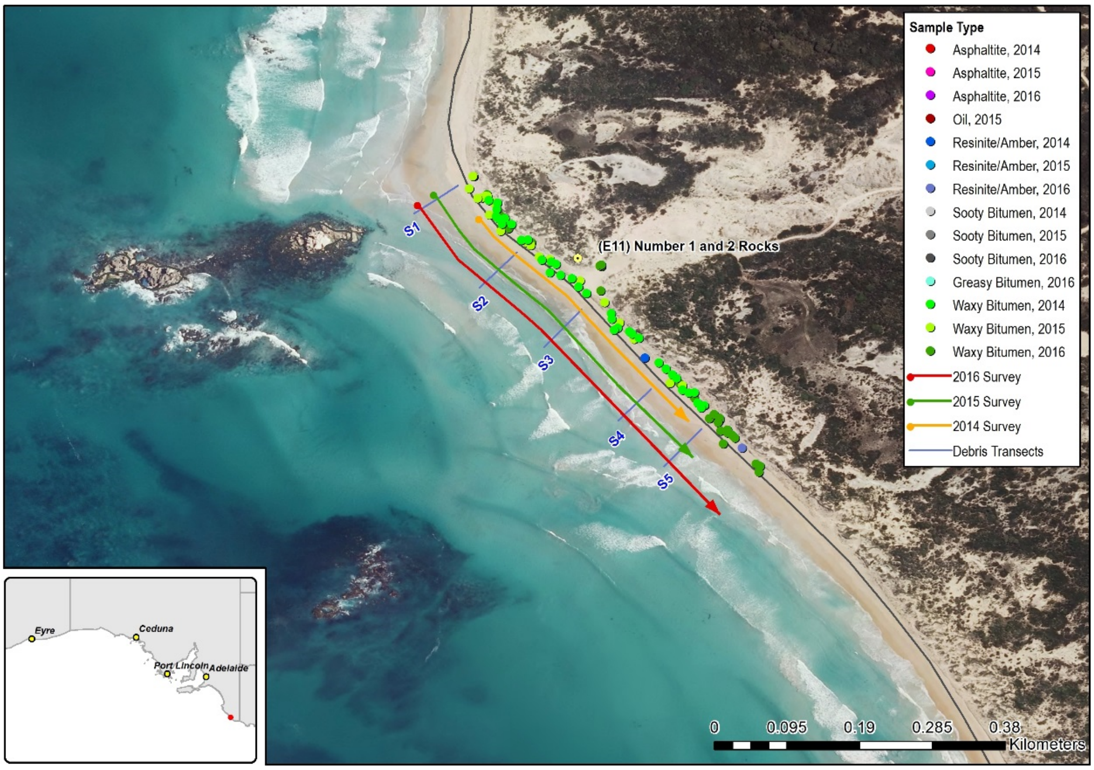


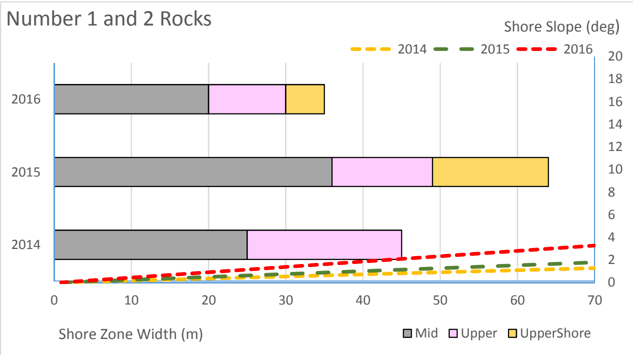
Figure 36: Satellite image of the Number 1 & 2 Rocks beach with surveys extents undertaken and locations of samples collected by year.

Figure 37: Images taken of the beach for each year for the Number 1 & 2 Rocks beach surveys.

Beach Summary Data

[sample types include asphaltite, tarball and resinite]

Beach Character Chart

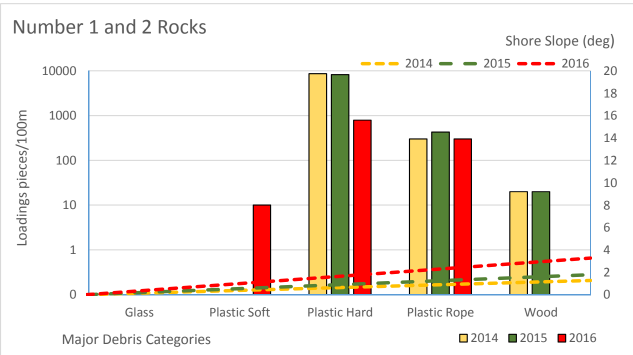


[2016 shore widths estimated]

