

Chapter 9 Basin Plan Environmental Outcomes Monitoring for Fish (2014/15 – 2019/20): New South Wales Border Rivers Water Resource Planning Area



<i>Citation Details</i>	363
<i>Acknowledgements</i>	364
<i>Introduction</i>	365
What This Report Includes	366
Sampling Methods	367
<i>Climate Overview</i>	370
<i>Flow Data</i>	371
<i>Species Diversity</i>	373
<i>Murray cod</i>	374
Population Structure.....	375
Temporal Trends in Abundance.....	377
Health.....	378
Distribution	379
<i>Golden perch</i>	380
Population Structure.....	381
Temporal Trends in Abundance.....	383
Health.....	384
Distribution	385
<i>Freshwater catfish</i>	386
Population Structure.....	387
Temporal Trends in Abundance.....	388
Health.....	389
Distribution	390
<i>Bony herring</i>	391
Population Structure.....	392
Temporal Trends in Abundance.....	393
Health.....	394
Distribution	395
<i>Australian smelt</i>	396
Population Structure.....	397
Temporal Trends in Abundance.....	398
Health.....	399
Distribution	400
<i>Common carp</i>	401
Population Structure.....	402
Temporal Trends in Abundance.....	403
Health.....	404
Distribution	405
<i>Threatened Species</i>	406
<i>Appendix</i>	412

Citation Details

Please cite the overall report when referring to this chapter:

Schilling, H., Crook, D. 2023. Basin Plan Environmental Outcomes Monitoring for Fish (2014/15 – 2019/20): Water Resource Planning Area Reports. NSW Department of Primary Industries. Fisheries NSW, Port Stephens Fisheries Institute. 517pp. (PUB23/369)

Cover image credit: NSW DPI FER Staff; Fish images credit: Gunther Schmida

Acknowledgements

This project is funded by the Commonwealth Government under the *Federation Funding Agreement – Environment on Implementing Water Reform in the Murray-Darling Basin*. The dataset used in the temporal analysis was generated by NSW DPI Fisheries from 1994–2022 and sourced from multiple internally and externally funded projects. The authors acknowledge past and present DPI Fisheries scientists (especially Dr Dean Gilligan), technicians and managers that contributed to its collection as well as the ongoing support of external collaborators and funding agencies (in particular, the Murray–Darling Basin Authority, the Commonwealth Environmental Water Office, and the NSW Freshwater Recreational Fishing Trust). We continue to be thankful for the ongoing site access granted by private landowners across NSW and acknowledge that we work on Country which always was and always will be Aboriginal land. The fish surveys that generated the data used in our analyses were conducted under permits approved by the NSW Fisheries Animal Care and Ethics Committee.

Introduction

This report spans the first series of the Basin Plan Environmental Outcome Monitoring – Fish (BPEOM-F) program, starting in 2014/15 as a pilot and running annually until 2019/2020. This report focusses on the New South Wales (NSW) Border Rivers Water Resource Planning Area (WRPA) shown in [Figure 9.1](#).

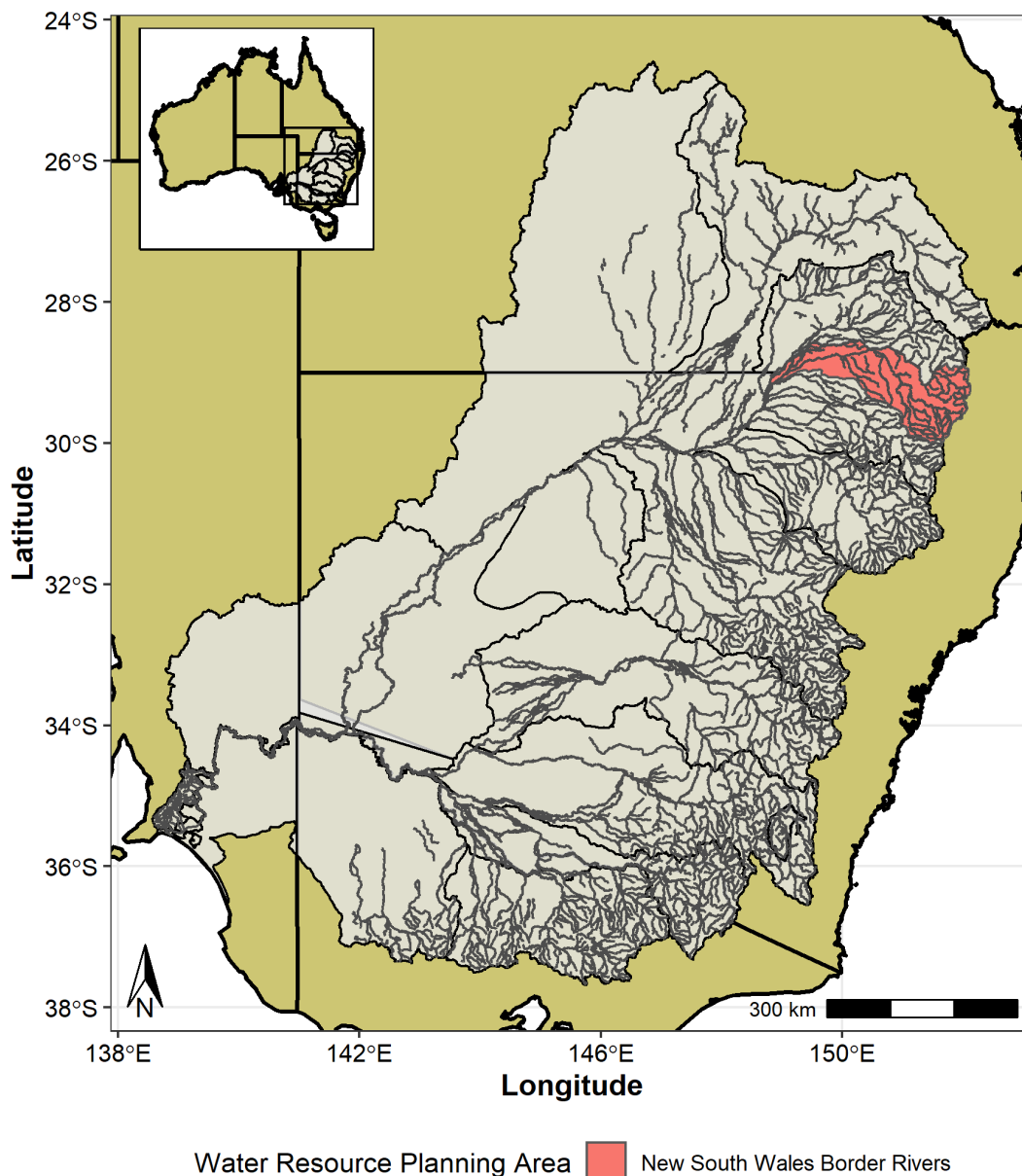


Figure 9.1: Murray-Darling Basin with the key region of this report highlighted. Inset map shows the whole of Australia with a box around the MDB.

What This Report Includes

This report starts with an overview of the BPEOM-F program including sampling details and statistics. An overview of the hydrological and climatic conditions during the reporting period is also provided as context for interpreting the fish population status data.

Following the introductory sections, we present a summary of *fish diversity* across the NSW Border Rivers WRPA. Separate plots for native and alien species show the total number of unique species observed at each site.

