Bridging ecology and infrastructure: The Oyster Creek success story

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Key points

- The Oyster Creek realignment demonstrates that ecological design can be successfully integrated into major transport infrastructure without compromising hydraulic or engineering performance.
- Post construction monitoring shows that the reconstructed channel maintains longitudinal connectivity, with the 115 m culvert extension remaining permeable to small bodied, juvenile and diadromous fishes.
- Constructed habitats support rapid colonisation, high native fish abundance and improved species richness relative to the baseline.
- Enhanced habitat complexity and connectivity have strengthened native assemblages while reducing the dominance of exotic species.

Abstract

The realignment of Oyster Creek, part of the M1 Pacific Motorway upgrade between Burleigh and Palm Beach on the southern Gold Coast, provided a rare opportunity to integrate ecological design principles into major infrastructure and evaluate their effectiveness. Oyster Creek, a tributary of Tallebudgera Creek, was realigned into a newly constructed 870 m long channel extending from the tidal interface upstream of the M1 culverts to Cowell Drive. To meet environmental approval conditions and maintain ecological connectivity, the new reach design included large refuge ponds fitted with LUNKERS and large woody debris, connected by run habitats stabilised with cross vanes to manage flow and reduce velocities for fish passage.

Post-construction monitoring was undertaken across three survey rounds using boat electrofishing and netting to assess the new fish community, habitat use and passage. Seven native fish species were recorded in the freshwater reaches, ranging in size from 10 to 445 mm, alongside a turtle hatchling and a diversity of waterbirds. By comparison, pre-construction surveys detected only three native species. These results demonstrate that the reconstructed channel is functioning effectively, facilitating upstream movement and supporting a developing native fish assemblage.

The success of the Oyster Creek realignment underscores the value of integrating ecological design into infrastructure delivery. It provides a compelling case study showing that well designed freshwater habitats can be constructed, rapidly colonised, and deliver measurable ecological benefits while meeting engineering and regulatory objectives.

Keywords

fish passage; ecological design; fish habitat reconstruction; waterway realignment; connectivity; fish habitat; eco-hydraulic design; fish-friendly design.

Introduction

Growing traffic volumes continue to place pressure on transport networks, often requiring upgrades that intersect with environmentally sensitive waterways. These waterway systems function as critical movement corridors for native fish and aquatic fauna, yet road crossings and channel realignments can disrupt hydraulic connectivity and degrade habitat if not carefully designed. Historically, such works often replaced natural streams with concrete trapezoidal drains or other hard-lined channels designed solely for rapid stormwater conveyance, resulting in simplified habitats and poor ecological outcomes. Contemporary practice increasingly recognises the need to balance transport objectives with ecological function, with design standards, and associated regulatory and environmental requirements, now mandating that new or upgraded crossings maintain or improve longitudinal connectivity and incorporate habitat features that mimic natural geomorphic and hydraulic conditions. In turn, projects of this nature require undergo a strict approvals process and generally include involvement of suitably qualified fish passage/ecology scientists to guide design development and oversee construction to ensure ecological performance is embedded from the outset. Approval conditions also typically stipulate post-construction monitoring to verify that the constructed works are functioning as intended and delivering the anticipated fish passage and habitat outcomes.

The Oyster Creek Realignment Project, delivered as part of the M1 Pacific Motorway upgrade between Burleigh and Palm Beach on the southern Gold Coast, provided an opportunity to apply these principles and evaluate their effectiveness. Oyster Creek is a small coastal tributary of Tallebudgera Creek that spans a tidal–freshwater transition zone and supports a mixed assemblage of estuarine, diadromous and freshwater fish species. Prior to realignment, the original stream was highly modified, overgrown with vegetation and had been previously straightened and bunded in several locations.

