TUGGERAH LAKES

WRACK HARVESTING STRATEGY

Prepared for Wyong Shire Council

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NSW GOVERNMENT | Office of Environment & Heritage

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INTRODUCTION

Healthy seagrasses are vital to the on-going biodiversity, health and amenity of Tuggerah Lakes. They have been demonstrated to be important nursery and feeding areas for prawns and a wide range of commercially and recreationally valuable and protected fish, and perform essential ecosystem services including stabilising sediments, improving water clarity and removing nutrients. Seagrasses naturally shed leaves throughout their lives, particularly when the leaves grow long or are subject to wind and waves. Plant material (including seagrass) that is moved about by wind and washed onto beaches or collects in shallow areas is often referred to as wrack. In Tuggerah Lakes, the majority of wrack is seagrass and associated algae.

Wyong Shire Council (Council) has approached NSW Office of Environment and Heritage (OEH) to provide advice on wrack harvesting in Tuggerah Lakes, prompted by a desire to redouble harvesting efforts in order to improve public amenity of lake foreshores. This document provides context, rationale, methodology and strategic planning advice to council staff dealing with this issue. OEH propose some new methods for harvesting wrack trapped in shallow nearshore areas which Council will have to investigate and assess. The aim of the strategy is to manage wrack accumulations in order to 1) improve public amenity of the shoreline, and 2) maintain / enhance the health of the lake ecosystem. OEH research shows clearly that management strategies for wrack and ooze require two main directions. The first is to minimise the inputs of nutrients and organic matter via stormwater. The second is to maximise the dispersal of inputs (and existing ooze) from the near-shore. It is also important to couple the strategy to an education program that aims to improve public awareness and dispel myths surrounding this issue.

BACKGROUND

WRACK PRODUCTION

Tuggerah Lakes supports large areas of seagrass (*Zostera muelleri* sub-species capricorni*)* which produces large volumes of wrack (detached leaves). In calm conditions wrack accumulates in the seagrass bed of origin. Once wave energy / water currents exceed a certain threshold, it is liberated from the bed and forms floating rafts which are transported around the lakes according to the prevailing wind-driven currents. Wrack rafts are primarily trapped against shorelines, shallow shoals and emergent seagrass / macroalgae. Floating wrack stays buoyant for approximately 2 – 3 weeks after which it sinks where it has been trapped.

Entrance management for flood mitigation has resulted in a relatively constant lake water level of ~0.6m AHD which is in stark contrast to natural conditions (before entrance management and modified shores) when lake water levels fluctuated between 0.5m and 2.0m AHD. Under natural conditions, wrack was periodically transported onto shore where it dried aerobically when flood waters receded. This natural mechanism of self cleansing now only occurs after prolonged heavy rainfall and to a far lesser extent. Under current conditions of entrance management and modified shorelines, only a tiny fraction of total wrack can ever be delivered onto shore, even where shorelines have gentle slopes. Large amounts of wrack accumulate in the nearshore and should be harvested from problem areas where ooze sediments occur.

CONTRIBUTION OF WRACK TO OOZE FORMATION

Seagrass wrack decomposes very slowly, and in the absence of any other organic material will persist for many months. In many situations, wrack accumulations along the shoreline reduce circulation currents and tend to trap other material (microalgae, inorganic sediment and macroalgae) which can greatly increase the overall rates of decomposition in the wrack pile. This can lead to a predominance of anaerobic decomposition (i.e. in the absence of oxygen) and the production of hydrogen sulfide which may lead to ooze formation. It is not the decomposition of wrack that forms ooze, but the decomposition of the trapped organic matter (macro algae, microalgae, organic material from storm drains).

