Background to fish sampling and index calculation

1 Purpose and scope

The purpose of this document is to provide some general information on fish sampling and index calculation.

2 Associated documents

Biological assessment:

- *Sampling fish communities using fyke nets*
- *Sampling fish communities using bait traps*
- *Sampling fish communities using gill nets*
- *Sampling fish communities using electrofishing*
- *Sampling fish communities using seine nets*
- *Sampling fish communities using cast nets*
- *Fish holding, identification and measurement of length and weight*
- *Fish collection and dissection for the purpose of chemical analysis of tissues*

3 Introduction

Fish communities are useful indicators in assessing aquatic ecosystem health (Kennard et al. 2001) because they are sensitive to changes in water quality and habitat structure which may occur as a consequence of either natural causes or anthropogenic activities (Pidgeon 2004). Sampling of fish communities both spatially and temporally can provide valuable information about any natural and/or human disturbances. Comparisons of fish community structure and abundance data collected across sites (including control and/or reference sites) and over time (if possible) can assist in identifying potential impacts from human activities such as water pollution events, poor land use practices, alteration in stream flow and connectivity, reduced riparian vegetation and sediment aggradation on the stream bed.

Fish communities have the following attributes, making them useful indicators for assessing aquatic ecosystem health (Kennard et al. 2001):

- fish are a taxonomic group commonly found in nearly all aquatic environments
- fish are relatively long-lived and mobile, thereby able to reflect conditions over a broad temporal and spatial scale, providing valuable information about the overall catchment health
- a variety of species make up the fish community over a range of trophic levels
- fish are consumed by humans, and consequently there is often a public interest in fish communities
- fish are useful in detecting potential contaminants through tissue analysis (see *Biological assessment—Fish collection and dissections* for further information)
- fish are easily collected using a variety of fish sampling methods, and it is possible to sample, identify and release the individuals back into the water unharmed.

There are a variety of methods for sampling fish communities, and designing a fish sampling program will need to take into consideration a number of factors, such as:

- the aim of the sampling

- habitats available for sampling
- amount of time available for sampling
- experience of the sampler/s
- equipment available
- necessary permits and authorities (e.g. General Fisheries Permit, Animal Ethics approval), and associated restrictions.

4 Fish sampling methods

Fish sampling methods can be either active or passive, with active gear moved through the water column to capture fish, whereas passive gear is set stationary within the water column to collect fish swimming into it. Each fish sampling technique has advantages and disadvantages, and the use of each will depend upon the environment to be sampled.

Active sampling techniques include electrofishing, seine netting and cast netting. These techniques allow the sampler to actively target communities and provide immediate results. These are ideal for rapid assessments; however, each method has some limitations. For example, electrofishing is less effective in high conductivity waters (e.g. >1000µs/cm), and seine netting is difficult in areas with many snags in the water.

Passive fish sampling techniques include fyke nets, gill nets and bait traps. These methods allow nets/traps to be set in targeted habitats, and are designed to be left in the water and collected after a predetermined amount of time. These methods may be more time-consuming as often they require the sampler to return to a site after a set period of time to collect the net and process the fish catch.

Fish sampling methods vary in efficiency across fish species, and environmental characteristics, e.g. water turbidity, depth, flow. Often, a variety of sampling techniques may be needed to address the aim of sampling.

Detailed information on each fishing method can be found in the documents listed in Section 2 – *Associated Documents*. Information on the permits and approvals required for conducting a fish survey can be found in the *Sampling design and preparation—Permits and approvals* document.

5 Fish indices

Fish indices have been developed to aid in interpretation of sampling results, particularly when sampling has been conducted in a quantitative manner. There are currently three fish indices prescribed as water quality objectives (WQOs) under the *Environmental Protection (Water) Policy 2009* (EPP Water), which falls under the *Environmental Protection Act 1994*. WQOs are measures established to protect the environmental values of the waterway, and apply to receiving waters. It should be noted that WQOs are not currently available for every catchment in Queensland[1].