As part of the upgrade, the existing channel was buried, after which approximately 870 m of the waterway was realigned and reconstructed. Works included the extension of five 1.8 m diameter culverts under the motorway to a new total length of 115 m, and the creation of a series of refuge ponds in the reconstructed channel connected by cross-vane-stabilised runs (Figure 1 and Figure 2). Habitat complexity within the ponds was enhanced using large woody debris and LUNKERS - engineered undercut bank structures designed to provide low-velocity refuge and mimic natural overhanging banks. These features were intended to maintain hydraulic connectivity, support upstream fish movement and create a mosaic of habitats within the newly constructed reach.

Pre- and post-construction monitoring allowed assessment of whether these interventions supported fish passage, habitat utilisation and the development of a native fish assemblage during the first year following construction. This paper presents the early ecological outcomes of the realignment, demonstrating how integrated engineering and ecological design can support living, connected waterways that continue to evolve under changing hydrological and landscape conditions.

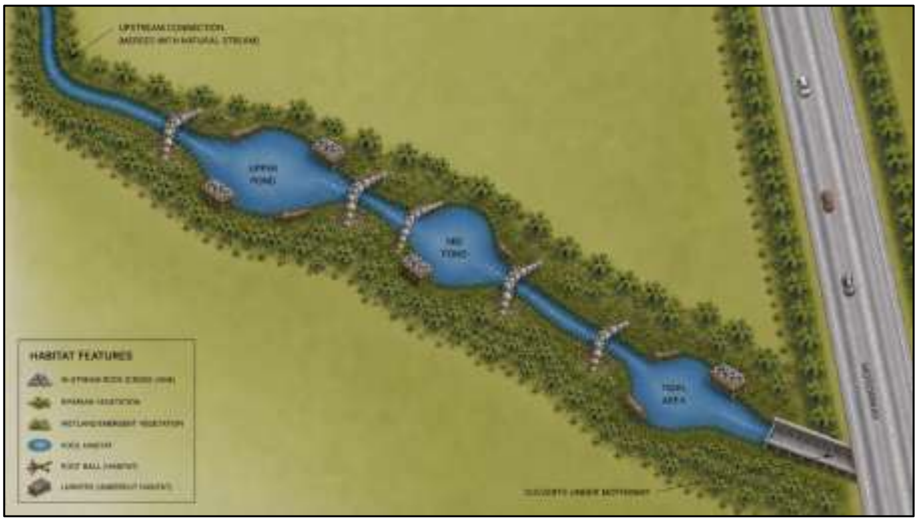

Figure 1 Habitat-focused conceptual map of the realigned channel, illustrating cross-vanes, refuge ponds containing root ball and LUNKER structures

Figure 2 Pre- and post-construction photos of Oyster Creek

Methods

Fish monitoring

Post-construction monitoring was undertaken during three sampling rounds: May 2025 (wet season), October 2025 (dry season/recessionary flow) and February 2026 (wet season). Ten sites were sampled during wet-season rounds, including locations downstream and upstream of the motorway culverts, at each of the five cross-vane run sites, the middle and upper refuge ponds, and the upstream connection with the natural channel (Table 1). During the October dry-season round, sampling was unable to be undertaken at each of the cross-vanes as no flow was present in the runs.

Fish communities were surveyed using a combination of passive netting and boat-mounted electrofishing. Nets were set at key migration points, including upstream and downstream of the motorway culverts and along run habitats at the upstream margin of each cross-vane. Refuge ponds were boat electrofished using standardised timed "shots" to sample across available habitat types. All fish captured were identified to species level, measured and returned to the waterway.

Table 1 Monitoring sites, assessment objectives and sampling effort across the three post-construction survey rounds (May 2025, October 2025 and February 2026). Ticks indicate when each site was sampled using the specified method

Site	Method/Assessment Objective	May 2025	Oct 2025	Feb 2026
Downstream of M1 Culverts	Characterise the fish community downstream of the culverts. Netting.	✓	✓	✓
Upstream of M1 Culverts	Determine which species and size classes successfully migrate through the culverts. Netting.	✓	✓	✓
Cross-vanes 1 - 5	Netting: Determine which species and size classes successfully migrate through the run-type reaches between ponds, including the cross-vanes.	✓		✓
Ponds (Middle and Upper)	Identify fish community composition within ponds and evaluate habitat use. Boat electrofishing.	✓	✓	✓
Upstream Connection	Determine whether fish are migrating through the realignment and into the natural upstream channel. Netting when flow.	✓		✓