SPATIAL VARIATION IN WRACK ACCUMULATION AND OOZE FORMATION

Results from surveys of ooze accumulations carried out by NSW OEH suggest that the presence of wrack accumulations varies widely at spatial scales of 100m to 1km depending on the interactions between a) the location of wrack sources; b) prevailing currents and wave energy; c) shoreline aspect / grade; and d) the existence of emergent vegetation. It should be noted that not all wrack accumulations will result in the formation of sulfidic black ooze. Comparisons between urban and natural shorelines suggest that sulfidic ooze development is largely confined to modified urban shorelines. Urban shorelines tend to have steep banks and no exposed sloping shores so wrack tends to accumulate at the waters edge. Nutrient-rich stormwater and groundwater discharges are also trapped in nearshore waters by the presence of offshore rafts of wrack, seagrass beds and rafts of macroalgae. Modified shorelines and high nutrient inputs, coupled with muddy sediments and low water flow, are the conditions that lead to the production of sulfidic ooze. Wrack accumulates at the water's edge at Canton Beach where high nutrient inputs are suspected from groundwater discharge. These wrack accumulations produce sulfidic odours but not sulfidic ooze. Wrack accumulations on sandy sediments in well flushed sites tend not to form ooze

IMPACT OF WRACK ACCUMULATIONS ON NEARSHORE FLUSHING

The lake basin and nearshore zone are effectively two separate water bodies which experience very little mixing. Wrack accumulations, seagrass beds and excessive macroalgal growth form a barrier to the mixing that could have occurred due to wind/wave energy. Groundwater seepage and small urban stormwater discharges are therefore concentrated in the vicinity of the discharge location, causing localised nutrient enrichment. Excessive nutrients form a positive feedback enhancing excessive macroalgae growth, which in turn greatly contributes to the development of sulfidic ooze. The problems of wrack accumulation and ooze development cannot be addressed by enhanced oceanic exchange and entrance management because they are exclusively due to near-shore processes.

WRACK HARVESTING STRATEGY

RATIONALE

The main aims for harvesting wrack are to

1) Improve public amenity of the shoreline, and

2) Maintain / enhance the health of the lake ecosystem.

Shoreline amenity is primarily impacted by the build up of organic matter, fine sediments, and sulfidic smells.

The key objectives of strategic wrack harvesting are to

a) improve flushing of the nearshore zone to reduce build up of nutrient-rich stormwater and groundwater

b) increase wave energy along the shoreline to promote dispersion of wrack and macroalgae

c) reduce the trapping of fine sediments resuspended from the lake basin

d) minimise the disturbance of desirable plant and sediment communities

e) minimise unintended impacts on nearby habitat

f) provide for appropriate 'wrack reserves' where natural accumulations of wrack can occur in areas not prone to nutrient enrichment

g) identify monitoring opportunities to assess management strategies

Any harvesting would also need to comply with the requirements of the Fisheries Management Act, with respect to the potential for damaging marine plants and disturbing protected species. Harvesting would also have to be undertaken in line with the requirements of Council's licence for wrack management issued by NSW Department of Primary Industries (Fishing and Aquaculture).

HARVESTING METHODOLOGY

Wrack harvesting should strive to strategically clear wrack accumulations to achieve maximum benefit with minimal negative impacts. Most wrack accumulations occur in shallow water (<30cm deep) adjacent to the shore, and are mostly underlain by either live seagrass or ooze sediments. Strategic seasonal harvesting of offshore and nearshore accumulations has the potential to greatly improve water quality in the nearshore through increased flushing. Council need to develop new harvesting methods for very shallow nearshore areas to ensure minimal disturbance to underlying living seagrass and sediments. It should be noted that wrack harvesting should not be confused with efforts to reduce existing accumulations of ooze sediments (see Ooze Management Strategy), however wrack harvesting from problem nearshore areas could be one component of ooze management.

TIMING AND LOCATION OF HARVEST

Strategic wrack harvesting will synchronise with seasonal patterns in wind and wrack production so that after wrack is harvested from an area, prevailing winds will move water into the nearshore zones that usually experience limited or no water flow. The strategy is divided into two streams:

1) Routine seasonal harvesting

2) Targeted harvesting in areas of high public amenity or large accumulation of wrack

These components are described in detail below.

ROUTINE SEASONAL HARVESTING

The aim of this component is to maximise exposure of nearshore zones to prevailing wave and current energy, and to clear seasonal build up of wrack at critical locations. This will aid in flushing of the nearshore zone and minimise the progressive build up of wrack throughout the season. An indicative harvest zoning map is shown in Figure 3. It is strongly recommended that the wrack model created by OEH as part of the Restoration of Tuggerah Lakes Project - Stage 2, in conjunction with local knowledge, is used to develop a detailed seasonal harvest strategy.

