CLYDE RIVER ESTUARINE SHORELINE HABITAT CONDITION REPORT CARD 2023

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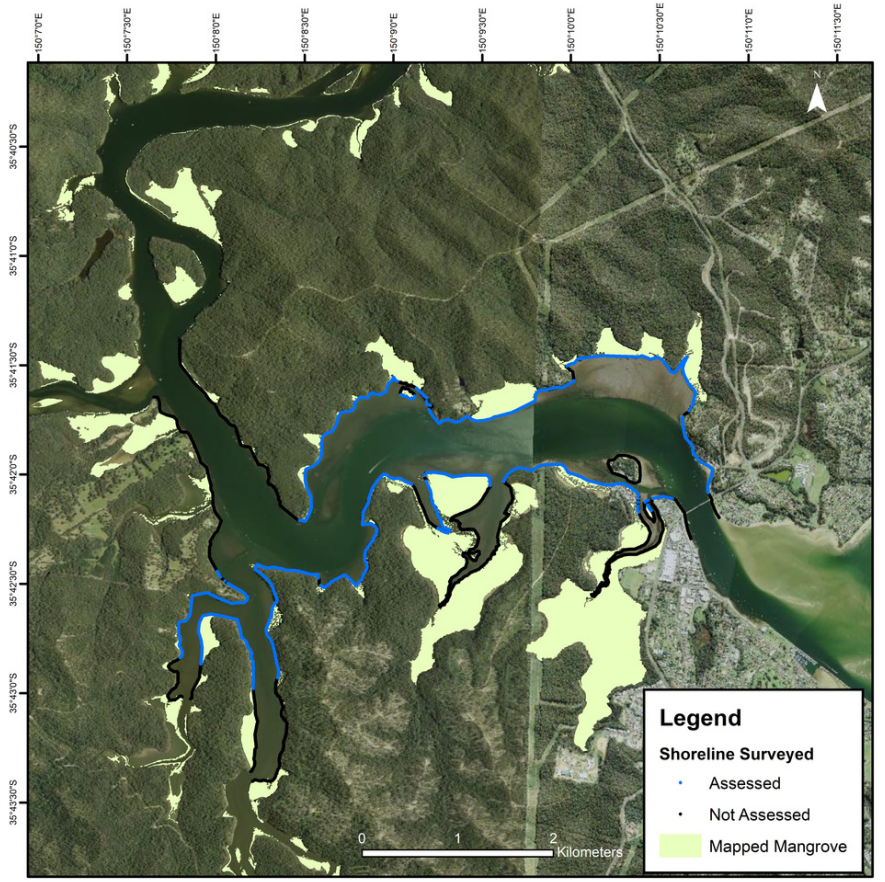
MangroveWatch

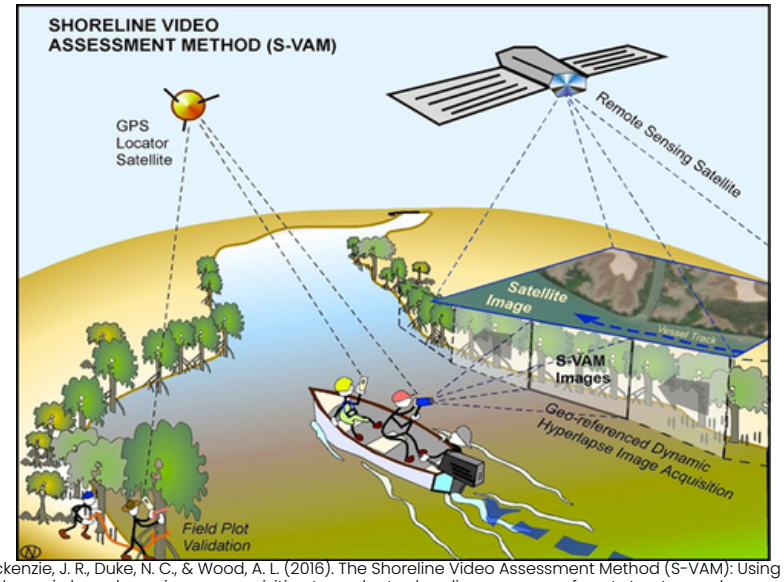
Data Collection

Lower Clyde River Estuary Shoreline Assessed = 56%
(2-10 km upstream including lower Waterfall & Mundarlow Creeks)
Survey Date: 10th August 2023.
12 community members & stakeholders,
1hr 45 mins filming, 18.6km shoreline surveyed