The main body of the report provides detailed information on the *population structure, relative abundance, health, and distribution* of six key fish species:

- Murray cod
- Golden perch
- Freshwater catfish
- Bony herring
- Australian smelt
- Common carp

Population structure information includes length frequency plots of observed fish and the proportion of fish classified as Young of the Year (YOY). This information can be used to infer the size structure of populations and the level of recruitment each year. For additional context, we provide a summary table showing any stocking which occurred for the species in each year (if relevant).

Relative abundance (a unit-less measure representing the number of fish in an area) information is presented based on the modelled outputs from a more in-depth publication ([Crook et al. 2023](#)) which considers all available electrofishing data within the NSW Murray-Darling Basin (MDB). The analysis uses Bayesian generalised additive mixed models to generate time series of relative abundance for each WRPA since the early 1990s. In this report we present the modelled time series of relative abundance showing the predicted number of fish observed per 90 second shot of electrofishing. The abundance trend for the NSW Border Rivers WRPA is contrasted with the overall NSW MDB dataset. It should be noted that these are modelled estimates of relative abundance, not absolute abundance as absolute abundance estimates require calibration surveys.

Health information is provided as a summary of any visible health conditions recorded for the key species. The number of health conditions observed in a fish population is generally reflective of water quality, competition, and many other factors. Fewer observations of health conditions indicate healthier populations. Healthier fish tend to have increased fecundity and reproductive success. The health conditions detailed are any that were observed as part of the biological measurements taken. We provide a comparison of the prevalence of health conditions in the NSW Border Rivers WRPA and greater MDB (excluding the NSW Border Rivers WRPA).

Distribution maps are provided for each species to show the observed distribution of each species from the BPEOM-F program (other sampling programs not reported in this report). The distribution maps also show the relative abundance (number of fish observed per 90 seconds of electrofishing) at each site to give an indication of how the population is spread over the landscape.

Finally, the distributions and numbers of *Threatened species* are reported. The report includes threatened species that were recorded by the BPEOM-F program in the NSW Border Rivers WRPA during the study period.

For each section of the report, we provide a *Summary Statement*. This statement provides a very brief overview of the key messages for each section.

Sampling Methods

Three main methods were used during the BPEOM-F program: boat electrofishing, backpack electrofishing and bait traps. This report mainly includes the electrofishing data with the bait traps informing the distribution of small bodied threatened species. The electrofishing was conducted using the standard methodology implemented in the Sustainable Rivers Audit (SRA). This usually includes 12 shots of 90 seconds “power on” during each sampling event. Sites included in this round of the BPEOM-F program were chosen using a stratified random approach.

Various amounts of sampling effort (number of sites) were conducted for each year of the reporting period (Table 9.1). At each site, sampling gear was applied as suited to the local conditions with either boat, backpack, or a hybrid of the two in addition to the 10 unbaited bait traps that are set in areas of the sampling reach that are not electrofished. Most sampling occurred between the months of September and May.

Table 9.1: Sampling effort (Number of sites sampled) each sampling season. The number of sites which were planned to be sampled but were dry are shown in brackets and excluded from the sampled count.

Sampling Season	Number of Sites Sampled (Dry Sites)
2014/2015	7 (0)
2015/2016	24 (1)
2016/2017	27 (0)
2017/2018	26 (6)
2018/2019	35 (2)
2019/2020	31 (2)

The sites sampled during the reporting period are shown in Figure 9.2. A breakdown of sites sampled each sampling season is shown in the Appendix (Figure 9.37).

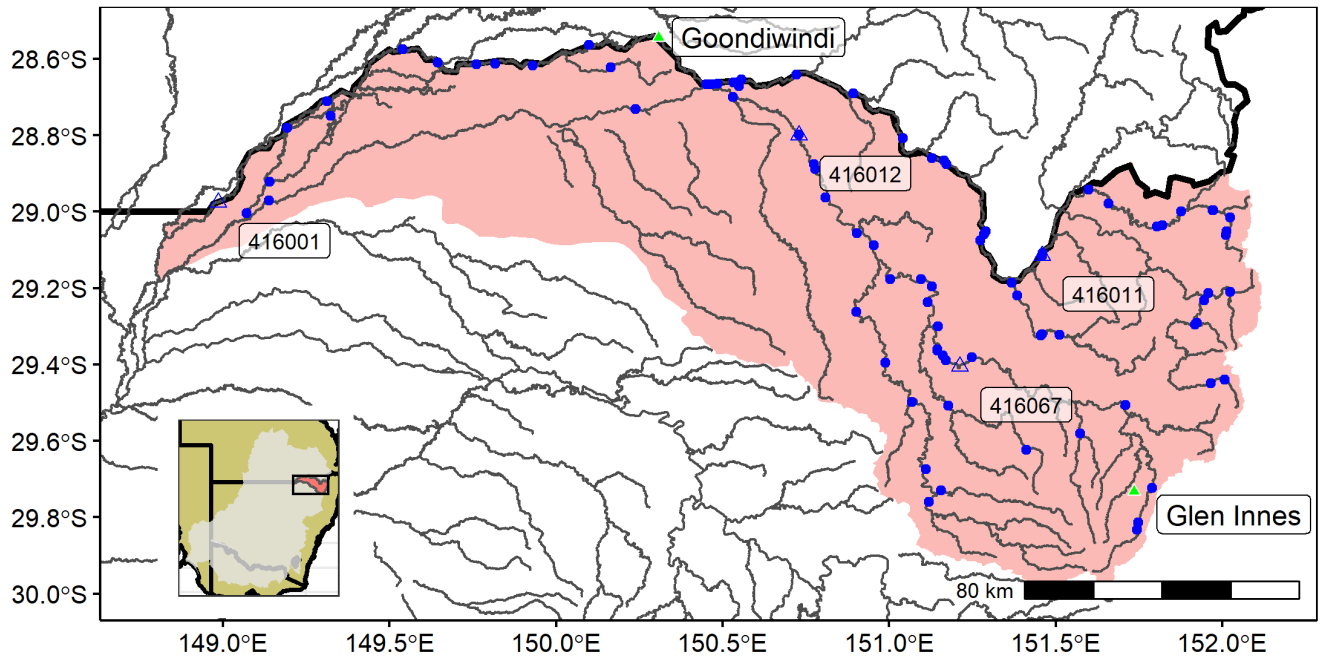


Figure 9.2: Sites (dots) sampled during the BPEOM-F program. Triangles show key flow gauges along with their gauge ID number. Dry sites are not shown.

Each sampling method has a different effectiveness at sampling each species. [Table 9.2](#) shows the total amount of each species caught by each method.

Table 9.2: Number of each key species caught by sample method over the whole program. Further data on total catch is provided in the Appendix.

Common name	Backpack Electrofishing	Boat Electrofishing	Bait Trap
Murray cod	155	1,501	0
Golden perch	0	368	3
Freshwater catfish	77	186	1
Bony herring	6	5,343	0
Australian smelt	13	599	0
Common carp	3	1,057	0

A subset of sampled fish had biological measurements taken during the surveys, including but not limited to length and weight measurements and visual health assessments. [Table 9.3](#) shows the number of biological measurements taken each year for the six species. Note 2014/2015 had substantially less sites sampled than the other seasons ([Table 9.1](#)).

