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# Monitoring of estuarine and diadromous fishes in Mundoo Channel and Boundary Creek during high freshwater inflows


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## Executive summary

After almost a decade of severe drought, the Murray-Darling Basin recently experienced high flows that enabled substantial and continuing fresh water to be released into the Coorong estuary from September 2010 to June 2011. Given that the last flows through the barrages were small volumes in 2006-2007, the biological significance of fresh water entering the Coorong requires assessment to inform current and future management.

This study examines temporal changes in fish assemblages and populations in Mundoo Channel and Boundary Creek from December 2010 to April 2011, and aims to determine if estuarine and diadromous fish species successfully recruit during substantial freshwater inflows to the estuary channels. Specifically, it relates to the Department of Environment and Natural Resources and the Department for Water's Intervention Monitoring objectives regarding large barrages releases.

In December 2010, the Coorong channels were inundated with fishes from the Lower Lakes. Consequently, of the 47,419 fish representing 27 species captured in the study, 47% were sampled in December, 22% in January, 11% in February, 6% in early March, 11% in late March and 3% in April. Freshwater fish dominated the catches in December and January, especially young-of-the-year (0+) alien redfin and carp. In February, alien fish were less abundant, with the exception of goldfish, and the catch was dominated by two native freshwater species, flathead gudgeon and bony herring.

Smallmouth hardyhead, an estuarine fish commonly found in the Coorong, was one of the most numerous estuarine species. Five estuarine goby species were recorded, including a high abundance of Tamar River goby captured throughout the study. Young-of-the-year and 1+ greenback flounder were captured in high relative abundances at the mouth of Mundoo Channel in January, but occurred in low numbers or were absent from sites throughout the remainder of the study period. There was an increase in the relative abundance of yellow-eye mullet at Mundoo Channel towards the end of the study.

This study shows that breeding occurred for two diadromous fish species at the Coorong prior to December 2010: congolli and common galaxias. Significantly, 0+ congolli occurred in moderate relative numbers at Mundoo Channel and Boundary Creek throughout the study period, with a second younger cohort apparent by February 2011. Very few adult congolli were captured. Common galaxias was captured in moderate abundances in both channels, with a strong recruitment apparent in Mundoo Channel. Breeding was confirmed for yellow-eye mullet but, given its relatively long life cycle, recruitment associated with the inflows was not observed.

This study found that under consistently high freshwater inflows, Mundoo Channel and Boundary Creek are often uninhabited by large-bodied estuarine fish species, which corresponds to overseas studies in estuaries. Conversely, freshwater fish species were abundant because the channels were an extension of the Lower Lakes. The study also demonstrates the importance of the sheltered channels for early life stages of small-bodied estuarine and diadromous fish species and their recruitment.

## Introduction

Flow regime is the major ecological driver of rivers and can affect biodiversity (Ward *et al*. 1999). Similarly, estuaries experience variable levels of freshwater input, which can influence biota. For example, Dolbeth *et al*. (2010) found that decreases in fish production in two estuaries during drought were attributed to direct and indirect effects of changes in freshwater inflow. Alternatively, during high inflows to an estuary in Portugal, with ensuing low salinities, there was a significant reduction in fish species richness owing to the absence of estuarine and marine fishes (Costa *et al*. 2007).

Worldwide, fish are impacted by numerous river modifications including flow regulation (Lévêque *et al*. 2008). Fish species that rely on unique habitats have specialized diets or exhibit obligate life-history strategies (e.g. diadromous fish), and are especially vulnerable to the effects of reduced freshwater flows due to changes in water quality, physical habitat and connectivity (Franssen *et al*. 2007). Drought and over-abstraction of water in the Murray-Darling Basin (MDB) led to a dramatic reduction in water levels and quality at the lakes from 2003 to 2009 (Aldridge *et al*. 2009), and the decline of numerous fish species (Wedderburn and Hillyard 2010; Zampatti *et al*. 2010).

High flows in the River Murray since winter 2010 have led to substantial freshwater inflows to the Coorong of between 10-126 GL/day (SA Water, unpublished data). Until September 2010, the Coorong estuary had received no substantial inflow for almost a decade. However, relatively small volumes were released over several weeks in 2005 (750 GL) and 2006 (8.5 GL) through Mundoo Channel and Boundary Creek (Geddes and Wedderburn 2007). The biological significance of vast amounts of fresh water entering the Coorong requires assessment to inform water use management.

This study aims to describe temporal changes in fish assemblages in Mundoo Channel and Boundary Creek from December 2010 to April 2011 during freshwater inflows. Specifically, it relates to the following Department of Environment and Natural Resources' and the Department for Water's Intervention Monitoring objectives regarding the life-cycles and recruitment of estuarine and diadromous fishes during and following the large barrage release:

1. To assess the benefits of approximately 100 GL being released over the barrages in spring/early summer 2010 on diadromous and estuarine fish.
2. To address the hypothesis that salinity reductions will be localised, restricted to areas close to the barrage release.

This study addresses objective 1 by describing shifts in fish assemblages throughout the 2010-2011 season, and determining if estuarine and diadromous fish populations successfully recruit during substantial freshwater inflows to the estuary's channels. However, given the continuous high flows over the study period, objective 2 could not be addressed. Future research suggestions are discussed that would provide detailed information regarding the influences of freshwater inflows on fish populations.

## Materials and methods

Sampling occurred at three sites in each of two channels at Hindmarsh Island, Lake Alexandrina (Table 1; Figure 1). Sampling at each site consisted of an overnight set with a large double wing (20 mm mesh) fyke net set facing downstream and a small single wing (5 mm mesh) fyke net set perpendicular to the bank. Sampling occurred on six occasions: 1-3 December 2010, 4-6 January 2011, 1-3 February 2011, 1-3 March 2011 (i.e. March-a), 28-30 March 2011 (i.e. March-b) and 27-29 April 2011.

Fish were identified to species and counted. Total lengths (TL) of fish were measured. Given that the objectives of the study relate to estuarine and diadromous species, only the first 10 randomly selected fish of each freshwater species were measured from each net. Due to an overwhelming number of fishes earlier in the study, sub-sampling was conducted at site 3 in Mundoo Channel (M3) and all Boundary Creek sites (B1-3) in December 2010 and at the three Mundoo Channel sites in January 2011. Sub-sampling involved removing one scoop (15 cm × 10 cm handheld aquarium dab net) of fish from the total catch for complete processing. An estimate of total catch was obtained by multiplying the processed numbers of each species by the number of remaining scoops.

At each site and each sampling event, water temperature, salinity, conductivity and pH was measured using a using TPS WP-81 meter, and Secchi depth was recorded. Water depth was measured on one occasion, but it remained constant throughout the study.

Table 1. Study sites and co-ordinates (Datum WGS 84, Zone 54H).

| Site ID | Site name | Location | Northing | Easting |
|---|---|---|---|---|
| M1 | Mundoo Channel | near barrage | 309943 | 6064572 |
| M2 | Mundoo Channel | mid-channel | 308778 | 6064148 |
| M3 | Mundoo Channel | channel mouth | 309759 | 6063810 |
| B1 | Boundary Creek | near barrage | 313728 | 6063411 |
| B2 | Boundary Creek | mid-channel | 312794 | 6062861 |
| B3 | Boundary Creek | channel mouth | 311542 | 6062755 |

Figure 1. Sampling sites at Mundoo Channel and Boundary Creek.

# Results

## Habitat summary

Mundoo Channel is a shallow, wide channel that meanders several kilometres to meet the Coorong near the Murray Mouth. At the study sites the habitat consisted of sandy sediment and no submerged structure. Boundary Creek is a deeper and narrower channel that similarly meanders to the Coorong, but enters several kilometres further from the Murray Mouth. At the study sites, the habitat consisted of muddy sediment and no submerged structure.

Salinity was low and decreased at all sampling sites throughout the study period, with a maximum of 0.62 mg/L and a minimum of 0.15 mg/L (Table 2). Secchi depth remained low, suggesting high turbidity corresponding with high River Murray inflows to the channels. The range of pH 7.67-8.62 was measured throughout the study.

## Fish summary

Twenty seven fish species were captured in the six sampling events (Table 3). Of the 47,419 fish captured in the study, 47% were taken during 1-3 December 2010, 22% during 4-6 January, 11% during 1-3 February, 6% during 1-3 March, 11% during 28-30 March and 3% during 27-29 April 2011.

Freshwater fish species dominated the catches in both channels for all sampling events (Figures 2 and 3). In December and January, redfin and carp were predominant. Goldfish became more abundant as the study progressed. By February, alien fish were less abundant and the catch was dominated by flathead gudgeon, bony herring and Australian smelt.

The relative abundances of diadromous fishes, congolli and common galaxias, remained relatively low but consistent throughout the study period. Estuarine species declined at both channels as the season progressed. Smallmouth hardyhead was the most numerous estuarine species, apart from a higher abundance of lagoon goby in April. Greenback flounder was relatively abundant in December and January, but was mostly absent thereafter. Five goby species were captured, with Tamar River goby and lagoon goby being the most numerous. There was an increase in the relative abundance of yellow-eye mullet at Mundoo Channel towards the end of the study.

