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EFFECTS OF THE JANUARY 2020 BUSHFIRES ON ESTUARINE SYSTEMS OF KANGAROO ISLAND

Post event field data collection

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Cover: Lower estuary in Stun'Sail Boom and surrounding burnt dunes. Source: Patrick Reis Santos

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ACKNOWLEDGMENTS

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INTRODUCTION

BACKGROUND

The 2020 summer bushfires on Kangaroo Island were the largest in the Island's recorded history, with over 200,000 hectares and more than 40 % of the island burnt (DEW, 2020). The impacts of these bushfires will not be confined to the terrestrial landscape and are likely to have substantial detrimental impacts on the island's aquatic systems, particularly after rainfall.

Post-fire exposed soils are highly erodible, and therefore intense precipitation events or seasonal rainfall can result in the runoff of nutrients and ash enriched sediments, debris and other products of combustion into waterways. These runoff events, allied to heavy sedimentation, can lead to deteriorating water quality, potentially triggering eutrophication, low oxygen events, and compromise aquatic fauna. In addition, contaminants, including trace elements and products of combustion such as polycyclic aromatic hydrocarbons (PAHs) can also enter waterways (Olivella et al 2006, Shakesby and Doerr, 2006, Smith et al 2011, Sequeira et al 2020).

One area of concern in Kangaroo Island are the estuarine systems downstream or adjacent to burnt areas. Despite the ecological importance of estuarine environments and the multiple ecosystem functions they provide (including nursery grounds for juvenile fish), the impacts of bushfires in estuaries are yet to be investigated. Furthermore, because estuarine systems in Kangaroo island are not permanently open to the sea, the impacts of accumulated soot, ash and sediment channelled into estuaries could be exacerbated, and have the potential to disrupt complex ecological and biogeochemical cycles, increase contaminant loadings and result in pervasive effects for local fish communities. Ultimately, there are substantial knowledge gaps in our understanding of water quality impacts and mobilisation of heavy metals and isotopes in the aftermath of bushfires in estuaries, and these add to the lack of understanding of the ecology and geochemistry of estuaries in South Australia.

In this context, the Bushfire and Natural Hazards CRC, via the Quick Response Fund, provided financial support for travel-related expenses to undertake surveys on Kangaroo Island in estuaries within areas directly affected by this unprecedented bushfire season, and control sites outside these areas. These sampling events are part of broader research where in the long term, we aim to evaluate the impacts of bushfires on estuarine water quality and on estuarine fish, as well as trace the mobilisation and fluxes of contaminants released by bushfires into estuarine systems.

UNDERTAKEN ACTIVITIES

POST EVENT DATA COLLECTION

Water and fish sampling

In late April and May 2020, we travelled to Kangaroo Island to collect water and fish in the Cygnet, Middle, Western, Stun'Sail Boom, Harriet, Eleanor and Chapman estuaries (Figure 1). Sampling targeted estuaries that were directly affected by bushfires (i.e. surrounding areas and catchments burnt), as well as estuaries where there were no direct fire impacts on the estuary but parts of their catchment were burnt (Cygnet), and estuaries where there were no direct impacts on the catchment (Chapman) (Figure 1, 2).

