Kinchant Dam fish habitat enhancement project

Final Report

June 2020

Queensland Government

This publication has been compiled by Andrew Norris, David Nixon and Michael Hutchison of Agri-Science Freshwater Fisheries Research Group, Department of Agriculture and Fisheries.

Contents

List of figures

List of tables

Summary

Recreational angling in impoundments is increasing in popularity and generates significant social and economic benefits to regional communities. Impoundments with high quality angling attract tourists from all over Queensland, interstate and overseas. Quality habitat is vital to support strong fish communities and angling opportunities. Strategically improving the quantity and quality of structural habitat in an impoundment has the potential to create fishing hotspots and improve fishing in and around these sites.

Kinchant Dam is a medium-sized impoundment near Mackay, primarily known for its barramundi fishing. Despite having good numbers of large fish, angling in Kinchant Dam has been reported to be difficult at times, especially for tourists and more occasional anglers. Apart from the marginal vegetation and dam infrastructure in areas closed to anglers, there is little in the way of structural habitat to aggregate the fish, making them difficult for anglers locate. Strategically improving the structural habitat complexity within the dam has the potential to improve fishing, increase tourism, and ultimately generate greater revenue from visitors within the Mackay region.

A joint project between the Department of Agriculture and Fisheries and Mackay Regional Council, was developed for Kinchant Dam to trial the installation of fish attracting structures (FAS). The project goals were to increase structural fish habitat diversity, improve angler experiences and catch rates, reduce the number of anglers fishing along the dam infrastructure in closed zones, and evaluate the response of fish to the installation of structural habitat.

Information from baseline surveys of the existing habitat and fish distributions, and community consultation were combined to develop a fish attraction plan (FAP) for the dam. The FAP outlined the number, types and locations of FAS to be installed and how they would be monitored. It was recommended that FAS clusters be installed at 36 sites around Kinchant Dam. A total of 197 FAS were used, comprising of 88 synthetic trees, 39 pipe bundles, 30 synthetic hedges, 23 Georgia cubes, 14 Kinchant cribs and 3 suspended FAS. All materials used to construct the FAS were durable and inert to ensure no detrimental impacts on the aquatic environment. The FAS types were also relatively snag-free, meaning anglers could fish right in amongst the habitat with less fear of losing gear. To minimise the risk of FAS becoming overgrown by aquatic vegetation or being a risk to water-skiers and boats at low water levels, FAS all were placed in water deeper than 3 m based on the 90th percentile for dam water levels.

The majority of FAS were constructed by community volunteers over the course of five working bees held on weekends. Additional FAS were also constructed by community groups in between the working bees.

Deployment of structures commenced in conjunction with a media launch day held on 10th November 2018. A small barge was chartered to enable larger structures to be loaded and easily deployed. All large FAS were deployed using the barge, with a number of synthetic trees and the suspended FAS deployed using a smaller DAF vessel. Deployment continued throughout the summer and autumn of 2019 and was completed by the end of May 2019.

Twice yearly boat electrofishing surveys (summer and winter) were used to monitor the response of fish to the installation of FAS and understand potential seasonal differences in habitat use. Monitoring sites were spread across four broad habitat categories: vegetated margins, open water, around dam infrastructure, and where FAS were installed. For the analysis, the data were divided into two depth

groups (shallow and deep) to counter the decline in electrofishing efficiency beyond 5 m water depth. Sonar imaging was used to assess the condition of the FAS and abundance of fish in their vicinity.

Following installation, the catch rates for barramundi at FAS sites did not differ significantly to those around existing dam infrastructure and at vegetated sites. This indicates the FAS were effectively attracting barramundi in similar proportions to the better-quality existing habitat in the dam. These three habitat types all had significantly higher catch rates than open water sites. Catch rates almost tripled at intervention sites once FAS were installed. Even at deeper water sites, where electrofishing was less efficient, barramundi were significantly more likely to be captured where FAS had been installed compared with the control open water sites.

Bony bream and fly-specked hardyhead were the most abundant prey species observed in the electrofishing surveys. These species were both attracted to FAS sites. Barramundi were frequently caught in close proximity to schools of bony bream and thus the bony bream around the FAS would likely help attract barramundi to those areas.

The Kinchant Dam Habitat Enhancement Project generated significant community and media interest. Stories were produced in newspapers, radio, fishing magazines, regional tourism guides, newsletters, podcasts and on multiple websites. Project signage was installed at the boat ramp and the coordinates of the FAS are available in several websites and brochures. This exposure should help attract more anglers to visit the Mackay region to fish the dam.

A follow-up project to value-add to the habitat enhancement project and keep Kinchant Dam in the media and tourism spotlight would be to acoustically track fish use of FAS and habitat within Kinchant Dam. This would provide anglers detailed information on when and where to fish. For anglers who do not fish the area regularly, this information will give them the best chance to catch a fish of a lifetime and encourage them to visit more frequently. This is especially pertinent given recent impacts on local tourism due to COVID-19 pandemic travel restrictions.

The installation of the FAS into Kinchant Dam has provided anglers with alternative habitat and areas to target fish. The FAS offer anglers the chance to target barramundi without having to fish the vegetated margins or closed zones around infrastructure in the dam. Installing the FAS beyond the weed-line means anglers can more readily troll or cast lures with less fear of snagging on aquatic vegetation. Trolling for barramundi is a popular technique for many older or travelling anglers because it is less physically taxing and has been proven to work in river systems and other dams. Together, these factors should make fishing at Kinchant Dam a more attractive proposition and encourage more anglers to visit. The extension activities from the project will help get the message out that the Mackay region is a premier fishing destination, and that people do not have to travel all the way to far northern Queensland to catch the barramundi of a lifetime.

Acknowledgements

This project would not have been possible without the amazing help from all of the project partners. Thanks goes to the Department of Agriculture and Fisheries (DAF) and Mackay Regional Council (MRC) whose valuable co-investment in the project made it possible. We also wish to acknowledge the hard work put in by all DAF staff to map, build and monitor the fish habitat structures throughout the project. Volunteers from a broad cross-section of the Mackay region community graciously donated their time to help construct and move the fish habitat structures. A wide range of community groups were involved, but special efforts were contributed from Mackay Area Fish Stocking Association, Walkerston Rotary, St Patricks Senior College and volunteers from MRC. A big thank you goes to David Meyer from DAF for his help in analysing the survey data. We are extremely grateful for everyone's contributions and hope they can now enjoy the fruits of their labour.

Background

Recreational angling in impoundments is increasing in popularity and generates significant social and economic benefits to regional communities. In 2019-20 the total number of Queenslanders participating in recreational fishing was 943,000 (DAF 2020). In addition, significant numbers of interstate and overseas visitors travel to Queensland to fish. One report suggests around 2 million domestic and international visitors fished in Queensland whilst visiting in 2016 (Tourism Research Australia 2017).

Angling-based tourism has the potential to deliver significant economic benefits to regional economies (Henry and Lyle 2003, Rolfe *et al*., 2005, Rolfe and Prayaga 2007, Gregg and Rolfe 2013). For example, Awoonga Dam in central Queensland was estimated to deliver more than $10.4 million in economic value to the local community each year (Gregg and Rolfe 2013). The renowned fishing at the dam attracts tourists from all over Queensland, interstate and overseas. In the same study the annual economic value of Kinchant dam was estimated at $1.1 million. Therefore, there is potential to improve tourism and the economic value of the fishery at Kinchant Dam.

Many recreational species do not breed in impoundments, either because the dam walls block their spawning migration routes, or because they require flowing water for breeding. Therefore, on-going stocking is required to create and maintain the fishery. Despite the requirement for ongoing stocking, impoundments can produce exceptionally fast growing fish and be very productive fisheries. Rutledge *et al*. (1990) found that for every dollar invested into the stocking program at Tinaroo Dam near Atherton, there was a return of $31 to the local economy. A study by Hamlyn and Beattie (1993) at Lake Leslie near Warwick showed that for every dollar spent on fish stocking, tourist anglers spent $18 in the local economy. The Mackay Area Fish Stocking Association has done a great job stocking barramundi and sooty grunter into Kinchant Dam for more than 25 years. There is potential to add value to their efforts, through improving the quality of fishing experiences in the impoundment. This could be achieved by influencing how fish are distributed around the impoundment to increase the chance of anglers catching them.

A wide range of variables impact the success of an impoundment fishery, but one of the major limiting factors is the condition of the fish habitat. Since the majority of impoundments are not designed, built or operated with fisheries as a major consideration, structural habitat is often lacking. Additionally, as impoundments age, the remnant habitat degrades over time. This habitat is vital to support strong fish communities and angling opportunities. Fish are rarely randomly distributed around an impoundment. Many iconic angling species, such as barramundi, have a strong affinity towards structural aquatic habitat. Strategically improving the quantity and quality of structural habitat in an impoundment could create aggregation points for prey species and ambush locations for predators. This has the potential to create fishing hotspots and improve fishing in and around these sites.