The Shoreline Video Assessment Method (S-VAM)

S-VAM surveys were conducted to capture the main estuary channel shorelines from the mouth to upstream estuary limits for a permanent visual record of shoreline habitat. A boat traveled along the Clyde River shoreline at a speed of 6-10 kts, with observers recording continuous video footage at a distance of up to 200m from shore. The camera was held at a 90-degree angle to the boat's direction. GPS tracking was recorded, and special points of interest were geotagged. In-field observations were also recorded via voice. Data was collected at low to mid tide during a neap tide period ensure clear shoreline visibility while maintaining safe navigation.

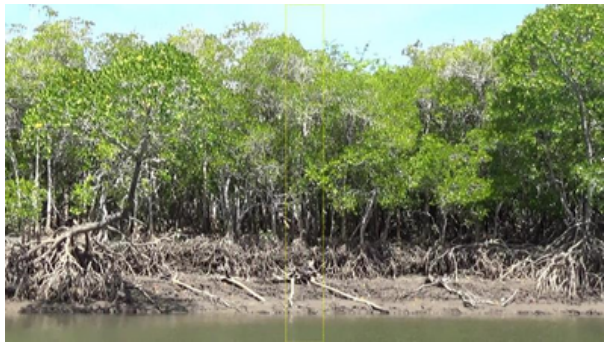


Mackenzie, J. R., Duke, N. C., & Wood, A. L. (2016). The Shoreline Video Assessment Method (S-VAM): Using dynamic hyperlapse image acquisition to evaluate shoreline mangrove forest structure, values, degradation and threats. Marine Pollution Bulletin.

Data Processing & Analysis

Data streams sent to MangroveWatch for processing → Video converted to 1-second still image frames → Data input into R to match video images & GPS to shoreline points

This section describes the methodology used to process data streams collected from shoreline surveys. The data was processed to enable criteria-based visual assessment of habitat attributes. The estuary video streams were converted to time-stamped 1-second still image frames, and shoreline shapefiles were generated in ArcMap 10.8. A point-shapefile was generated for each estuary shoreline, representing 10-meter shoreline intervals. R-studio was used to match video and still image video to 10 m shoreline points along the surveyed shoreline using the perpendicular GPS bearing. Each surveyed shoreline point has an associated still frame image.



Generating Shoreline Habitat Scores and Metrics

Features visible in still-frame imagery associated with shoreline points were scored using a criteria-based image analysis. The scoring system used is based on experience and knowledge of tropical and sub-tropical shoreline estuary habitats. The assessment was done on images associated with 10-meter interval shoreline points. Mangrove presence, shoreline naturalness, flood damage and point features (e.g. litter) were scored every 10 m, whereas habitat features (density, maturity, connectivity and condition) and shoreline process were scored every 50 m. The shoreline and mangrove habitat features were grouped into different habitat metrics: habitat structure, condition, shoreline process and shoreline naturalness, each reflecting ecosystem service provision potential, resilience and risk. An additional measure of mangrove forest stand size (length along shoreline) and determination of high value stand based on structural attributes was calculated. Features were scored from the middle of images. Further details on the scoring and grading calculations are provided here: https://wettropicswaterways.org.au/wp-content/uploads/2023/07/Methods-2021-22-V4.0.pdf

Shoreline Mangrove Cover

Overall Shoreline Mangrove Cover = 70.1%

Overall Mangrove Cover Score = Moderate

Method Summary

Mangrove presence/absence was scored at 10m intervals along the shoreline to generate a percentage cover score. A percent cover score was generated for each 1km of estuary channel along the surveyed shoreline based on standard MangroveWatch report card values.

Overview

Mangrove cover along the lower Clyde River River estuary is 'Moderate' compared to other surveyed estuaries with 70% cover. Mangrove cover was lowest (49%) in the upper reaches of the estuary surveyed (7-9 km) and near the estuary mouth (59%, 2-3km). Throughout the estuary, mangrove establishment is limited by steep rocky shorelines. Towards the mouth of the estuary, shoreline modification limits mangrove development. Despite the 'moderate' shoreline mangrove cover, mangroves are consistently present along the shoreline as narrow stands, isolated patches and dense mature stands in protected embayments.