Data analysis

Catch rates were standardised as fish per minute to enable comparison across sites and sampling periods. Passage effectiveness at the motorway culverts was evaluated by comparing upstream and downstream species composition and size structure across sampling rounds, with composition and relative abundance assessed by habitat type and season. For the most abundant species, mean lengths were compared between upstream and downstream sites using Welch's two-sample t-tests where sample sizes allowed, providing a variance-robust test for potential size-selective passage effects.

Pre-construction monitoring of Oyster Creek was undertaken by frc environmental in February–March 2019 (frc environmental, 2019). Seven sites were sampled: two tidally influenced locations (upstream and downstream of the M1 culverts) and five freshwater sites comprising four isolated pools separated by modified bunds and pipe culverts, and one run habitat where flows were present. Sampling was conducted using a combination of fyke, seine and dip nets, providing a baseline fish community dataset against which post-realignment changes in species richness, abundance and spatial distribution were qualitatively assessed.

Results

Species composition across sites

Sixteen species (14 native, 2 exotic) were recorded across all sampling rounds. The assemblage was strongly dominated by four species, which together accounted for 96.7% of all captures: estuary glassfish (*Ambassis marianus*) (36.3%), empire gudgeon (*Hypseleotris compressa)* (32.8%), eastern gambusia (*Gambusia holbrooki*) (14.5%), and sea mullet (*Mugil cephalus*) (13.2%). The remaining 12 species collectively contributed only 3.3% (Figure 3).

Species composition at the culverts was similar upstream and downstream, with estuary glassfish and empire gudgeon dominating all rounds. Several estuarine vagrants (common silverbiddy (*Gerres subfasciatus*), crescent grunter (*Terapon jarbua*), eastern bluespot goby (*Pseudogobius olorum*), yellowfin bream (*Acanthopagrus australis*) and the amphidromous Pacific blue-eye (*Pseudomugil signifer*) were detected only downstream, while giant herring was recorded only upstream in February.

Habitat-specific patterns were evident. Cross-vane sites alternated between empire gudgeon and gambusia dominance depending on season, while pond habitats showed strong seasonal turnover, including increasing sea mullet dominance through summer.

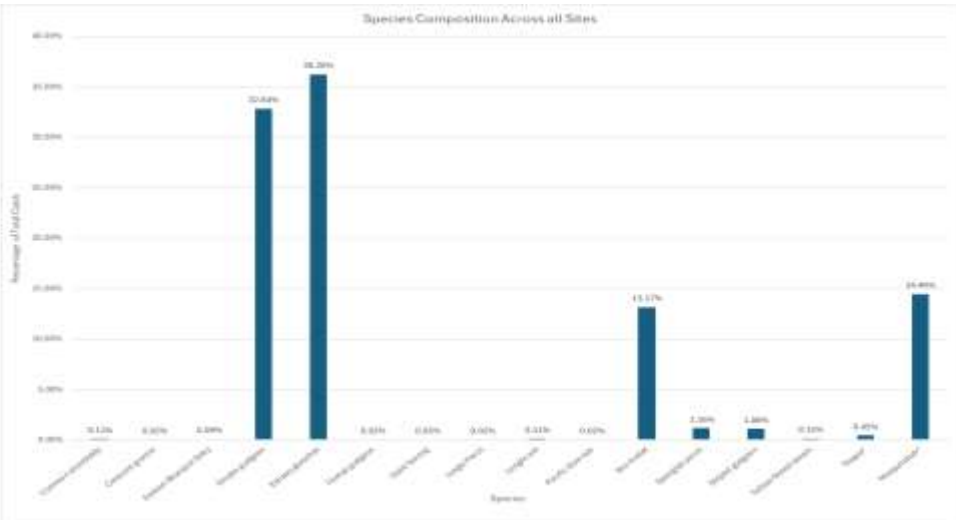

Figure 3 Species composition across all sampling rounds, showing the dominance of estuary glassfish, empire gudgeon, gambusia and sea mullet