The buildup of wrack along shorelines follows broad seasonal patterns depending on 1) the timing of maximum wrack production, and 2) the prevailing winds over the preceding season. The frequency distributions of winds at Norah Head Lighthouse between 1970 and 2010 are presented in Figure 1 as a guide to seasonal wind patterns in Tuggerah Lakes, which can be summarised as:

- **Summer** is dominated by alternate northeast and southeast wind events,
- **Autumn** sees an increase in the occurrence of westery to north westerly winds,
- **Winter** is dominated by westerly to north westerly winds
- **Spring** is characterised by wind events from the northeast, southeast and northwest

The wind-wave energy at the sediment surface under winds from the northwest, northeast, and southeast wind quarters is shown in Figure 2. These maps give an indication of wave / current energy along the shoreline of the lakes, which broadly equate to the likely accumulation zones for wrack. The aim of wrack harvesting should be to reduce wrack accumulations along the lake margin of the nearshore zone during the seasons when the shoreline is exposed to maximum wind-wave energy. This will promote water circulation in the nearshore and the flushing of nearshore pollutants, greatly reducing the conditions favourable to the formation of ooze.

Table 1 Proposed seasonal harvest schedule including brief rationale for each phase.

Season	Winds	Harvest Locations	Aims
Spring	NNW, NE, SE	Long Jetty, Canton Beach, Toukley , Budgewoi, Gorokan (north)	• Reduce winter accumulations, • improve wave penentration in areas exposed to NE and SE directions • Better circulation
Summer	NE, SSE	Killarney Vale, Berkeley Vale, Chittaway Bay (south)	• Reduce large accumulations due to NE wind events in spring-summer, • improve wave penentration in areas exposed to NE direction – • Better circulation in nearshore zones prone to ooze formation during summer
Autumn	NE, S, SSE, NW	Tuggerawong, Gorokan (south) , San Remo, Budgewoi, Munmorah (north)	• Clear large seasonal accumulations in areas less prone to ooze formation. • Better circulation in areas with low energy during winter

The harvest schedule (including all areas currently licensed for harvesting) are shown in Figure 3. During spring, wrack harvesting efforts should aim to reduce accumulations of wrack resulting from the prevailing NW winds. This will clear shorelines exposed to NE and SE wind events and increase wave penetration and water circulation in the nearshore zone. Harvesting along the Long Jetty shoreline should commence at the northern end of and progress south towards Killarney Vale and westward to Berkeley Vale. This will capitalise on the onset of strong northeast winds and promote unimpeded flow along the shoreline. In early – mid summer, wrack should be cleared from the Killarney Vale shoreline to improve water circulation and wave penetration. Improved flushing along this shoreline is a priority given its susceptibility to ooze formation during summer. Harvesting during Autumn should aim to clear accumulations that will impede circulation during the oncoming winter. Broadly, this equates to shorelines sheltered from the prevailing NW winds.

TARGETED HARVESTING

Council are obliged to collect wrack from all areas in the 3 lakes approved in their license however there is a focus on areas in front of public foreshores. Harvester staff should consider as part of their daily/weekly planning whether prevailing winds will aid the harvest effort. If not, staff may consider moving to an alternate, nearby site more suited to the prevailing winds/wave currents.

Unseasonal winds may result in unexpected or excessive wrack accumulations at some locations. Where these accumulations are adjacent to large urban stormwater inputs or judged to be impeding circulation / wave energy into problem areas for example, they should be removed as a priority

RECOMMENDATIONS FOR ADAPTIVE STRATEGY

It should be noted that there is considerable inter-annual variation in the direction and intensity of winds along the east coast of Australia. Recommendations in this strategy are based on the analysis

of 'average' conditions and are therefore broad guidelines. It is recommended that an adaptive strategy be developed that allows harvesting to be targeted in response to real-time prevailing conditions and observations of wrack accumulation. The adaptive strategy would adhere to the general principles outlined in the table above, however more targeted harvesting would greatly improve the ability to meet objectives. The adaptive strategy could be based on three added initiatives:

1) Further develop the wrack model developed by NSW OEH as part of this study to run at near real-time in Wyong Council. This would require coding the model in a suitable software platform and setting up a direct link to the Bureau of Meteorology allowing the daily download of wind data to force the model. The model would then provide an in-house tool allowing the prediction of wrack accumulation hotspots around the lake based on the wind conditions during the preceding months.

