Investigating the ecological implications of wrack removal on South Australian sandy beaches

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ABSTRACT

Accumulations of seagrass, macroalgae and other matter, collectively known as wrack, commonly occur on many sandy beaches, and can play an important role in coastal and nearshore ecosystems. Despite this, wrack removal from sandy beaches is a widespread and increasingly common practice globally, and there is little information regarding the ecological effects of such wrack removal on sandy beaches. The aim of this thesis was to establish the ecological importance of wrack in South Australian (SA) sandy-beach ecosystems. As a first step in furthering our understanding of the effects of wrack removal, I aimed to assess the importance of wrack, independent of the effects of wrack removal. The second over-riding aim of this thesis was to assess the ecological effects of wrack removal on aspects of these systems.

To date, the methods used for quantifying the size of wrack deposits on sandy beaches have had limited use due to the time and expertise required to conduct thorough sampling. In Chapter 2, I thus tested the accuracy of a rapid "photopoint" method to visually estimate percentage wrack cover as well as provide an archived record. Comparisons of results obtained from conventional transects with those from photopoints indicated that the photopoint technique can be used to rapidly and accurately estimate % wrack cover on sandy beaches. The photopoint method has a wide range of potential applications and represents a valuable advance in the field.

Currently our knowledge of the amounts and types of wrack on SA shores is limited, despite these accumulations being a feature of some SA beaches. Wrack deposits in three biogeographical regions of SA were thus repeatedly surveyed to assess spatial (between and within regions) and temporal (seasonal and inter-annual) variation (Chapter 2). Both wrack cover and the composition of wrack deposits varied spatially and temporally. Wrack deposits contained a diverse array of seagrass, algal, other biotic materials and anthropogenic debris. The South East region of SA had distinctly-different wrack deposits compared to the Metropolitan and Fleurieu Peninsula regions; in general, the cover of wrack was higher, and the diversity and biomass of kelps, red algae and green algae was higher in this region compared to the

other two regions. South Australian wrack deposits are thus dynamic and complex.

The amount of wrack deposited and retained on a beach may be affected by the beach morphology but, to date, few studies have investigated this link. I assessed wrack cover on beaches with a range of morphodynamic types and found that beaches that were more dissipative in nature had a greater cover of wrack than beaches of the reflective type. I also examined whether wrack deposits affected the sediment characteristics of underlying and nearby sediments. Wrack deposits had little measurable effect on underlying sediments and did not affect particle-size distribution or organic-matter content. There was, however, a trend for beaches in the South East region of SA to have higher organic matter content in their sediments, and these beaches also have higher wrack cover and higher proportions of algae in their deposits. There was also a trend for beaches with higher wrack cover to have less compacted sediments, although this trend was not consistent.

Overnight pit-fall trapping surveys of the macrofauna on four SA sandy beaches indicated that local macrofaunal communities were diverse (representing 72 species from 19 Orders in total), abundant, and variable in both time and space. The macrofauna encountered were mostly terrestrial taxa with only 2 truly marine species, and spanned multiple trophic levels, concurring with the results of previous studies. Macrofaunal abundances were higher where associated with wrack than in bare sand, and macrofaunal communities differed between the driftline of wrack and wrack patches away from the driftline. Within the driftline itself, there were few differences between bare sand and wrack-covered areas, suggesting that the entire driftline area is important as a habitat and food resource. Thus, wrack deposits provide an important habitat and food source for macrofauna, and the driftline provides an area of beach with concentrated resources, which in turn concentrates a distinct macrofaunal community.

Wrack deposition on sandy beaches varies spatially and is affected by morphological features on the beach-face such as cusps. In Chapter 5, I thus tested a series of hypotheses regarding the differences in wrack deposits, sediments and macrofaunal communities between cusp bays and horns. Bays had greater cover and larger pieces of wrack than horns. Sediment organic-matter content was greater on horns than in bays but mean particle size did not differ consistently between bays and horns. Macrofaunal diversity was higher in bays and this pattern was probably driven by differences in the cover of wrack between bays and horns. Cusp morphology thus influences the distribution of wrack on the beach-face, which in turn influences the distribution of macrofauna. Studies of sandy beaches with cusps should therefore be explicitly designed to sample cusp features and their associated wrack deposits.

Chapter 6 assesses the incorporation of wrack into beach and nearshore ecosystems via two pathways: decomposition and incorporation into trophic webs. I assessed the decomposition of algal and seagrass wrack using litterbag experiments and found that after a very rapid initial loss of mass, likely due to cell lysis and leaching, the rate of decomposition of wrack was much slower. Most release of nutrients from organic matter decay thus appears to occur in the first few days after deposition and the processes affecting the rate and nature of wrack decomposition vary among taxa (i.e. algal versus seagrass and among species). Stable isotopes of C and N were used to assess whether beach macrofauna or nearshore macro-invertebrates and fish might rely on wrack as a source of nutrition. I found that seagrasses did not provide a food source for any consumers but algae, particularly brown algae including kelps, appeared to be potential sources of nutrition for beach and nearshore consumers. The incorporation of wrack into beach and nearshore ecosystems may thus occur primarily through consumption of algal wrack by herbivores such as amphipods and dipterans, with predation on them being important pathways for the transfer of nutrients and energy into higher trophic levels. The amount of wrack in the surf zone did not affect the abundance and species richness of fish and invertebrates netted there.

The aim of Chapter 7 was to determine the effects of wrack removal on sandy beach macrofaunal communities. In the first study the effects of large-scale commercial harvest of wrack on the macrofaunal communities at Kingston were assessed. The macrofaunal communities present in the 'Natural' area of Kingston beach were far more diverse and abundant, and included different species, compared to the 'Cleared' area at Kingston. In the second part of Chapter 7, I experimentally removed wrack from the driftline of beaches to assess short-term effects on macrofaunal communities. The experimental treatment did not appear to have any measurable effects on the macrofaunal communities. I also analysed material that was removed from the beach in the raking experiments and found that a large proportion of the material (e.g. 81% of the DW) was sand. I recommend that future studies into the effects of wrack removal use large cleared areas of beach, attempt to use the same wrack removal methods and/or machinery used locally, and assess the macrofaunal communities repeatedly and over longer times following wrack removal activities.

In Chapter 8, I attempt to assess the effects of removal of wrack for beach 'cleaning' or commercial 'harvest' of wrack by comparing key indicators from Chapters 2 to 7. Implications and recommendations for the management of wrack are discussed, including with regard to the techniques used in this thesis and their applicability in managing wrack deposits. I attempt to identify the shortcomings of this research as well as directions for further research.

Thus I have demonstrated that wrack in SA provides an important link between offshore habitat and nearshore, beach and terrestrial habitats via the transfer of organic matter and nutrients. Wrack interacts with beach morphology and sediments, provides habitat for macrofauna, remineralises nutrients through its decomposition, and provides the basis of a complex trophic web. I conclude that wrack is a key component in beach ecosystems.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference in made in the text.

Stephanie Duong
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