Catch rates and spatial–seasonal patterns

Catch rates varied across the 10 sampling locations between May 2025 and February 2026 (Figure 4). Because different sampling methods were used - electrofishing in the two pond habitats and netting at all other sites - catch rates are presented separately to avoid methodological bias. Electrofishing in the pond habitats produced the highest catch rates, with Middle Pond reaching 4.96 fish/min in May and Upper Pond 4.76 fish/min in October, reflecting high fish densities and the efficiency of electrofishing in confined habitats. Netting results across the remaining eight sites showed lower catch rates.

Cross-vane sites (CV1–CV5) consistently recorded values below 0.5 fish/min, including a minimum of 0.002 fish/min at CV1 in February (1 fish in 425 minutes). Seasonal patterns were evident, with October producing the highest catch rates at the Downstream and Upstream Culvert sites (3.97 and 3.68 fish/min, respectively), while May and February values ranged between 1.0–1.5 fish/min. The Upstream Connection site remained relatively stable across sampling rounds (2.34 fish/min in May and 1.24 fish/min in February), with 767 fish captured in total.

Size structure and passage-related patterns

Length-frequency distributions were broadly similar upstream and downstream of the culverts, with most individuals falling within the 29–59 mm size range, indicating a juvenile-dominated assemblage (Figure 5). However, mean lengths were consistently greater upstream, particularly in October and February.

Welch's t-tests for the two most abundant species revealed no significant downstream–upstream differences in May, but highly significant upstream-larger patterns in October for both estuary glassfish ($p < 0.0001$) and empire gudgeon ($p < 0.001$) (Figure 6). February showed the same pattern for glassfish ($p < 0.0001$), while low upstream gudgeon numbers limited inference.

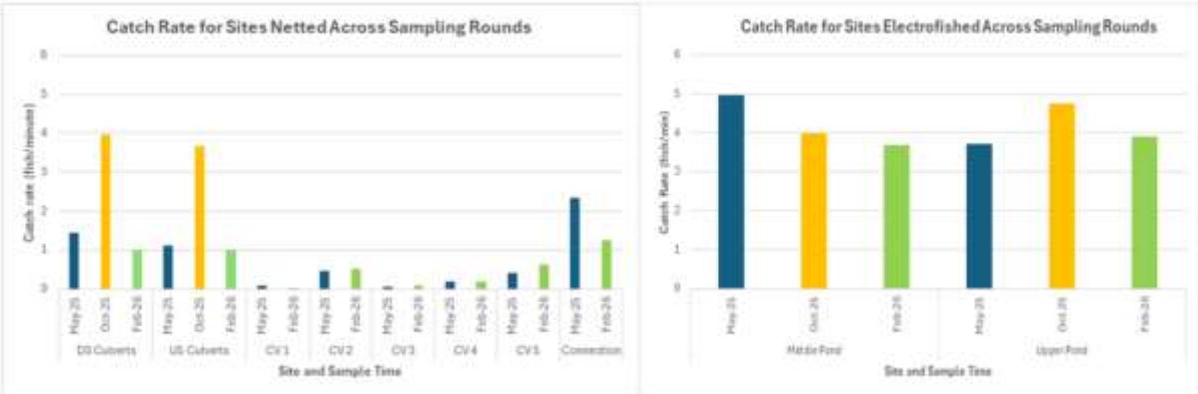

Figure 4 Catch rates (fish min^{-1}) across constructed habitat types in the Oyster Creek realignment during the May 2025, October 2025 and February 2026 monitoring rounds. Standardised electrofishing and netting data show strong spatial and seasonal variation among ponds, culvert sites and cross-vane runs