2) Establish wrack monitoring sites at key locations (e.g. within each of the areas licensed for wrack harvesting) to allow a) field verification of model outputs, b) important observations about the nature of wrack accumulations, and c) an assessment of the effectiveness of the strategy to meet objectives (performance indicators).

3) Annual review and modification of harvesting strategies based on feedback from monitoring and analysis of performance indicators

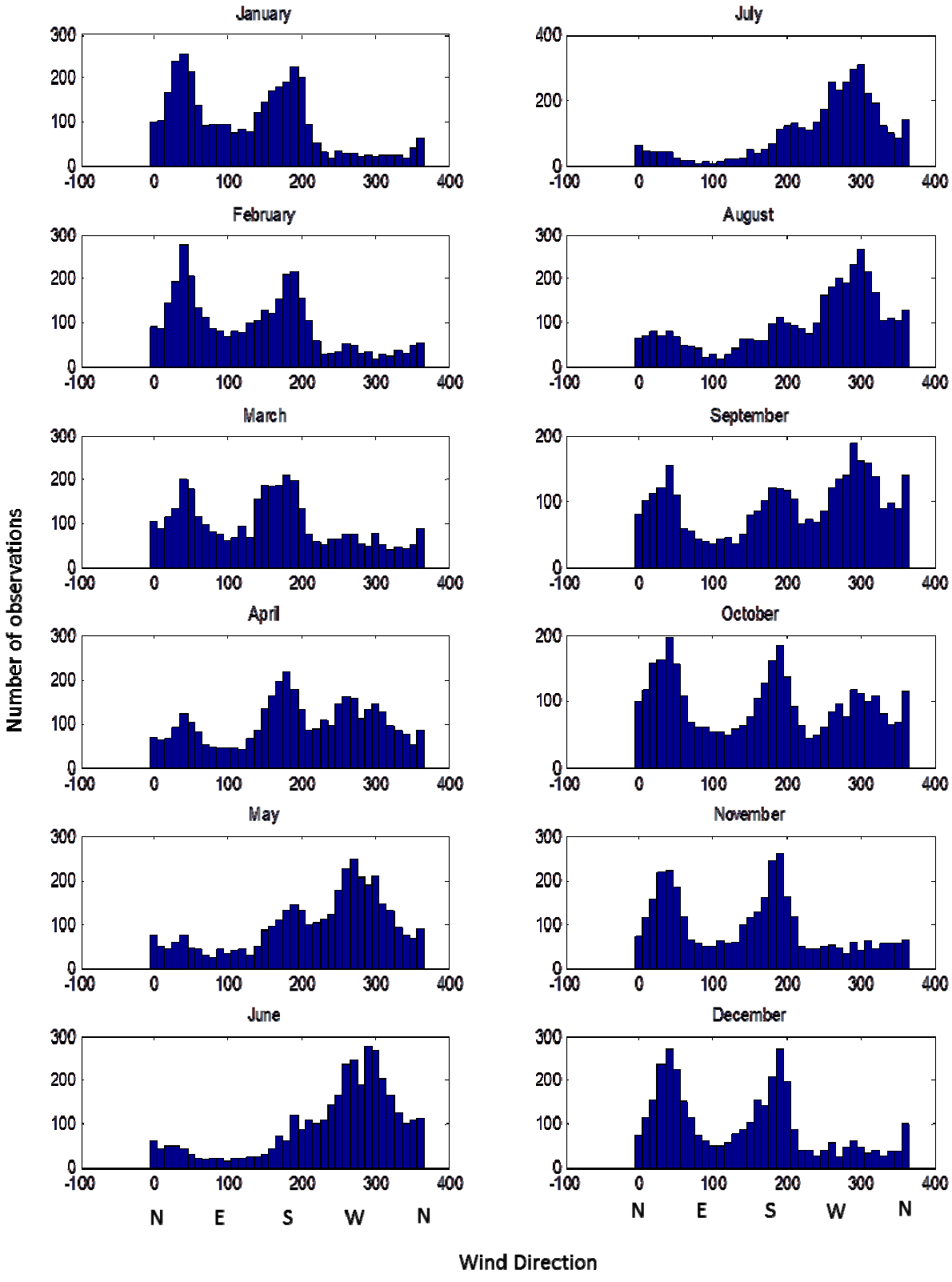

Figure 1 Histograms of wind direction at Norah Head Lighthouse during each month

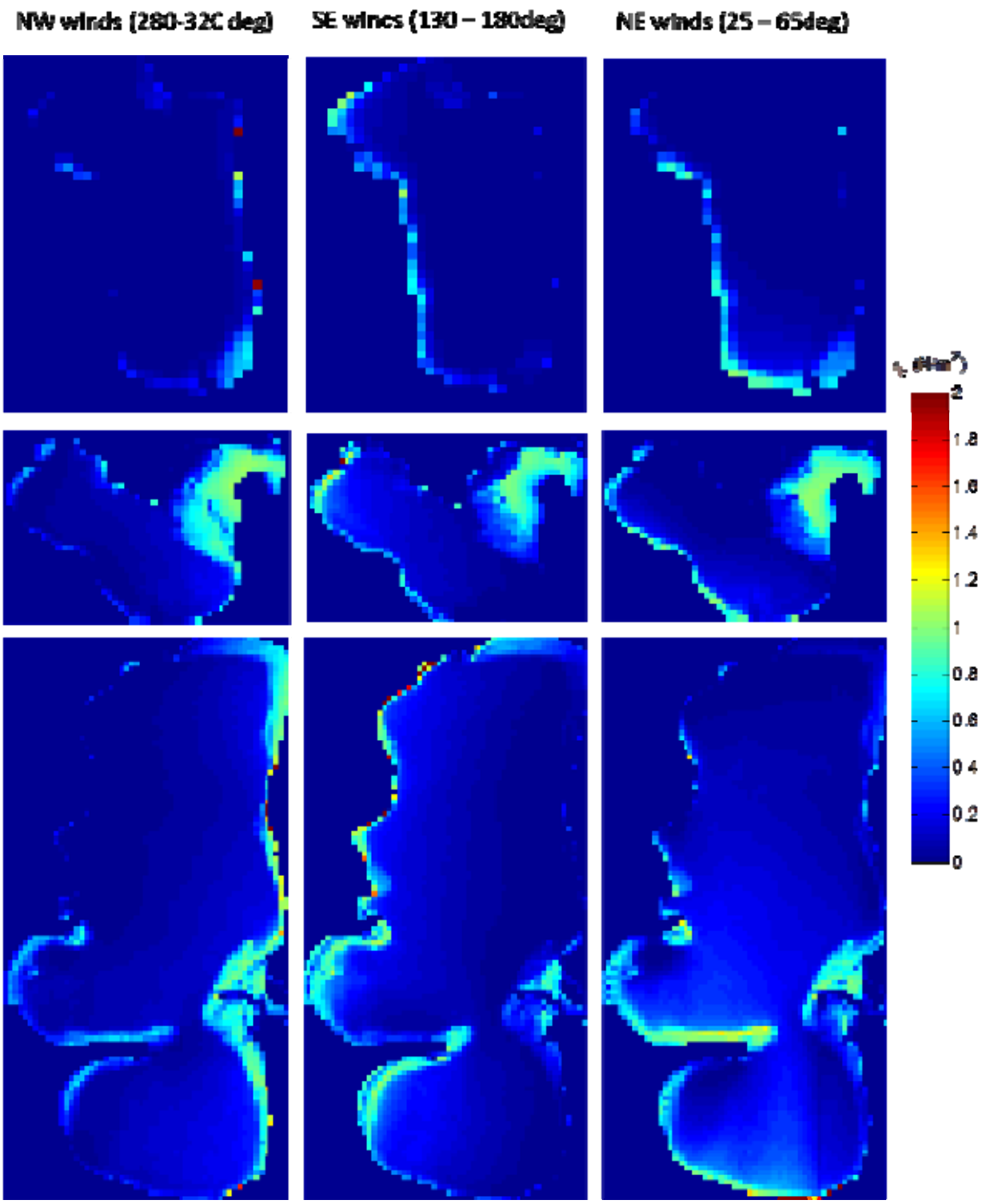

Figure 2 Bed shear stress due to wind-wave energy for each of the predominant wind directions (estimated for the Tuggerah Lakes ERM). Increased energy along the shoreline aids water circulation. Areas of high energy shown in the plots above also indicate areas prone to wrack accumulation during thos conditions.