Table 2. Habitat measures for Mundoo Channel (M1-3) and Boundary Creek (B1-3).

| Site code* | Date sampled | EC ($\mu Scm^{-2}$) | Salinity ($g L^{-1}$) | pH | Temp. (°C) | Secchi (cm) | Depth (cm) |
|---|---|---|---|---|---|---|---|
| **M1** | 2/12/2010 | 853 | 0.417 | 8.42 | 22.7 | 21 | |
| | 5/01/2011 | 598 | 0.278 | 8.15 | 20.5 | 13 | |
| | 2/02/2011 | 663 | 0.315 | 8.32 | 20.8 | 16 | 48 |
| | 2/03/2011 | 399 | 0.185 | 8.32 | 16.2 | 22 | |
| | 30/03/2011 | 411 | 0.192 | 8.37 | 14.4 | 21 | |
| | 29/04/2011 | 333 | 0.154 | 8.31 | 16.1 | 31 | |
| **M2** | 2/12/2010 | 943 | 0.475 | 8.22 | 22.5 | 20 | |
| | 5/01/2011 | 668 | 0.370 | 7.95 | 21.3 | 13 | |
| | 2/02/2011 | 676 | 0.314 | 8.28 | 22.8 | 16 | 53 |
| | 2/03/2011 | 399 | 0.183 | 8.15 | 17.9 | 23 | |
| | 30/03/2011 | 422 | 0.201 | 8.39 | 15.5 | 24 | |
| | 29/04/2011 | 339 | 0.156 | 7.93 | 16.6 | 34 | |
| **M3** | 2/12/2010 | 1265 | 0.623 | 8.62 | 24.6 | 24 | |
| | 5/01/2011 | 771 | 0.369 | 8.03 | 22.9 | 13 | |
| | 2/02/2011 | 752 | 0.361 | 8.23 | 22.9 | 17 | 56 |
| | 2/03/2011 | 414 | 0.188 | 8.07 | 18.3 | 23 | |
| | 30/03/2011 | 450 | 0.210 | 8.47 | 15.1 | 23 | |
| | 29/04/2011 | 376 | 0.174 | 8.24 | 16.5 | 24 | |
| **B1** | 3/12/2010 | 964 | 0.471 | 8.22 | 22.7 | 18 | |
| | 6/01/2011 | 691 | 0.328 | 7.87 | 20.7 | 17 | |
| | 3/02/2011 | 623 | 0.291 | 7.88 | 21.1 | 18 | 85 |
| | 3/03/2011 | 403 | 0.188 | 7.75 | 16.9 | 26 | |
| | 29/03/2011 | 407 | 0.190 | 8.03 | 14.5 | 25 | |
| | 28/04/2011 | 337 | 0.156 | 7.67 | 16.8 | 24 | |
| **B2** | 3/12/2010 | 898 | 0.438 | 7.96 | 22.3 | 20 | |
| | 6/01/2011 | 705 | 0.338 | 8.15 | 22.1 | 19 | |
| | 3/02/2011 | 627 | 0.297 | 8.07 | 21.6 | 15 | 72 |
| | 3/03/2011 | 410 | 0.190 | 7.81 | 16.9 | 27 | |
| | 29/03/2011 | 411 | 0.192 | 8.26 | 15.1 | 22 | |
| | 28/04/2011 | 333 | 0.154 | 8.09 | 16.7 | 27 | |
| **B3** | 3/12/2010 | 871 | 0.417 | 7.92 | 23.9 | 21 | |
| | 6/01/2011 | 737 | 0.348 | 8.09 | 24.3 | 17 | |
| | 3/02/2011 | 631 | 0.297 | 8.09 | 21.9 | 16 | 66 |
| | 3/03/2011 | 416 | 0.193 | 7.99 | 17.9 | 19 | |
| | 29/03/2011 | 404 | 0.191 | 8.28 | 16.1 | 23 | |
| | 28/04/2011 | 346 | 0.161 | 8.13 | 16.1 | 24 | |

*Explanation of site codes in Table 1.

Table 3. Fish species and total captured at each sampling event. See scientific names and catch details in Appendices (Tables 4-10).

| **Functional group** | **Common name** | **Total captured** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Dec** | **Jan** | **Feb** | **Mar-a** | **Mar-b** | **Apr** |
| Diadromous | Congolli | 82 | 258 | 60 | 15 | 13 | 22 |
| | Common galaxias | 41 | 103 | 56 | 32 | 45 | 50 |
| | Short-finned eel | 0 | 0 | 1 | 0 | 0 | 0 |
| Estuarine | Smallmouth hardyhead | 2313 | 1280 | 141 | 27 | 131 | 18 |
| | Blue-spot goby | 51 | 91 | 0 | 0 | 0 | 0 |
| | Tamar River goby | 273 | 221 | 104 | 33 | 18 | 11 |
| | Long-finned goby | 5 | 9 | 1 | 0 | 0 | 1 |
| | Lagoon goby | 355 | 2053 | 58 | 128 | 47 | 88 |
| | Bridled goby | 47 | 35 | 60 | 12 | 3 | 5 |
| | Greenback flounder | 128 | 190 | 19 | 1 | 1 | 0 |
| | Long-snouted flounder | 39 | 8 | 0 | 0 | 0 | 0 |
| | Yellow-eyed mullet | 14 | 0 | 4 | 1 | 25 | 27 |
| Marine | Garfish | 2 | 0 | 0 | 0 | 3 | 3 |
| | Sandy sprat | 402 | 48 | 2 | 0 | 0 | 0 |
| | Soldier fish | 63 | 0 | 0 | 0 | 0 | 0 |
| | Luderick | 1 | 0 | 0 | 0 | 0 | 0 |
| Freshwater | Golden perch | 0 | 0 | 43 | 22 | 26 | 4 |
| | Bony herring | 730 | 876 | 1805 | 1095 | 701 | 442 |
| | Flathead gudgeon | 2770 | 3484 | 1244 | 919 | 491 | 319 |
| | Carp gudgeon | 3 | 5 | 3 | 0 | 4 | 2 |
| | Australian smelt | 1540 | 348 | 62 | 80 | 399 | 111 |
| | Murray hardyhead | 0 | 0 | 0 | 0 | 1 | 0 |
| | Unspecked hardyhead | 1 | 0 | 0 | 0 | 0 | 0 |
| | Carp | 1571 | 861 | 889 | 152 | 194 | 70 |
| | Goldfish | 0 | 2 | 274 | 283 | 152 | 82 |
| | Redfin | 12039 | 684 | 203 | 233 | 223 | 102 |
| | Gambusia | 0 | 0 | 0 | 0 | 3 | 0 |

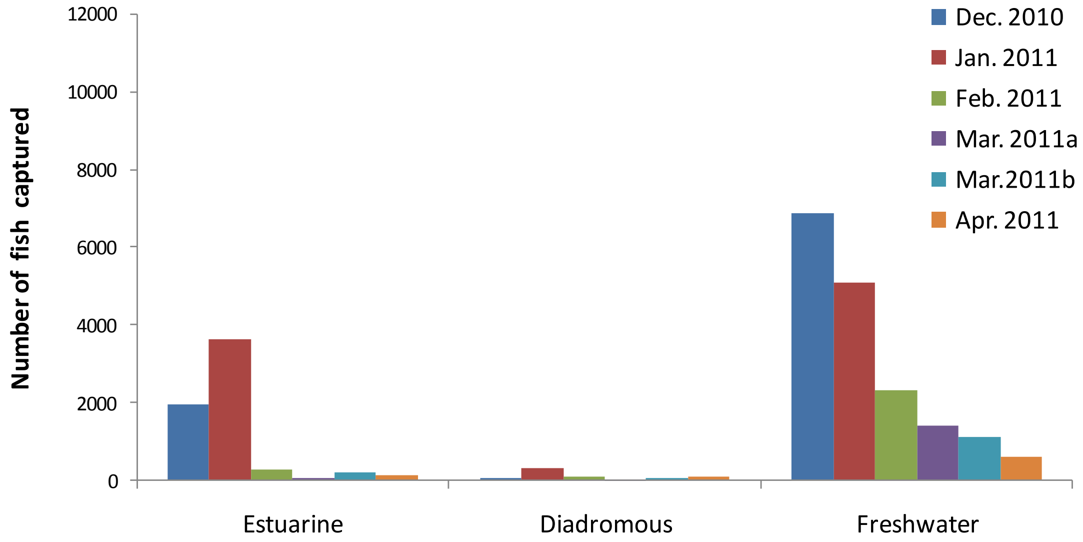


Figure 2. Relative abundance (total number of fish captured) of each functional group at Mundoo Channel for the six sampling events.

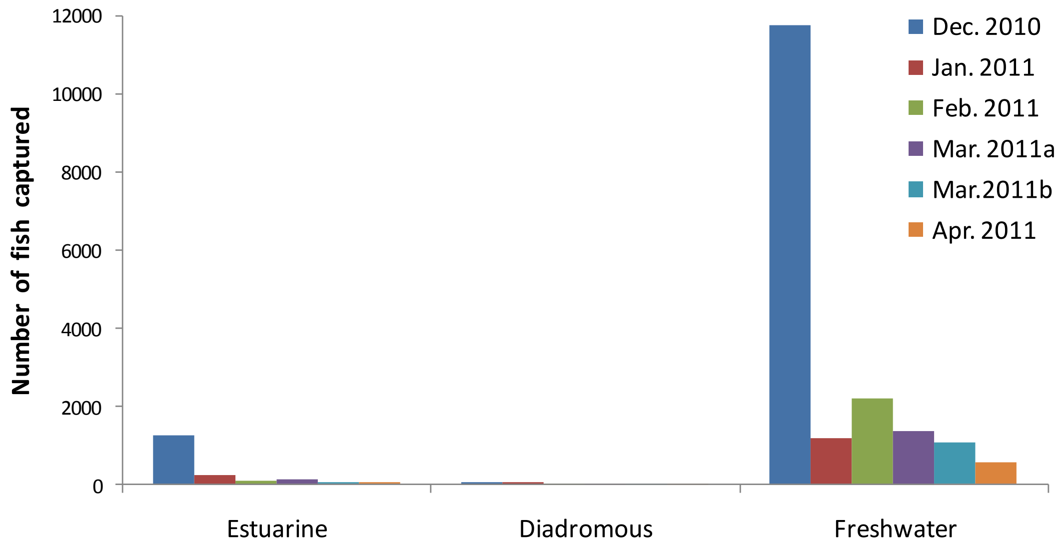


Figure 3. Relative abundance (total number of fish captured) of each functional group of fish at Boundary Creek for the six sampling events.

## Diadromous fishes

### *Congolli*

Congolli was low in relative abundance at Mundoo Channel during December, but substantially higher numbers of 0+ fish were recorded in January (Figure 4). Apart from a moderately high relative abundance in December, low numbers of 0+ congolli were captured at Boundary Creek.

Two 0+ cohorts were apparent from the bimodal length frequency distribution for Mundoo Channel in February (Figure 5). The oldest cohort (~80-90 mm TL) occurred at lower frequency, whilst the youngest cohort (~50 mm TL) was numerically dominant in Mundoo Channel and Boundary Creek (see photo above). Four adult congolli (185-260 mm TL) were captured from all sampling events at Boundary Creek, whereas only two adult fish were captured at Mundoo Channel (245 and 255 mm TL).

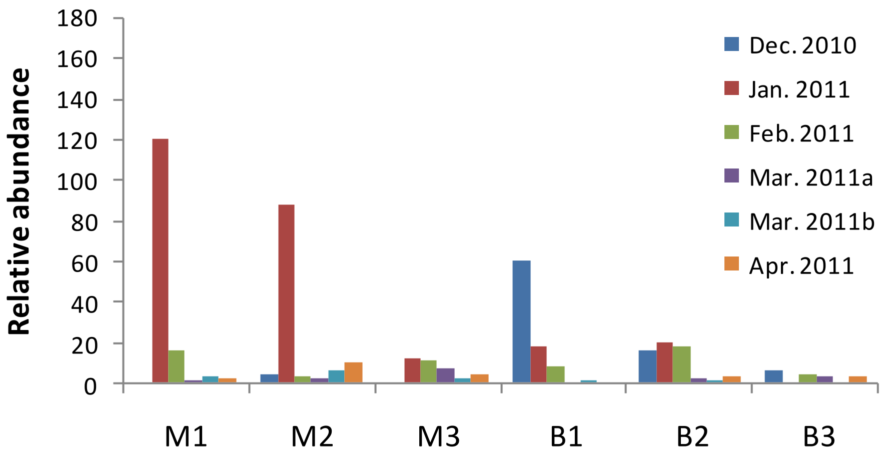


Figure 4. Relative abundance of congolli at each site for the six sampling events.

