

## Reply

### Reply to the comment by Crook and Koster (2006) 'Temporal change in fish assemblages in the lower Goulburn River, south-eastern Australia'

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**Abstract.** In an earlier paper, multivariate statistics were used on historic fisheries data sets to show spatial differences between fish communities in the Goulburn Catchment (Victoria, Australia). In this reply paper, some further statistical analyses are presented to provide evidence for the assertion that fish communities at each site were stable over the temporal scale of the data was valid. Indeed, evidence for the stabilisation and persistence of fish communities after a major disturbance has also been recognised in other studies. Furthermore, in making judgements about the stability and persistence of fish communities, the scale of a study is an important factor, with patterns at the catchment scale often not being the same as those at smaller spatial scales.

We welcome the opportunity to reply to comments made by Crook and Koster (2006) on our paper, Pollino *et al.* (2004). In that paper, we presented analyses that demonstrated fish communities differed spatially in the highly altered Goulburn River and tributaries. These analyses temporally aggregated fisheries data from individual sites throughout the catchment (main channel and tributaries). The data used originated from irregular fish surveys conducted between 1970 and 2002 using a range of sampling gears, as indicated in the original manuscript (Pollino *et al.* 2004) and by Crook and Koster (2006).

Aggregating temporal data over such a time scale is problematic, as was recognised in the original manuscript and by Crook and Koster (2006). Crook and Koster (2006) challenge the findings in Pollino *et al.* (2004) stating that 'aggregation of data over several decades is unlikely to provide a reliable means of assessing the current condition of fish assemblages'. To demonstrate this, fish survey data collected during 2003–2004 from sites between Goulburn Weir and Yambuna (Victoria, Australia) were compared with 1982–1983 fish community data from approximately the same region using multivariate analyses (Crook and Koster 2006). This response paper does not dispute the findings.

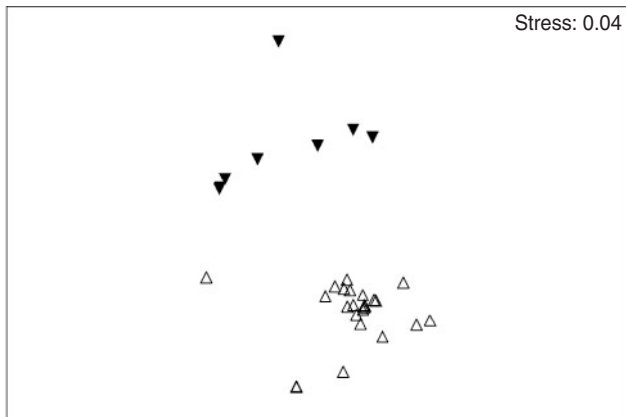
A major recommendation of the Pollino *et al.* (2004) paper was that more regular fish surveys were required in order to enable more rigorous analyses of the status of fish communities in the Goulburn Catchment to be assessed. It is satisfying to us that such surveys are now being carried out in the Catchment.

Crook and Koster (2006) also state that no data were presented in Pollino *et al.* (2004) to support the assertion that fish assemblages in the Goulburn River (there is no mention of tributaries) were stable over the last 32 years. Using only a small subset of the dataset from Pollino *et al.* (2004), this short paper seeks to demonstrate that the methods used for analyses in our previous paper can be supported.

Before introducing the results of these analyses, the contrasts between the statistical analyses of Crook and Koster (2006) and Pollino *et al.* (2004) should be noted:

- Crook and Koster (2006) did not include small-bodied fish in their analyses, whereas Pollino *et al.* (2004) used the complete data set;
- relative abundance data were analysed by Pollino *et al.* (2004) (not absolute abundance or catch per unit effort);
- the 2003–2004 survey data was not used by Pollino *et al.* (2004) because it was not available; and
- the sampling methods of the 1982–1983 database (Department of Sustainability and Environment, Victoria, Australia) were not fully described in the database documentation.

Using the statistical methods of Pollino *et al.* (2004), we have undertaken further analyses to show the temporal variation in the fisheries data at each site. In the analyses shown below, the absolute abundances of fish communities at two sites (Eildon – GEi and Shepparton – GS) were considered, with fishery sampling dates used as an explicit factor in



**Fig. 1.** Non-metric multidimensional scaling (NMDS) plot showing fisheries data from Eildon (white triangle) and Shepparton (black triangle). Individual symbols represent individual survey dates, including the 1983–1984 survey.

analyses. Analysis of all sites considered by Pollino *et al.* (2004) is beyond the scope of this response paper.