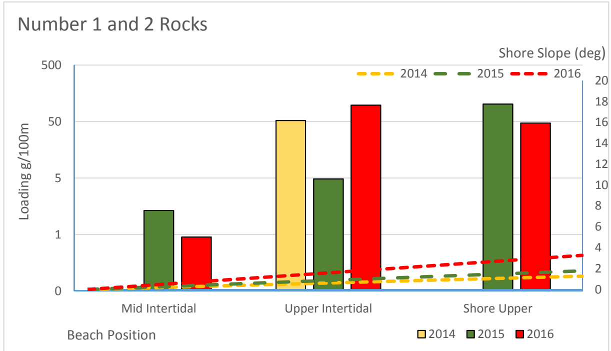
Asphaltite Frequency Chart

No asphaltites found on this beach

Debris Loadings Chart



Sample Loadings per 100m Chart



Tarball Frequency Chart

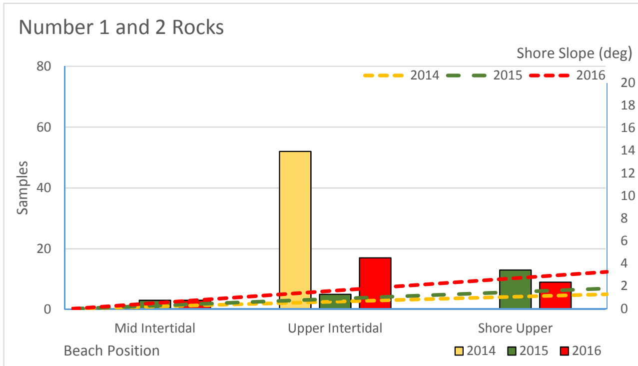


Figure 38: Compilation of beach survey data graphs for Number 1 & 2 Rocks.

Beachport Conservation Park

Beachport Conservation Park is also located on the Limestone Coast and like Number 1 & 2 Rocks was a beach previously studied by Padley (1995). It is classified as a wave-dominated reflective beach and lies at the lower energy end of the wave-dominated beach spectrum (http://www.ozcoasts.gov.au; Short, 2012). The 1,060 m length of beach surveyed comprises a concave south to southwest aspect cove (Figure 39). At the northern end of the cove there is a rocky limestone headland, from which a mainly submerged rocky platform extends to the southeast into the cove. At the southern end of the cove is a smaller rocky point with a few rocky outcrops which extend a short distance offshore (Figure 39). The beach character is typical of many of the beaches studied during the project.

Shoreline photographs from each year show at the macro scale the beach is relatively devoid of stranded materials (Figure 40) and the beach morphology does not appear to change considerably.

The beach varied in width from 25 to 40 m (dependant on survey year) and a low slope of between 2.3 and 3.7 degrees (Figure 41). The beach is composed of fine white sand and the back beach character is primarily vegetated dunes.

This beach was the source of a low number of large tarballs collected on the upper shore in 2014 and 2015 (Figure 41), with no asphaltites collected during these survey seasons. The 2016 survey collected a larger number of tarballs from both the upper intertidal and upper shore zones. However, these were on average smaller than those encountered during previous years (based on loadings data, Figure 41). In addition, one asphaltite was found on the upper shore in 2016. Unlike Number 1 & 2 Rocks, the materials collected appear to be weighted toward the southern end of the beach suggesting that long shore drift is transporting stranded materials to this location where they then accumulate (Figure 39). The exception to this pattern is the 2016 strandings where they appear to be more uniformly distributed (Figure 39). This suggests that these materials have not had time to be transported down the beach and is consistent with the theory that the majority of these 2016 materials were deposited during the storm just prior to the survey. Anthropogenic materials were less prevalent on this beach with hard plastic concentration two orders of magnitude less than at the Number 1 & 2 rocks locality.

Whilst the beaches at both Beachport Conservation Park and Number 1 & 2 Rocks have many similar properties, the deposition and transport of stranded materials is radically different at these two sites. The explanation for this is likely to be the combination of nearshore rocky outcrops and beach shape. For example, the beach at Number 1 & 2 Rocks is linear and constrained to the north and south by rocky outcrops limiting the potential for materials to 'spill' from the beach and near shore environment. However, the broad concave cove of the Beachport Conservation Park allows longshore drift and material to be lost at the southern end of the cove back into the marine environment.

Similar beach properties (aspect, beach shape) to those morphologies observed at Number 1 & 2 Rocks can be found at Sandy River where in 2016 when the beach angle was at its lowest (1.4 degrees) and a large number of tarballs were collected.