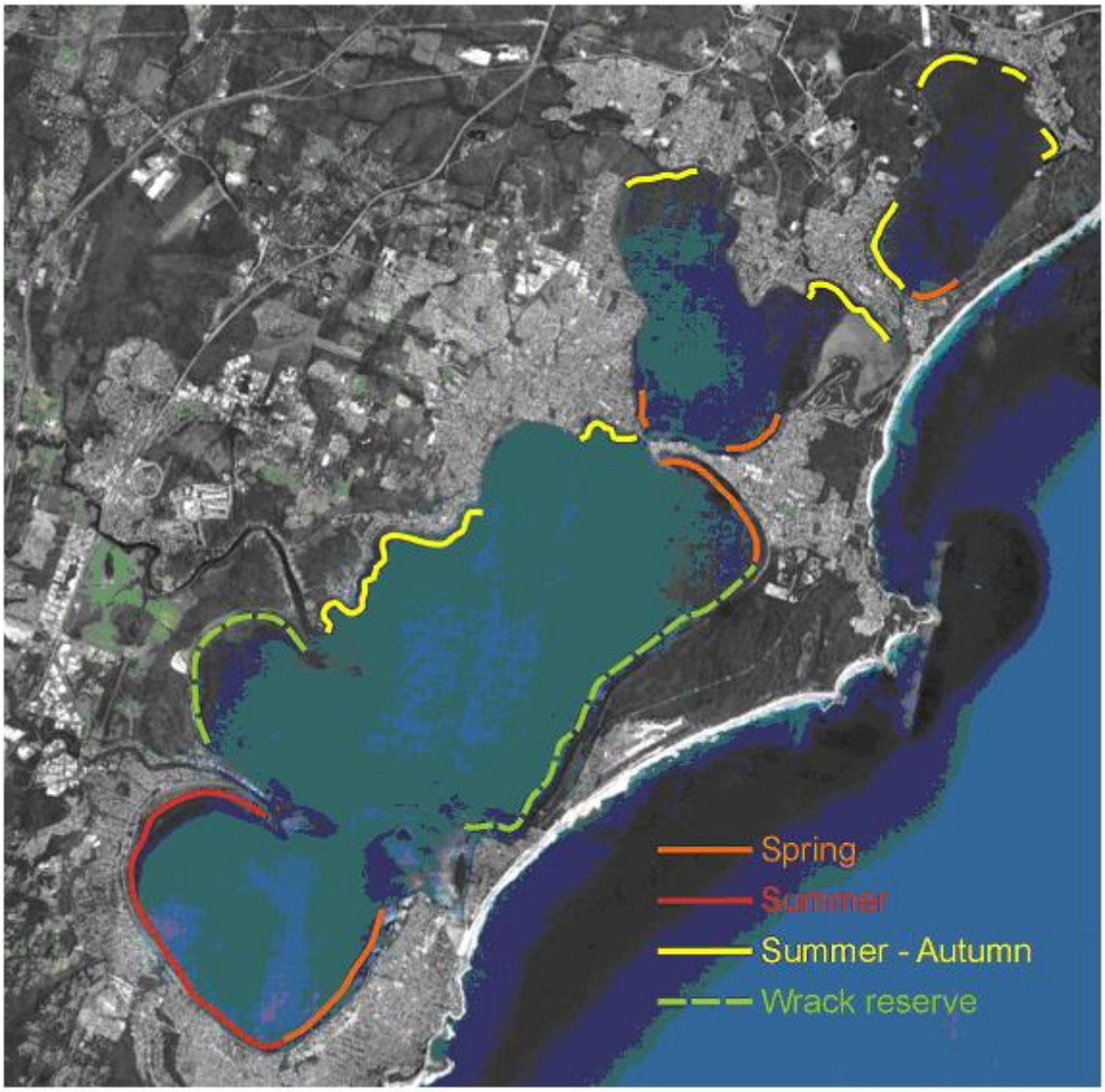

Figure 3 Wrack harvest zoning map showing the seasonal timing of routine harvesting efforts in Tuggerah Lake. This map is intended to be indicative of the general approach, and will be updated using a combination of modelling and local knowledge.