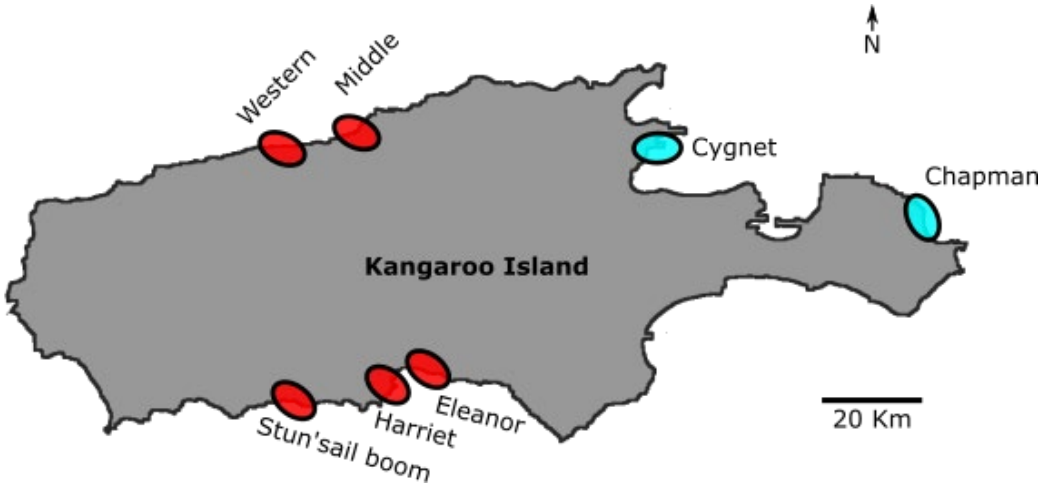

FIGURE 1 – MAP OF SAMPLED ESTUARIES ON KANGAROO ISLAND. IN RED, ESTUARIES AFFECTED BY THE SUMMER 2020 BUSHFIRES ON THE ISLAND, IN BLUE, ESTUARIES IN AREAS NOT DIRECTLY AFFECTED BY THE SUMMER BUSHFIRES.

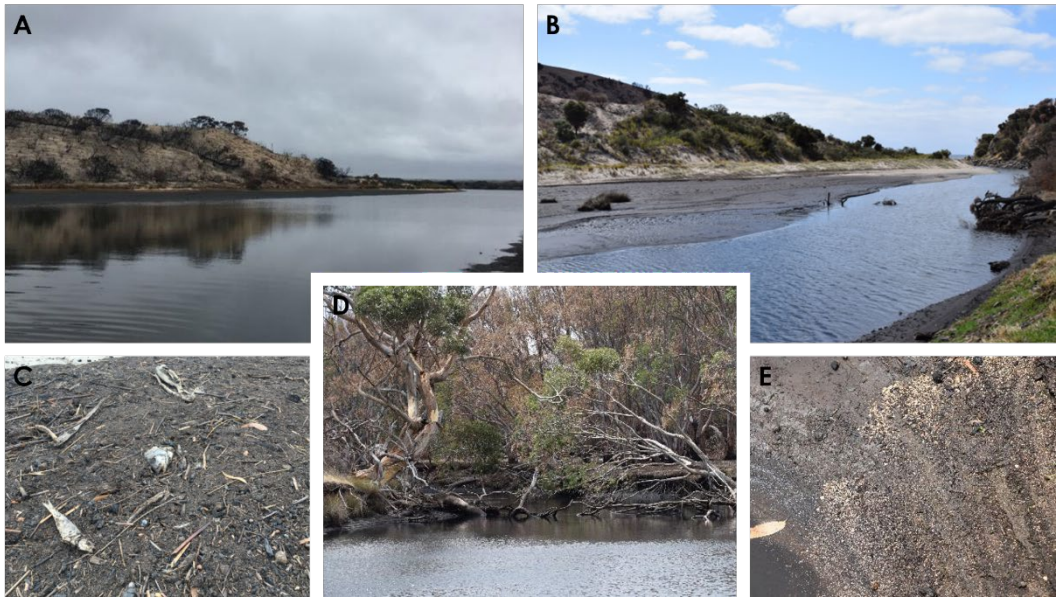

FIGURE 2 – ESTUARIES AFFECTED BY BUSHFIRES. A) LOWER ESTUARY STUN'SAIL BOOM AND SURROUNDING BURNT AREAS, B) MOUTH OF THE WESTERN ESTUARY WITH HEAVY SEDIMENTATION C) EVIDENCE OF FISH KILLS IN THE HARRIET ESTUARY, D) BURNT VEGETATION SURROUNDING THE UPPER MIDDLE ESTUARY, AND E) ASH AND FIRE DERIVED SEDIMENTS IN MIDDLE RIVER.

We sampled two sites per estuary (though this was not possible in some cases due to access limitations). At each site, we measured a set of physicochemical parameters, including temperature, salinity, dissolved oxygen, and pH using a multiparameter probe. For quantification of the concentrations of dissolved nutrients (e.g. ammonia nitrogen, oxides of nitrogen, filterable reactive phosphorus) and dissolved organic carbon (DOC) waters were collected and immediately filtered through a 0.22µm filter. Unfiltered water samples were also collected for measurements of total nutrient concentrations (total nitrogen, total phosphorus). Larger volumes of water (1L) were collected for estimates of total suspended solids and particulate organic carbon, as well as for contaminant, metal and isotope analysis (e.g. Mn, δ^{87}Sr, PAH).

