Project Plan SP 2021-040

Benefits of marine parks for marine fishes in a changing climate

BCS Marine Science

Project Core Team

X X **Supervising Scientist** Jordan Goetze
Data Custodian Jordan Goetze

Project status as of Jan. 10, 2023, 9:31 a.m.

X X Update requested

Document endorsements and approvals as of Jan. 10, 2023, 9:31 a.m.

X X
Project Team granted
Program Leader granted
Directorate granted
Biometrician granted
Herbarium Curator not required
Animal Ethics Committee granted

Benefits of marine parks for marine fishes in a changing climate

Program

BCS Marine Science

Departmental Service

Service 6: Conserving Habitats, Species and Communities

Project Staff

X X X **Role Person Time allocation (FTE)**

Research Scientist Sahira Bell 0.05

Supervising Scientist Jordan Goetze 0.3

Research Scientist Thomas Holmes 0.05

Research Scientist Will D Robbins 0.05

Research Scientist Claire Ross 0.05

Research Scientist Shaun Wilson 0.05

Related Science Projects

SP 2012-008 Marine Monitoring Program: We will be utilising data collected by this program and have gained approval and will be working with project leader Tom Holmes.

Proposed period of the project

June 7, 2022 – June 7, 2025

Relevance and Outcomes

Background

To conserve WAs marine biodiversity, a network of marine parks has been established under the principles of being comprehensive (incorporating all major bioregions), adequate (of sufficient size and number) and representative (representing all species of plants and animals found in WA), known as the CAR approach. The principal objectives of the CAR approach requires knowledge of ecological assets over a statewide scale and is complicated by a changing climate/environment, where marine habitats and species distributions are unlikely to remain static (Pecl *et al.*, 2017). Finfish are a mobile component of marine biodiversity and have been identified as a key ecological asset due to their high ecological and social values. Accordingly, finfish were identified as a high priority for research and monitoring across nine marine parks in WA (Kendrick *et al.*, 2016) and a long-term monitoring program was established by DBCA in 2009 to collect information on the condition of finfish with respect to natural and anthropogenic pressures.

While data from the marine monitoring program provides an opportunity for understanding how fish assemblages differ according to zoning within and among marine parks (Goetze *et al.*, 2021), it does not collect data outside of marine parks. Environmental changes are leading to shifts in the composition of fish assemblages (Cheung *et al.*, 2012), and it is unclear how well the current network of marine parks represents fish diversity across the state. The proposed project will combine DBCA finfish monitoring data with information collected by external collaborators to assess fish biodiversity both inside and outside of WA marine parks over the last decade. This will include new information on fishes from the Kimberley marine parks, collected using a remotely operated vehicle (ROV). This method is being used increasingly, to monitor fish assemblages in locations that divers cannot access safely (Schramm *et al.*, 2020a). However, further research is needed to understand how data collected by ROV, compares to that of the current methods used to monitor fish assemblages (e.g., diver operated video). To achieve these goals, data will be collated in GlobalArchive (https://globalarchive.org), a centralised repository that allows users to store data in a standardised and secure manner, makes meta-data discoverable, and encourages collaboration and synthesis of datasets within the community of practice (Harvey *et al.*, 2021). This dataset will be synthesised and then analysed at a workshop that includes key collaborators and DBCA staff, with an overarching goal of describing state-wide spatial and temporal patterns of finfish composition and distribution.

Aims

1. Collate a statewide finfish dataset with key collaborators to enable biodiversity assessments of fish inside and outside of marine parks, over the last decade.
2. Develop conversion factors that will enable the synthesis of DBCA finfish data (diver operated video, DOV) with legacy datasets (underwater visual census, UVC) and emerging methods (remotely operated vehicle, ROV).
3. Compare the composition, biodiversity and productivity of fish assemblages among marine parks relative to non-reserved locations.
4. Assess if the composition, biodiversity and productivity of finfish assemblages within marine parks has changed over time and if any changes correspond with climatic events or are due to fishing pressure.
5. Finally determine if these changes persist through time and whether patterns of change differ among parks located along the WA coast.