Table 9.3: Number of biological measurements taken for the key species each sampling season.

	Murray cod	Golden perch	Freshwater catfish	Bony herring	Australian smelt	Common carp
2014/2015	28	3	2	99	10	18
2015/2016	307	92	20	492	128	226
2016/2017	224	60	55	422	0	206
2017/2018	554	131	71	914	48	337
2018/2019	424	69	80	356	95	219
2019/2020	95	13	36	250	72	54

Reference:

Crook D. A., Schilling H. T., Gilligan D. M., Asmus M., Boys C. A., Butler G. L., Cameron L. M., Hohnberg D., Michie L. E., Miles N. G., Rayner T. S., Robinson W. A., Rourke M. L., Stocks J. R., Thiem J. D., Townsend A., van der Meulen D. E., Wooden I., Cheshire K. J. M. (2023) Multi-decadal trends in large-bodied fish populations in the New South Wales Murray–Darling Basin, Australia. *Marine and Freshwater Research* <https://doi.org/10.1071/MF23046>

Climate Overview

The following is a summary of the climatic conditions during the BPEOM-F program in terms of how the observed conditions compare to long term records. These are direct extracts from the [Australian Bureau of Meteorology climate summaries archive](#) and are written in the given year. As an example, 2014 states it was the warmest year on record, meaning 2014 was the warmest year on record up to and including 2014 but not the more recent years.

2014

New South Wales experienced its warmest year on record in 2014, with several heatwaves and persistently warm conditions across the State. Rainfall was well below average in the northeast, and close to average elsewhere.

2015

New South Wales recorded well above average temperatures in 2015. Nights were particularly warm, the sixth-warmest on record for the State. Rainfall was close to average for the state as a whole.

2016

2016 was a generally wet, warm year for NSW as a whole, with substantial variability throughout the year and across the state. Following a record-warm start to the year, May to September was the wettest such period on record for NSW, with cooler weather in much of the west of the state. Minimum temperatures were the warmest on record for the State as a whole, with record-warm daytime temperatures on parts of the east coast.

2017

The year 2017 was the warmest on record for New South Wales for both mean and daytime temperatures. It was also the State's driest year since 2006. Following the warmest summer on record for the State, heavy rain in March across the east then made way for a very dry winter and start to spring. Winter overnight temperatures were the lowest since 1997, but daytime temperatures remained above average for most of the year, and were the warmest on record overall.

2018

2018 was the warmest on record for New South Wales for both mean temperature and mean maximum temperature, whilst the mean minimum temperature was fourth-warmest on record. The year was dominated by very dry conditions, with the third-driest January to September on record. October to December saw some relief from the dry, with above average rainfall across parts of the State. Despite this, New South Wales experienced its sixth-lowest annual rainfall on record; its driest year since 2002.

2019

2019 was the driest and warmest year on record for New South Wales. Despite some rain in some months, most of the State received much less rainfall than usual, with the northeast and far west particularly dry. Heatwaves in January brought very high temperatures, and large fires from September onward caused extensive damage and persistent smoke.

2020

2020 saw above average temperature and rainfall in New South Wales. Temperatures were above average across the state in most months except during autumn. There was widespread rain during autumn and spring and in December, but early winter and November rain was below average.

Flow Data

Below shows a summary of flow data from a variety of flow gauges in the NSW Border Rivers WRPA (Figure 9.3).

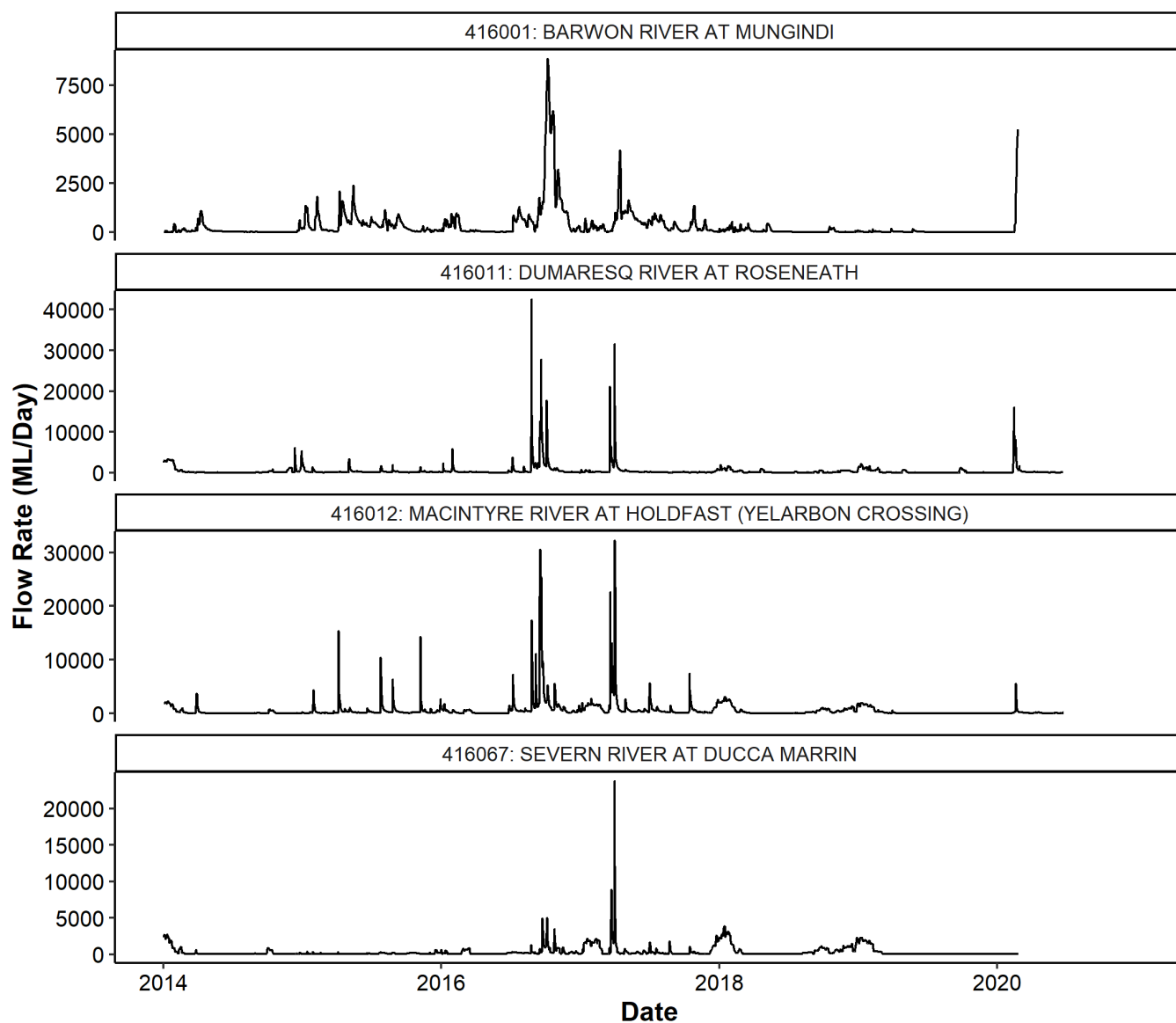


Figure 9.3: Flow data from various gauges in the Macquarie-Castlereagh WRPA over the reporting period. Gauge locations can be seen on Figure 9.2. Note the differing scales on the y-axis.