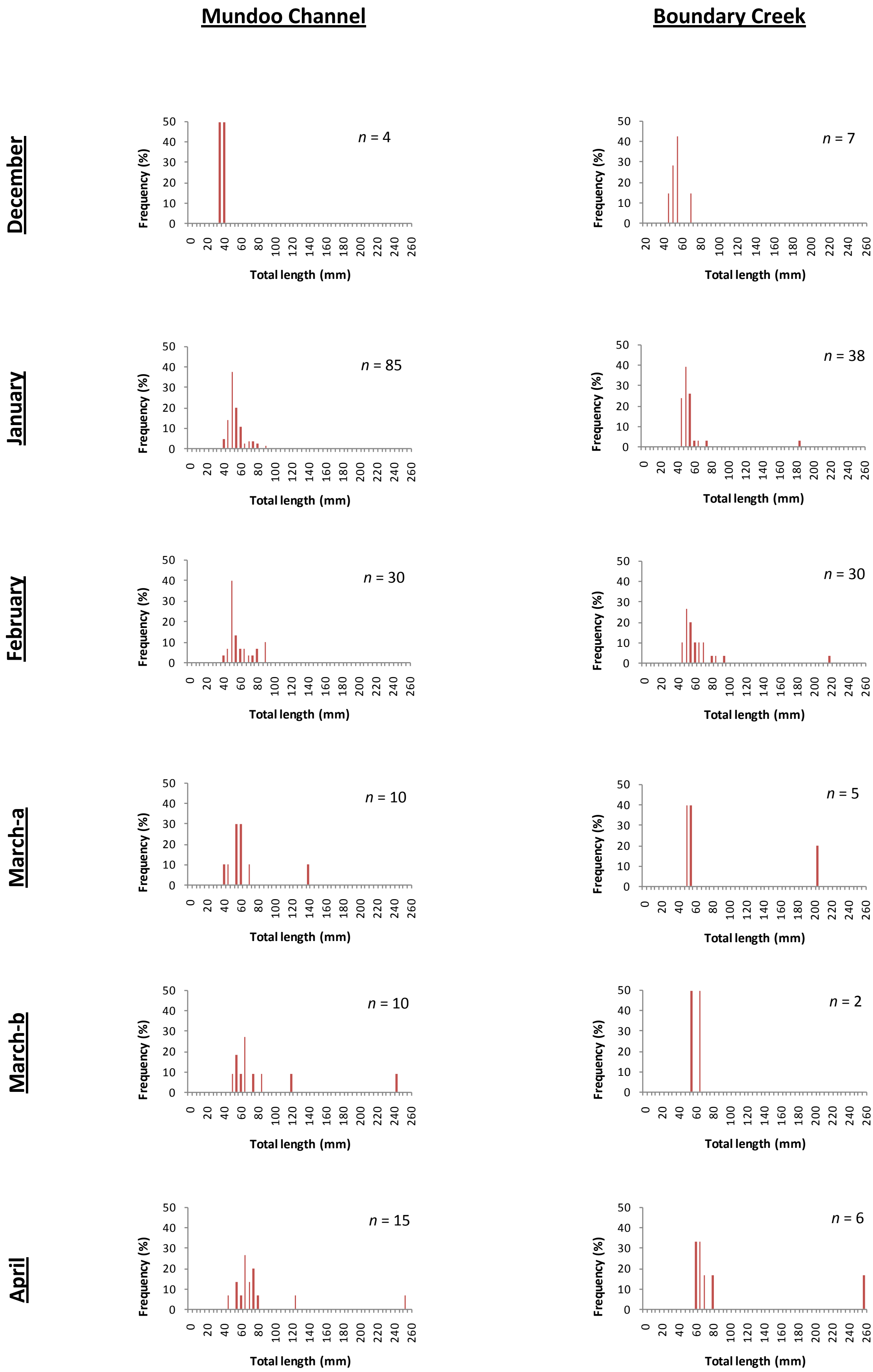


Figure 5. Length frequency distributions of congolli.

*Common galaxias*

Relative abundance of common galaxias was highest in January, particularly at the mid-channel sites M2 and B2 (Figure 6). Higher relative abundances were recorded at Mundoo Channel on most sampling events.

Length frequencies show that one 0+ cohort dominated the population (Figure 7). The larger adult fish (>80 mm TL; possibly 1+) were mostly detected at Mundoo Channel.

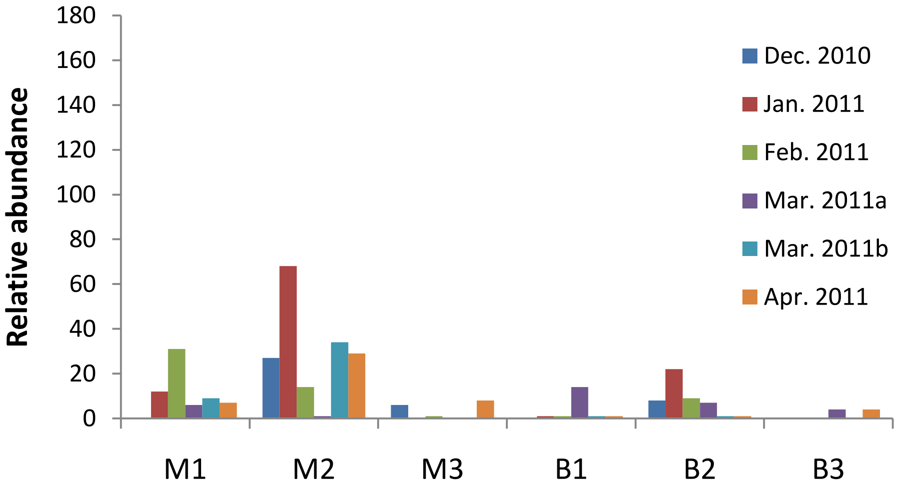


Figure 6. Relative abundance of common galaxias at each site for the six sampling events.

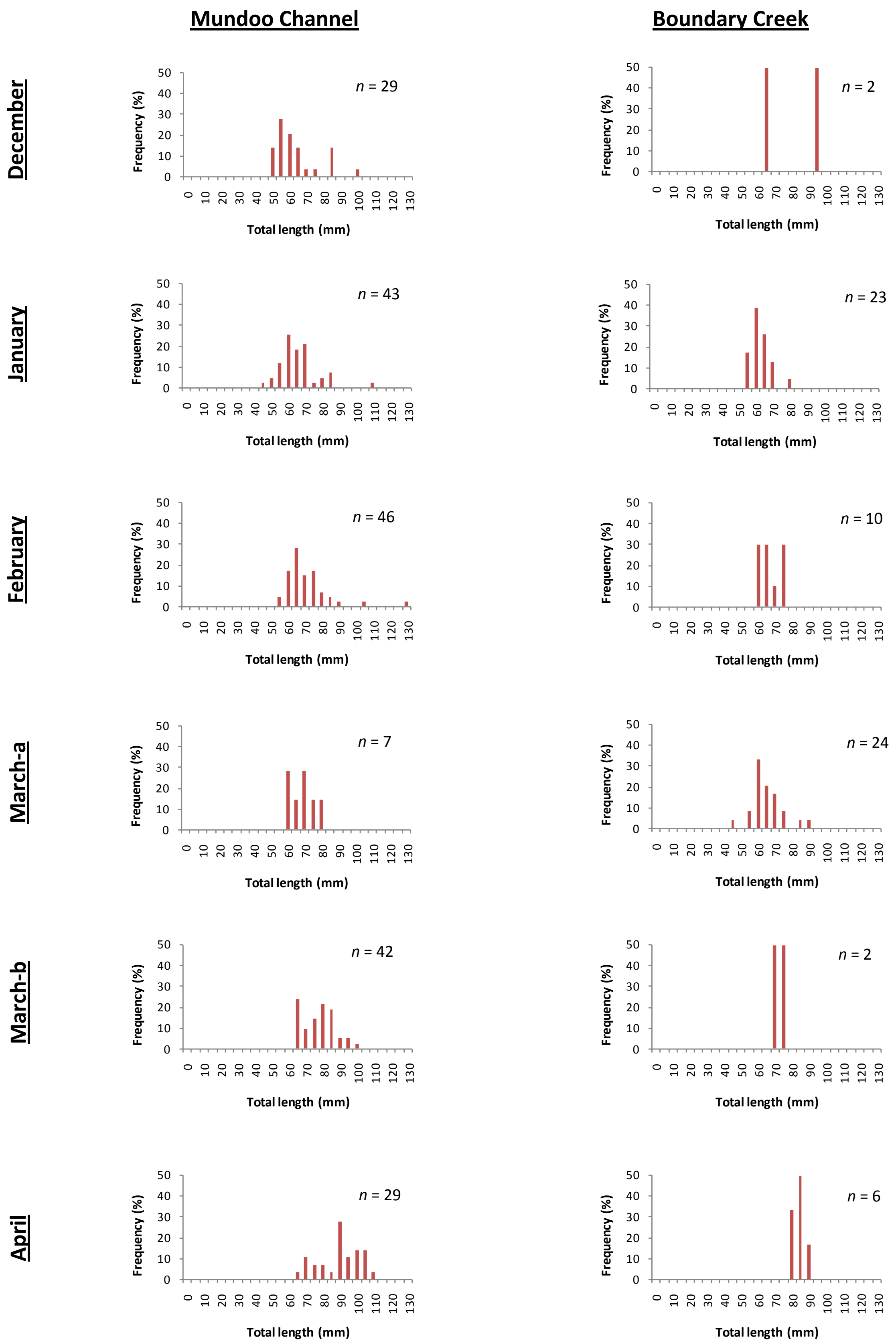


Figure 7. Length frequency distributions of common galaxias.

## Estuarine fishes

### *Smallmouth hardyhead*

Smallmouth hardyhead was one of the most abundant species captured in the study, with an extremely high abundance recorded just below the barrage at Mundoo Channel in December (Figure 8).

Length frequencies show that a single 0+ cohort dominated in December and January at Mundoo Channel and Boundary Creek (Figure 9). This cohort is likely to have hatched late in the 2009-2010 season (cf. Molsher *et al*. 1994). By February 2011, it cohabits with a second 0+ cohort (~40 mm TL) from the 2010-2011 season, as suggested by the bimodal frequency distributions. In April 2011, the two 0+ cohorts (~55 and ~100 mm TL) are also apparent in Mundoo Channel.