Expected outcome

The project will provide important information on marine park design and organization that will assist with adaptive management in a changing environment. It will also provide important evidence for marine park planning, should re-zoning or proposed marine parks arise. Further, it will increase the capacity and value add to DBCAs finfish monitoring program, through the provision of comparable data outside of marine parks and increased ability to produce and continue long-term time series data using historic and emerging methodologies. This state-wide synthesis of finfish data will assess whether the current system of marine parks is following the CAR principles to conserve the biodiversity of marine fishes across WA. Specifically, it will provide guidance on long-term marine park planning and management, and important information that can be used to determine where future parks may be best placed (Aim 3). It will also provide an improved understanding of how marine parks function in a changing environment (Aims 4 and 5). We will develop a standard operating procedure for collecting finfish data using ROVs and protocols for increasing the size/scope of finfish datasets, facilitating a better understanding of spatial and temporal trends in fish assemblages (Aim 1 and 2). The development of conversion factors will ensure that legacy data is “future proofed”, enabling compatibility with emerging methods due to technological advances (e.g., ROV surveys). By addressing these aims, we will enable the evaluation of WAs conservation management within a global context and provide scientific evidence to support an adaptive and therefore more resilient management framework for finfish in a changing environment.

Knowledge transfer

Regional staff across multiple parks have provided support to the development of the project, and we will work closely with staff in the Kimberley to complete field work. I have also been working with the planning branch to ensure this information can be used to inform the plan for our parks initiative and marine park design principles. Findings from the project will be disseminated within DBCA via information sheets, meetings, and internal presentations, ensuring results are communicated with regional and planning staff. As results will also be of interest to international researchers and conservationists, they will be published in high-ranking peer reviewed journals, presented at conferences and circulated through social media.

Tasks and Milestones

[]@ll@

Milestone/Task	**When**	Collate DBCA an Global Archive
March 2022	Data cleaning and synthesis	May 2022
August 2022	Workshop to analyse data and develop manuscripts	Sept 2022
March 2023	Write up results on biodiversity inside vs outside of marine parks	Sept 2023

March 2024	Communication of results at appropriate conference	April 2024

References

Cheung W. W. L., Meeuwig J. J., Feng M., Harvey E., Lam V. W. Y., Langlois T., ... Pauly D. (2012). Climate-change induced tropicalisation of marine communities in Western Australia. Marine and Freshwater Research, 63(5), 415–427.

Fisher R., Wilson S. K., Sin T. M., Lee A. C. & Langlois T. J. (2018). A simple function for full-subsets multiple regression in ecology with R. Ecology and evolution, 8(12), 6104–6113.

Goetze J. S., Bond T., McLean D. L., Saunders B. J., Langlois T. J., Lindfield S., ... Harvey E. S. (2019). A field and video analysis guide for diver operated stereo-video (ed McPherson J.). Methods in ecology and evolution / British Ecological Society, 10(7), 1083–1090.

Goetze J. S., Wilson S., Radford B., Fisher R., Langlois T. J., Monk J., ... Harvey E. S. (2021). Increased connectivity and depth improve the effectiveness of marine reserves. Global change biology, 27(15), 3432–3447.

Halpern, B.S., Lester, S.E., Kellner, J.B., 2009. Spillover from marine reserves and the replenishment of fished stocks. Environ. Conserv. 36, 268–276.

Harvey E. S., McLean D. L., Goetze J. S. & Saunders B. J. (2021). The BRUVs workshop–An Australia-wide synthesis of baited remote underwater video data to answer broad-scale ecological questions about fish, sharks and rays. Marine Policy.

Kendrick A., Wilson S. & Friedman K. J. (2016). Strategic marine ecological research priorities for CALM Act marine parks and reserves 2016–2021. Conservation Science.

Morais R. A. & Bellwood D. R. (2020). Principles for estimating fish productivity on coral reefs. Coral reefs , 39(5), 1221–1231.

Mouillot, D., Graham, N.A.J., Villéger, S., Mason, N.W.H., Bellwood, D.R., 2013. A functional approach reveals community responses to disturbances. Trends Ecol. Evol. 28, 167–177.

Pecl G. T., Araújo M. B., Bell J. D., Blanchard J., Bonebrake T. C., Chen I.-C., ... Williams S. E. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. Science, 355(6332). https://doi.org/10.1126/science.aai9214.