Water temperature data, where available, are also shown in [Figure 9.4](#).

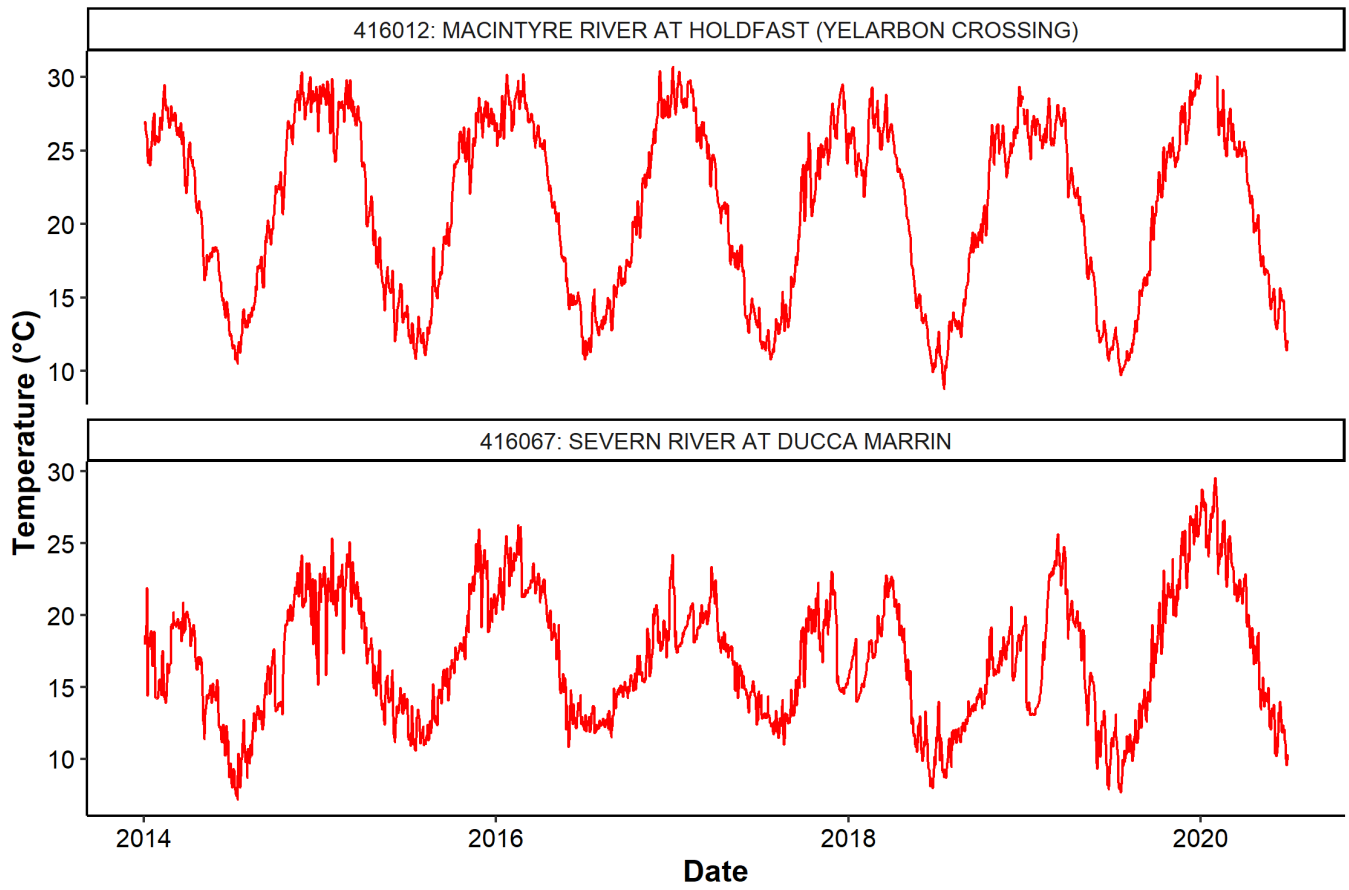


Figure 9.4: Water temperature data from various gauges in the NSW Border Rivers WRPA over the reporting period. Gauge locations can be seen on [Figure 9.2](#). Note the differing scales on the y-axis.

Species Diversity

A total of 18 fish species were observed across the NSW Border Rivers WRPAs including four alien species. [Figure 9.5](#) shows the number of native and alien species found at each site. The full list of species caught and observed is in [Table 9.7](#).

