Ningaloo Outlook Symposium Program

Thursday 1st February 2024

Light lunch — ***12:00***

Presentations (Chair: Brett Molony)

Welcome	Brett Molony	12:30
Introduction	Dr Denise McCorry	12:40
Theme 1: Turtles	Mat Vanderklift / Daniel Axford / Nick Mortimer	12:50
Theme 2: Whale sharks	Toby Patterson / Anthea Donovan / Colby Bignell	13:35
Break		14:20
Theme 3: Shallow reefs	Damian Thomson / Daphne Oh	14:30
Theme 4: Deep reefs	John Keesing / Nick Mortimer / Logan Hellmrich	15:15

Refreshments — ***16:00***

Symposium conclusion — ***17:00***

Abstracts

Theme 1: Turtles

Insights into the life of green turtles at Ningaloo – Mat Vanderklift, Daniel Axford, Nick Mortimer

The Ningaloo Outlook turtle research has focussed on discovering movement and diet patterns, estimating abundance, and estimating age. Over ten years, we have captured and tagged over 400 green turtles *Chelonia mydas*, with 28 of them recaptured at least once. Satellite tagging of green turtles at Ningaloo has shown that they move relatively little, other than for nesting or mating. The median displacement (distance between locations of capture and final transmission, transmitted over 72-416 days) of 19 satellite-tagged "resident" turtles captured in the water (74-108 cm CCL) was 2.3 km, while the median displacement of 13 females tagged on the beach following nesting (94-104 cm CCL) was 179 km. After nesting, females migrated either north or south, between the Kimberley and Shark Bay (a span of 10 degrees of latitude and ~1,500 km). Multiple turtles with vitellogenic (yolk-bearing) follicles identified with ultrasound were followed for their entire nesting migration. Each migrated >200 km from Ningaloo to nesting beaches on islands off the Pilbara coast, and then returned to Ningaloo (in one case the final transmission was 400 m from the location she was captured). Examination of GPS locations transmitted during the nesting period provided information on the likely number of successful nesting attempts (~4–7 clutches per individual).

Efforts to estimate age have combined epigenetic ageing with growth estimates from recaptured individuals. Growth rates decline from ~1.5 cm/y from small individuals that have recently recruited to coastal habitats (from the oceanic habitats they live as juveniles) to 0.2 cm/y in individuals that are 100 cm long. Epigenetic ageing relies on calibrations from captive individuals, which grow faster than wild individuals, so needs to be calibrated — this is in progress.

Since 2020, surveys with uncrewed aerial vehicles (AUV, aka drones) have encompassed over 100 km^2. We have collected over 90,000 images of the sea surface, over 50,000 of these have been manually analysed to build a training dataset to enable machine learning methods to detect turtles from images. Over 2000 images of turtles have been isolated along with other marine fauna. Manual analysis has yielded around 50 individual turtles per km^2 visible to the drone. The machine learning training dataset will be made available through CSIRO's Data Access Portal.

Theme 2: Whale Sharks

Movement patters of whale sharks at Ningaloo – Colby Bignell

Whale Shark tagging studies at Ningaloo have previously revealed complex movement strategies influenced by a myriad of factors. However, most studies have focused on juvenile and sub-adult males, and with relatively short track duration. Here we present a dataset of 39 whale sharks satellite tagged at Ningaloo Reef, with equal numbers of males and females ranging in size from 3.75 to 9.5 m and some of the longest tag deployments on record for this species. Track lengths in this study averaged 5508 ± 45 km with an average deployment span of 109 days and maximum of 340 days. Coastal and oceanic diving patterns were characterised from long-term vertical movement data, with >90% of time spent in epipelagic waters ≤200 m and a maximum recorded diving depth of 1906 m. Summarised horizontal and vertical satellite data were integrated to investigate the drivers of movement using Generalised Additive Models (GAMs), providing novel insights into the sex-specific movement patterns of whale sharks. This talk will provide an overview of whale shark movement patterns and results of modelling for males and females.