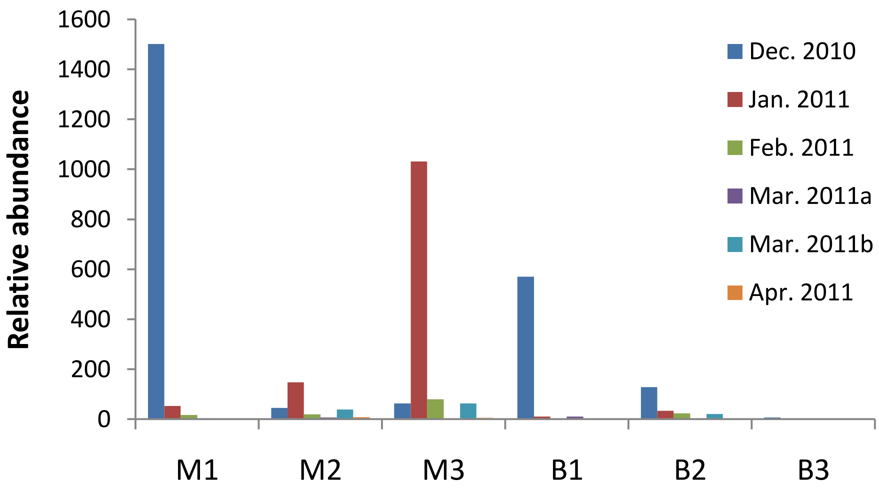


Figure 8. Relative abundance of smallmouth hardyhead at each site for six sampling events.

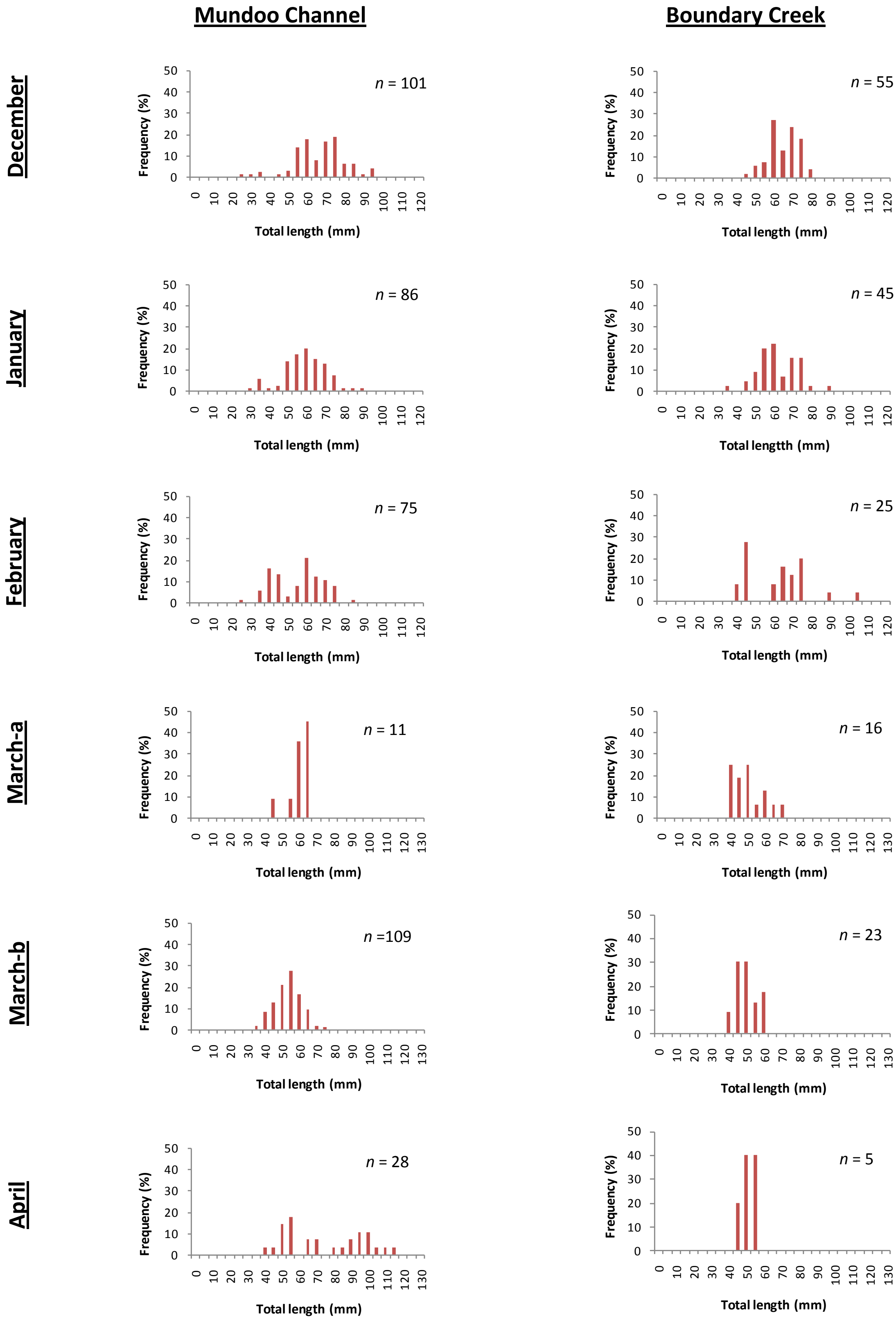


Figure 9. Length frequency distributions of smallmouth hardyhead.

### *Greenback flounder*

Greenback flounder (left in photo) was generally most abundant at the mouth of Mundoo Channel, where it was captured in high relative abundance in January 2011 (Figure 10). Low numbers were recorded at Boundary Creek, where it was not captured in January. Long-snouted flounder (right in photo) was also recorded at low relative abundance in December 2010, but was mostly absent thereafter.

Length frequencies display 0+ (~45 mm TL) and 1+ (80-120 mm TL) greenback flounder cohorts (cf. Noell *et al*. 2009), with the exception of one adult fish (285 mm TL) captured at Mundoo Channel in December 2010 (Figure 11). The 0+ fish were from the June-August 2010 breeding season. In January and February 2011, the catches were mostly an apparently fast growing 0+ cohort (~60 mm TL and 70-90 mm TL, respectively). The catch in February 2011 returned to an even mix of 0+ and 1+ greenback flounder.

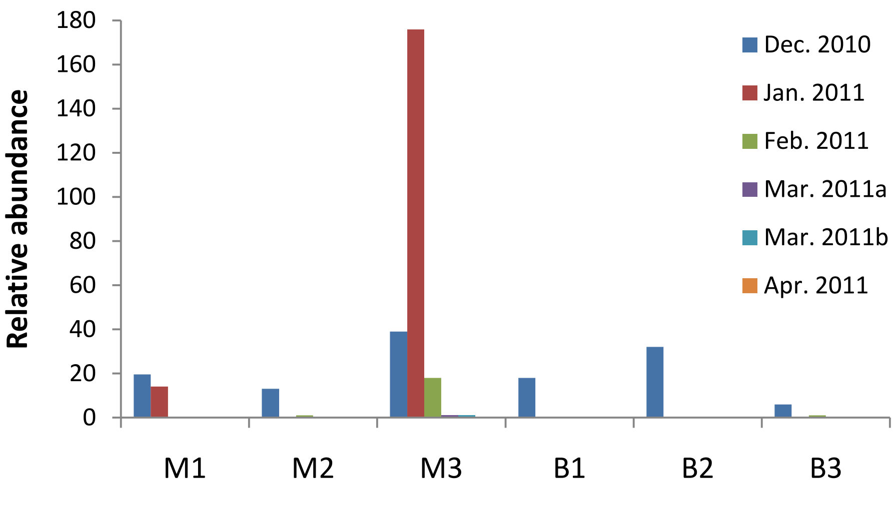


Figure 10. Relative abundance of greenback flounder at each site for the six sampling events.

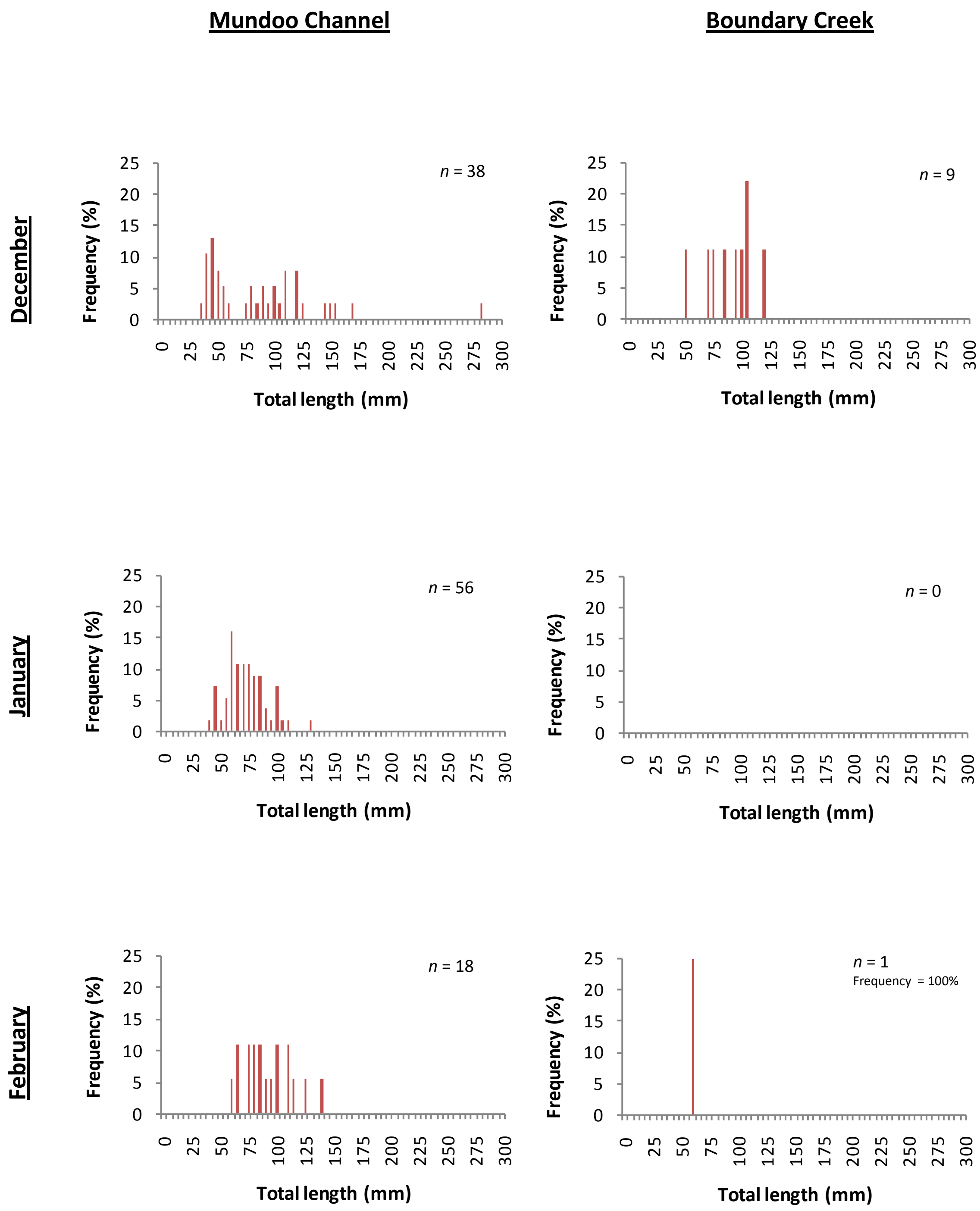


Figure 11. Length frequency distributions of greenback flounder.