There is a convincing body of evidence from the USA that habitat enhancement in impoundments positively influences their fisheries (Norris 2016). The recreational fishery in many USA dams has been significantly improved, or even completely revitalised, through the strategic use of fish habitat enhancement techniques. This has led to significant improvements in the number of tourists visiting or utilizing these impoundments and resulted in flow on benefits to the local communities. Additionally, the installation of habitat to attract fish can help manage conflicts between different waterway user groups and improve fishing for shore-bound or mobility-limited anglers. So far, little work in this field has been conducted in Australia.

Kinchant Dam is a medium-sized impoundment (~ 920ha) managed by Sunwater and located approximately 40 km west from Mackay. The dam was built in 1977 to supply water for the Eaton irrigation area (Sunwater 2017) and is also used for a variety of recreational purposes. The dam only has a small catchment, so most water is pumped in from the Pioneer River. The dam is essentially a tree-less basin with an extensive band of marginal aquatic vegetation. Water levels fluctuate approximately 3 meters seasonally with rainfall, pumping and irrigation releases.

Kinchant Dam is popular for a range of recreational activities including swimming, sailing, water skiing and fishing. Primarily known for its barramundi fishing, the dam also holds sooty grunter, sleepy cod and forked-tail catfish. There is a moderate to high abundance of fish within the dam, especially barramundi which are caught regularly at large sizes. However, angling in Kinchant Dam has been reported to be difficult at times, especially for tourists and more occasional anglers. Apart from the marginal vegetation, there is little in the way of structural habitat to aggregate the fish, making them difficult for anglers to locate. Some of the best structural habitat is found along the rocky dam walls. However, these are designated *no fishing* zones in order to protect Sunwater's dam infrastructure. Anglers still illegally fish in these zones despite the warning signs. There is also some level of interaction and occasionally conflict between anglers and other water users such as water skiers.

Strategically improving the structural habitat complexity within the dam has the potential to improve fishing, better separate different waterway users, improve tourism, and ultimately generate greater economic input from visitors within the Mackay region. Habitat enhancement has been widely and successfully used by fishery managers in the USA to achieve similar goals (Norris 2016). This joint project led by the Department of Agriculture and Fisheries (DAF), and co-funded by Mackay Regional Council MRC), was developed at Kinchant Dam to:

- Increase structural fish habitat diversity,
- Improve angler experiences and catch rates,
- Reduce the number of anglers fishing along the dam infrastructure in closed zones,
- Decrease interactions between anglers and water skiers, and
- Evaluate the response of fish to the installation of structural habitat.

Strategic fish habitat installation at Kinchant Dam would complement actions in the *Mackay region recreational fishing strategy 2017-2022* and the recent ban on commercial net fishing between St. Helens and Cape Hillsborough. The overall goal is help Mackay become a premier recreational fishing destination. This was one of the first projects of its kind in Australia to implement impoundment habitat enhancement at such a large scale.

Development of the fish attraction plan

The initial phase of the project focused on developing a plan to ensure the project outcomes would be achieved. Baseline information on the fish and existing habitat distributions within Kinchant Dam were combined with input from key stakeholders to develop a fish attraction plan (FAP). The FAP provided the blueprint for the habitat structures to be constructed, their deployment locations and the monitoring protocols to be implemented.

Baseline habitat survey

A sonar survey of Kinchant Dam was conducted by DAF in February 2018 to map the bathymetry and existing fish habitat. Depth and habitat features were mapped using a Lowrance HDS 9 side-scan sonar unit, and the bathymetry calculated, and habitat identified using Reefmaster software (version 2.0, Reefmaster Software Ltd, West Sussex, United Kingdom). The water level at the time of the survey was unusually low at 54.09 m AHD with the dam at 54% capacity. A strong thermocline was detected between 4.5-6 m depth across most of the dam. The low water level restricted bathymetric surveying of the very shallow, heavily vegetated marginal sections of the dam, but enabled clear identification of the extent and margins of the aquatic vegetation in the dam. This information was critical to ensure the fish attraction structures (FAS) were located at sites where they wouldn't become overgrown.

The survey confirmed there was limited structural complexity in the dam likely to aggregate fish and highlighted the need for the introduction of FAS. The dam's habitat was dominated by silty flats with extensive vegetation around the shoreline. Three shallow channel complexes were also identified, which contained firmer substrate and some small drop-offs (Figure 1).

The shoreline on the southern side of the dam typically had mild gradients and more extensive aquatic vegetation. Marginal submerged and floating macrophyte growth was dense to around 2.5 m depth around much of the dam shoreline, with more scattered clumps occasionally extending to 5 m depth in parts. The deeper margins of the dense vegetation often formed well-defined edges, but short new growth extending from the vegetation beds was observed in a few locations. Several simple tree trunks and logs were present in the vicinity of both major channels and adjacent to the boat ramp, and day use areas. These logs lacked structural complexity (no branching or apparent root balls) and were likely to offer little habitat for most fish species. Only a single emergent tree was observed in the south west of the dam. This tree was surrounded by the remnant stumps from an old building and was in a zone containing dense growth of aquatic vegetation. As such, at the low water levels observed during the survey, it was unlikely to provide much cover for fish.

Dam infrastructure provided the most complex structures. The dam's rock wall was the dominant structure likely to attract fish, and contained the vast majority of hard structure present. This extensive wall provides rocky habitat around approximately 40% of the dam's shoreline on the northern side, and in areas has created steep gradients and drop-offs into deep water. A 100 m exclusion zone exists along the wall for navigational safety, so this area is not accessible to anglers. The infrastructure for the water offtake tower also created significant vertical relief and structural complexity and would prove highly attractive to many fish species. The other piece of dam infrastructure likely to influence fish distributions in the dam is the inlet channel. When in operation, significant volumes of water enter the dam through the channel, creating a strong current which may act as an attraction flow for fish. The inlet current has scoured bottom substrate, so a small, well defined rock ledge has formed on the southern side of the channel where the incoming water enters the dam. The substrate surrounding the inlet channel consists of clay, mud and gravel and aquatic vegetation growth is mostly scattered in the area.

The limited fish habitat in the dam outside of the off-limits area supported the need for introducing FAS and suggested they would likely be utilised by the resident fish population. It was decided the addition of FAS in waters beyond the weed line would most likely create more areas where anglers could target barramundi and sooty grunter, and enable a wider variety fishing techniques to be more effectively used.

