THE EFFECTS OF OIL AND DISPERSED OIL ON THREE TEMPERATE AUSTRALIAN SEAGRASSES – SCALING OF POLLUTION IMPACTS

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Certificate of Authorship

I certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as part of the requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

The thesis is a comprehensive assessment of the effects of oil and dispersed oil on subtidal seagrass using a range of *in situ* and laboratory experiments on whole plants and seagrass leafblade sections. Apart from assessing the effects of oil and dispersed oil on seagrass between seasons, locations, and morphologically different species, the study determines whether laboratory results are indicative of those obtained *in situ* as an initial step in developing a rapid laboratory testing protocol for seagrass assessment. Petrochemical treatments, consisting of a range of concentrations of the water accommodated fraction (WAF) of oil alone (Tapis crude, IFO-380), dispersant alone (Corexit 9527, Ardox, Slickgone, Corexit 9500) and dispersed oil were exposed to whole plants, in both the laboratory and *in situ*, for ten hours followed by a four day recovery period, and for five hours in the leafblade experiments. Photosynthetic health was monitored by assessing the effective quantum yield of photosystem II ($\Delta F/F_m'$) and chlorophyll *a* pigment concentrations, whilst semi-quantitative methods of total petroleum hydrocarbon (TPH) concentration were used to determine the percent TPH remaining in the water column following the exposure period.

In most cases, the non-dispersed oils, Tapis crude oil and IFO-380, had less of an impact to both *Zostera capricorni* and *Halophila ovalis* than the dispersed oil treatments, whilst *Zostera muelleri* did not show any negative impact from either dispersed or non-dispersed Tapis crude oil. Winter *in situ* experiments found slightly greater reductions of $\Delta F/F_m'$ in *Z. capricorni* in most treatments compared with summer *in situ*, but generally there was minimal impact whilst *Z. muelleri* exhibited a stimulatory response to both non-dispersed and dispersed Tapis crude oil in Corio Bay, Victoria (summer *in situ* only). Laboratory whole plant experiments found *Z. capricorni* was for the most part less resilient to Tapis crude oil (non-dispersed and dispersed) treatments than *Halophila ovalis* whereas, with exposure to IFO-380 (non-dispersed and dispersed) *H. ovalis* was less resilient than *Z. capricorni*. Quite severe, and, or prolonged, photosynthetic stress was evident in both *Z. capricorni* and *H. ovalis* when exposed to most of the dispersant alone treatments (Corexit 9527, Ardrox and Corexit

9500), however the Slickgone alone treatment caused only a very short-lived stress response in *H. ovalis* only. The results of the laboratory whole plant experiments, conducted under Sydney summer water temperature conditions, were generally more similar to those observed in the summer *in situ* experiments than those observed in winter *in situ*. The effects to the leafblades of *Z. capricorni* were commonly greater than those observed in the whole plant experiments, even within the short exposure period. $\Delta F/F_m'$ appeared a more reliable indicator than that achieved with the chlorophyll *a* pigment analyses. Large differences in the percent TPH recovered between *in situ* and laboratory experiments suggests microbrial activity and sediments play a substantial role in the partitioning of oils in these experiments. This research suggests that assessments of seagrass health in laboratory experiments can in some cases be representative of that observed *in situ* when similar experimental conditions are maintained. The increased sensitivity of leafblade sections is considered beneficial when rapid comparisons of different petrochemical impacts to seagrass are required, i.e. once an oil spill has occurred.

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List of Abbreviations

AMSA	Australian Maritime Safety Authority
ANOVA	Analysis of Variance
API	American Petroleum Industry
bbl	barrel
BTEX	benzene, toluene, ethylbenzene, xylene
Chl *a*	Chlorophyll *a*
cSt	centistoke
$\Delta F/F_m'$	Effective quantum yield of photosystem II
EWG	Environmental Working Group
GC-MS	Gas Chromatography –Mass Spectrometry
HPLC	High Performance Liquid Chromatography
mg L^{-1}	milligrams per Litre
NEBA	Net Environmental Benefit Analysis
NOAA	National Oceanic and Atmospheric Association…
OSC	Oil Spill Coordinator
PAH	Polycyclic Aromatic Hydrocarbon
PAM	Pulse Amplitude Modulation
ppm	parts per million
ppt	parts per thousand
PSI	Photosystem I
PSII	Photosystem II
psu	percent salinity unit
rmANOVA	repeated measures Analysis of Variance
TPH	Total Petroleum Hydrocarbons
UV	Ultra-Violet
UVF	Ultra-Violet Fluorescence
WAF	Water Accommodated Fraction
WSF	Water Soluble Fraction
μg L^{-1}	micrograms per Litre