### *Tamar River goby*

Tamar River goby was one of the most abundant estuarine species captured throughout the study (Figure 12). Its high relative abundance was most notable in Mundoo Channel, but high numbers were also recorded at Boundary Creek in December. The declines in overall abundances from February onwards are reflected by changes in the population age structure. Length frequencies show that a 1+ adult cohort dominated the population in December 2010 and January 2011 (Figure 13). From February, a younger 0+ cohort (cf. Noell *et al*. 2009) occupied both channels, and the larger individuals were absent suggesting that they had either died or moved to other habitats.

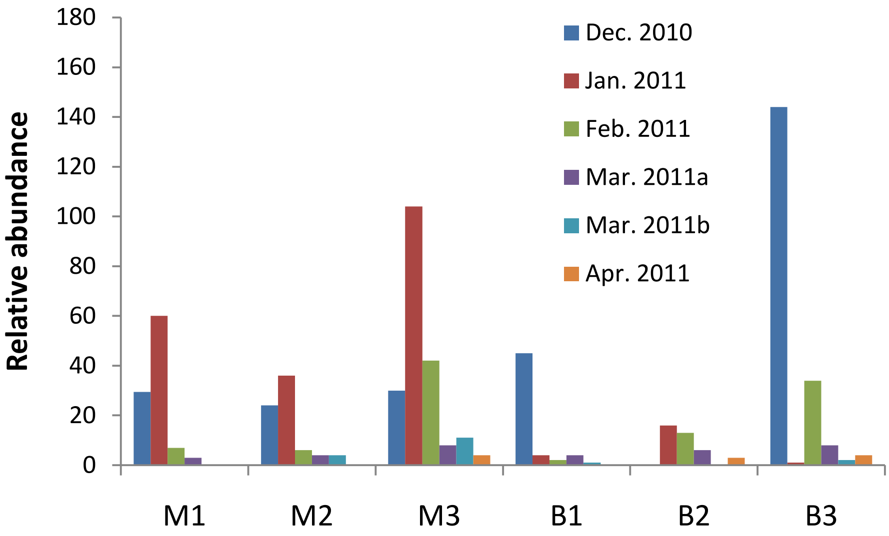


Figure 12. Relative abundance of Tamar River goby at each site for the six sampling events.

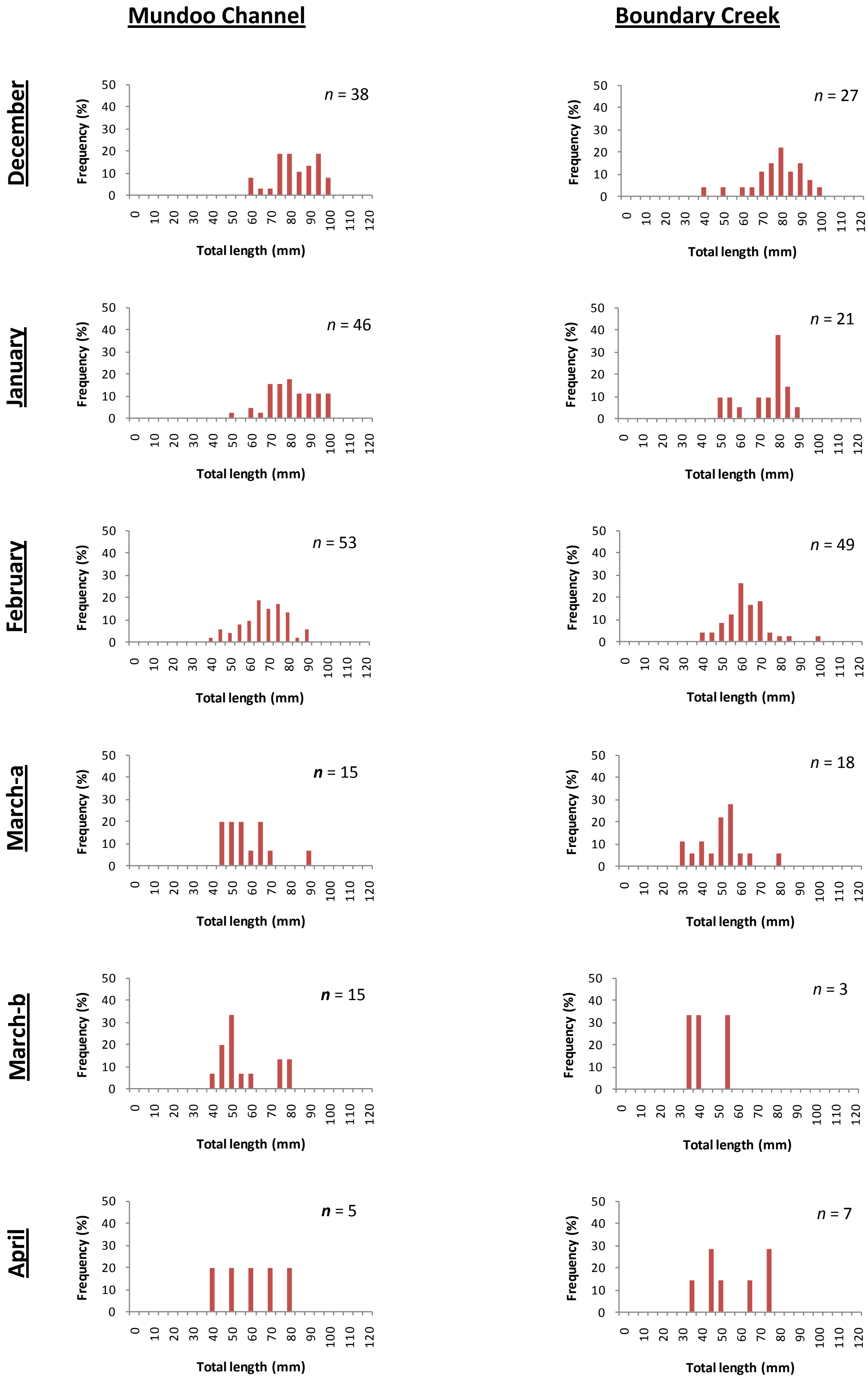


Figure 13. Length frequency distributions of Tamar River goby.

### *Yellow-eye mullet*

Yellow-eye mullet was captured in low relative abundances at Mundoo channel, but increased to moderate abundances in March and April 2011 (Figure 14). The increase was also detected by commercial fishermen, and is likely linked to saltwater incursions during higher than average tides (D. Hoad, Hoad Fisheries, personal communication). The species was not recorded from Boundary Creek until two adult fish were captured moving upstream near the barrage in April 2011.

Length frequencies for yellow-eye mullet indicate 0+ and 1+ fish in December 2010 (Figure 15). The cohort (*n* = 10; 50-100 mm TL) was likely from a breeding event that occurred during the 2009-2010 season (cf. Higham *et al*. 2005). Given that low numbers were captured in the preceding three months, it is difficult to determine if the cohort survived and grew through the study period. However, two fish captured in February 2011 were within the size range expected for two months of growth (*n* = 2; 100 and 125 mm TL).

The increase in relative abundance of yellow-eye mullet in late March 2011 includes a wide variety of size classes that were predominantly 3+ fish (>240 mm TL: Higham *et al*. 2005). Notably, in April 2011 the population was predominantly 0+ yellow-eye mullet, indicating that a breeding event occurred late in the 2010-2011 season.

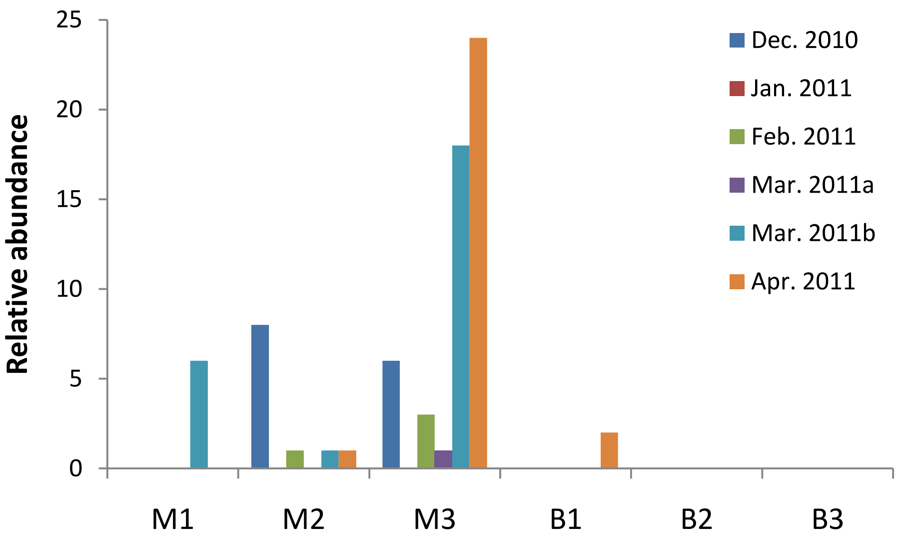


Figure 14. Relative abundance of yellow-eye mullet at each site for the six sampling events.