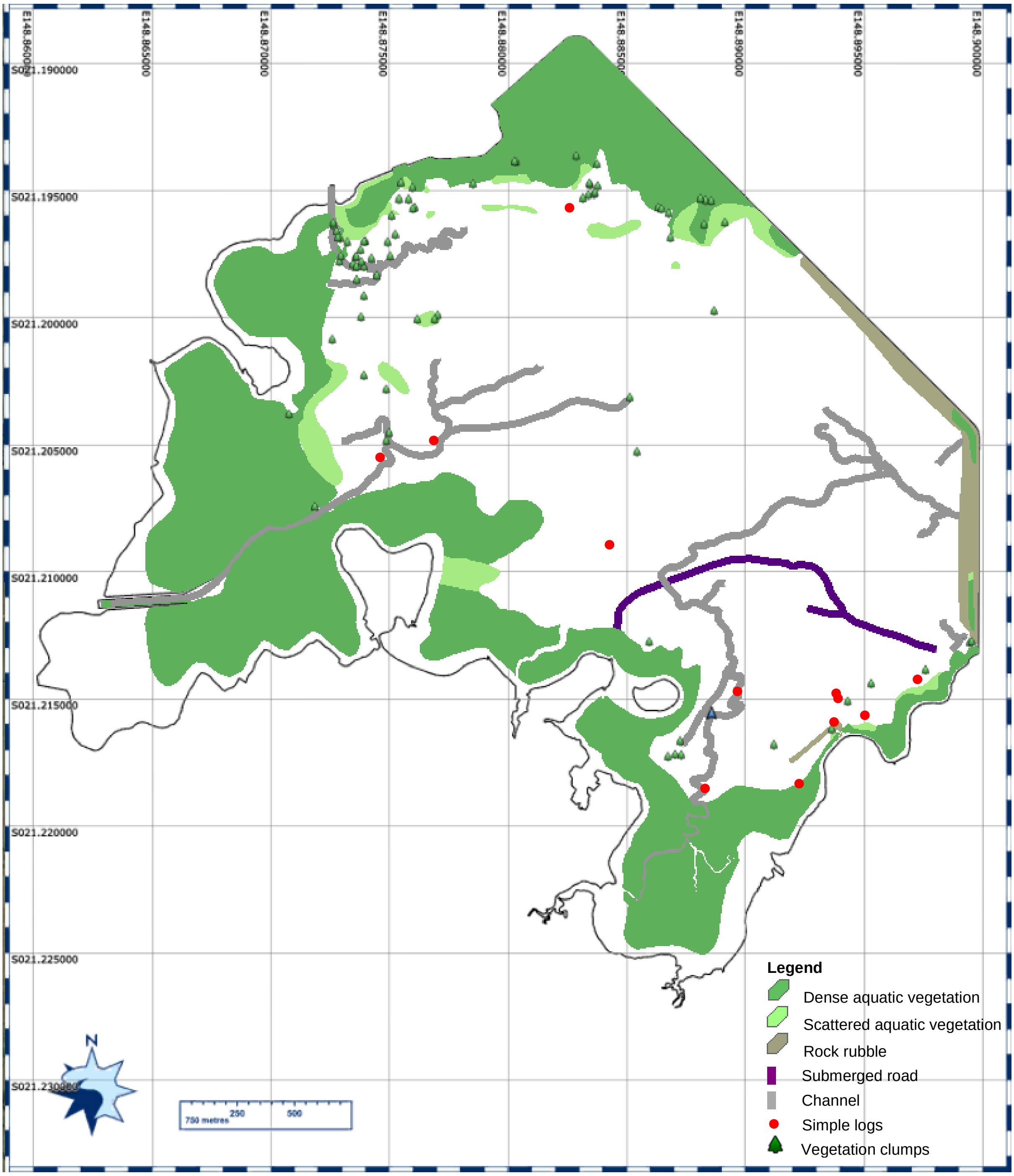


Figure 1 Existing habitat recorded in Kinchant Dam during the February 2018 survey. The dam supply level was 54.09 m AHD.

Baseline fish survey

Kinchant Dam is stocked by the Mackay Area Fish Stocking Association (MAFSA) under Queensland's Stocked Impoundment Permit scheme (SIPs). The dam was originally stocked with sooty grunter (*Hephaestus fuliginosus*) and sleepy cod (*Oxyeleotris lineolata*) for recreational angling, but since 2000, barramundi (*Lates calcarifer*) have also been released (Keiron Gallety, MAFSA personal communication).

Standardised electrofishing shots were conducted at 40 locations around the margins of the dam, and in areas where FAS were likely to be deployed (refer to the *Monitoring and Evaluation* section for more details). The baseline data provided information on how fish were using the available habitat and provided a baseline against which changes from the introduction of FAS could be compared. A total of 212 barramundi (221-1000 mm TL), 10 sooty grunter (420-445 mm TL) and 17 sleepy cod (80-279 mm TL) were captured. A range of prey species were also detected during electrofishing, with bony bream being particularly abundant. The abundance of prey species was categorically recorded to assess whether FAS alter their distribution (refer to the *Monitoring and Evaluation* section for more details).

Barramundi and sooty grunter are the primary targets for most recreational anglers and were primarily found in the vicinity of the extensive beds of aquatic vegetation. Barramundi are also found in the open waters at times, hovering near the thermocline beneath schools of bony bream. Barramundi and sooty grunter are also both attracted to flowing waters, and one of the key aggregation points in Kinchant Dam is the inlet channel when water is being pumped into the dam from the Pioneer River. During the fish survey no sooty grunter and very few barramundi were captured from open water sites away from vegetation or inflowing water.

Stakeholder consultation

A broad range of stakeholders were consulted during the preparation of the fish attraction plan. The primary stakeholders for Kinchant Dam include Mackay Regional Council (co-investors), Sunwater (waterway operator), Mackay Area Fish Stocking Association (local fish stocking group), Mackay Recreational Fishing Alliance (MRFA) and Fisheries Queensland.

In-depth discussions were held with Sunwater regarding the use of FAS in Kinchant Dam to improve recreational fishing and encourage angling in areas outside of restricted access zones. These discussions resulted in support for the project and on-site assistance from staff located at the Kinchant Dam offices.

A community forum was held on Saturday 24th February 2018 to discuss the project and was attended by the aforementioned stakeholders plus a local charter fisherman and representatives from St Patricks College, a local tackle shop and one of the Men's Shed groups. Additional organisations were contacted following the meeting including local Rotary groups and another Mackay College. Although water-skiing, wake-boarding and riding PWC are popular on the dam, no representative organisations for these activities could be identified with which we could directly engage. The meeting discussed the objectives of the project, monitoring, materials that might be available, and began identifying people willing to assist in the construction and deployment of the FAS.

The fish attraction plan

The fish attraction plan (FAP) tied together data from the baseline surveys, dam hydrology, requirements from Sunwater, and input from key stakeholders. The FAP outlined the type, quantity and location of fish attracting structures to be installed during the project, and recommended methods to monitor the outcomes. A draft FAP was circulated to stakeholders for comment before being finalised in mid-2018. The final FAP was approved by Sunwater, enabling the habitat structures to be deployed in Kinchant Dam.

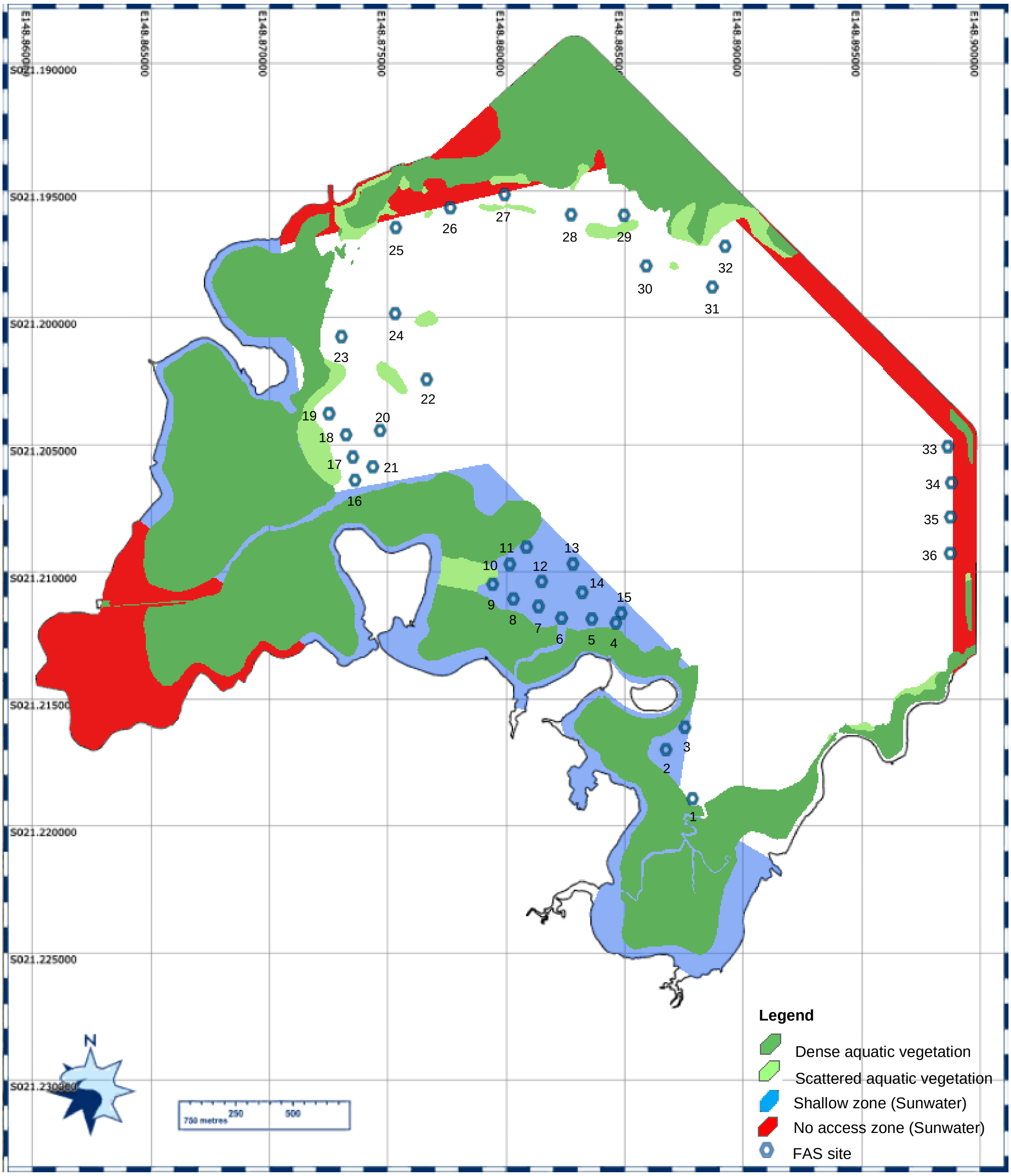


Figure 2 The location of proposed FAS sites around Kinchant Dam relative to Sunwater dam management zones and aquatic vegetation. Clusters of different structure types were deployed at each site to provide habitat diversity

The FAP recommended installation of 197 FAS at 36 sites around Kinchant Dam (Figure 2). The goals were to disperse angler effort and provide accessible habitat for fish and anglers throughout the year. All FAS were readily accessible to boat anglers most of the time and located outside of restricted access zones. No FAS were placed in the middle of the dam to minimise interactions between anglers and skiers, and to minimise potential collisions.