Hard wall structures in the lower estuary are suitable for habitat enhancement using living shoreline approaches to enhance mangrove cover in the lower estuary and provide additional ecosystem service benefits including fisheries production and water quality moderation.

Shoreline Mangrove Habitat Structure

Descriptor: A combined score representing shoreline mangrove cover, mangrove stand density, stand maturity and tidal connectivity.

Mean Habitat Structure Score = 3.1

Overall Mangrove Cover Score = Moderate

Method Summary

Mangrove structural attributes including stand density, age of trees and tidal connectivity were scored every 50m where mangroves were present. The average of these scores for each estuary reach was combined, standardised and factored relative to mangrove shoreline cover to provide a measure of mangrove habitat structure.

Mangrove Forest Density (MD):
1 = Isolated Individuals, 2 = Dense Patch, 3 = Open Continuous Forest, 4 = Closed Canopy
Mangrove Forest Maturity (Stand Age) (MM):
1 = Seedlings, 2 = Saplings, 3 = immature trees, 4 = mature trees, 5 = old growth
Mangrove Tidal Connectivity (TC):
1 = no connectivity, 2 = indirect connectivity, 3 = direct high tide connectivity 4 = low tide connectivity

Mangrove Forest Structure Score = (%Cover Score + MD + (MM/5)*4 + TC)/4

Overview

Overall shoreline mangrove forest structure in the Clyde River estuary is 'moderate', but also highly variable with narrow open fringing mangroves along rocky shorelines interspersed with dense, old growth mangrove forest in protected embayments. Mangrove forest structure is highest in the lower-mid estuary (4-6km upstream), including Pelican Inlet. 51% of mangroves in this section of the estuary were classified as 'old growth' mature stands with high habitat value. Overall, 79% of shoreline mangroves were classified as either mature (44%) or 'old growth' (35%). This high-level of mature mangrove stand development is indicative of a historically relative stable estuary, free from natural and human disturbance. Mature mangrove stands have high biodiversity and carbon storage values. These mangroves therefore have high conservation significance and should be considered an important feature of the marine park and marine estate.

Shoreline Mangrove Continuity

Overall Habitat Continuity Score = 0.35

Overall Habitat Continuity Grade = Moderate

Method Summary

The length of mangrove shoreline stands was recorded along the estuary. Each stand was assigned a unique value. The habitat continuity score was derived by normalizing the continuous length of mangrove presence along the shoreline to a scale of 0-4, ensuring equivalence to discrete scores

Overview

Habitat patch size is directly linked to habitat values, particularly biodiversity, water quality moderation and fisheries values. Reduced patch size increases estuarine shoreline habitat vulnerability to flooding and erosion, and increases the risk of damage to shoreline infrastructure. Mangrove habitat continuity along the Clyde River estuary is classed as moderate. Many non-contiguous mangrove stands (<40m) were observed along steep rocky shorelines interspersed with contiguous mangrove stands in protected embayments. Contiguous mangroves are present along much of the lower-mid estuary shoreline, 2-3km upstream, with 75% continuous mangrove habitat. Habitat continuity is low (8%) in the upper-mid estuary (8-9km upstream) and in lower Waterfall Creek.

Shoreline Mangrove Condition

Mean Habitat Condition Score = 2.6

Overall Habitat Condition Grade = Moderate

Method Summary

The health of mangroves along the shoreline was scored every 50m where mangroves were present based on canopy cover density and estimated canopy loss associated with dieback and tree mortality within the fringing mangrove stand.
The condition scores were 5: 0% canopy loss (no dieback), 4: 1-10% canopy loss (minor dieback), 3: 10-30% canopy loss (moderate dieback), 2: 30-60% canopy loss (significant dieback), 1: 60-90% canopy loss (major dieback), 0: >90% canopy loss (severe dieback & stand mortality).

Overview

Mangrove condition along the Clyde River is overall 'moderate'. The majority (62%) of fringing shoreline mangroves were either in good to very good condition. A high proportion (15%) of mangroves were classified as 100% dead, resulting in the lower overall condition score.

Healthiest mangrove stands were in the lower-mid estuary 4-5km upstream and in the upper-mid estuary (8-9km upstream). Mangroves in poor and very poor condition were present 7-8km upstream and in Waterfall and Mundarlow Creeks.