Sala, E., Mayorga, J., Bradley, D., Cabral, R.B., Atwood, T.B., Auber, A., Cheung, W., Costello, C., Ferretti, F., Friedlander, A.M., Gaines, S.D., Garilao, C., Goodell, W., Halpern, B.S., Hinson, A., Kaschner, K., Kesner-Reyes, K., Leprieur, F., McGowan, J., Morgan, L.E., Mouillot, D., Palacios-Abrantes, J., Possingham, H.P., Rechberger, K.D., Worm, B., Lubchenco, J., 2021. Protecting the global ocean for biodiversity, food and climate. Nature 592, 397–402.

Schramm K. D., Marnane M. J., Elsdon T. S., Jones C., Saunders B. J., Goetze J. S., ... Harvey E. S. (2020a). A comparison of stereo-BRUVs and stereo-ROV techniques for sampling shallow water fish communities on and off pipelines. Marine environmental research, 162, 105198.

Schramm K. D., Harvey E. S., Goetze J. S. & Travers M. J. (2020b). A comparison of stereo-BRUV, diver operated and remote stereo-video transects for assessing reef fish assemblages. Journal of Experimental.

Warwick, R.M., Clarke, K.R., 1995. New “biodiversity” measures reveal a decrease in taxonomic distinctness with increasing stress. Mar. Ecol. Prog. Ser. 129, 301–305.

Wilson S. K., Graham N. A. J., Holmes T. H., MacNeil M. A. & Ryan N. M. (2018). Visual versus video methods for estimating reef fish biomass. Ecological indicators, 85, 146–152.

Study design

Methodology

Aim 1: Collate a statewide finfish dataset

a.) Collation of existing data

Stereo diver operated video (DOV) data collected by DBCA and external collaborators will be uploaded to GlobalArchive. While standard operating procedures for the uploading of baited video data exists, we will need to work with researchers from UWA to develop procedures for cleaning, uploading, and hosting DOV data on GlobalArchive. Data stored in GlobalArchive is secure and only collaborators that have signed a data sharing agreement will be able to access data. By uploading to GlobalArchive, data can be synthesised into one dataset using R scripts that ensure all data is clean and in a comparable format. DOV data is limited to shallow water reefs, so does not capture the full diversity of finfish within a location. However, data collected using baited video has already been synthesised following these processes and can be used in addition to DOV data to provide a more comprehensive assessment of finfish diversity. With the additional collection of data outlined in Aim 1b and the contribution of data from external collaborators, a state-wide finfish dataset ranging from the far south (Esperance) to the far north (Kununurra) of WA will be available. This will include inside/outside assessments of eight existing and two proposed marine parks (the South Coast and the Kimberley) and will consider variation in zoning schemes for existing parks.

b.) Collection of data in key data gap (Kimberley)

Because of the risks associated with diving in many Kimberley locations there is currently no DOV or UVC data available on finish within the region. We will therefore work with the Kimberley monitoring team and regional staff to collect finfish data using a stereo remotely operated vehicle (stereo-ROV) in coral reef habitats. In principle, similar sampling procedures (e.g. transect dimensions, stereo-video design and video analysis procedures) as used for stereo diver operated video (Goetze *et al.*, 2019) can be followed using stereo-ROVs. However, a standard operating procedure that covers specific procedures for the use of stereo-ROVs for sampling fish assemblages will be drafted and submitted to a peer reviewed journal. As a starting point we plan to complete at least ten sites with 6 x 50 m transects within Kimberley Marine Parks in October 2022, using an ROV available through the Kimberley Program. This fieldwork will form a pilot study that can provide the baseline for ongoing monitoring of finfish in the Kimberley over time. This data will be used to compare fish assemblages in this region to the rest of the state (Aim 3).

Aim 2: Development of conversion factors

While there has been emerging research into the use of stereo-ROVs for sampling finfish and their comparability to other methods (Schramm *et al.*, 2020a, 2020b), these studies have been localised and have not examined whether conversion factors are needed across the range of metrics used to monitor finfish. Conversion factors have been developed to increase the compatibility of fish biomass data collected by underwater visual census (the most commonly used method historically) to stereo diver operated video (the current method used to monitor finfish at DBCA), enabling broader temporal and spatial scales to be examined (Wilson *et al.*, 2018)**.** The field component for comparing stereo-DOVs to stereo-ROVs has already been completed, with data collected by both methods simultaneously in both temperate (Jurien Bay Marine Park) and tropical (Ningaloo Marine Park) locations. Estimates of assemblage composition, species richness and the abundance/biomass of key species will be compared using permutational significance tests and location incorporated as a fixed factor. If metrics are found to differ significantly, conversion factors will be developed to enable synthesis of data between methodologies. Results from this comparison will be published in a peer reviewed journal.