Understanding the dam hydrology was critical in determining the placement of FAS. Data from Sunwater for the last decade indicated Kinchant Dam typically had relatively high supply levels during that period. Although water levels in Kinchant Dam can fluctuate up to 5 m, they are typically high for much of the time. The 90th percentile of water level heights in the dam was 54.90 m AHD, 2.31 m below full supply, and this level was used to determine the minimum depth that the FAS would be set at. At this level, any FAS located beneath the surface should remain submerged for 90% of the time, minimising the potential for becoming a navigational hazard. To minimise the risk of FAS placed in shallow water becoming overgrown by aquatic vegetation and rendered of limited value, no FAS were placed in water shallower than 3 m based on the 90th percentile for water levels.

Where possible, FAS sites were selected to enhance the structural complexity of existing habitat, particularly remnant creek channels and the edges of aquatic vegetation beds. Where no existing habitat was present, FAS were used to create new fishing hotspots. Flow rates in the dam are very low and all FAS were well ballasted, so there is little risk of structures drifting. Several FAS sites were therefore contained within or adjacent to the remnant creek channels creating an area with the potential to develop into a trolling run. Four FAS sites were established in the deep water outside of the closed zone along the dam wall. The goal here was to attract and hold fish from the nearby rock and rubble. These sites have potential for deep trolling runs or vertical jigging upon the installed structures. Three suspended FAS sites were located around a deep water spit and drop-off. Several FAS were deployed on the bottom substrate around the float's mooring to provide additional structural complexity.

Six different types of habitat structures were utilised in the project and at each site, a cluster of FAS was used to create habitat complexity. A description of each structure type is covered in the next section of this report and more details on deployment distributions can be found in the FAP (Norris 2018). FAS were deployed in an open circle or cross pattern. These designs create gaps between the structures for fish to move through and have been reported to be the most utilized and effective designs in the USA (Miranda 2017).

Construction and deployment of fish attracting structures

A variety of different habitat structures were utilised in Kinchant Dam to provide diverse habitat. A total of 197 structures were used (Figure 3), comprising of 88 synthetic trees, 39 pipe bundles, 30 synthetic hedges, 23 Georgia cubes, 14 Kinchant cribs and 3 suspended FAS. The designs were chosen to provide diverse structural complexity and were suitable for deployment at different depths. All construction materials were durable and inert to ensure there were no detrimental impacts on the aquatic environment. Where possible, clean recycled materials were used. The main materials used for construction were PVC and polyethylene pipe. The designs were relatively snag-free, meaning anglers could fish right in amongst the habitat with little fear of losing gear. All FAS were suitably weighted with concrete blocks or cast concrete bases, and set at depths to ensure tampering was minimal. Water skiing, wakeboarding, and riding PWCs is extremely popular at Kinchant Dam, so in addition to being set at minimum depths, all FAS were also designed to minimise impact or injury if struck by a boat or towed person.

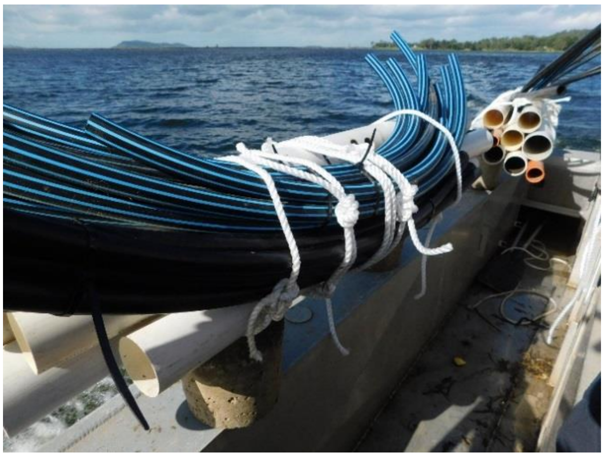
a) Kinchant cribs

b) Georgia cubes

c) Synthetic hedges

d) Synthetic trees

e) Pipe bundles



f) Suspended FAS

Figure 3 Examples of the different FAS designs used to enhance fish habitat in Kinchant Dam

The majority of FAS were constructed by community volunteers over the course of five working bees held at the MRC nursery compound on Saturday mornings. The working bees were attended by a broad range of volunteers from MRC, MAFSA, Walkerston Rotary, a local tackle shop, Mackay Recreational Fishers Alliance, local schools, a local charter guide and other interested people who had heard about the project and wanted to become involved. At working bees, volunteers underwent a site induction and daily briefing before commencing construction activities. In addition to attending the working bees, volunteers from St Patrick's College and Walkerston Rotary constructed additional FAS between events. These groups were supplied with materials and construction guidelines and their extra efforts sped up the construction process.

Constructed FAS were initially stored at MRC's nursery compound until they overwhelmed the available space. The Kinchant Outdoor Education Centre (Queensland Department of Education) was identified as a potential storage site owing to an abundance of accessible land in close proximity to Kinchant Dam, and they kindly permitted FAS to be stored on their grounds until deployment arrangements could be finalised (Figure 4). In July 2018 all FAS were moved to the Outdoor Education Centre with the assistance of staff from MRC, along with council vehicles, trailers, and a side-tipper truck for the larger structures.


Figure 4 Cribs and Georgia cubes in storage at Kinchant Outdoor Education Centre (at left), and FAS at Kinchant Dam boat ramp staging area prior to deployment (at right).

Deployment of structures commenced in conjunction with a media launch day held on 10 November 2018. Completed structures were moved from the Outdoor Education Centre to the boat ramp area prior to this event with assistance from MRC staff and equipment (Figure 4). An 8.5 m barge (*Miss Daisy*, All Island Barge and Ferry Services) was chartered for the day, with a 3.0 m beam and a ramp on the bow that enabled larger structures, such as Georgia cubes and Kinchant cribs, to be loaded from the front and easily deployed through a side gate. All structures were suitably ballasted using concrete blocks and deployed in a cluster around a central waypoint according to the FAP. All large FAS were deployed using the barge, with a number of synthetic trees and the suspended FAS deployed in the following days using a smaller DAF vessel (Figure 5).

Deployment of FAS continued throughout the summer of 2018/19 as more structures were completed. The last working bee occurred on 18 May 2019, where 30 synthetic trees, 3 suspended FAS and 39 pipe bundles were finalised. These remaining FAS were transported to the Kinchant Dam boat ramp with assistance from MRC staff and equipment, and promptly deployed using a DAF vessel over the following days. All FAS were constructed and deployed at locations specified in the FAP by the end of May 2019.

Figure 5 Ballasted Georgia Cube being deployed from side of barge (at left), and synthetic tree being deployed from the gunwale of the smaller DAF vessel (at right).

Monitoring and evaluation

Electrofishing surveys

Electrofishing was used to monitor the response of fish to the installation of FAS in Kinchant Dam. Electrofishing provides an instantaneous sampling method to survey the fish assemblage and is the standard sampling technique used by freshwater fisheries research organisations around the world. Fish are stunned by pulsing an electric current through the water, with the stunned fish subsequently netted. Electrofishing is typically limited to relatively shallow waters because the stunning range only extends up to 3-5 m from the anodes. At each monitoring site, fish were actively targeted by electrofishing using a total power on time of 300 seconds per site. Only recreationally targeted species were measured and counted during surveys. The abundance (fish per electrofishing shot) of smaller species such as bony bream and fly-specked hardyhead was classified into four categories: absent, low (1-20), medium (21-100) and high (>100). Due to the ability of a netter to only capture one or two large barramundi at a time, all stunned barramundi and sooty grunter seen on the surface were counted, regardless of whether they were netted or not. Netted fish were temporarily held in a live-well and measured before release. Barramundi were measured for total length whilst sooty grunter were measured to fork length.

Forty sites were monitored during the baseline fish survey. These sites covered a variety of habitats around the dam. Following development of the FAP, the locations of the monitoring sites were adjusted to better cover four broad habitat categories: vegetated margins, open water, around dam infrastructure, and where FAS were to be installed. The majority of sites selected occurred in water less than 5 m depth where electrofishing is most effective. Several deeper locations were included to cover deeper habitat sites, but it was expected fewer fish would be captured here due to the decline in electrofishing efficiency. Twice-yearly electrofishing surveys were conducted in summer and winter to account for potential seasonal changes in habitat use by fish.