Shoreline Mangrove 2020 Fire Impact

Proportion of mangrove habitat impacted by fire = 21% (2.7km shoreline habitat)

Method Summary

Mangroves with obvious fire were recorded every 10m. Fire damage was determined by the presence of multiple dead and stressed trees associated with adjacent terrestrial forest dieback.

Overview

The 2019/2020 'Black Summer' bushfires significantly impacted mangrove habitats across 16 estuaries in NSW. This was the first recorded large-scale mangrove dieback event caused by fire. In the Clyde River, 5% (14.5 ha) of mapped mangroves were recorded as being impacted by fire. In the lower and mid Clyde River estuary, 21% of shoreline mangroves were documented as bushfire impacted. Mangroves impacted by fire had nearly 100% mortality. There was no evidence of transition zones between impacted and unimpacted mangroves.

Shoreline survey data suggests that fire had a greater impact on mangrove habitat in terms of linear shoreline habitat (21%) compared to assessments of total area (5%). Impacts to narrow fringing mangrove stands along estuary shorelines are important to consider as these stands have distinct characteristics and values that set them apart from the broader habitat areas including habitat continuity, fish habitat, sediment trapping and nutrient exchange and shoreline stability. The potential loss and degradation of 20% of fringing shoreline habitat in an otherwise healthy estuary should be cause for concern.

The 2019/2020 'black summer' bushfire is the primary driver of poor condition mangroves in the Clyde River

Shoreline Mangrove 2023 Fire Recovery

Proportion of mangrove habitat impacted by fire in recovery/regrowth phase = 13% (0.35km shoreline habitat)

Method Summary

Mangroves with obvious recent fire damage were recorded every 10m. Fire damage recovery was determined by the presence of seedlings and epicormic resprouting.

Overview

Only 13% (350 m) of fire impacted shoreline mangroves were recorded as showing signs of recovery 3.5 years after the initial impact. Based on recovery trajectories of mangroves elsewhere following severe natural disturbance events (eg. Boyne River, Gladstone), it is possible that these mangroves may never recover.

Recent La-Nina driven high tide levels, combined with sea level rise, likely sediment surface elevation subsidence and erosion following tree death and biogeochemical changes in dead forests, may be impeding mangrove seedling establishment. The presence of dead wood movement in the tidal zone also has the potential to damage new recruitment and prevent recovery.

Based on evidence to date, natural recovery of fire impacted mangroves in the Clyde River appears unlikely to occur in the future.

2020 Fire Impact on Clyde River Mangrove Forest Biomass & Carbon Stocks

Method Summary

The impact of fire on mangrove forest structure was measured in the field along 4 'Rapid Long PLot' belt transects in Waterfall Creek and at Chinaman's Point. Transects ran parallel to the shoreline to quantify impact along an elevation contour and within a tidal zone. Transects were of variable length and width depending on forest stand density. Each transect captured a minimum of 25 mature trees to account for structural variability. Mangrove tree species, diameter, height and condition were recorded for each tree within the belt transect area. Above-ground and below-ground biomass and carbon stores were estimated for each transect using standard allometric equations to provide an estimate of mangrove biomass loss due to fire.

Mangrove Forest Atttributes

Mean Canopy Height = 3.1 m
Mean stem diameter = 6.9 cm
Mean stem density = 3,831/ha
Live trees = 0.8% Dead trees = 99.2%
Mean Mangrove Biomass = 187 ± 84 t per ha

At the four mangrove transect locations impacted by fire, 99% of trees were dead irrespective of species and size. No seedling establishment was recorded along the transects indicating lack of recovery. Epicormic resprouting was observed on some Grey Mangrove (Avicennia marina) trees outside the transect bounds.

Based on the estimates of mangrove forest biomass derived from transect measures, if there is no recovery of fire affected mangroves it is estimated that the 2019/2020 'Black Summer' bushfire mangrove death in the Clyde River could result in the release of ~8,900 ± 4,300 tonnes of CO_2, equivalent to the annual emissions of between 325 and 858 Australians. This figure does not include the lost carbon sequestration potential. The above figure is an estimate only to highlight the importance of intervention to prevent carbon emissions in addition to habitat loss prevention.

Shoreline Mangrove Condition in mangroves not impacted by fire

Mean Unimpacted Habitat Condition Score = 3.3

Unimpacted Habitat Condition Grade = Good

Method Summary

The mean condition score of mangroves without fire impact.