ASPECTS OF A LOW IMPACT APPROACH FOR NEARSHORE HARVESTING

The current harvester used by Wyong Council can only operate at depths >50cm and not above living seagrass beds. Most wrack accumulations occur in shallow water (<30cm deep) close to shore, and are mostly underlain by either live seagrass or ooze sediments. Strategic seasonal harvesting of offshore accumulations should be coupled with wrack harvest from the adjacent nearshore in problem areas with large volumes of oozey sediments. The objective is to improve nearshore flushing with lake basin water and increase wave energy along the shoreline.

Currently, Council do not collect wrack from shallow nearshore areas but harvesting there would have great benefits for increasing water flow, restoring ecological processes and reducing the likelihood of ooze formation. Saturated wrack accumulations may contribute to ooze formation

under certain conditions. When wrack sinks to the lake floor it can no longer be harvested, hence floating or buoyant wrack is the target of current harvesting efforts. New harvesting methods are needed for very shallow nearshore areas that do not impact on underlying living seagrass and sediments.

METHOD 1: MOVE WRACK OFFSHORE

OEH recommends that Council trial a new method which skims wrack across the surface of problem areas using a modified floating, shallow-water, seine net deployed on the inshore edge of wrack accumulations. The objective is to carefully drag wrack into deeper water, using one or two boats, where it can be harvested by Council's existing harvester. This method would allow clearing of large areas relatively quickly with minimal disturbance to underlying plant communities or sediments. This method is still at the conceptual stage and OEH is not aware of it being used by other local Councils as part of an estuary management plan. DPI Fisheries will need to be consulted about legal and other issues involved in the use of nets in this manner. It is suggested that perhaps the commercial fishing fleet could be involved in development and trialling of this new method.

METHOD 2: MOVE WRACK ONTO SHORE

In some locations it may be appropriate to implement shoreline-based harvesting of wrack where it accumulates against urban shorelines prone to groundwater seepage such as Canton Beach. This will reduce the development of sulfidic conditions common to these areas. High nutrient inputs in the vicinity of saturated wrack leads to anaerobic metabolism and the release of rotten egg gas. Even though ooze does not form in the sediments at Canton Beach, the sulfidic odour is strong and unpleasant. Anaerobic accumulations of wrack could be moved onto shore and disposed of (preferably used for compost).

Any shore-based harvesting must take into account the potential for damage to existing littoral/riparian vegetation. Damage to saltmarsh must be completely avoided.

A range of methods could be used depending on the characteristics of the nearshore and the adjacent shore.

- Wrack could be raked manually onto shore or the grass foreshore by a team of on-ground staff
- Wrack could be raked onto shore using a low impact, land-based tractor but only if shore characteristics allow
- Wrack could be raked onto shore using a low impact tractor or 'amphibious' machine but ONLY IF NEARSHORE CONDITIONS ALLOW. ANY USE OF LOW-IMPACT MACHINERY SHOULD BE RESTRICTED TO THE FIRST 5 METRES FROM SHORE AND ONLY BE CONSIDERED FOR SITES WHERE
    1) sediments in nearshore are firm, sandy and without ooze AND
    2) living seagrass does not occur within first 20 m of shore

This method should not be used on soft sediments or close to living seagrass.

METHOD 3: COMMUNITY TO HARVEST WRACK FOR COUNCIL COLLECTION

Some residents who live on the foreshore are keen to improve the health and amenity of their lake foreshore. Previously council would collect wrack that was harvested by locals and taken to designated collection points. OEH recommends that Council provide guidance about appropriate wrack collection and shoreline management techniques to minimise damage and then reinstate the community wrack collection assistance to

- get the community involved with caring for the lakes
- increase the communities 'ownership' of the lakes
- help improve the condition of the nearshore zone in front of privately owned land

MINIMISE IMPACTS TO SURROUNDING HABITATS

All harvesting activities should aim to minimise disturbance to seagrass communities and sediments. Machinery should not be used directly on or over soft or ooze sediments. The use of sediment containment booms to minimise the influence of poor water quality arising from net or shore-based harvesting activities on neighbouring areas of the lake should be considered in areas known to have significant ooze accumulations (e.g. Killarney Vale and Berkeley Vale). A portion of clean wrack that is harvested can be spread onto fringing saltmarsh, whereas wrack taken from nutrient enriched areas should be composted offsite.