Aim 3: Biodiversity and productivity assessments inside/outside of marine parks

Here we plan to map the diversity, functional composition and productivity of finfish in relation to WAs marine parks. The key metrics that will be examined include diversity (taxonomic distinctness and beta diversity), assemblage composition (biomass of major functional groups) and productivity. While methods for assessing diversity (Warwick & Clarke 1995) and assemblage composition (Mouillot et al., 2013) are well established, a method for calculating productivity using a trait-based approach has only recently been described (Morais & Bellwood, 2020). Productivity will be calculated for each individual fish observed using the “rfishprod” package in R. Diversity, biomass of functional groups and productivity will then be compared inside and outside of each marine park, to assess whether marine parks (as a whole) are providing conservation benefits to marine fishes. We will also examine the potential of productivity to spillover from sanctuary zones (and other highly protected zones) into areas open to fishing. Previous assessments of spillover have used static metrics such as abundance and biomass (Halpern et al. 2009), whereas productivity is process based so will provide an assessment of the current status of finfish as well as their potential to support fisheries.

A major factor influencing the effectiveness of marine parks is the percentage of highly protected areas/zones within their boundaries (Sala et al. 2021) and the degree to which this highly protected zones are connected to each other (Goetze et al. 2021). These factors alongside key socio-economic (e.g., gravity) and environmental drivers will be incorporated into models, to assess the importance of design and environmental factors in driving conservation success within marine parks. A full subset modelling approach will be used to assess the benefits of marine parks across the range of metrics identified above (Fisher et al., 2018). Finally, areas with unique diversity and high productivity outside of marine parks will be highlighted, providing evidence for suitable locations to achieve a representative network of marine parks for finfish in the future.

Aim 4 and 5: Biodiversity and productivity assessments over time

Finfish data collected through MSPs monitoring program (supplemented by external organisations) spans over a decade and covers both tropical and temperate environments (e.g. Esperance to the Rowley Shoals) across seven marine parks. This will enable a temporal assessment of changes in diversity, assemblage composition and productivity. Information on water temperature and key habitat status/health (collected by MSPs monitoring program), a proxy for human impacts (known as gravity; Cinner et al. 2018) and other key drivers of fish abundance will be collected and modelled with these key metrics using generalised additive mixed models and a full subsets approach (Fisher *et al.*, 2018). This will allow us to distinguish the effect of key pressures including fishing and climate change and how it has shaped the distribution of fish assemblages across the state over the last decade. These patterns will be related to the current system of marine parks, to understand how they are capturing biodiversity as the WA marine environment changes with climate.

Biometrician's Endorsement

granted

Data management

No. specimens

Herbarium Curator's Endorsement

not required

Animal Ethics Committee's Endorsement

granted

Data management

Video are stored on external HDs with multiple backups due to their large size, however, cloud storage is being explored through the Pawsey Supercomputing Centre. Meta-data and ecological data is stored on MSPs SharePoint and will also be uploaded to GlobalArchive: https://globalarchive.org/ as private data. This means only meta-data (e.g. survey details and locations) is visible and ecological data will only be accessible to project collaborators who have signed data sharing agreements. Data custodian: Marine Science Program, Jordan Goetze

Budget

Consolidated Funds

to | X | X | X | X |

Source	Year 1	Year 2	Year 3
FTE Scientist	0.5	0.5	0.5
FTE Technical	0.05	0.05	0.05
Database Development	5,000		
Vehicle			
Travel	25,0003,500		
Other	5,0005,000	3,000	
Total	35,0005,000	6,500	

External Funds

to | X | X | X | X |

Source	Year 1	Year 2	Year 3
Salaries, Wages, Overtime	0.1 FTE	0.1 FTE	0.1 FTE

Overheads

Equipment

Vehicle

Travel

Other $7,500$

Total $7,500$