Overview

Mangroves not impacted by fire in the Clyde River estuary are mostly healthy to very healthy. Very little dieback or tree mortality in shoreline mangroves was observed in unimpacted mangrove stands. Avicennia marina (Grey Mangrove) often show low-level dieback in relation to changing climate conditions, sea level variations, natural disturbance events, pollution and estuary modification. The high proportion of healthy mangroves with no or <10% estimated canopy loss suggests mangroves in the Clyde River estuary are highly productive and relatively free from disturbance and stressors outside of the fire impact. This observation corresponds with the well-developed mature stands within the estuary. This data highlights the significance of the 2020 bushfire impact on an otherwise healthy mangrove system, and demonstrates that even healthy, well-protected mangroves are vulnerable to climate change-related disturbance events.

Shoreline Physical Process

Overall Shoreline Process Grade = Very Good

Proportion of shoreline eroded = 0.9% (~150 m)

Proportion of shoreline expanding = 0%

Method Summary

Shoreline changes were assessed every 50m: severe erosion with habitat and infrastructure damage received a -2 score, minor erosion a -1, densely populated mature mangrove seedlings a 2, and sparse seedlings or evident sediment deposits a 1. The overall shoreline process score was derived by summing these weighted scores and dividing by the maximum potential score. Negative scores indicate more erosion than deposition

The Clyde River estuary shoreline is stable with very little erosion or deposition recorded. Low levels of physical and hydrodynamic processes have likely contributed to the presence of healthy, we-developed mangrove stands in the estuary.

Shoreline Naturalness

Overall Shoreline Naturalness score = 5.4

Overall Shoreline Naturalness Grade = Good

Method Summary

The length of mangrove shoreline stands was recorded along the estuary. Each stand was assigned a unique value.

Only 3.8% (630m) of shoreline is modified in the lower Clyde River estuary. Most shoreline modification occurs towards the estuary mouth. Existing rock wall structures have high 'living shoreline' enhancement potential.

Shoreline Marine Debris

Total items observed = 14
(0.83 items per km)
Small litter = 9, Large Debris = 5,
Abandoned Crab Pots = 0

Method Summary

The presence of small litter, larger debris items (eg. barrels) and abandoned crab pots was recorded at 10m intervals

Minimal litter and marine debris was observed in the estuary along the shoreline. Field observations indicate the majority of litter and debris in the estuary originates from oyster industry activities, such as mesh, floats and rack material.

Other human disturbance

Trimmed mangroves = 100m

A small section of trimmed mangroves for view maintenance is present at the confluence of McLeods Creek. It is unlikely that this trimming has significant impact on mangrove habitat values or resilience. However, this activity should not be encouraged elsewhere and may reflect poor local attitudes to mangrove habitats.

Targeted Management Actions

It is recommended that intervention is undertaken to assist mangrove recovery in the Clyde River estuary. Based on the findings from this assessment, there is minimal natural post-fire recovery occurring at the estuary scale. Recent direct planting efforts in impacted mangroves have also been mostly unsuccessful. Field observation indicate that limited natural seedling establishment is occurring at the high intertidal margins, indicating that a surface elevation deficit and increased tide levels may be preventing seedling establishment lower down the tidal profile.

Without recovery in the near future, there is the possibility that 20% of shoreline mangrove habitat will be lost. As time progresses, recovery will become increasingly less likely as surface sediment continues to subside and erode, and sea levels rise. The loss of 20% (2.4km) of shoreline habitat will have implications for estuary biodiversity, fisheries production, water quality, carbon storage and the local oyster industry.

The oncoming El-Nino climate event presents a window of opportunity to undertake broadscale assisted mangrove rehabilitation. During the oncoming El-Nino period tidal amplitude will be dampened and there is a reduced risk of riverine flooding creating suitable conditions for mangrove establishment and growth. The installation of temporary or permanent structures to trap sediment and increase surface elevation, whilst minimising wave action, will be necessary to facilitate natural recruitment. Without such intervention there is a high probability of continued recovery failure. Additional physical removal or processing of woody debris in impacted areas should also be considered to prevent physical damage to mangrove seedlings.

Intervention should occur quickly and simultaneously with ongoing research into the long-term effects of mangrove dieback.

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