A MBARCI design was used to examine the influence FAS installation on electrofishing catch rates. Vegetated sites and those around dam infrastructure were utilised as reference sites because they represented existing complex habitats which were known to attract fish. All FAS were installed in open water areas, therefore open water sites represented the control and the intervention (treatment) sites occurred where FAS were installed. This design enabled before and after comparisons, as well as comparison between habitat types. The limitations of electrofishing efficiency in deeper water necessitated that the survey data be split into shallow (<5.1 m) and deep (≥5.1 m) sites for analysis.

The electrofishing data were analysed with a Generalised Linear Model (GLM) using a Poisson distribution with log-link function (Genstat edition 19) to compare survey catch rates between habitat types and seasons. Water depth was included as a covariate in the analysis to cover any impact on electrofishing efficiency (i.e. catch rates) associated with depth within the shallow sites (<5.1 m). The adjusted mean catch rates from the GLM were compared between habitat types using Fisher's least significance difference test (LSD). A GLM using a Poisson distribution with log-link function and water depth as a covariate was also used to compare catch rates at sites before and after installation of FAS. As outlined previously, bony bream and fly-specked hardyhead observations were recorded categorically during surveys. For the analysis of catch data from these species, a middle catch rate value from each category was used: Absent = 0, low = 10, medium = 60, high = 120. This permitted more informative statistics to be performed.

A GLM was also used to investigate the barramundi catch rates at sites in water deeper than 5.1 m. Only open water and FAS sites were present at this depth. The GLM for the deep water sites was insignificant for any of the treatment factors (habitat or season), partially due to the very low catch rates. To explore the data further, the binary contrast of absences of barramundi at sites within each habitat were compared using Chi-square tests.

Pairwise Kolmogorov-Smirnov two-sample tests were used to examine differences in the length-frequency distributions for barramundi between each survey period.

Sonar imaging

The condition of the FAS and their use by fish were monitored using a Lowrance HDS 9 sonar system. Sonar images over and around the FAS indicated their orientation, integrity and the

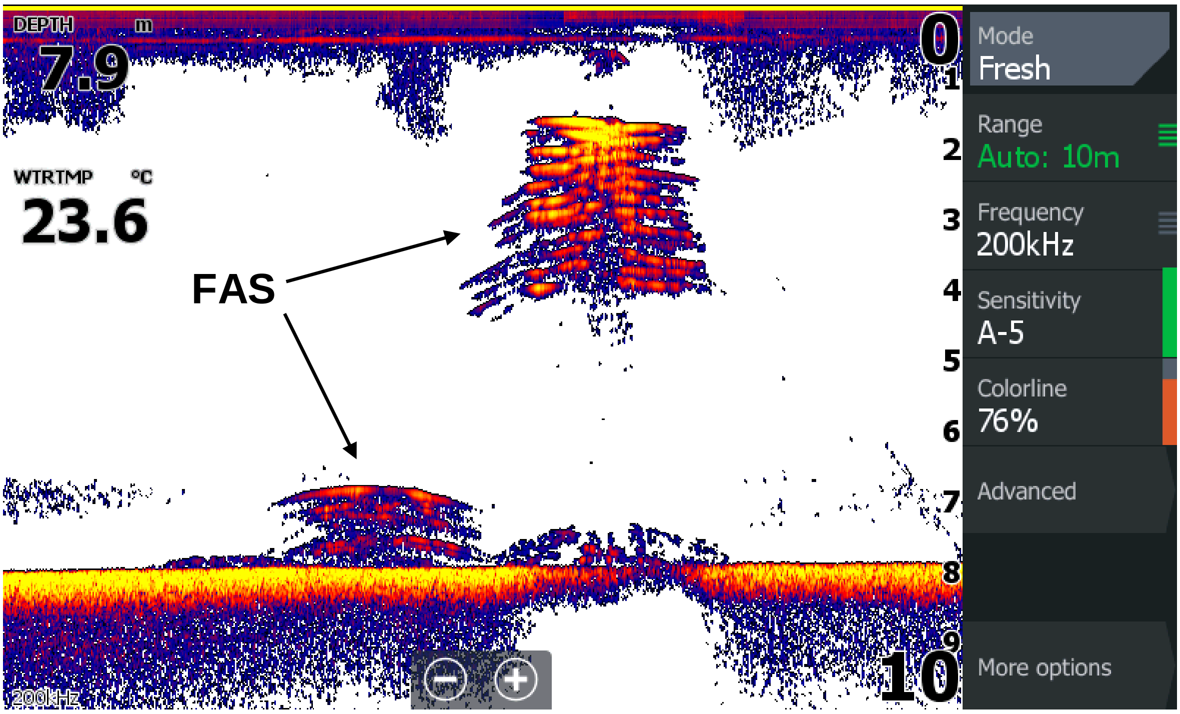


Figure 6 Sonar image showing a suspended FAS near the surface and substrate based structures around the mooring blocks.

abundance of associated fish. Over the duration of the project no FAS displayed apparent structural breakdown or damage (Figure 6).

Sonar imaging also provided evidence of FAS use by fish (Figure 7). This was particularly important at deeper sites where electrofishing could not effectively stun fish through the entire water column. Large fish marks were frequently observed hovering at a depth of 4-6 m, around the thermocline, but these fish were too deep, and could not be raised during electrofishing surveys. The sounder images were also useful to identify schools of prey species, particularly bony bream.

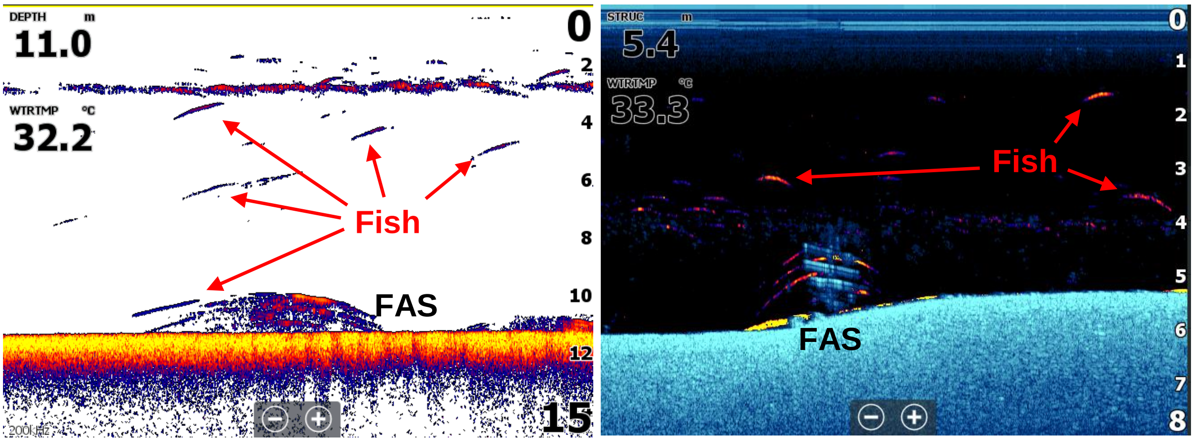


Figure 7 Sonar shots near FAS showing large fish marks, some of which were beyond the reach of electrofishing equipment. The left image is from standard sonar and the right image is from Lowrance Downscan.

Outcomes

The electrofishing surveys identified three highly abundant fish species in the dam which were analysed with regard to catch rates in each of the different habitat types. Of the recreationally targeted fish species, only barramundi were captured at a high enough abundance for meaningful analyses to be performed. The catch rates of two key prey fish species, bony bream and fly-specked hardyhead, were also analysed to determine if they were aggregating around FAS. Such aggregations would likely attract barramundi and other predators to the vicinity of the FAS as well.

Barramundi

Barramundi were the most abundant large fish species caught in the electrofishing surveys. The total number of barramundi captured in a survey period ranged from 42-212 fish. The GLM indicated that depth ($P<0.001$), habitat $P<0.001$) and season ($P=0.009$) were all significant factors at the shallow sites (<5.1 m) and there was no significant interaction between habitat and season ($P=0.148$).

The adjusted means from the GLM indicated barramundi catch rates were highest around existing dam infrastructure, followed by FAS sites and vegetated sites. Catch rates were lowest in open water (Figure 7). Further examination using Fisher's least significance difference test (LSD) found the barramundi catch rate around existing dam infrastructure was significantly higher than at vegetated and open water sites, but not significantly higher than FAS sites (Figure 7). The LSD also found catch rates were not significantly different between FAS and vegetated sites, but were significantly lower in open water sites compared with all other habitat types.

There were no significant differences ($P=0.81$) when comparing survey catch rates pre-FAS installation and post-FAS installation in vegetated, open water and infrastructure sites. However, direct comparison at sites where FAS were installed indicated the catch rate increased significantly (P=0.013). Adjusted mean catch rates almost tripled following the installation of FAS.