Abstracts

Close kin mark recapture – Toby Patterson

Whale sharks are highly migratory animals and are only readily encountered in known aggregation sites. In Ningaloo, like in most aggregations globally, animals are mostly juvenile males. The lack of access to adults and females makes understanding their population size and other aspects of their population ecology highly challenging. Additionally, for long lived and highly mobile species, understanding generational scale connectivity with traditional methods is difficult This talk will briefly go through the mark recapture data obtained from the project to date and look at the challenges for mark recapture for a species like whale shark. The whale shark project will use recently developed close kin mark recapture (CKMR) techniques on samples collected at Ningaloo and from other sites overseas. The approach uses the prevalence of closely related individuals (parents and offspring, half siblings) to estimate adult population size, adult mortality rate and other parameters of interest. This talk will give an overview of CKMR and how we will use it to inform on whale shark populations.

Ningaloo's Whale Shark – Anthea Donovan

To obtain data on growth rates and recaptures of large free swimming animals that cannot be "marked" with external tags it is necessary to identify individuals. For whale sharks, method for identify individuals based on their spot pattern have previously been developed. We used Wildbook to identify individuals and stereo video to measure length of individuals. The ability to identify individuals enabled us to obtain estimates of population size (for the Ningaloo population) and estimates of growth rates. Annual field trips were conducted in the first week of June from 2015 – 2023 (excluding 2020 due to Covid). During this time, the team has encountered 644 whale sharks. At each encounter, the aim is to obtain a suite of data from the animal (including photographs for identification, video for length analysis and a biopsy sample for genetics). Since 2015, 305 whale sharks have only been sampled once and 140 have been sampled numerous years (one shark has even been sampled 5 times during this project). It's these resighted sharks, with data at multiple time points that will allow growth rates to be calculated. This talk will cover the methods used to identify individuals and obtain length measurements and will discuss the challenges of this approach.

Theme 3: Shallow Reefs

Erosion – Damian Thomson

The Ningaloo Outlook shallow reef program has focused on understanding processes operating in shallow depth (0–20 m). Reef erosion is one such process, which plays a crucial role in shaping the physical structure of coral reefs. Quantifying reef erosion, however, is challenging due to its occurrence both beneath and above the reef surface. In our research at Ningaloo Reef, we employed direct measurements of external and internal erosion, along with estimates from parrotfish, urchins, and water velocity, to provide detailed estimates of erosion across various reef habitats. Our findings revealed a high total erosion rate, with reef slopes experiencing higher erosion compared to lagoons, mainly due to intense grazing by parrotfish. The erosion rates were significantly influenced by the species and size of parrotfish, with *Chlorurus microrhinos* being the primary contributor to bioerosion. In contrast, the grazing urchin *Echinometra mathaei* contributed only 17% of total erosion. Micro and macroborer erosion rates were generally low, likely due to heavy parrotfish grazing and the short deployment period. Surprisingly, a substantial portion of external erosion could not be attributed to bioeroders and showed poor correlation with wave exposure. This suggests that unaccounted processes contribute to this aspect of erosion. Our results highlight the significant role of parrotfish, especially *Chlorurus microrhinos*, in bioerosion atNingaloo Reef, emphasizing the importance of these large-bodied individuals in conserving key ecological processes.

Disentangling structural complexity with a three-dimensional coral model – Daphne Oh
Ecosystems with more complex three-dimensional habitats are typically associated with greater biodiversity. On coral reefs, the variability in the shapes, sizes and arrangement of hard corals provide shelter for reef-associated species. Various metrics have been used to quantify structural complexity, but capturing shelter for fish, in particular under overhanging corals, remains challenging. We used Coralcraft, a 3D mechanistic model, to explore the correlations between existing structural complexity metrics and shelter metrics we developed (shelter volume, protection from predators, and size-dependent shelter) across different community types of varying morphological diversity. Structural and shelter metrics increased over time in coral communities with greater morphological diversity. Yet, some monospecific communities, both of complex and simple coral morphologies, provided some of the highest structural complexity and shelter. The commonly assumed link between morphological diversity, structural complexity and shelter did not hold true for all coral community types. This suggests increased morphological diversity does not imply higher structural complexity and shelter for fish. Therefore, understanding the impact of structural complexity on fish requires consideration of the morphological composition, in addition to overall diversity, of coral communities.