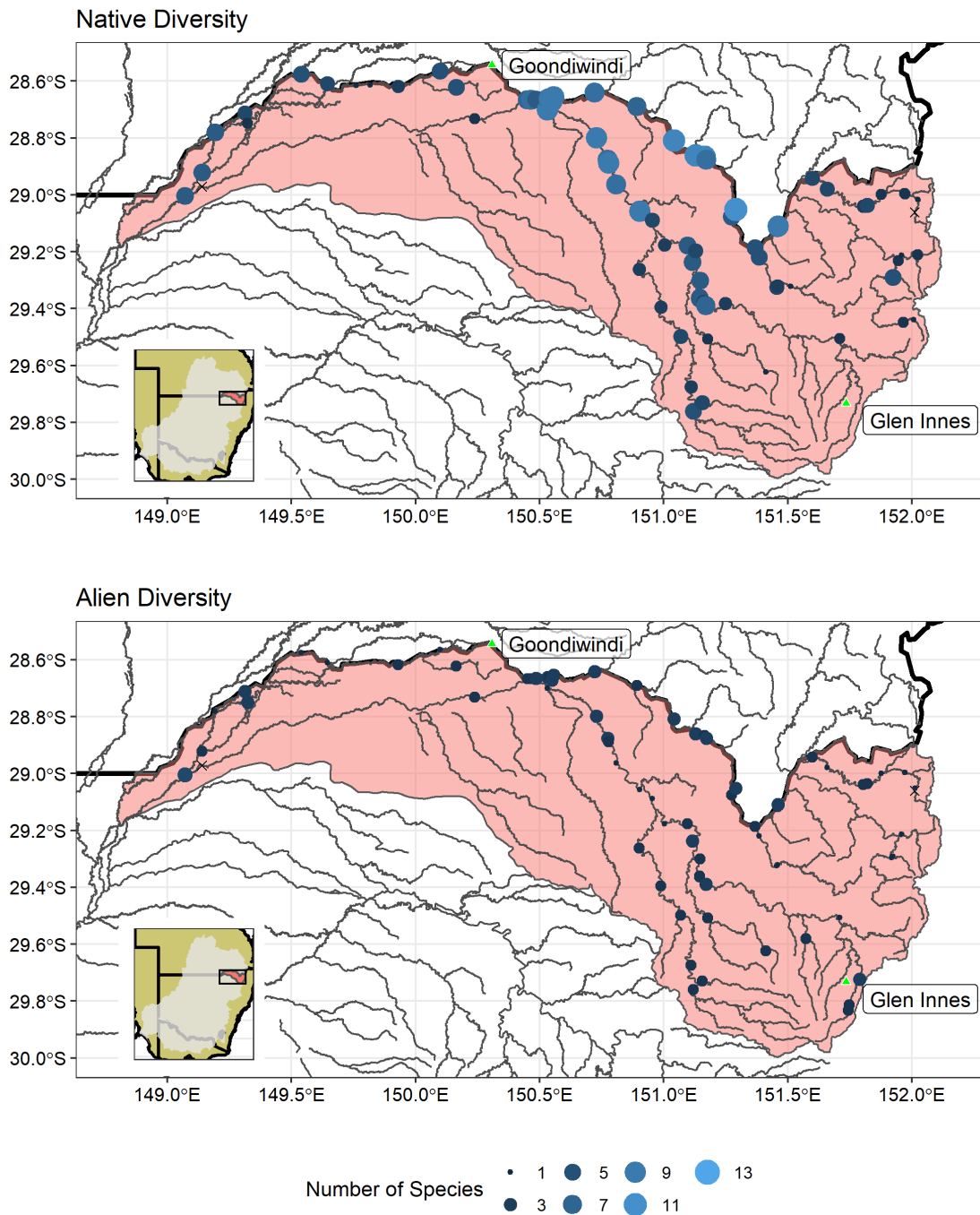


Figure 9.5: Diversity across all sampling sites. Bubble size represents the number of unique species observed at each site across all sampling methods and events. X represents a site that had water and was sampled, but no fish species were caught at all. Dry sites are excluded.

Summary Statement:

Native diversity was slightly higher in the central area of the NSW Border Rivers WRPAs. Alien diversity was highest in the central and western areas, with alien species being absent or in very low limited diversity in the eastern upland areas.

Murray cod



Population Structure

Figure 9.6 shows the observed length frequency plot for Murray cod for each of the sampling seasons. The observed numbers of Young of the Year (YOY) ranged from 2 to 83, and 2% to 50% of measured fish within a season.

Overall, during the BPEOM-F program, across all the MDB water resource planning areas, the percentage YOY for Murray cod was 15% (323 out of 2,218).

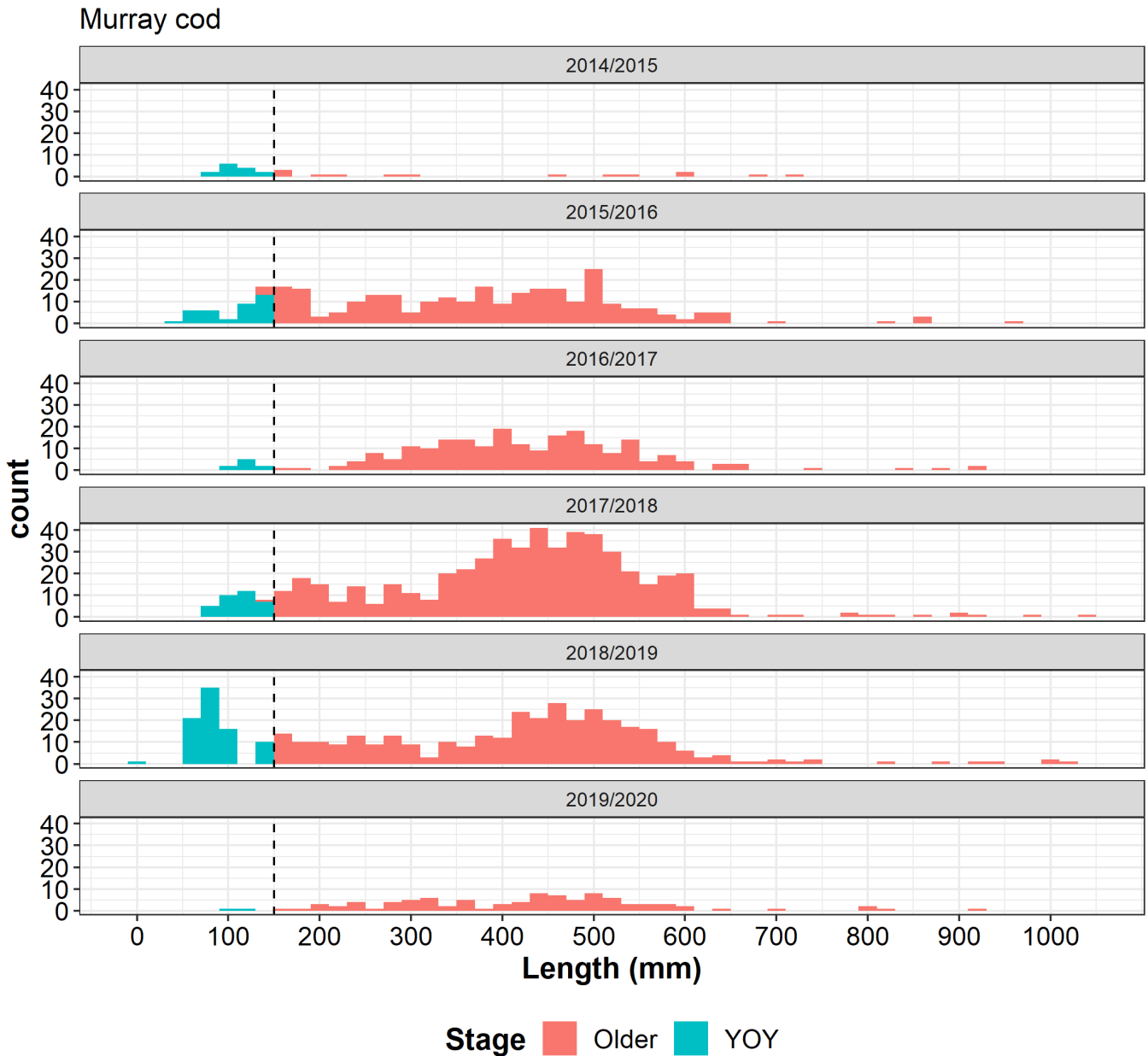


Figure 9.6: Length frequency plots for Murray cod by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Regular recruitment although low numbers of Young of the Year were observed in 2016/17 and 2019/20 suggesting possible recruitment limitation. Good range of sizes in all years.

Stocking

A total of 146,866 Murray cod were stocked into the waterways of the NSW Border Rivers WRPA during the reporting period. Of these fish, 93,997 (64%) were stocked into impoundments while 52,869 (36%) were stocked into rivers or creeks. Table 9.4 shows the detailed breakdown of stocking by season, location and life stage while Figure 9.7 shows the locations of stocking.

Table 9.4: Number and life stage of stocked Murray cod each sampling season.