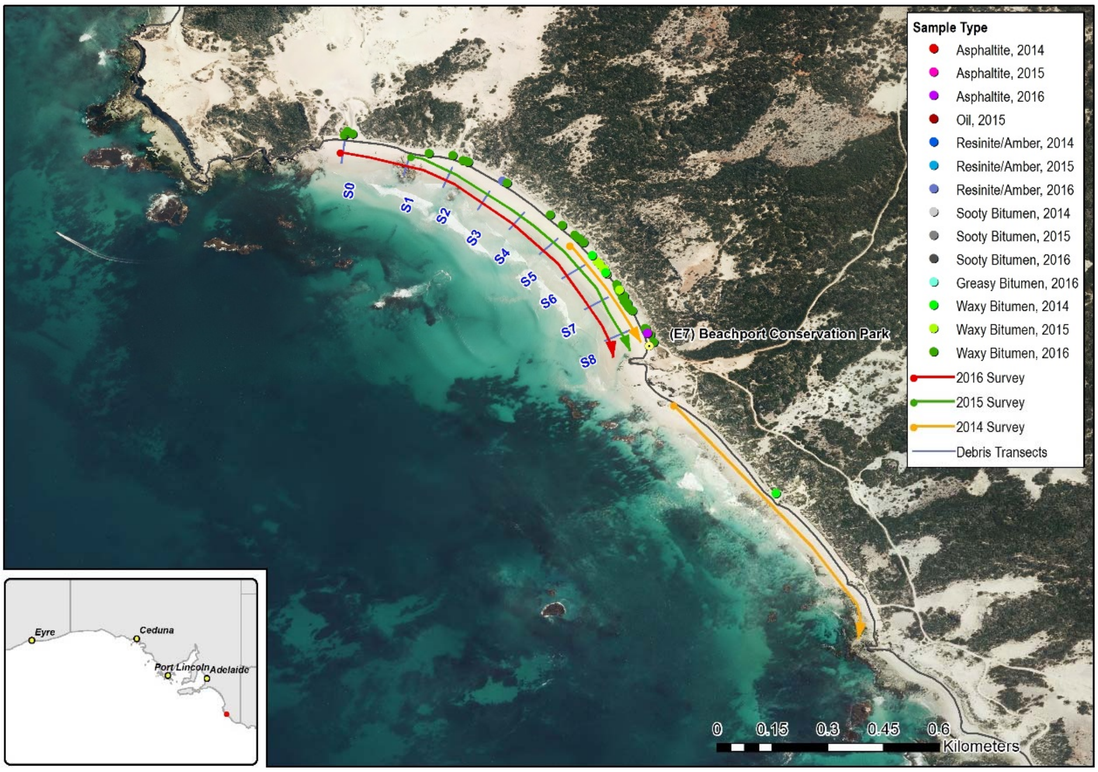


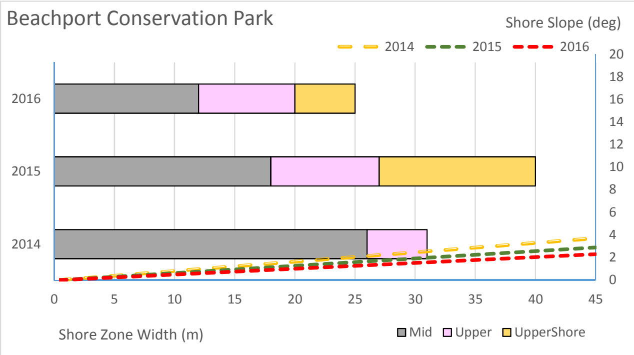
Figure 39: Satellite image of the Beachport Conservation Park beach with surveys extents undertaken and locations of samples collected by year.

Figure 40: Images taken of the beach for each year for the Beachport Conservation Park beach surveys.

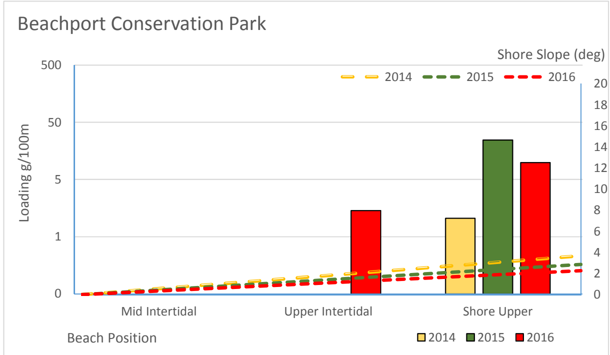
Beach Summary Data

[sample types include asphaltite, tarball and resinite]