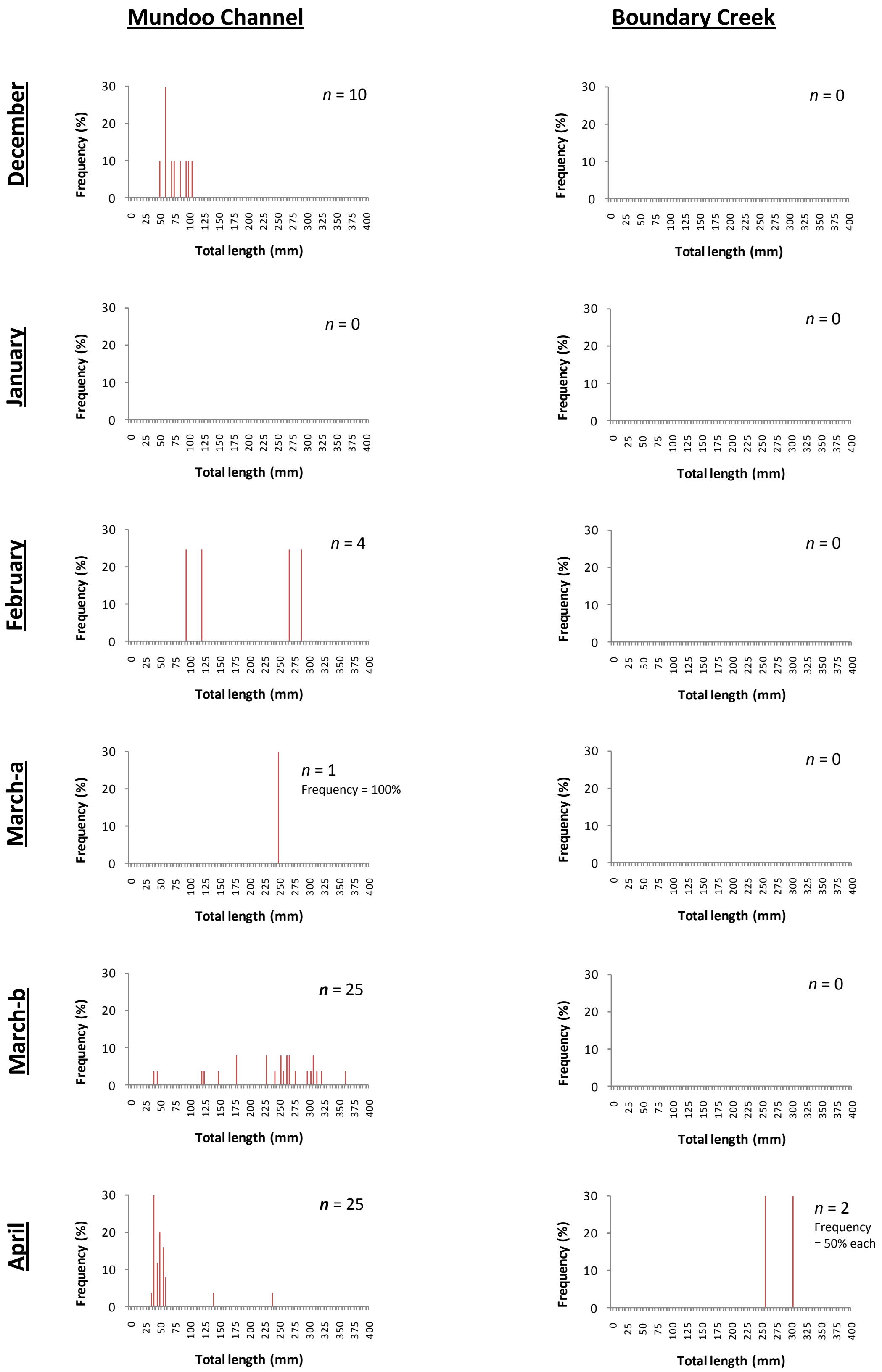


Figure 13. Length frequency distributions of yellow-eye mullet.

# Discussion

This study successfully assessed the benefits of freshwater inflows to fish assemblages in Mundoo Channel and Boundary Creek from December 2010 to April 2011 (objective 1). The benefits to some small-bodied estuarine and diadromous fish species are apparent. However, the continuous freshwater inflows that were far in excess of the 100 GL anticipated meant the channels were effectively an extension of the river. Therefore, estuarine conditions were absent in the channels throughout the study, and were apparently unfavourable to other estuarine species. Similarly, the constantly high inflows prevented testing of the hypothesis that salinity reductions will be localised, restricted to areas close to the barrage release (objective 2).

## Diadromous fishes

### *Congolli*

This study verifies that breeding occurred for two diadromous fish species at the Coorong and Lower Lakes prior to December 2010. Significantly, young-of-the-year (0+) congolli occurred in moderate numbers at Mundoo Channel and Boundary Creek. Congolli declined during the recent drought, due mostly to the disconnection of the river and the Coorong, which inhibited its life cycle (Zampatti *et al*. 2010). Specifically, breeding occurs when female congolli move downstream to the estuary which is inhabited by the males (Crook *et al*. 2010). Increased abundances of the 0+ cohorts recorded in this study likely coincide with the re-establishment of connectivity around August to December 2010. Daily ageing of otoliths may help discern whether there was a single breeding event or multiple events through the season. For example, it would be important to know if the opening of the Goolwa Barrage boat lock in July-August 2010, specifically to encourage female congolli into the Coorong, led to a breeding event. Notably, this active management strategy was only possible during the drought due to the elevated water levels achieved through the Goolwa Channel Water Level Management Plan.

### *Common galaxias*

Young-of-the-year common galaxias were captured in moderate abundances in both channels. Only a few 1+ adults were detected in the study, which corresponds to a Western Australian study which found that only 7% of fish live more than one year (Chapman *et al*. 2006). Recruitment can occur in landlocked populations of common galaxias where flowing tributaries are accessible (Pollard 1971). This is the case in the Lower Lakes, where common galaxias persisted during the drought (Wedderburn and Barnes 2009). However, it is likely that the high inflows to the estuary had a larger-scale positive effect on the Coorong and Lower Lakes population. In this instance, length frequencies display successful recruitment of common galaxias in the Coorong over the 2010-2011 season, as indicated by the presence of a strong adult cohort by April. Interestingly, the species showed a preference for the mid-channel sites, which corresponds to a previous study (Geddes and Wedderburn 2007).

## Estuarine fishes

### *Smallmouth hardyhead*

Several estuarine fish species showed signs of early recruitment. Most numerous was smallmouth hardyhead, which has a one-year life cycle with multiple spawning from September to December in the Coorong (Molsher *et al*. 1994). Length frequencies show that a 0+ cohort and a 1+ cohort of the species occupied both channels in high numbers in February 2011. The older cohort was from the 2009-2010 breeding season, whilst the younger cohort was from the 2010-2011 season (cf. Noell *et al*. 2009). The older cohort began to decline by April 2011, which was expected given its short life cycle. The results are similar to another study conducted from 2006-2008 (Noell *et al*. 2009), suggesting that the 2010-2011 freshwater inflows had no obvious influence on the population. The species is highly adaptable and can successfully recruit in a wide range of salinities (Molsher *et al*. 1994). Therefore, it is likely that the inflows were not the main factor leading to successful recruitment. Indeed, Molsher *et al*. (1994) suggested that low salinities might disadvantage the species by impacting its preferred prey (e.g. estuarine amphipods and polychaetes: Lamontagne *et al*. 2007), but this requires testing.

### *Greenback flounder*

Young-of-the-year and 1+ greenback flounder also occurred in high relative abundance in the earlier stages of the study, predominantly at the mouth of Mundoo Channel. Its decline in relative abundance by February 2011, which is when long-snouted flounder became absent, might relate to a preference of flounder for higher salinities. Consequently, both flounder species likely moved to other parts of the Coorong or out to sea where estuarine conditions prevailed. Given that greenback flounder reproduces during the winter months in the Coorong (Noell *et al*. 2009), a breeding event associated with the high freshwater inflows over 2010-2011 was not observed in this study.

### *Gobies*

Five estuarine goby species were captured, with bridled goby being the only goby to increase in relative abundance throughout the study. Its incursion to the Lower Lakes over recent years was likely related to salinisation during drought (Wedderburn and Hillyard 2010), so fish might be moving back to the Coorong as the lakes freshen. Tamar River goby was the most consistently numerous. Interestingly, 1+ adults of the species were gone from both channels by February 2011, and were replaced by the 0+ cohort. The results correspond to a study in the Coorong during the recent drought (Noell *et al*. 2009).

### *Yellow-eye mullet*

The 0+ cohort of yellow-eye mullet recorded in April 2011 was likely from a breeding event that occurred during the high inflows late in 2010, but this could be confirmed through otolith examinations. Although sample numbers are small, the age structure in March-April 2011 is a mix of 0+ and mature adult fish (>22 cm TL: Harris 1968), which suggests that the population was sustainable during the drought. Indeed, Noell *et al*. (2009) recorded three or four strong cohorts during the drought. This corresponds to the suggestion that the species is not highly estuarine-dependant (Chubb *et al*. 1981). Given the recreational and commercial value of the yellow-eye mullet stock (Higham *et al*. 2005), it would be important to know if the high inflows to the Murray estuary have a positive influence on recruitment levels and growth rates. This could be determined by sampling the stock during the 2011-2012 season, and analysing length-frequencies and otolith microstructures (see 'Future research suggestions' below).

## Freshwater fishes

Several freshwater fish species dominated assemblages throughout the study, especially alien species: 0+ carp, goldfish and redfin. An extremely high number of 0+ redfin (av. 43 mm TL) and five adults (av. 216 mm TL) were captured in December 2010, when it was four times more abundant than any other species. Redfin typically is a prolific breeder at the Lower Lakes even during the recent drought (Wedderburn and Hillyard 2010), as is the case in many lakes and reservoirs worldwide (e.g. Lewin *et al*. 2004). Therefore, it is likely that the redfin captured in this study were sourced from the Lower Lakes. By February 2011, the 0+ cohort had grown in size (av. 67 mm TL) but numbers had reduced substantially. The fish unlikely moved back upstream, given that a similar decline was observed in the Lower Lakes (Wedderburn and Barnes 2011). At least part of the decline was due to predation on the 0+ fish by large fishes, including adult redfin and callop (S. Wedderburn, unpublished data).

Two native freshwater species, flathead gudgeon and bony herring, dominated assemblages by February 2011. Indeed, bony herring was the only freshwater species to increase in relative abundance throughout the study. The species can be a prolific breeder between December to January in the lower River Murray (Puckridge and Walker 1990), so large number might have moved (perhaps involuntarily) downstream to the Coorong with the high flow rates. Thousands of bony herring were reportedly washed up along the coastline near the Murray Mouth over summer 2010-2011 (D. Hoad, Hoad Fisheries, personal communication).

Notably, forty 0+ golden perch were captured at Boundary Creek in February 2011 (av. 40 mm TL). Young-of-the-year of the species were undetected in Mundoo Channel, but three larger 1+ golden perch were captured (av. 90 mm TL). Golden perch were likely sourced from the River Murray or Lower Lakes by moving or being washed downstream towards the Coorong.