Sampling Season	River/Creek or Impoundment	Life Stage	Number Stocked
2014/2015	Impoundment	Fry	1,649
2014/2015	River/Creek	Fry	7,121
2015/2016	Impoundment	Fry	20,950
2015/2016	River/Creek	Fry	11,070
2016/2017	Impoundment	Fingerling	3,898
2016/2017	Impoundment	Fry	47,000
2016/2017	River/Creek	Fingerling	7,360
2016/2017	River/Creek	Fry	3,000
2018/2019	Impoundment	Fry	20,000
2018/2019	River/Creek	Fry	18,000
2019/2020	Impoundment	Fry	500
2019/2020	River/Creek	Fry	6,318

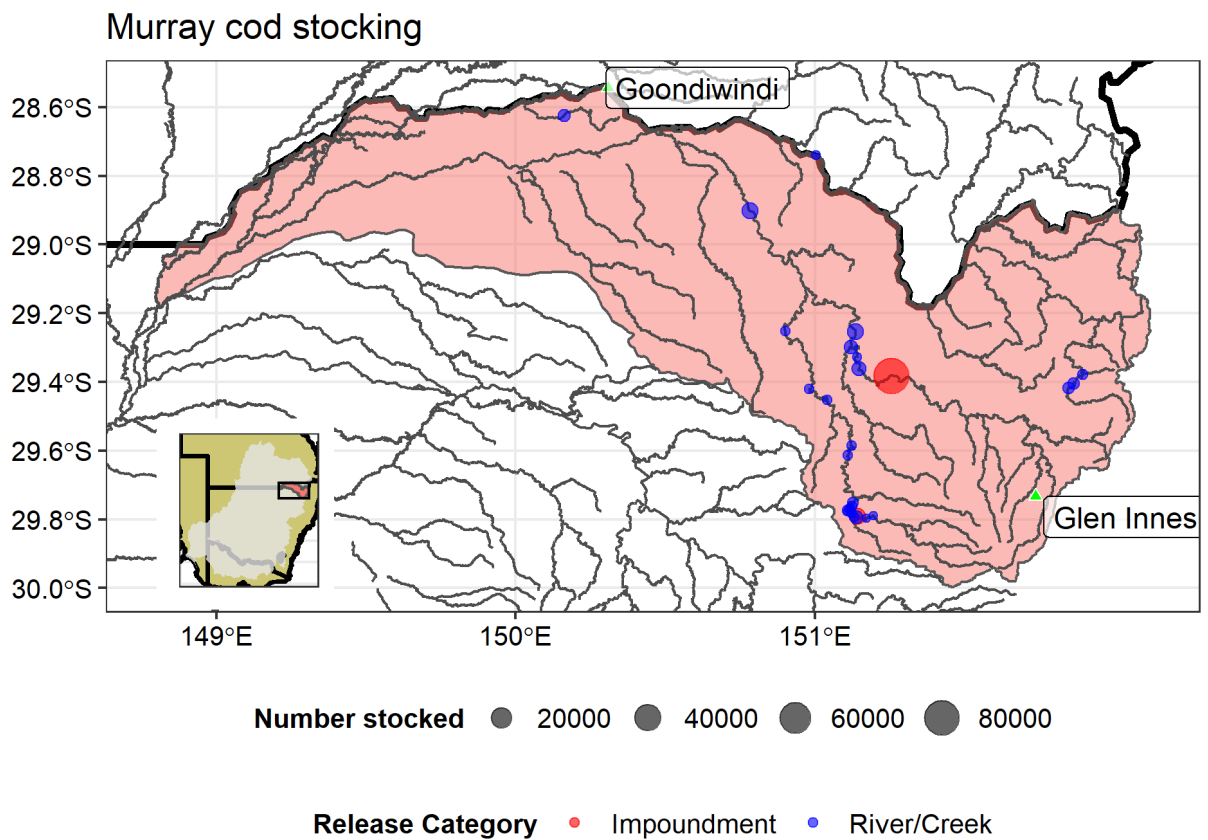


Figure 9.7: Locations of Murray cod stocking. Colours show whether a site was a river/creek site or an impoundment while the size of the point reflects the total number of fish stocked over the reporting period.

Temporal Trends in Abundance

We have modelled the relative abundance of Murray cod since 1994 based on all suitable boat electrofishing data. The left-hand panel of [Figure 9.8](#) shows the abundance trend for the NSW Border Rivers WRPAs and the right-hand panel shows the overall trend across the NSW MDB.

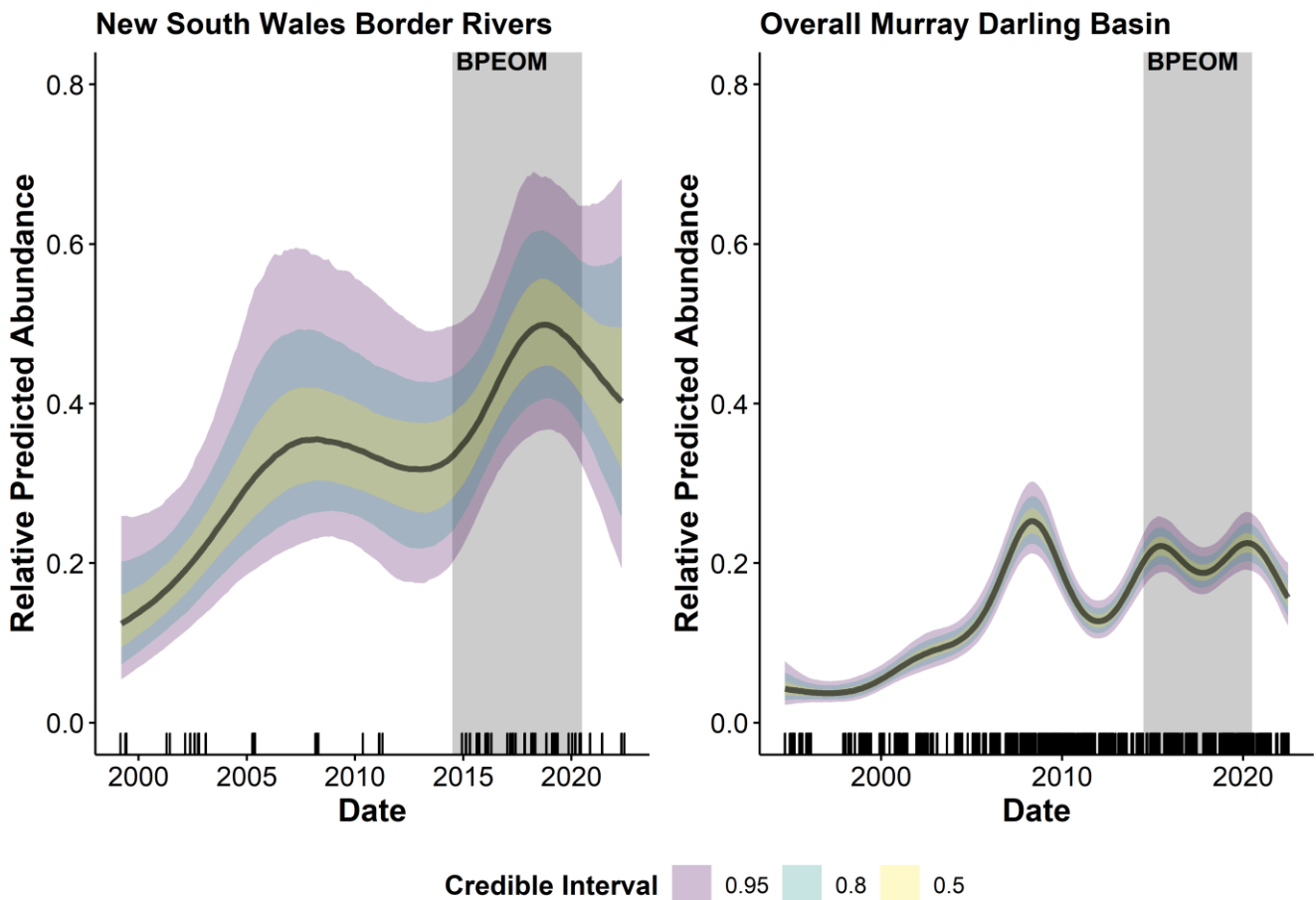


Figure 9.8: Relative abundance of Murray cod in both the NSW Border Rivers WRPAs and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and are the output of Bayesian generalised additive mixed models. The grey shaded region represents the period during which the BPEOM-F program was run. The black lines on the x-axis represent data coverage while the colours on the figure show various levels of confidence. Note when overlapping, the colours look slightly different due to the transparency and the y-axes vary between chapters of this report.