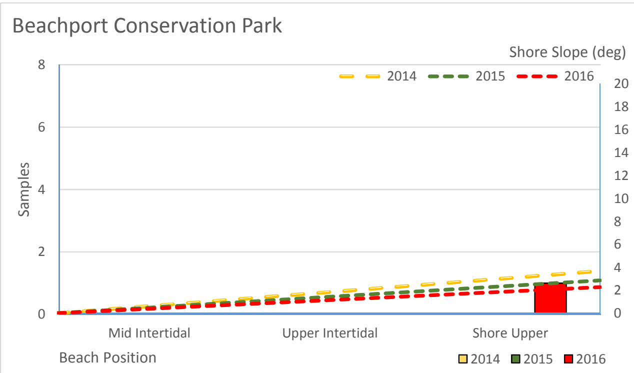
Beach Character Chart



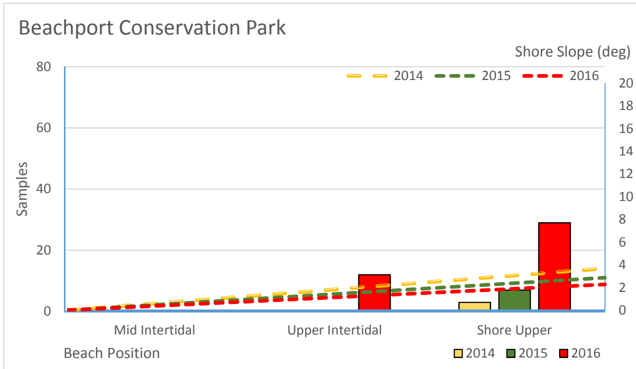
Sample Loadings per 100m Chart



Asphaltite Frequency Chart



Tarball Frequency Chart



Debris Loadings Chart

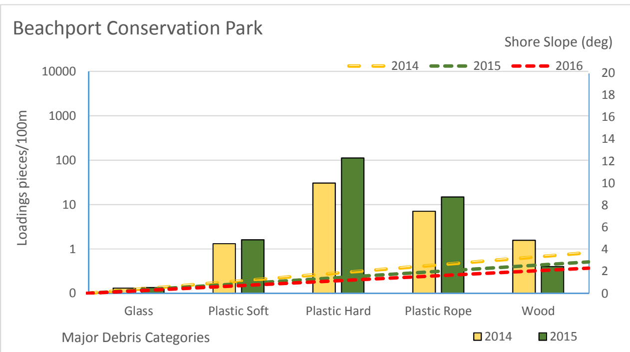


Figure 41: Compilation of beach survey data graphs for the Beachport Conservation Park beach.

Tractor beach

Like Beach Port Conservation Park, Tractor Beach is classified as a wave-dominated reflective beach and lies at the lower energy end of the wave-dominated beach spectrum (http://www.ozcoasts.gov.au; Short, 2012). It represents an atypical beach both in the number of asphaltites collected and its substrate and aspect. Tractor Beach is located on the western Eyre Peninsula and had not been previously surveyed for asphaltites and tarballs prior to this study. The 820 m length of beach surveyed comprises a west to northwest-facing concave cove (Figure 42). At the western and eastern ends of the cove there are shallow submerged limestone reefs which are replaced by seagrass meadows further offshore (Figure 42). Due to its aspect, and as evidenced by the abundance of seagrass in shallow waters offshore, the beach is very sheltered.

Shoreline photographs from each year show that at the macro scale the beach is complex with a rocky/pebbly substrate on to which dead seagrass is mounded (Figure 43). This shows that during storm events the beach can be impacted by larger waves than were observed during the three survey visits. The beach width diminished from 34 m in 2014 to 17 m in 2016, and has a low slope of between 3.4 and 4 degrees (Figure 44). The back beach character is primarily vegetated bluffs, dunes and rocks.

This beach was the source of a significant number of asphaltites found during the study in 2015 and 2016, with samples collected in the mid and upper intertidal zones and on the upper shoreline (Figure 44). The materials collected in 2015 were found close to the western end of the cove, whilst the 2016 samples were distributed along the entire beach survey length (Figure 42). This suggests that a westerly long-shore drift may affect samples with long residence times (long period between storm events and survey in 2015), whereas samples which have short residence times are more evenly distributed (short period between winter storm and survey in 2016). The lack of tarball strandings on the beach is confounding and would suggest that the processes that lead to the arrival of the asphaltites on this beach are different to those for the tar balls. There is also a low abundance of anthropogenic debris (plastics) recorded along this beach, which could also suggest that the stranding processes of these materials and tarballs are similar. The modes of transport of both plastics/tarballs and asphaltites discussed below (Part 4 Oceanography) are likley to be different. Tarballs and plastics are more likely to be affected by windage when floating at sea, more so than asphaltites. These differences may have an influence on the stranding of these materials with respect to beach aspect.