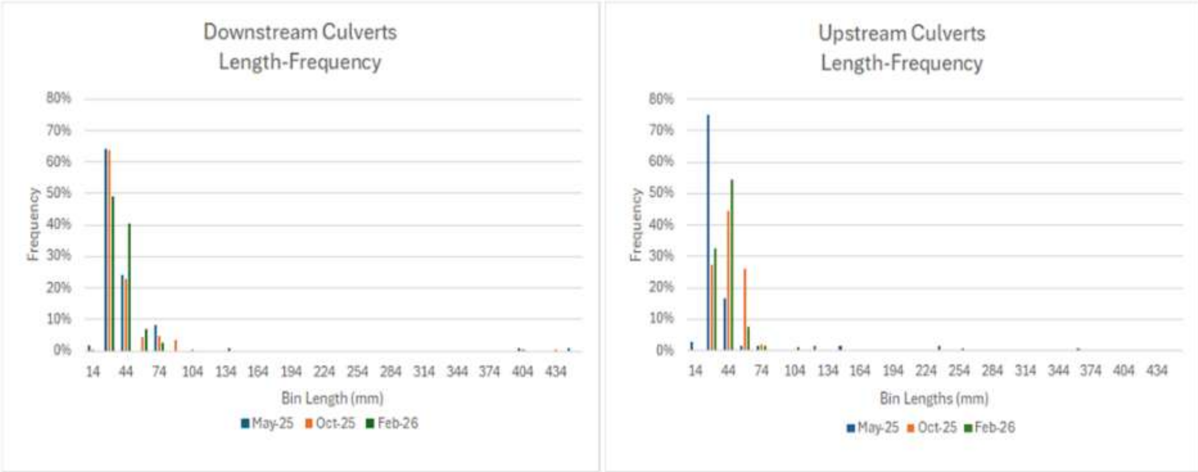

Figure 5 Length-frequency distributions of fish captured downstream and upstream of the M1 culverts across the May 2025, October 2025 and February 2026 surveys. Most individuals fell within the 29–59 mm size range, indicating a juvenile-dominated assemblage

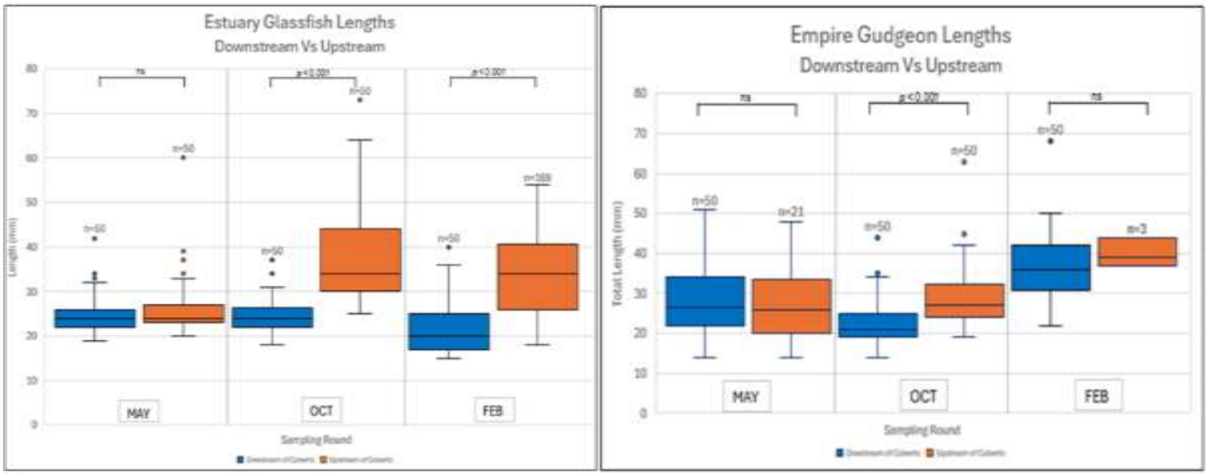

Figure 6 Side-by-side boxplots showing downstream (DS) and upstream (US) length distributions for estuary glassfish (left) and empire gudgeon (right) across the May 2025, October 2025 and February 2026 sampling rounds. Boxes show medians and interquartile ranges, with whiskers to 1.5× IQR. Welch's t-tests indicate significant DS–US differences in October for both species and in February for estuary glassfish, with no significant differences in May. Sample sizes (n) are shown for each group