Non-metric multidimensional scaling (NMDS) was used to plot patterns in fish assemblage composition (Fig. 1). Analysis of Similarity results indicate that differences between sampling dates (ranging from 1970 to 2002) were insignificant ( $R = 0.182$ ,  $P = 0.15$ ). In contrast, significant spatial differences between data sets can be demonstrated ( $R = 0.935$ ,  $P = 0.001$ ). These results clearly show that fish communities had changed little over the temporal scale considered by Pollino *et al.* (2004). For this reason, relative abundance was used in analyses. This conclusion was reached using a different data set to that of Crook and Koster.

When analysing historical data sets, multiple collection methodologies can be a confounding factor (Fitzgerald *et al.* 1997; Fairchild *et al.* 1998; Bonner and Wilde 2000; Gido *et al.* 2002; Quinn and Kwak 2003; Reid 2004). As stated in our earlier paper, analyses using presence/absence and relative abundance data for the Goulburn Catchment were compared, and similar outputs were obtained. There is only limited value in presenting presence/absence data. Historical binary data limits interpretations of how successful a species is in an environment, which is an obvious drawback in assessing the difference between communities (Poole 1974). The use of historical data is important in evaluating which processes may have been important in altering community structure (Fitzgerald *et al.* 1997). Such studies are not unique (e.g. Quinn and Kwak 2003; Phillips and Johnston 2004; Santoul *et al.* 2005); however, few such studies have been undertaken in Australia.

In aggregating historical data sets from the Goulburn Catchment, we stated in Pollino *et al.* (2004) that fish communities in the Goulburn Catchment (for each site considered) were remarkably stable. The stability of the fish community across spatial and temporal scales reflects both the length

of time and the intensity of disturbance under investigation (Connell and Sousa 1983). Clearly, impoundments do have an impact on fish assemblages after construction (e.g. Bonner and Wilde 2000; Gehrke *et al.* 2002; Penczak 2004), but after this initial disturbance, fish communities have been shown to stabilise (Reid 2004), with native fish communities often shifting from specialist to generalist taxa (Fitzgerald *et al.* 1997).

The stability and persistence of fish assemblages in streams has been widely studied (e.g. Grossman *et al.* 1982; Connell and Sousa 1983; Hansen and Ramm 1994) and generally, fish communities are found to be more persistent and species abundances more stable in environmentally stable streams (Moyle and Vondracek 1985; Ross *et al.* 1985; Hansen and Ramm 1994). This can be particularly so downstream of impoundments where variability in flow is often reduced owing to dam operations, resulting in stable communities being established. Such stability downstream of impoundments has been observed in macroinvertebrate communities (Voelz and Ward 1991) and fish communities (Penczak 2004).

When examining the level of community stability, issues of scale must be taken into account (Connell and Sousa 1983; Ross *et al.* 1985). The spatial scale of a study can affect judgements of temporal stability or persistence of a fish community (Connell and Sousa 1983). Streams with overall consistent faunas may, at the scale of a sampling site, have as much as or more faunal change than with greater overall faunal change, since even small perturbations can cause local extinctions (Ross *et al.* 1985). The definitions and composition of fish assemblages used in analyses, as well as the types of analyses can also lead to alternative interpretations of data sets (Grossman *et al.* 1982; Rahel *et al.* 1984; Yant *et al.* 1984).

Unfortunately, no baseline studies were undertaken in the Goulburn Catchment before the building of Goulburn Weir (upstream of Shepparton) in 1889 or Eildon Dam (upstream of Eildon) in 1921. Thus, the changes to fish communities after these gross system disturbances and the subsequent pattern of recovery and establishment of altered fish communities were unmeasured. Comparatively minor changes have occurred in the Goulburn Catchment since the construction of impoundments.

When interpreting differences between assemblages across spatial scales in the Goulburn Catchment, every effort was made in Pollino *et al.* (2004) to limit the confounding differences caused by different sampling methods and temporal variation in fish communities. Subsequent analyses with absolute fisheries data, using Bayesian networks, continued to show spatial differences between fish communities in the Goulburn Catchment, but little temporal variation (Pollino *et al.* in press).

As stated in Crook and Koster (2006: 303) 'A major conclusion reached by Pollino *et al.*, was that fish communities in the Goulburn River are in poor condition and are currently

dominated by introduced species'. The analyses used to support this assertion are challenged by Crook and Koster, using fisheries data from a smaller spatial scale, and not the entire Goulburn River or its tributaries. Given the contrasts between studies, it is our opinion that the original conclusion of Pollino *et al.* (2004) is sound.

Given the vulnerability of native fish communities in the Goulburn catchment, it is important to routinely and rigorously monitor fish communities in the catchment. The fish kill downstream of Goulburn Weir in January 2004 demonstrates that not only are fish in the upper part of the lower catchment vulnerable, but so too are fish in the lower Goulburn River. By continuing to investigate the variation in fish assemblages across habitats, studies such as Pollino *et al.* (2004) and Crook and Koster (2006) can be used to further inform and improve catchment management.

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