CREATION OF WRACK RESERVES

Given the enormous volume of wrack generated in Tuggerah Lakes, even redoubling the wrack harvest will not capture most of the wrack. Wrack constitutes an important part of the Tuggerah Lakes ecosystem, providing services such as food and habitat for invertebrate, fish and bird species. It is desirable therefore that wrack should be allowed to accumulate in areas that are not prone to urban stormwater or groundwater inputs and will not impede use of high amenity shores. OEH recommends that in some locations accumulations of wrack drying on shore in aerobic conditions should be left to decompose in situ. Large mounds of wrack do not produce ooze if it is drying on sandy sediments above the high tide mark at sites exposed to high wave energy. Under these conditions, wrack will help to stabilise the shoreline and be a valuable habitat and food source for invertebrates and ultimately fish.

LIMITATIONS OF EQUIPMENT

There are several factors which limit the productivity of the wrack harvest. The first limitation is the age of the harvester, which moves very slowly and experiences significant downtime due to mechanical failure. The second factor is that there is only one crew that are trained in operating the harvester and the same crew operates the dredge at The Entrance, so only the dredge or the harvester is operational at any given time. OEH recommends that more staff be trained in operating the harvester and/or dredge giving Council more flexibiity in their work plans. Another limitation of the harvester is that its operation is dependent on weather conditions. This means that staff may

not always carry out the harvest at scheduled locations. If a strategic plan is in place, wrack harvesting could become a more productive endeavour and contribute to improving the condition of the nearshore.

OEH understands that Council have recently begun using a barge in conjunction with the harvester. Harvested wrack is unloaded onto the barge for transport back to the shore. This should improve the productive hours of the harvester. Council also use a second harvester at times which will help the harvesting effort.

EDUCATION STRATEGY

The wrack harvesting strategy should include an integrated education program for local residents and council staff to gain a better appreciation of the role "weed" plays in Tuggerah Lakes. A common perception is that "weed is BAD" and the solution is to "bring in the dredge".

Seagrass, wrack, and balanced macroalgae growth are integral parts of the lake ecosystem, essential to invertebrate (e.g. prawns), fish, and birds. Healthy reference sites (e.g. Tuggerah Bay, Wyrrabalong) could be used to illustrate the nature of a healthy shoreline. The CSIRO anecdotal report confirms that the lakes have always been "weedy" and that wrack has always washed up along the shoreline. The alteration to water level regimes through entrance management has exacerbated the severity of accumulations however this can be managed through strategic harvesting.

The education strategy needs to stress that it is nutrient enrichment of wrack accumulations (and subsequent macroalgal blooms) that cause wrack accumulations to turn to ooze. It is therefore the actions and choices of local residents that largely determine the amenity of their local shoreline. Wrack harvesting by council can help moderate smelly ooze problems, but they will persist in a different form until the chronic drip of urban stormwater and groundwater to the nearshore is stemmed.

MONITORING STRATEGY

The wrack harvesting strategy should be regarded as an adaptive management program that strives to improve and adjust practices in line with quantitative evidence from an ongoing monitoring program. This will ensure maximum effectiveness in achieving the overall aims of the strategy. A comprehensive monitoring strategy is required to measure the effectiveness of wrack harvesting in:

1) Maintaining shorelines within active management zones clear of major wrack accumulations

2) Enhancing water circulation within cleared zones

3) Reducing the occurrence / depth of sulfidic ooze

4) Reducing the occurrence of macroalgae blooms

5) Improving public perceptions of shoreline amenity

REFERENCES

Scott, A. (1999) Ecological History of the Tuggerah Lakes Final Report. CSIRO Land and Water, Technical Report 18/99