Summary Statement:

Abundance has increased overall since the late 1990s. Current relative abundance higher than the overall abundance across the NSW MDB.

Health

The prevalence of any health issues ranged from 2% of sampled fish in 2017/2018 to 13% of sampled fish in 2019/2020 (Figure 9.9). The most common health issue for Murray cod in the NSW Border Rivers WRPAs was *Leerneae*, which was observed in a total of 53 fish, corresponding to 3% of all Murray cod measured.

Across the other NSW MDB WRPA, 25% of Murray cod (556 out of 2,218 Murray cod) showed a health condition (excludes the NSW Border Rivers WRPAs).

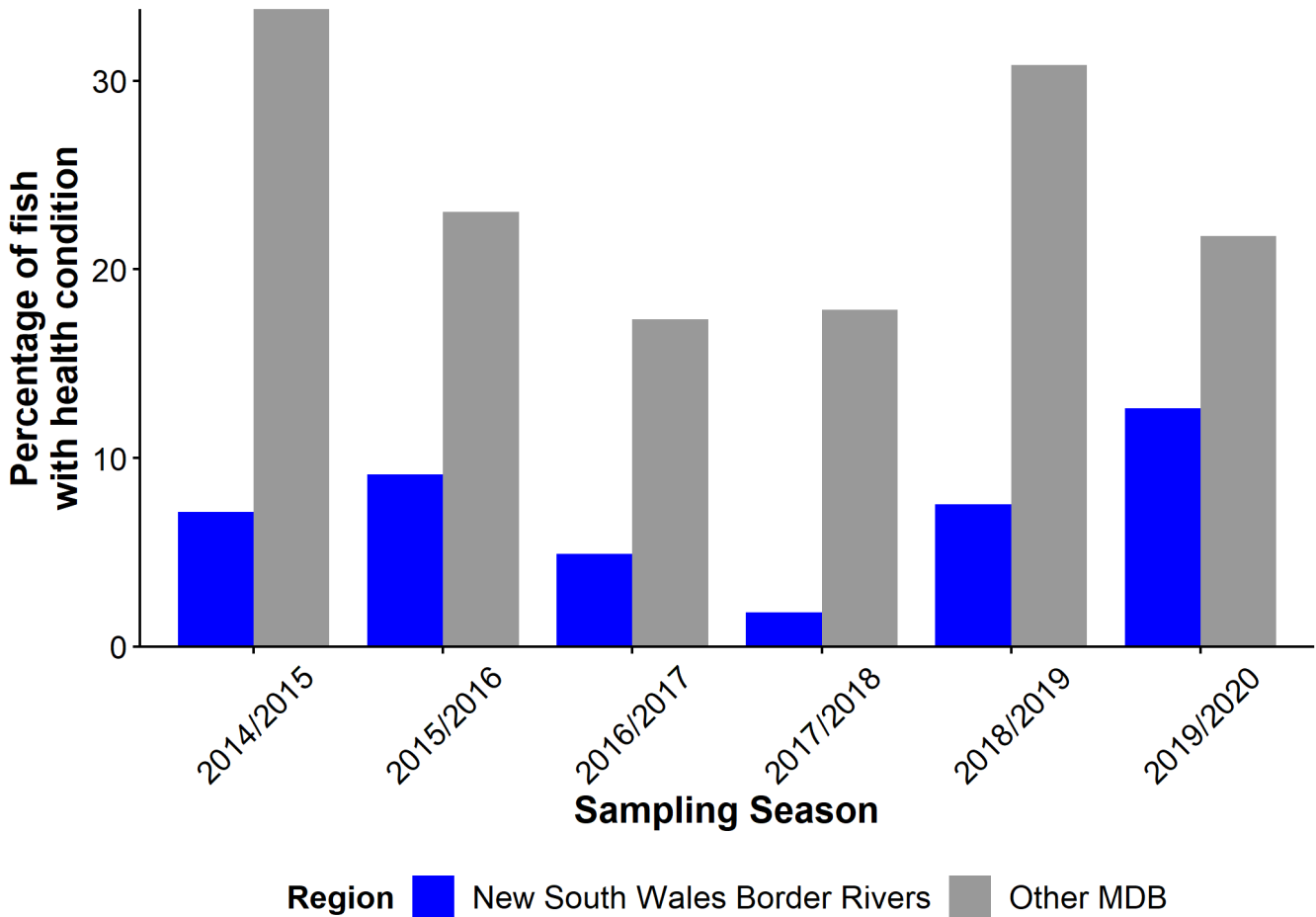


Figure 9.9: Timeseries showing the prevalence of health conditions in Murray cod. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA.

Summary Statement:

Presence of observable health conditions was low to moderate across all years and consistently lower than the rest of the NSW Murray-Darling Basin.

Distribution

Murray cod were recorded at 58 out of 83 sites in the NSW Border Rivers WRPA. The maximum observed relative abundance at a site was 6.4 fish caught per 90 seconds of electrofishing. [Figure 9.10](#) shows the distribution and relative abundance of Murray cod across the NSW Border Rivers WRPA.