Comparison with pre-construction baseline

Relative to the pre-construction survey conducted by frc environmental (2019), post-construction monitoring recorded higher species richness, greater abundance, and expanded longitudinal distribution (Table 1). Several estuarine vagrants and diadromous species absent in 2019 were detected post-construction, indicating improved connectivity. It should be noted that the *Hypseleotris spp*. recorded during pre-construction surveys was likely an unresolved identification, and therefore not a distinct species from the *Hypseleotris* detected post-construction.

Two exotic species were recorded post-construction: Mozambique tilapia (*Oreochromis mossambicus*) (low numbers, absent at culverts) and eastern gambusia (widespread but absent at both culvert sites). Pre-construction surveys recorded only eastern gambusia, often at very high densities.

Table 1 Summary fish species recorded within the Oyster Creek freshwater reaches pre-construction (2019) and post-construction (2025–2026), showing changes in species presence and the addition of new native and exotic taxa following channel reconstruction. *exotic species

Common Name	Scientific Name	Pre-Construction	Post-Construction
Carp gudgeon	Hypseleotris spp.	✓	✗
Empire gudgeon	Hypseleotris compressa	✓	✓
Firetail gudgeon	Hypselotris gallii	✗	✓
Jungle perch	Kuhlia rupestris	✗	✓
Longfin eel	Anguilla reinhardtii	✗	✓
Sea mullet	Mugil cephalus	✗	✓
Spangled perch	Leiopotherapon unicolor	✗	✓
Striped gudgeon	Gobiomorphus australis	✓	✓
Tilapia*	Oreochromis mossambicus	✗	✓
Gambusia*	Gambusia holbrooki	✓	✓

Discussion

Fish passage performance at the M1 culverts

Patterns in species composition and size structure upstream and downstream of the M1 culverts indicate that the extended 115 m structures continue to provide effective longitudinal connectivity. The dominance of estuary glassfish, empire gudgeon and sea mullet at both culvert sites across all sampling rounds, together with the detection of estuarine vagrants and diadromous species upstream of the culverts, demonstrates that tidal migrants are routinely reaching, and in several cases traversing, the culverts.

Size-based analyses further support functional passage. In May, mean lengths of estuary glassfish and empire gudgeon did not differ between the culvert sites, indicating unrestricted movement during this period. The larger upstream size classes observed in October and February could superficially suggest size-selective passage; however, seasonal life-history dynamics may also provide a plausible explanation. For glassfish, the concentration of small individuals downstream during spring and summer aligns with peak recruitment in mangrove-lined nursery habitats. Their presence upstream of the culverts, including a broad size range, confirms that individuals can traverse the culverts when required. For empire gudgeon, the downstream bias in small size classes may reflect natural larval drift toward estuarine habitats and subsequent juvenile recruitment, rather than a barrier effect. This interpretation is supported by the May sampling round, where no significant size difference was detected between upstream and downstream culvert sites, indicating unrestricted movement through the culverts under low flow conditions. Additional sampling across a broader range of flow conditions would help further resolve any subtle size-related passage patterns.

Collectively, these patterns indicate that the culverts remain hydraulically suitable for small-bodied and juvenile fishes. Continuous submergence and low-velocity reverse tidal flows likely facilitate movement. While behavioural factors such as light avoidance were not assessed, the biological evidence strongly supports ongoing functional passage. These findings contribute to the growing evidence base that long culvert extensions, when designed to maintain depth and low-velocity conditions, can remain permeable to small-bodied native fishes.

Habitat functionality and use of constructed features

Habitat associations observed during monitoring were consistent with expected ecological patterns and previous rounds. Macrophyte beds in the constructed ponds, water primrose (*Ludwigia peploides* subsp. *montevidensis*), waterlily (*Nymphaea* sp.) and ribbon weed (*Vallisneria nana*) supported high abundances of small-bodied natives, particularly gudgeons and spangled perch, and provided spawning habitat evidenced by breeding colouration in October. These observations align with the low-flow recruitment framework, in which many species spawn during stable low-flow periods, allowing larvae to develop in littoral habitats before wet-season dispersal.