The three fish indices currently prescribed as WQOs under the EPP Water are:

- Percentage of Native Species Expected (PONSE)
- Ratio of Observed to Expected species ratio (O/E_{50}) and,
- Percent of Alien Fish individuals.

Each of these indices is described below.

5.1 Percentage of Native Species Expected (PONSE)

The Percentage of Native Species Expected (PONSE) indicator is the number of native fish species observed at a site as a percentage of the number of native fish species expected to occur at a physically similar site under minimally-disturbed conditions. Kennard et al. (2001) found that the number of native fish species declines with increasing level of disturbance, and the PONSE indicator can reflect a variety of sources of

[1] Further information can be found at http://www.des.qld.gov.au/water/policy/

disturbance at a range of spatial and temporal scales. Only the total number of different native species found at a site compared to the expected number is used to calculate this index; the identities of the native species present are not taken into account.

To calculate the PONSE index, a numeric model is used to determine the expected number of native fish species, usually based on landscape (e.g. site elevation, distance from river mouth, distance from source) and/or habitat variables (e.g. stream width, depth). PONSE is expressed as a percentage, with a score of 100% indicating the number of native fish species observed is the same as expected at a site under minimally disturbed conditions; and a score close to 0% suggesting there is a high level of disturbance at the site. The current WQOs for the PONSE index are 100%.

Background on the development of the original model for PONSE can be found in Kennard et al. (2001, 2006a). Details of data requirements and model predictions may be obtained via e-mail from water.data@qld.gov.au.

5.2 Ratio of Observed to Expected native species (O/E_{50})

The ratio of Observed to Expected native species (O/E_{50}) is the ratio of native fish species observed at a site against the native fish species expected to occur with ≥50% probability of occurrence at a physically similar site under minimally-disturbed conditions. The O/E_{50} ratio varies from the PONSE index in that it takes into account, at least in part, the identity of the native fish species caught and predicted to occur, rather than just the number of different native fish species. This means changes in species composition at a site from a minimally disturbed site can be assessed. As with the PONSE index, a numeric model is used to determine the expected native fish species at a site.

O/E_{50} scores are expressed as a ratio, with a score closer to one suggesting the fish assemblage observed at the site is close to what is expected at the site under minimally-disturbed conditions; and a score closer to zero suggesting the fish assemblage is different to what is expected at a minimally disturbed site, possibly due to anthropogenic disturbance. Kennard et al. (2001) found that low O/E_{50} scores were strongly associated with poor in-stream habitat, and disturbances due to land use, changes in water chemistry and channel degradation. The current WQOs for the O/E_{50} index are set at one. Details on the development of the original model used to calculate the O/E_{50} can be found in Kennard et al. (2001, 2006b), and a description of an improved model has been provided by Rose et al. (2016b). Details of data requirements and model predictions may be obtained via e-mail from water.data@qld.gov.au.

5.3 Percentage of alien fish individuals

The percentage of alien fish index is the number of alien[2] fish individuals expressed as a percentage of the total number of individuals caught. Research conducted by Kennard et al. (2001, 2005), and Rose et al. (2016c) indicated that water bodies affected by human activity and modification are more susceptible to invasion by alien fish species, and conversely, often less suitable as habitat for sensitive native fish species. As such, fewer native species and more alien species may be expected (Kennard et al. 2001, Rose et al. 2016c).

The current WQOs for the proportion of alien fish is zero.

6 References and additional reading

Kennard, MJ, Harch, BD, Arthington, AH, Mackay, SJ and Pusey, BJ 2001, ‘Freshwater fish as indicators of ecosystem health’, in MJ Smith and AW Storey (eds), *Design and Implementation of Baseline Monitoring (DIBM3): Developing an Ecosystem Health Monitoring Program for Rivers and Streams in Southeast Queensland*, *South-East Queensland Regional Water Quality Management Strategy*, unpublished report, Brisbane, pp. 9.1-9.61.

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Kennard, MJ, Arthington, AH, Pusey, BJ and Harch, BD 2005, ‘Are alien fish a reliable indicator of river health?’

[2] Alien species are fish species originating from outside of Australia. Species translocated within Australia are not classified as alien fish.

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