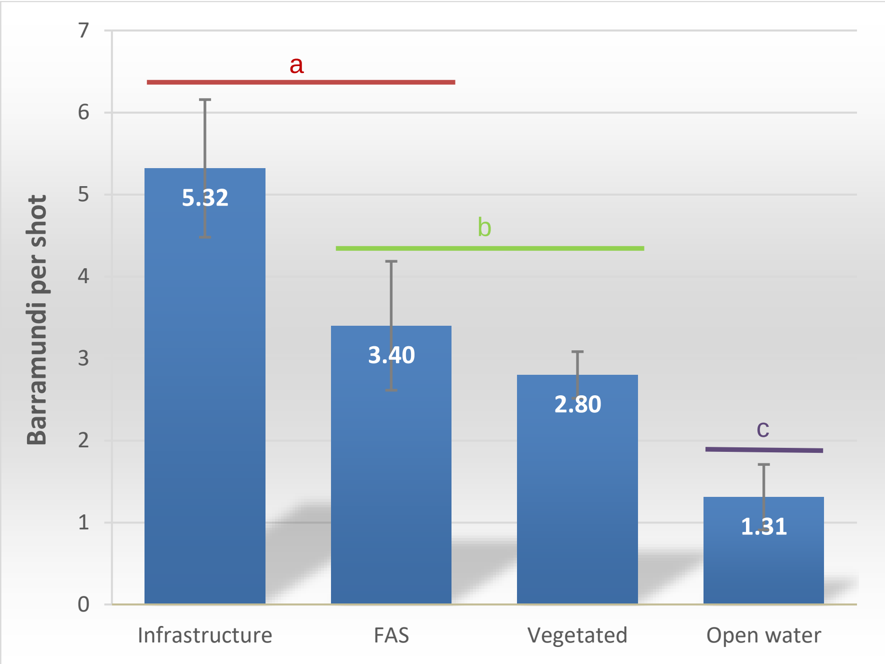


Figure 8 Adjusted means (± SE) from the generalised linear model for barramundi catch rates from different habitats in Kinchant Dam. The labelled lines above the columns link catch rates that were not significantly different from each other based on Fisher's LSD results.

At sites deeper than 5.1 m, the overall mean catch rates for barramundi were 0.82 (SE=0.24) fish per shot for FAS sites and 0.60 (SE=0.17) fish per shot for open water sites. These were not significantly different in the GLM, but catch rates were 37% higher at FAS sites. In open water, 71% of the electrofishing shots caught zero barramundi, whilst at FAS sites 39% of shots caught no barramundi. This binary contrast was significant (Chi-square (1 d.f.) = 5.47; P = 0.019).

The mean length of barramundi varied between surveys (Figure 9). Pairwise Kolmogorov-Smirnov two-sample tests were used to examine differences in the length-frequency distributions for barramundi between each survey period (Table 1, Figure 10). Comparisons between summer 2018 and winter 2018, summer 2018 and winter 2019, summer 2019 and winter 2019, and summer 2019 and summer 2020 were significantly different (Table 1). Some of the differences can be explained by inter-seasonal growth (Figure 9). In 2018, the bi-modal distribution followed growth of small barramundi (<500 mm TL) between summer and winter, whilst very large fish (> 900 mm TL) became much less frequently captured. The reason behind the decline in large fish is unclear because there were no over-topping events or major fish kills between surveys. In 2019 a similar trend in growth was observed, with the modal peak shifting from 850 mm to 950 mm length between summer and winter surveys. During 2019 water levels were higher for both surveys and few small fish were captured. The smaller fish may have been distributed up amongst the dense vegetation in the shallows where the electrofisher could not access.

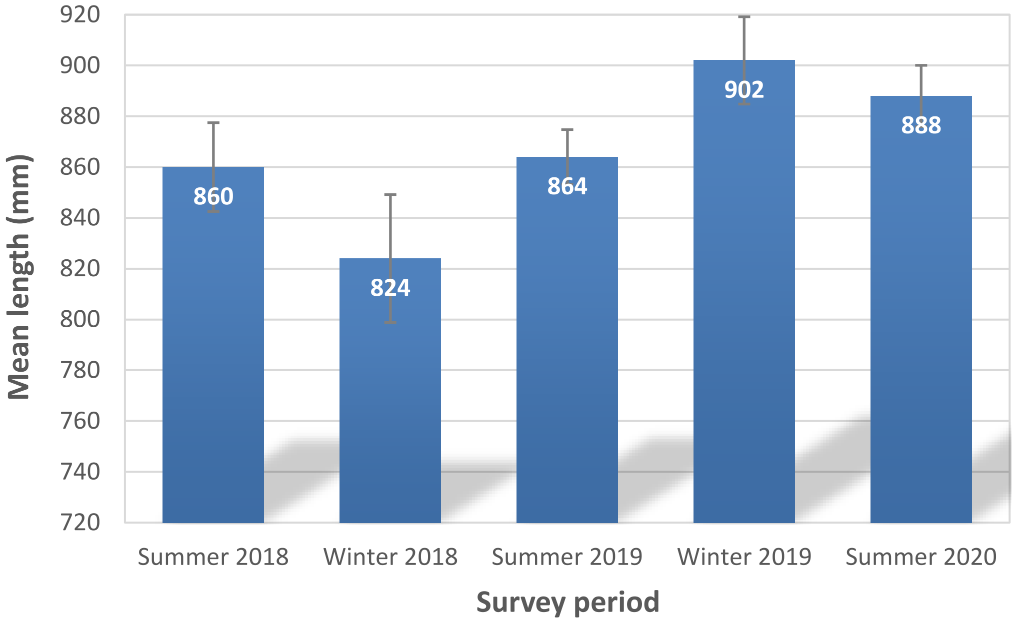


Figure 9 Mean length (mm ± SE) of barramundi captured during the electrofishing surveys at Kinchant Dam.

*Table 1 Kolmogorov-Smirnov two-sample test results for pairwise comparisons of barramundi length-frequency distributions between each survey period. * denotes a significant difference*

Pairwise comparison		**Probability**
Summer 2018	*Winter 2018*	*0.039**
Summer 2018	*Summer 2019*	*<0.001**
Summer 2018	Winter 2019	0.576
Summer 2018	Summer 2020	0.198
Winter 2018	Summer 2019	0.253
Winter 2018	Winter 2019	0.070
Winter 2018	Summer 2020	0.076
Summer 2019	*Winter 2019*	*0.002**
Summer2019	*Summer 2020*	*0.002**
Winter 2019	Summer 2020	0.332