## Conclusions

Fish assemblages sampled in this study resembled those of the Lower Lakes during the recent drought (Wedderburn and Barnes 2009; Wedderburn and Hillyard 2010). Sampling in December 2010 detected large numbers of fish that apparently entered Mundoo Channel and Boundary Creek from the Lower Lakes. Predominantly, they were freshwater fish, including the alien redfin and carp, and the native flathead gudgeon and Australian smelt. Interestingly, goldfish increased in relative abundance throughout the study period. The inundation of fish from the Lower Lakes also included an abundance of several estuarine goby species. The masses of freshwater and estuarine fishes entering the estuary likely provided a substantial input to the Coorong food web (e.g. prey for waterbirds and large bodied estuarine fishes), but this requires confirmation. Equally warranting investigation is the contribution of freshwater zooplankton to the early life stages of fishes in the channels during inflows, especially during drier years. For example, it would be essential in terms of water allocation planning to understand the ecological consequences of freshwater inflows to the channels during drought. An earlier study gathered some information in this regard (Geddes and Wedderburn 2007), but failed to examine the link between flows, plankton and the diets of 0+ fishes in Boundary Creek and Mundoo Channel.

The early life stages of all fish species were missed due to the late commencement of the study. For example, sandy sprat was detected in lower numbers than expected, so its breeding and early development likely occurred prior to the first sampling event. A study at the same Coorong channels in 2006 found that early life stages of many species (e.g. common galaxias) were present in September and October (Geddes and Wedderburn 2007). Similarly, smallmouth hardyhead begins breeding in September (Molsher *et al*. 1994). Future studies should run from September to April in order to fully understand the life history of each fish species over its first season.

Salinity in Mundoo Channel and Boundary Creek was very low compared to previous years. For example, in October 2006 Boundary Creek ranged from 2.8-8.3 mg/L (Geddes and Wedderburn 2007), whereas it measured 0.15-0.62 mg/L throughout the current study. The low salinity in 2010-2011 might account for the absence or low relative abundances of some estuarine fish species in the channels. However, 0+ diadromous and small-bodied estuarine fishes apparently utilised the habitats. Similarly, 0+ and 1+ mullet and flounder occupied the channels for short periods. Studies demonstrate that high freshwater inflows to estuaries can cause the decline of estuarine, marine and diadromous species by creating non-preferred low salinity habitats (Costa *et al*. 2007; Strydom *et al*. 2002; Whitfield and Harrison 2003).

## Future research suggestions

The following research suggestions aim to gather information regarding the ecological consequence of providing freshwater inflows to Mundoo Channel and Boundary Creek, which will be essential for water allocation planning. Such information will be particularly important during drought, when competing water demands are strained. Specifically, the information will assist in maintaining viable fish populations for conservation, and sustaining commercial and recreational fishing stocks. There would also be obvious flow-on benefits for other biota, including fish-eating waterbirds.

### *Seasonal timing*

The late start in the current study likely missed the early life stages of many estuarine and diadromous fish species. In the current study, there were six sampling events every four weeks beginning on 1 December 2010. If other studies are conducted, sampling should commence in September to determine which fish species were spawning early in the season. A September commencement might also detect other species that were utilising the channels earlier in the season. For example, black bream and lamprey inhabit the Coorong channels mostly in September-October. In a future study, six sampling events every six weeks from mid-September to the end of April would be appropriate. However, there could be a seventh 'floating' sampling event factored into the project as a contingency should an important incident be noted during one of the six scheduled sampling events.

### *Length frequency analyses*

Early life stages of medium and long-lived species such as yellow-eye mullet and flounder were captured in the current study, but their growth to sexual maturity will take at least a year (Noell *et al*. 2009). Although a 0+ cohort of yellow-eye mullet was recorded in this study, it is still unknown whether it will make it through the first year of life. This could be determined by sampling during 2011-2012 and examining length frequencies. However, otolith microstructure analyses would greatly strengthen the testing of any hypotheses in this regard.

### *Otolith examinations*

The environmental history of a fish can be investigated using otolith chemistry, whereby life history, movements and habitat use can be assessed (Elsdon *et al*. 2008). Although extremely useful for fisheries stock assessment and management (e.g. mulloway: Ferguson *et al*. 2011), most procedures are costly and time consuming, and probably beyond the scope of the Intervention Monitoring program. However, some simpler techniques could be utilised to strengthen or support the findings of length frequency analyses. For example, otolith microstructures can be examined to quantify recruitment success. In the future, strong year classes can be aged to test the hypothesis that an age node exists that corresponds to the large barrage flows of 2010-2011. Specifically, otolith increment widths will show where favourable conditions promoted strong growth periods (wide bands) that can be matched with environmental conditions (e.g. freshwater inflows). Otoliths can be collected for a range of medium to long-lived species (e.g. mullet, congolli, bream, mulloway), either through direct sampling or from local professional fishermen.

### *Dietary investigations*

Although breeding and recruitment was confirmed for several fish species in this study, the ecological interactions that led to this event remain unclear. For example, flooding in estuaries can facilitate divergence in the diets of smallmouth hardyhead, common galaxias, flathead gudgeon and blue spot goby and lead to increased productivity of each species (Becker and Laurenson 2007). It would be important to determine if such benefits occur in the Coorong during inflow events, so dietary comparisons are required. For example, gut analyses of some selected species would improve knowledge of the link between primary producers, zooplankton and fish during inflows to Boundary Creek and Mundoo Channel. The early life stages of two diadromous species and two estuarine species could be examined to determine if they have a diet that relies on, or benefits from, freshwater input to the estuary (e.g. freshwater plankton: Aldridge and Brookes 2011;

Shiel and Aldridge 2011). It could also test whether dietary overlap is minimised during inflows (cf. Becker and Laurenson 2007). This can be linked back to productivity (e.g. growth rates, condition) during high inflows examined through otolith or length-weight analyses, or both.

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# Appendices

Table 4. Fish species captured in this study.

| **Functional group** | **Common name** | **Scientific name** |
|---|---|---|
| Diadromous | Congolli | *Pseudaphritis urvillii* |
| | Common galaxias | *Galaxias maculatus* |
| | Short-finned eel | *Anguilla australis* |
| Estuarine | Smallmouth hardyhead | *Atherinasoma microstoma* |
| | Blue-spot goby | *Pseudogobius olorum* |
| | Tamar River goby | *Afurcagobius tamarensis* |
| | Long-finned goby | *Favonigobius lateralis* |
| | Lagoon goby | *Tasmanogobius lasti* |
| | Bridled goby | *Arenigobius bifrenatus* |
| | Greenback flounder | *Rhombosolea tapirina* |
| | Long-snouted flounder | *Ammotretis rostratus* |
| | Yellow-eyed mullet | *Aldrichetta fosteri* |
| Marine | River garfish | *Hyporhamphus regularis* |
| | Sandy sprat | *Hyperlophus vittatus* |
| | Soldier fish | *Gymnapistes marmoratus* |
| | Luderick | *Girella tricuspidata* |
| Freshwater | Golden perch | *Macquaria ambigua* |
| | Bony herring | *Nematalosa erebi* |
| | Flathead gudgeon | *Philypnodon grandiceps* |
| | Carp gudgeon | *Hypseleotris* sp. |
| | Australian smelt | *Retropinna semoni* |
| | Murray hardyhead | *Craterocephalus fluviatilis* |
| | Unspecked hardyhead | *Craterocephalus stercusmuscarum fulvus* |
| | Carp | *Cyprinus carpio* |
| | Goldfish | *Carassius auratus* |
| | Redfin | *Perca fluviatilis* |
| | Gambusia | *Gambusia holbrooki* |

Table 5. Relative abundance of fish for 1-3 December 2010.

| | Common name | M1 | M2 | M3 | B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| **Diadromous** | Congolli | 0 | 4 | 0 | 60 | 16 | 6 |
| | Common galaxias | 0 | 27 | 6 | 0 | 8 | 0 |
| | Short-finned eel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Estuarine** | Smallmouth hardyhead | 1501 | 45 | 63 | 570 | 128 | 6 |
| | Blue-spot goby | 0 | 4 | 18 | 15 | 8 | 6 |
| | Tamar River goby | 30 | 24 | 30 | 45 | 0 | 144 |
| | Long-finned goby | 0 | 2 | 3 | 0 | 0 | 0 |
| | Lagoon goby | 95 | 1 | 3 | 210 | 40 | 6 |
| | Bridled goby | 3 | 2 | 3 | 31 | 8 | 0 |
| | Greenback flounder | 20 | 13 | 39 | 18 | 32 | 6 |
| | Long-snouted flounder | 0 | 21 | 18 | 0 | 0 | 0 |
| | Yellow-eyed mullet | 0 | 8 | 6 | 0 | 0 | 0 |
| **Marine** | Garfish | 2 | 0 | 0 | 0 | 0 | 0 |
| | Sandy sprat | 352 | 27 | 15 | 0 | 8 | 0 |
| | Soldier fish | 0 | 45 | 18 | 0 | 0 | 0 |
| | Luderick | 0 | 0 | 1 | 0 | 0 | 0 |
| **Freshwater** | Golden perch | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bony herring | 333 | 22 | 9 | 342 | 24 | 0 |
| | Flathead gudgeon | 371 | 49 | 273 | 1335 | 208 | 534 |
| | Carp gudgeon | 0 | 3 | 0 | 0 | 0 | 0 |
| | Australian smelt | 846 | 11 | 6 | 645 | 32 | 0 |
| | Unspecked hardyhead | 0 | 0 | 0 | 1 | 0 | 0 |
| | Carp | 239 | 50 | 663 | 447 | 88 | 84 |
| | Goldfish | 0 | 0 | 0 | 0 | 0 | 0 |
| | Redfin | 3312 | 93 | 609 | 5535 | 2232 | 258 |

Table 6. Relative abundance of fish for 4-6 January 2011.