To evaluate estuarine fish communities, we used a small hand-held seine net to collect fish (at the same sites of water collections). Three replicate short hauls were made per site to assess fish species composition, abundance, and potential variations in functional diversity.

Preliminary findings

Travel-related expenses supported by the Bushfire and Natural Hazards CRC Quick Response fund, were essential for this sampling to take place. Data will be compared in the long term with sampling that has been previously undertaken by us, as well as other collections we aim to perform later in the year. Nutrient, element, and isotopic analyses from these sampling times are ongoing, affected by COVID-19 related delays, and pending the start of an associated Coastal Research & Development Grant from the Department for Environment and Water (DEW), South Australia that will covers analytical costs.

Preliminary findings of field-collected data show variation in physicochemical properties and nutrients, with data indicative of potential eutrophication, with nutrient enrichment, and low dissolved oxygen in several estuarine sites. Whilst dissolved oxygen concentrations were between 95 and 101 % for the Chapman estuary (our control site), the remaining sites had lower dissolved oxygen, with a minimum of 27.4% at Stun'Sail Boom. Total nitrogen (µgN/L) was highest for Stun'Sail Boom at both sampling times (2400 & 2000 µgN/L) with overall values for the remaining estuaries varying between 395 µgN/L (Harriet) and 1400 µgN/L (Middle). For total phosphorus, the highest values were found at the upper Middle river (110 µgP/L) followed by Stun'sail Boom 79 (µgP/L).

A range of post-fire conditions, including heavy sedimentation, turbidity and poor water quality will likely compromise survival and fish abundance in estuaries. We documented fish mortality, with evidence of fish kill events noticeable along the shores of a few of the sampled sites (e.g. Middle, Harriet, Stun'Sail Boom) (Figure 2). Fish were present in all estuaries, but there was low diversity (maximum 3 species). Overall, the main species present were smallmouth hardyheads *Atherinosoma microstoma* and black bream *Acanthopagrus butcheri*. One of the most interesting findings was the collection of numerous age 0^{+} individuals of black bream, including in the areas of Stun'Sail Boom where the lowest oxygen measurements were observed. Whilst larger juvenile and adult black bream were found in several estuaries (e.g. Harriet, Middle, Chapman), the assemblages were dominated by smallmouth hardyheads, especially in the lower Eleanor and Chapman estuaries.

FUTURE DIRECTIONS

ONGOING WORK, RESEARCH PRIORITIES AND EXPECTED OUTCOMES

This is a unique opportunity to gain valuable data documenting recovery following bushfires. Recurring sampling will be essential to assess changes over time, and therefore characterise the short and longer-term impacts of the summer bushfires on the estuarine systems of Kangaroo Island. In particular, to understand how nutrients, metals and toxins from the combustion of organic matter affect estuarine systems, as well as quantify their local fluxes using isotope tracers, and constrain their sources and bio-geochemical pathways, additional analyses will be undertaken.

We have previously collected water samples and other water quality data post-fire but before significant rainfall, and immediately after rainfall. Further sampling is also expected, supported by a Coastal Research & Development Grant from the Department for Environment and Water (DEW), South Australia, which also covers analytical costs. All data on water quality and fish assemblages can also be compared to historical data.

Fire severity varied throughout Kangaroo island, and the areas surrounding the multiple estuaries on the island and their respective catchments have been differently affected (DEW, 2020). At present, there is no information on the spatial and temporal scale of these impacts or how they may relate to fire intensity and other catchment scale variables (e.g. percentage of catchment burnt). We will strive to relate our results on water quality, metal and isotopic variations, and variations in fish communities to burn severity in each catchment.

Fish were collected in both sampling events. This suggests that individuals found refugia, or coastal individuals are re-settling or opportunistically using the estuaries following the opening of the estuarine entrances. This warrants further research, allied to understanding if the levels of persistent compounds or contaminants (heavy metals, PAHs) entering the estuaries due to the bushfires pose any deleterious risks to the fish community or jeopardise estuarine nursery function. Greater knowledge on post-fire impacts to variations in concentrations of contaminants will also be relevant concerning the consumption of local biota.

TEAM MEMBERS

This project was coordinated by Professor Bronwyn Gillanders and Dr Patrick Reis Santos. Field surveys were completed by Dr Patrick Reis Santos, Dr Judith Giraldo and Mr Koster Sarakinis.

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