Woody structures and LUNKERS showed limited fish use during monitoring, consistent with early-stage colonisation. These structures are still developing periphyton and invertebrate communities that typically enhance habitat value. Sampling limitations, particularly the difficulty of detecting fish within submerged cavities of the LUNKERS may also have contributed to low observed use. As biological colonisation progresses, increased utilisation of these features is expected, and complementary methods such as underwater cameras or sonar technology could improve detection. The rapid uptake of macrophyte-rich ponds highlights how constructed habitats can function as dynamic ecological assets rather than static engineering features, supporting the concept of living, evolving waterways.

Ecological outcomes relative to pre-construction conditions

Comparison with the 2019 baseline demonstrates substantial ecological improvement following realignment. Species richness increased, native species expanded their spatial distribution, and estuarine vagrants, diadromous species absent from the baseline were detected throughout the system. These changes reflect enhanced connectivity and improved habitat diversity within the reconstructed channel and ponds.

Seasonal monitoring highlighted the importance of temporal context. Spring surveys (October) produced the highest catch rates and species abundances, consistent with recruitment pulses and increased movement under favourable conditions. Wet-season surveys (May and February) confirmed upstream movement of juveniles and small-bodied fishes, demonstrating that the reconstructed alignment supports passage across a range of flow conditions.

Colonisation, recruitment and system-wide connectivity

Juvenile and sub-adult size classes dominated catches across the system, indicating active recruitment and successful colonisation of newly created habitats. Seasonal shifts in upstream size structure suggest multiple cohorts moving through the system and occupying upstream habitats as they develop. The presence of diadromous species requiring estuarine or marine connectivity, such as jungle perch and large sea mullet, further confirms that the reconstructed reach supports movement by species with diverse life-history strategies. The widespread distribution of small-bodied natives, including very small empire and striped gudgeons, demonstrates rapid utilisation of ponds, runs and cross-vane habitats.

Exotic species dynamics and implications

Post-construction monitoring recorded two exotic species, gambusia and tilapia, compared with only gambusia in 2019. Tilapia occurred in low numbers, likely reflecting recent colonisation facilitated by regional flooding. Gambusia remained widespread but were absent from both tidal culvert sites, suggesting salinity-related constraints. Their highest abundances occurred in shallow run habitats at cross-vane sites during February.

Importantly, exotic species no longer dominate the system as they did pre-construction. Increased habitat complexity and improved connectivity appear to support stronger native assemblages that may be limiting exotic proliferation. Although exotic richness increased, their ecological influence appears reduced relative to baseline conditions.

Conclusions

Post-construction monitoring shows that the realigned Oyster Creek channel and extended M1 culverts are performing as intended, maintaining ecological connectivity and supporting a diverse native fish community. Upstream–downstream patterns in species composition and size structure confirm that the 115 m culvert extension remains permeable to small-bodied fishes, juveniles and diadromous migrants, with seasonal size differences likely reflecting life-history cycles rather than passage constraints.

Constructed habitats, particularly macrophyte-rich ponds and runs, are supporting high abundances of small-bodied natives and providing spawning and nursery functions, while early colonisation of woody structures and LUNKERS is progressing. Relative to the 2019 baseline, species richness, spatial distribution and recruitment have all improved, indicating a broader and more connected assemblage. Although exotic species persist, their influence appears reduced under the more complex habitat conditions.

Overall, the realignment has delivered measurable ecological benefits, restored connectivity and supported a more resilient fish community. The project shows that contemporary design standards, and the regulatory and environmental requirements that underpin them, can deliver strong ecological outcomes while still meeting essential hydraulic and engineering objectives. It provides a practical example of engineering and ecological design working together to create living, resilient waterways.

Acknowledgements

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