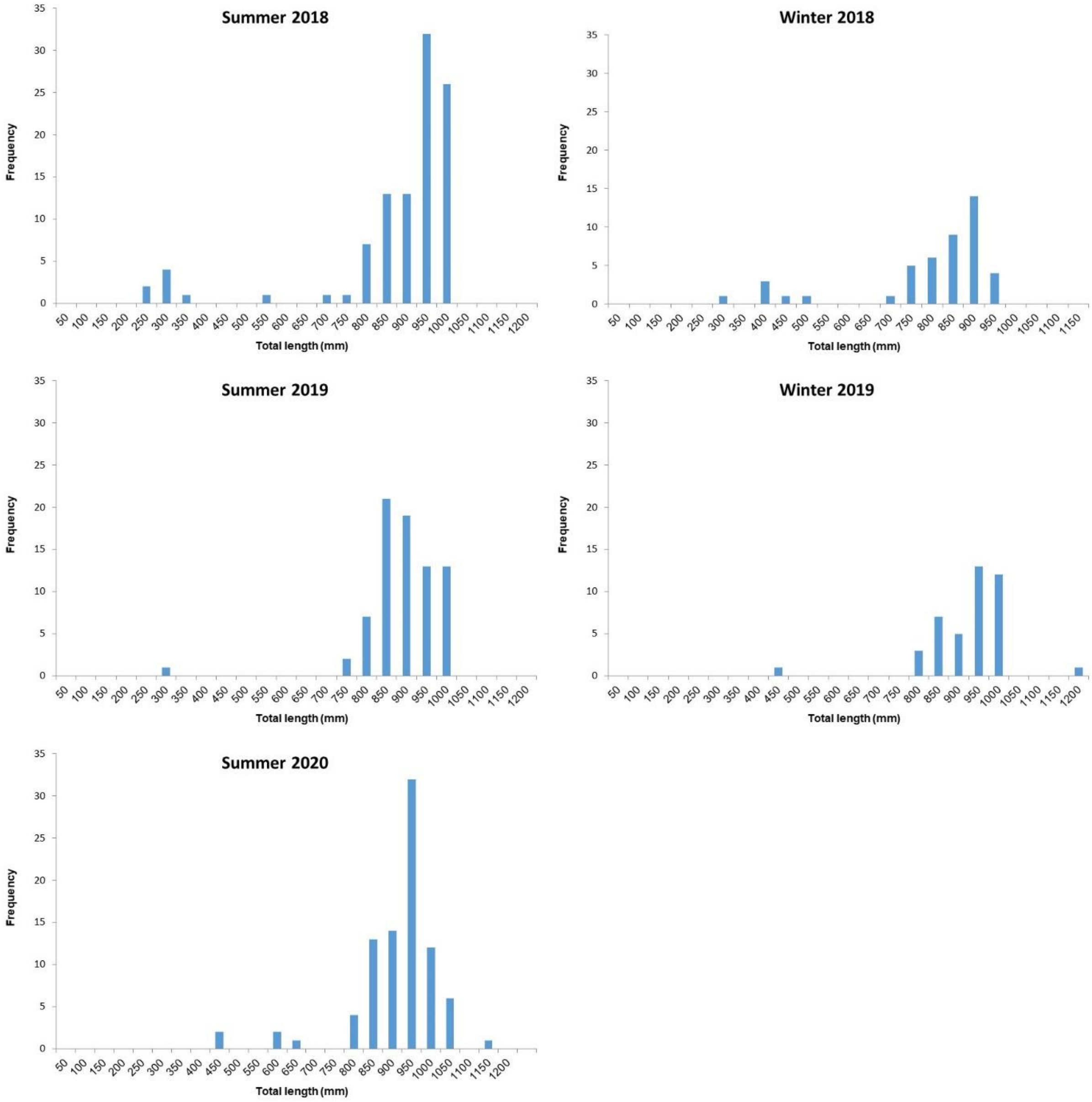


Figure 10 Barramundi length-frequency distributions for the total catch from each survey period.

Bony bream

Bony bream were the most abundant prey species observed in the electrofishing surveys. Barramundi were frequently stunned in close proximity to a school of bony bream. At shallow water sites, the GLM indicated water depth ($P<0.001$) habitat type ($P=0.004$) and season ($P<0.001$) were all significant factors in bony bream catch rates, and there was also a significant interaction between season and habitat. The highest catch rates were in vegetated sites, followed by FAS and infrastructure sites. Fisher's LSD test indicated catch rates at the control open water sites were significantly lower, but that catches did not significantly differ between FAS, vegetated and infrastructure sites (Figure 11). The adjusted means from the GLM indicated bony bream abundance almost doubled at FAS sites following their installation. On average twice the number of bony bream were captured in summer (89.6 ± 4.0) than winter (44.7 ± 3.8) surveys.

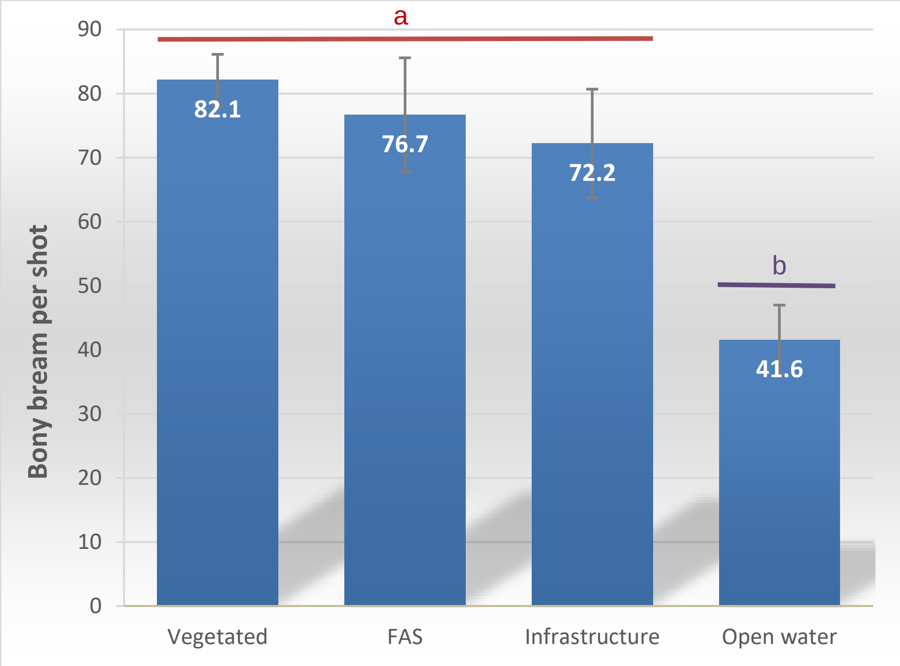


Figure 11 Adjusted means (± SE) from the generalised linear model for bony bream catch rates from different habitats in Kinchant Dam. The labelled lines above the columns link catch rates that were not significantly different from each other based on Fisher's LSD results.

Fly-specked hardyhead

Fly-specked hardyhead were also an abundant prey species. The GLM for shallow sites indicated habitat type was the only factor significantly influencing catch rates (P=0.019). The highest catch rates occurred in vegetated sites, followed by infrastructure and FAS sites. Fisher's LSD test indicated the catch rates at open water sites were significantly lower than those from other habitats, but catches were not significantly different between FAS, vegetated and infrastructure sites (Figure 12).

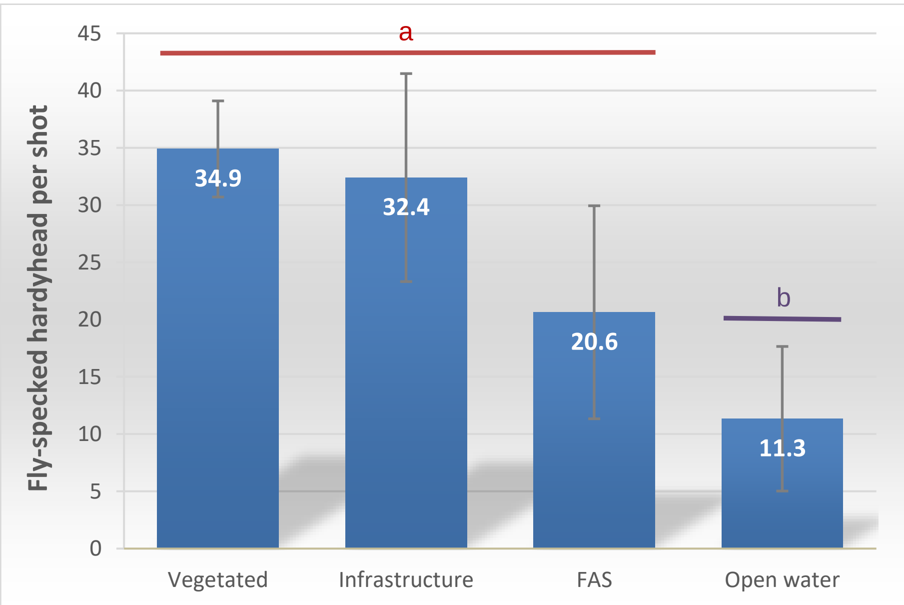


Figure 12 Adjusted means (± SE) from the generalised linear model for fly-specked hardyhead catch rates from different habitats in Kinchant Dam. The labelled lines above the columns link catch rates that were not significantly different from each other based on Fisher's LSD results.

Installation of FAS appears to have almost doubled the abundance of fly-specked hardyhead at those sites post FAS installation, while no seasonal differences in catch rates were observed.

Extension activities

The Kinchant Dam Habitat Enhancement Project has generated a lot of community and media interest and involvement. Stakeholder and community consultation and engagement was a core component of the project.

Following initial discussions with MRC and Sunwater, a community consultation forum was held on Saturday 24 February 2018 to discuss the project with stakeholders and potential contributors and seek input into the design of the fish attraction plan. Participants at the meeting included members of local angling and stocking groups, tackle shop owners, school teachers, MRC staff, a representative from a Men's Shed and a local fishing charter operator. The meeting discussed the objectives of the project, potential monitoring approaches, explored what materials might be available and began identifying people who would be willing to help construct and deploy the fish attractors. Once the draft FAP was completed, it was circulated for feedback through the forum participants and other community members who couldn't make it to the forum. Five working bees with community volunteers were then held to construct and transport the FAS. After the last electrofishing survey, a volunteer appreciation event was held on the 22 February 2020 to thank the volunteers for all of their hard work and to provide initial feedback on the results from the electrofishing surveys.

A FAS design competition was held in conjunction with St Patrick's College. Students were asked to consider what the habitat requirements are for fish and to design a modular habitat unit that would provide these requirements and attract fish. Kirsty Edwards came up with the best design and won a rod and reel for her efforts.