| | Common name | M1 | M2 | M3 | B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| **Diadromous** | Congolli | 120 | 88 | 12 | 18 | 20 | 0 |
| | Common galaxias | 12 | 68 | 0 | 1 | 22 | 0 |
| | Short-finned eel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Estuarine** | Smallmouth hardyhead | 54 | 148 | 1032 | 11 | 34 | 1 |
| | Blue-spot goby | 48 | 40 | 0 | 0 | 3 | 0 |
| | Tamar River goby | 60 | 36 | 104 | 4 | 16 | 1 |
| | Long-finned goby | 0 | 0 | 8 | 1 | 0 | 0 |
| | Lagoon goby | 384 | 432 | 1056 | 150 | 28 | 3 |
| | Bridled goby | 7 | 8 | 15 | 2 | 2 | 1 |
| | Greenback flounder | 14 | 0 | 176 | 0 | 0 | 0 |
| | Long-snouted flounder | 0 | 0 | 8 | 0 | 0 | 0 |
| | Yellow-eyed mullet | 0 | 0 | 0 | 0 | 0 | 0 |
| **Marine** | Garfish | 0 | 0 | 0 | 0 | 0 | 0 |
| | Sandy sprat | 0 | 48 | 0 | 0 | 0 | 0 |
| | Soldier fish | 0 | 0 | 0 | 0 | 0 | 0 |
| | Luderick | 0 | 0 | 0 | 0 | 0 | 0 |
| **Freshwater** | Golden perch | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bony herring | 584 | 0 | 79 | 127 | 3 | 83 |
| | Flathead gudgeon | 2052 | 828 | 128 | 133 | 324 | 19 |
| | Carp gudgeon | 0 | 0 | 0 | 2 | 3 | 0 |
| | Australian smelt | 162 | 128 | 16 | 27 | 15 | 0 |
| | Unspecked hardyhead | 0 | 0 | 0 | 0 | 0 | 0 |
| | Carp | 161 | 212 | 180 | 114 | 105 | 89 |
| | Goldfish | 1 | 0 | 0 | 1 | 0 | 0 |
| | Redfin | 147 | 100 | 292 | 38 | 102 | 5 |

Table 7. Relative abundance of fish for 1-3 February 2011.

| | Common name | M1 | M2 | M3 | B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| **Diadromous** | Congolli | 16 | 3 | 11 | 8 | 18 | 4 |
| | Common galaxias | 31 | 14 | 1 | 1 | 9 | 0 |
| | Short-finned eel | 0 | 0 | 0 | 1 | 0 | 0 |
| **Estuarine** | Smallmouth hardyhead | 17 | 19 | 80 | 2 | 23 | 0 |
| | Blue-spot goby | 0 | 0 | 0 | 0 | 0 | 0 |
| | Tamar River goby | 7 | 6 | 42 | 2 | 13 | 34 |
| | Long-finned goby | 0 | 0 | 1 | 0 | 0 | 0 |
| | Lagoon goby | 30 | 1 | 8 | 4 | 0 | 15 |
| | Bridled goby | 5 | 0 | 41 | 4 | 0 | 10 |
| | Greenback flounder | 0 | 1 | 17 | 0 | 0 | 1 |
| | Long-snouted flounder | 0 | 0 | 0 | 0 | 0 | 0 |
| | Yellow-eyed mullet | 0 | 1 | 3 | 0 | 0 | 0 |
| | River garfish | 0 | 0 | 0 | 0 | 0 | 0 |
| **Marine** | Sandy sprat | 1 | 0 | 0 | 0 | 1 | 0 |
| | Soldier fish | 0 | 0 | 0 | 0 | 0 | 0 |
| | Luderick | 0 | 0 | 0 | 0 | 0 | 0 |
| **Freshwater** | Golden perch | 0 | 0 | 3 | 22 | 8 | 10 |
| | Bony herring | 497 | 7 | 675 | 198 | 25 | 403 |
| | Flathead gudgeon | 217 | 236 | 79 | 254 | 234 | 224 |
| | Carp gudgeon | 0 | 0 | 1 | 2 | 0 | 0 |
| | Australian smelt | 10 | 3 | 14 | 15 | 16 | 4 |
| | Unspecked hardyhead | 0 | 0 | 0 | 0 | 0 | 0 |
| | Carp | 149 | 67 | 170 | 230 | 99 | 174 |
| | Goldfish | 0 | 1 | 35 | 149 | 32 | 57 |
| | Redfin | 29 | 27 | 73 | 21 | 37 | 16 |

Table 8. Relative abundance of fish for 1-3 March 2011.

| | **Common name** | **M1** | **M2** | **M3** | **B1** | **B2** | **B3** |
|---|---|---|---|---|---|---|---|
| **Diadromous** | Congolli | 1 | 2 | 7 | 0 | 2 | 3 |
| | Common galaxias | 6 | 1 | 0 | 14 | 7 | 4 |
| | Short-finned eel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Estuarine** | Smallmouth hardyhead | 3 | 8 | 0 | 11 | 4 | 1 |
| | Blue-spot goby | 0 | 0 | 0 | 0 | 0 | 0 |
| | Tamar River goby | 3 | 4 | 8 | 4 | 6 | 8 |
| | Long-finned goby | 0 | 0 | 0 | 0 | 0 | 0 |
| | Lagoon goby | 10 | 2 | 0 | 91 | 18 | 7 |
| | Bridled goby | 3 | 1 | 7 | 0 | 1 | 0 |
| | Greenback flounder | 0 | 0 | 1 | 0 | 0 | 0 |
| | Long-snouted flounder | 0 | 0 | 0 | 0 | 0 | 0 |
| | Yellow-eyed mullet | 0 | 0 | 1 | 0 | 0 | 0 |
| | River garfish | 0 | 0 | 0 | 0 | 0 | 0 |
| **Marine** | Sandy sprat | 0 | 0 | 0 | 0 | 0 | 0 |
| | Soldier fish | 0 | 0 | 0 | 0 | 0 | 0 |
| | Luderick | 0 | 0 | 0 | 0 | 0 | 0 |
| **Freshwater** | Golden perch | 0 | 3 | 2 | 8 | 5 | 4 |
| | Bony herring | 153 | 15 | 488 | 122 | 17 | 300 |
| | Flathead gudgeon | 161 | 98 | 10 | 255 | 235 | 160 |
| | Carp gudgeon | 0 | 0 | 0 | 0 | 0 | 0 |
| | Australian smelt | 22 | 8 | 0 | 47 | 0 | 3 |
| | Unspecked hardyhead | 0 | 0 | 0 | 0 | 0 | 0 |
| | Carp | 54 | 2 | 24 | 15 | 10 | 47 |
| | Goldfish | 84 | 6 | 90 | 32 | 7 | 64 |
| | Redfin | 32 | 35 | 111 | 16 | 12 | 27 |

Table 9. Relative abundance of fish for 28-30 March 2011.

| | Common name | M1 | M2 | M3 | B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| **Diadromous** | Congolli | 3 | 6 | 2 | 1 | 1 | 0 |
| | Common galaxias | 9 | 34 | 0 | 1 | 1 | 0 |
| | Short-finned eel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Estuarine** | Smallmouth hardyhead | 4 | 40 | 64 | 1 | 22 | 0 |
| | Blue-spot goby | 0 | 0 | 0 | 0 | 0 | 0 |
| | Tamar River goby | 0 | 4 | 11 | 1 | 0 | 2 |
| | Long-finned goby | 0 | 0 | 0 | 0 | 0 | 0 |
| | Lagoon goby | 9 | 4 | 2 | 7 | 4 | 21 |
| | Bridled goby | 0 | 0 | 3 | 0 | 0 | 0 |
| | Greenback flounder | 0 | 0 | 1 | 0 | 0 | 0 |
| | Long-snouted flounder | 0 | 0 | 0 | 0 | 0 | 0 |
| | Yellow-eyed mullet | 6 | 1 | 18 | 0 | 0 | 0 |
| | River garfish | 0 | 0 | 3 | 0 | 0 | 0 |
| **Marine** | Sandy sprat | 0 | 0 | 0 | 0 | 0 | 0 |
| | Soldier fish | 0 | 0 | 0 | 0 | 0 | 0 |
| | Luderick | 0 | 0 | 0 | 0 | 0 | 0 |
| **Freshwater** | Golden perch | 0 | 0 | 1 | 25 | 0 | 0 |
| | Bony herring | 71 | 7 | 269 | 179 | 37 | 138 |
| | Flathead gudgeon | 122 | 98 | 95 | 35 | 36 | 105 |
| | Carp gudgeon | 0 | 1 | 0 | 3 | 0 | 0 |
| | Australian smelt | 35 | 4 | 67 | 163 | 91 | 39 |
| | Unspecked hardyhead | 0 | 0 | 0 | 0 | 0 | 0 |
| | Murray hardyhead | 0 | 0 | 1 | 0 | 0 | 0 |
| | Carp | 75 | 10 | 16 | 33 | 33 | 27 |
| | Goldfish | 2 | 7 | 118 | 2 | 1 | 22 |
| | Redfin | 16 | 9 | 92 | 33 | 6 | 67 |
| | Gambusia | 1 | 0 | 2 | 0 | 0 | 0 |

Table 10. Relative abundance of fish for 27-29 April 2011.

| | Common name | M1 | M2 | M3 | B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| **Diadromous** | Congolli | 2 | 10 | 4 | 0 | 3 | 3 |
| | Common galaxias | 7 | 29 | 8 | 1 | 1 | 4 |
| | Short-finned eel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Estuarine** | Smallmouth hardyhead | 0 | 8 | 5 | 0 | 3 | 2 |
| | Blue-spot goby | 0 | 0 | 0 | 0 | 0 | 0 |
| | Tamar River goby | 0 | 0 | 4 | 0 | 3 | 4 |
| | Long-finned goby | 1 | 0 | 0 | 0 | 0 | 0 |
| | Lagoon goby | 8 | 6 | 36 | 2 | 35 | 1 |
| | Bridled goby | 1 | 0 | 4 | 0 | 0 | 0 |
| | Greenback flounder | 0 | 0 | 0 | 0 | 0 | 0 |
| | Long-snouted flounder | 0 | 0 | 0 | 0 | 0 | 0 |
| | Yellow-eyed mullet | 0 | 1 | 24 | 2 | 0 | 0 |
| | River garfish | 0 | 0 | 3 | 0 | 0 | 0 |
| **Marine** | Sandy sprat | 0 | 0 | 0 | 0 | 0 | 0 |
| | Soldier fish | 0 | 0 | 0 | 0 | 0 | 0 |
| | Luderick | 0 | 0 | 0 | 0 | 0 | 0 |
| **Freshwater** | Golden perch | 0 | 0 | 1 | 2 | 0 | 1 |
| | Bony herring | 46 | 0 | 99 | 220 | 7 | 70 |
| | Flathead gudgeon | 86 | 76 | 67 | 12 | 71 | 7 |
| | Carp gudgeon | 1 | 0 | 1 | 0 | 0 | 0 |
| | Australian smelt | 28 | 33 | 29 | 3 | 11 | 7 |
| | Unspecked hardyhead | 0 | 0 | 0 | 0 | 0 | 0 |
| | Carp | 5 | 0 | 2 | 33 | 2 | 28 |
| | Goldfish | 4 | 2 | 40 | 6 | 3 | 27 |
| | Redfin | 7 | 2 | 49 | 14 | 4 | 26 |