Theme 4: Deep Reefs

Research on Deep Reef habitats at Ningaloo Reef – Logan Hellmrich
The Deep Reefs theme of the Ningaloo Outlook 2 program is exploring unknowns of Mesophotic Ecosystems at Ningaloo Reef. Mesophotic Ecosystems are intermediate depth (>30m), low light ecosystems characterised by the presence of coral. Mesophotic habitats are understudied globally due to the logistical and cost constraints of sampling in deeper water however research in these field has increased in the past decade. Although more than 50% of the Ningaloo Marine Park consists of depths greater than 30 m deep, mesophotic research there remains limited. Building on previous habitat classification and mapping of deep reef habitats in WAMSI and Ningaloo Outlook 1, our aim is to take a deeper dive into the ecology of these habitats and understand how they are utilised by different species of fish and invertebrates. Aspects of recruitment and linkages between deep and shallow reef habitats are also being explored. As these habitats are in close proximity to the coast but beyond the practical use of SCUBA, our approach has been to utilise remote imagery and eDNA approaches that can be undertaken from small vessels. The research has four main ecological objectives. 1) To improve the use of Remotely Operated Vehicles (ROV) and long-run remotely deployed video cameras for a range of survey techniques; 2) To describe the benthic mesophotic assemblages; 3) To determine how these habitats are used by organisms at different times of the diel cycle; 4) To examine differences in recruitment of invertebrates between habitat types, and 5) To identify the impact of habitat on the demersal fish assemblages. Previous research has highlighted the lack of fish wariness towards the ROV in comparison to diver-based video survey, while producing data that is comparable and supplemental between methods. As such we have deployed the ROV with forward-looking stereo cameras for fish surveys. The studies have used a variety of new and well-established technology such as ROVs, BRUVs (baited remote underwater video) and 24-hour cameras to extensively understand these relatively unexplored ecosystems. This research will take the next step in understanding the

importance and ecological function of mesophotic habitats at Ningaloo, addressing knowledge gaps and improving the understanding of mesophotic habitats to inform future policy and management.

Predation on mushroom corals by short spined COTS– John Keesing

Large, mesophotic mushroom coral beds comprising dense assemblages of a single species, *Cycloseris distorta,* are a notable feature of the suite of deep reef habitat types in about 40 m water depth off Ningaloo Reef. The short spined crown-of-thorns starfish *Acanthaster brevispinus* inhabits these deeper water habitats, in contrast to the more infamous long-spined crown-of-thorns starfish population outbreaks of which have been responsible for widespread shallow-water coral mortality throughout the Indo-West Pacific region. *Acanthaster brevispinus* has not previously been regarded as a threat to corals or coral reefs. However, on Ningaloo Reef, we found *A. brevispinus* were found on the *C. distorta* mushroom coral beds and using a remotely operated vehicle (ROV) confirmed predation by *A. brevispinus* on *C. distorta*. This was the first confirmed report of predation on hard corals by *A. brevispinus.* Subsequently *A. brevispinus* in high abundances were found to predate upon the dendrophylliid solitary coral *Heteropsammia cochlea* on the southern Great Barrier Reef. While there are yet to be any records of population outbreaks of this species at Ningaloo Reef, such outbreaks could have a significant effect on the mesophotic solitary coral assemblages there.

Long-run remote underwater stereo camera systems – Nick Mortimer

Long-run (ca. 24 hour) remote underwater stereo camera systems have been developed as part of the Ningaloo Outlook 2 project and have been deployed to conduct ecological research on deep reef habitats at Ningaloo. Each camera system consists of a pair of GoPro 9 cameras and a video light, each powered by sufficient battery systems sufficient to record for up to 24 hours. 512 Gb micro-SD cards allow recording of up to 22 hours of video. The cameras have been operated using GoPro Labs QR Codes. This has allowed the automating of programming and set-up of GoPro cameras, delivering longer run times and higher reliability. Recording 24 hours of vision on each camera generates approximately 512 Gb of video per camera each deployment, deploying 15 stereo cameras each day requires the efficient downloading of 15 Tb of data in the field each evening and we have developed open-source python codes for managing this large data flow.

Acknowledgement

We acknowledge the Baiyungu, Thalanyji and Yinikurtura People, the Traditional Owners and original custodians of the Ningaloo Coast and pay our respect to their elders past and present.