Figure 13 The hardworking volunteers at the first working bee (at left) and Kirsty Edwards receiving her prize for winning the student FAS design competition (at right)

A media launch day was held on Saturday 10 November 2018 to publicise the first of the habitat deployments in Kinchant Dam. This event was well attended by members of the local community, along with local MP Julianne Gilbert, Mackay Mayor Greg Williamson, and representatives from the local media. As part of the day's activities, the prize for the student design competition was awarded (Figure 13). The Mackay Area Fish Stocking Association also released another batch of barramundi fingerlings into the dam on the day to hopefully one day take up residence in the newly deployed habitat structures. The launch day resulted in a number of media pieces in the local newspaper and on local radio stations.

Over the time span of the project, a large number of media and extension articles have been produced, including:

- 2 x DAF press releases
- Mackay freshwater fishing booklet - https://www.mackayregion.com/images/HookedOnMackay/dam-fishing-booklet.pdf
- Podcasts
  - DAF podcast “Dam of dreams” in Surf n Turf – 4 October 2019
  - Podtail “Kinchant Dam barramundi with Luke Galea” – 22 February 2019
- Fishing magazines
  - QFM Article November 2018
  - Bush n Beach article 14 May 2018
  - Freshwater Fishing Australia article “If we build it they will come” by Luke Galea
- Newspaper articles
  - Daily Mercury article “Reeling in a big barra is about to get easier” 11 November 2018
  - Noosa News 25 August 2017 “Strategy to reel anglers in”
- Radio
  - Hit FM 27 June 2018
  - Triple M interview 12 November 2018
- Stakeholder newsletters
  - St Patricks College November 2018 Newsletter
  - FFSAQ newsletter 2 December 2019 and 27 April 2020
- Presentations
  - Queensland freshwater fishing and stocking workshop 2-4 November 2018
  - Reservoir Fisheries Habitat Partnership conference, USA– 4-6 October 2019
- Websites
  - MRC Waterways web page https://www.mackay.qld.gov.au/environment/waterways/kinchant_dam_habitat_enhancement_project
  - Wiki Fishing Spots - https://www.wikifishingspots.com.au/kinchant-dam-mackay-fishing-spots/
  - Fisheries Queensland Facebook page

A number of approaches have been taken to make it easy for anglers to find the sites where FAS have been installed. A large sign was erected at the dam’s boat ramp which includes a brief summary of the project and a map and coordinates for each of the FAS clusters (Figure 14). The coordinates are also available from several websites, including the MRC waterways webpage, Wiki Fishing Spots and Fisheries Queensland Recreational Fishing page. The FAS locations are also included in the Mackay Freshwater Fishing booklet.

Figure 14 Project information signage at the Kinchant Dam Boat ramp. The sign contains a project summary and the locations of the installed FAS.

It is anticipated that additional extension opportunities will arise from the release of the final project report. Outcomes from the project will also be incorporated into the best practice guidelines currently being developed.

What next?

The introduction of the fish attracting structures has provided focal points to target for locals and visitors alike, and increased the areas and techniques which can be used to fish for barramundi in the dam. Due to budgetary constraints, the habitat enhancement project included only limited monitoring and evaluation, the results of which have been very positive. Kinchant Dam has historically been regarded as difficult to fish at times, potentially limiting visitation to more keen anglers. However, information on how and when barramundi are using the installed FAS plus information on their daily and seasonal movement patterns around the dam is lacking and would greatly assist anglers targeting these iconic sports fish. Anglers catching more fish are likely to have a better fishing experience and thus potentially visit more often or stay longer, leading to greater expenditure in the region.

The Department of Agriculture and Fisheries proposes a follow-up project to value-add to the habitat enhancement project and keep Kinchant Dam in the media and tourism spotlight. This is especially pertinent given recent impacts on tourism from Covid-19 pandemic travel restrictions. We propose a project to track the movements of barramundi in the dam over a period of two years. This will obtain detailed information on how and when the fish are using the fish attracting structures and also how the fish move around the dam at different times of the day and through the different seasons. For anglers who do not fish the area regularly, this information will provide them with the best chance to catch a fish of a lifetime and encourage them to visit more frequently.

Acoustic tracking of barramundi in the dam is probably the most cost-effective way to obtain information on their detailed movement patterns and use of FAS. Acoustic tracking involves surgically implanting food-safe acoustic tags into the abdominal cavities of fish and monitoring their movements using an array of underwater receivers. The position of the fish in the dam is determined by triangulating its location when three or more receivers detect the tag. This passive form of tracking means fish exhibit their natural behaviours without being influenced by tracking vessels. This delivers the most accurate data, whilst at the same time minimising project costs. Kinchant Dam is an ideal location to acoustically track fish because the water level is relatively stable (~3 m fluctuation) and most anglers practise catch and release, so the risk of tagged barramundi being taken for consumption is low.

DAF already possesses a substantial number of acoustic receivers, which would substantially reduce the cost of an acoustic tracking project in Kinchant Dam. DAF also has expertise in acoustic fish tracking and analysis of fish tracking data. For this project to proceed, we would require co-investment from MRC and leverage these funds with a third party, such as FRDC, to obtain the remaining investment required.

Information acquired from acoustic tracking would be of great interest to anglers, especially those who fish the dam less frequently. It would provide them with even better information on when and where to catch fish. Such information should encourage more anglers to visit the dam, thus further promoting angling tourism in the Mackay region. The outcomes of the tracking would make great topics for fishing magazines and online forums, and create a multitude of media opportunities for stories that would promote the Mackay region as a premier fishing destination.

Conclusion

The installation of the FAS into Kinchant Dam has provided anglers with alternative habitat and areas to target fish. Electrofishing surveys demonstrated that barramundi and key prey species abundances at sites with FAS were significantly higher than similar open water sites with no FAS. The installation of FAS almost tripled the barramundi catch at those sites. Fish abundances at FAS sites were often higher than those observed in the marginal vegetation where many anglers typically target fish. The durable materials and robust designs of the FAS will ensure they continue to attract fish for years to come. The FAS offer anglers the chance to target barramundi without having to fish the vegetated margins or closed zones around dam infrastructure. Installing the FAS beyond the weed-line means anglers can more readily troll or cast lures with less fear of snagging on aquatic vegetation. Trolling for barramundi is a popular technique for many older or travelling anglers because it is less physically taxing and has been proven to work in river systems and other dams. Together, these factors should make fishing at Kinchant Dam a more attractive proposition and encourage more anglers to visit. The numerous extension articles from the project will help get the message out there that the Mackay region is a premier fishing destination, and that people do not have to travel all the way to far northern Queensland to catch the barramundi of a lifetime.

References

Department of Agriculture and Fisheries (2020) *2019-20 State-wide recreational fishing survey* https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-compliance/monitoring-reporting/recreational-fishing/statewide-recreational-fishing-surveys

Gregg, D. and Rolfe, J. (2013) *An economic assessment of the value of recreational angling at Queensland dams involved in the Stocked Impoundment Permit Scheme.* CQ University, North Rockhampton. 47 pp.

Hamlyn, A. and Beattie, B. (1993) *Pilot survey, angling expenditure and economic impact, Lake Leslie.* Queensland Department of Primary Industries, Fisheries Division. 15 pp.

Henry, G.W. and Lyle, J.M. (2003) *The National Recreational and Indigenous Fishing Survey.* FRDC Project 99/158. 188 pp.

Mackay Regional Council (2017) *Mackay Region Recreational Fishing Strategy 2017-2022 Final Report.* MRC 50 pp.

Miranda, L.S. (2017) *Reservoir fish habitat management.* Lightning Press, Totowa, New Jersey. 306 pp.

Norris, A. (2016) *Increasing Australian impoundment fisheries potential: Habitat enhancement to improve angling and productivity in impoundments.* Winston Churchill Fellowship Report. 98 pp.

Norris, A. (2018) *Kinchant Dam fish attraction plan*. Department of Agriculture and Fisheries, Queensland 92 pp.

Rolfe, J., Prayaga, P., Long, P. and Cheetham, R. (2005) *Estimating the value of freshwater recreational fishing in three Queensland dams.* Faculty of Business and Law, Central Queensland University, Rockhampton Queensland. 44pp.

Rolfe, J and Prayaga, P (2007) Estimating values for recreational fishing at freshwater dams in Queensland. *Australian Journal of Agricultural and Resource Economics* 51: 157–174.

Rutledge, W. Rimmer, M, Russell, D.J., Garrett, R. and Barlow, C. (1990) Cost benefit of hatchery-reared barramundi, *Lates calcarifer* (Bloch) in Queensland. *Aquaculture and Fisheries Management* 21, 443-448.

Sunwater (2017) *Kinchant Dam emergency action plan,* Sunwater Limited. 119 pp.

Tourism Research Australia (2017*) National and International visitor survey data year ending September 2016*, cited in Mackay Regional Council (2017) *Mackay region recreational fishing strategy 2017-2022*, Mackay, Queensland.