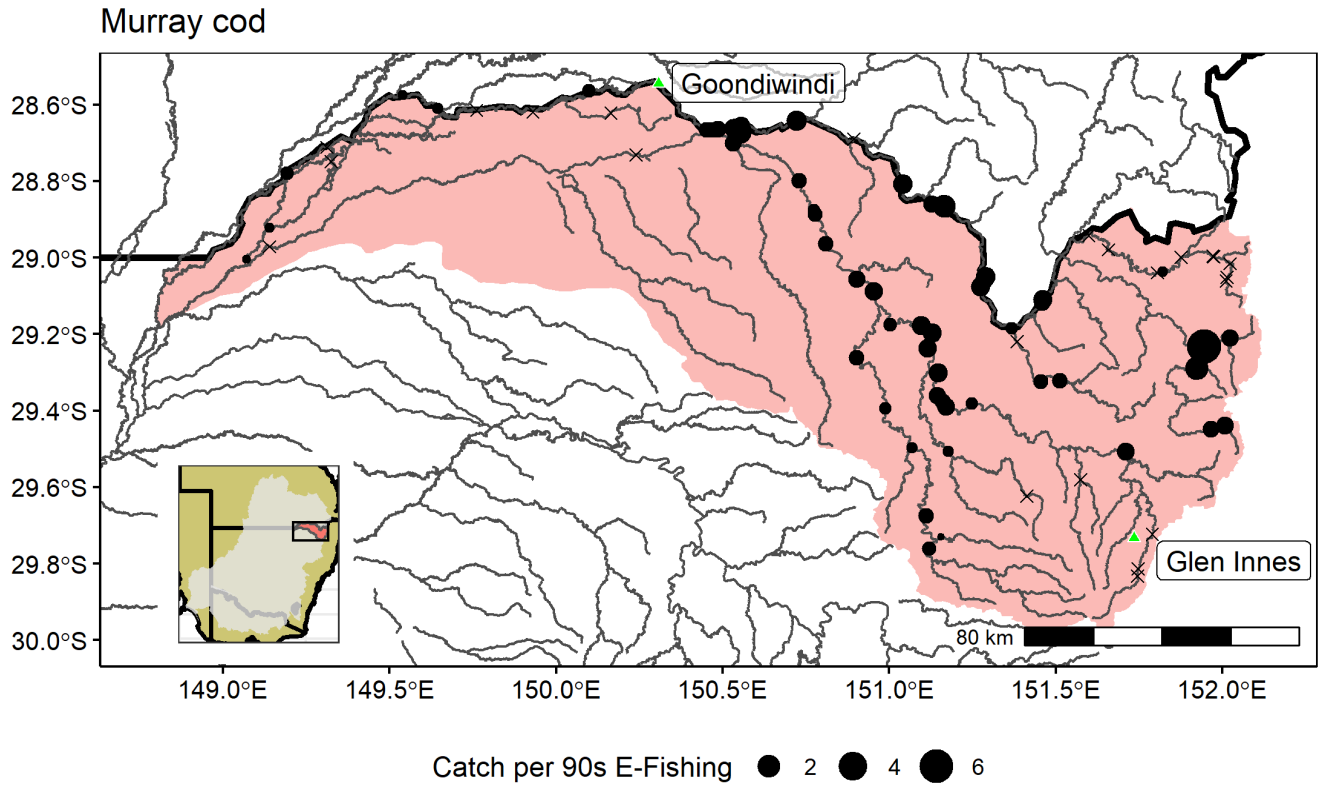


Figure 9.10: Distribution of Murray cod. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Murray cod were recorded across the NSW Border Rivers WRPA but were most abundant in the eastern mid-reaches (east of Goondiwindi).

Golden perch



Population Structure

Figure 9.11 shows the observed length frequency plot for Golden perch for each of the sampling seasons. The observed numbers of Young of the Year (YOY) ranged from 0 to 12, and 0% to 9% of measured fish within a season.

Overall, during the BPEOM-F program, across all the MDB water resource planning areas, the percentage YOY for Golden perch was 13% (253 out of 1,933).

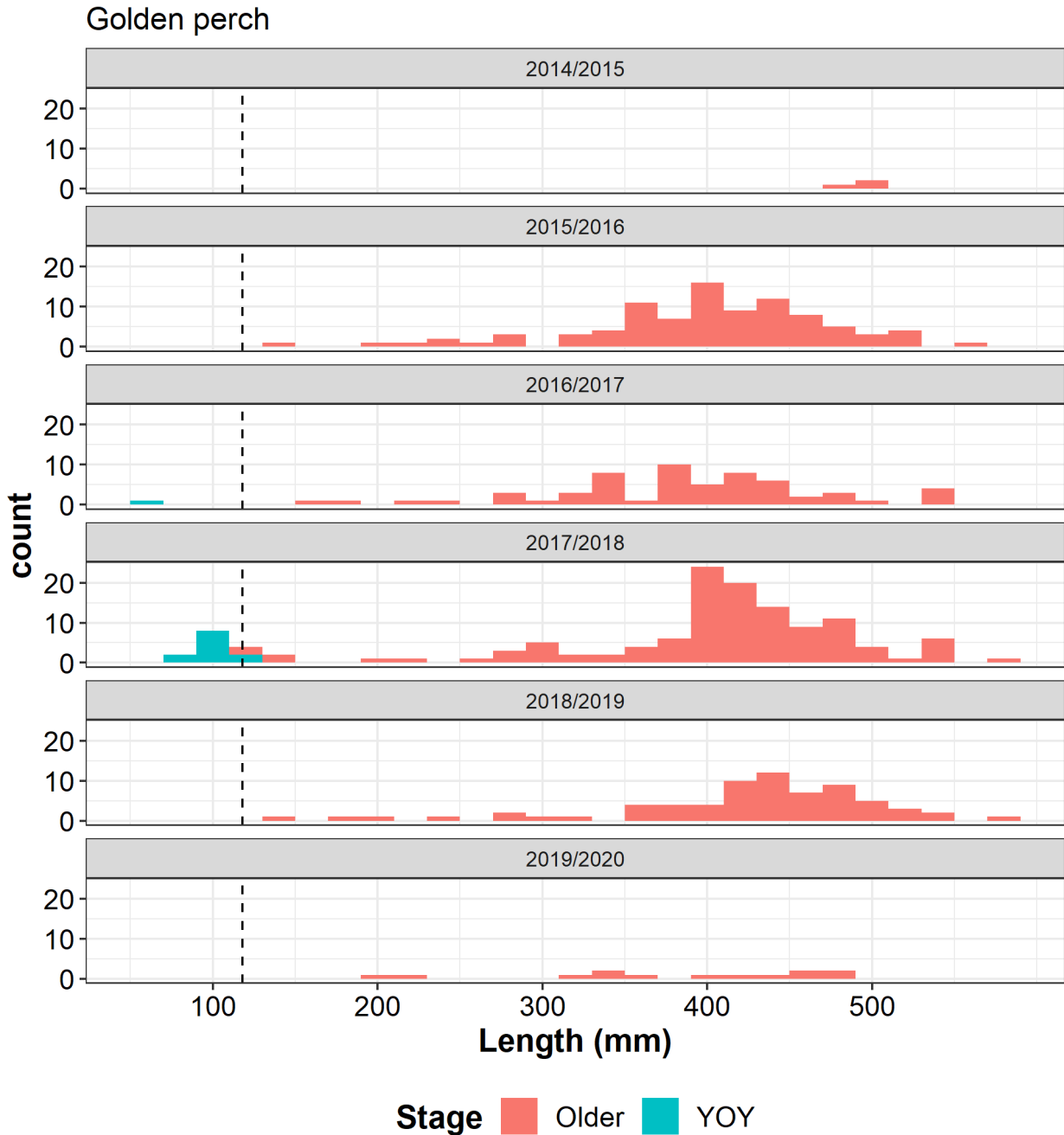


Figure 9.11: Length frequency plots for Golden perch by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Limited or poor recruitment in most years with young of the year only observed in 2016/17 and 2017/18. Suggests recruitment limitation in most years. Population structure dominated by larger (older) fish.

Stocking

A total of 177,633 Golden perch were stocked into the waterways of the NSW Border Rivers WRPA during the reporting period. Of these fish, 79,464 (44.7%) were stocked into impoundments while 98,169 (55.3%) were stocked into rivers or creeks. Table 9.5 shows the detailed breakdown of stocking by season, location and life stage while Figure 9.12 shows the locations of stocking.

Table 9.5: Number and life stage of stocked Golden perch each sampling season.

Sampling Season	River/Creek or Impoundment	Life Stage	Number Stocked
2014/2015	Impoundment	Fry	5273
2014/2015	River/Creek	Fry	37919
2015/2016	Impoundment	Fry	1906
2015/2016	River/Creek	Fry	39638
2016/2017	Impoundment	Fingerling	1285
2016/2017	Impoundment	Fry	30000
2016/2017	River/Creek	Fingerling	15612
2017/2018	Impoundment	Fry	41000
2017/2018	River/Creek	Fry	5000

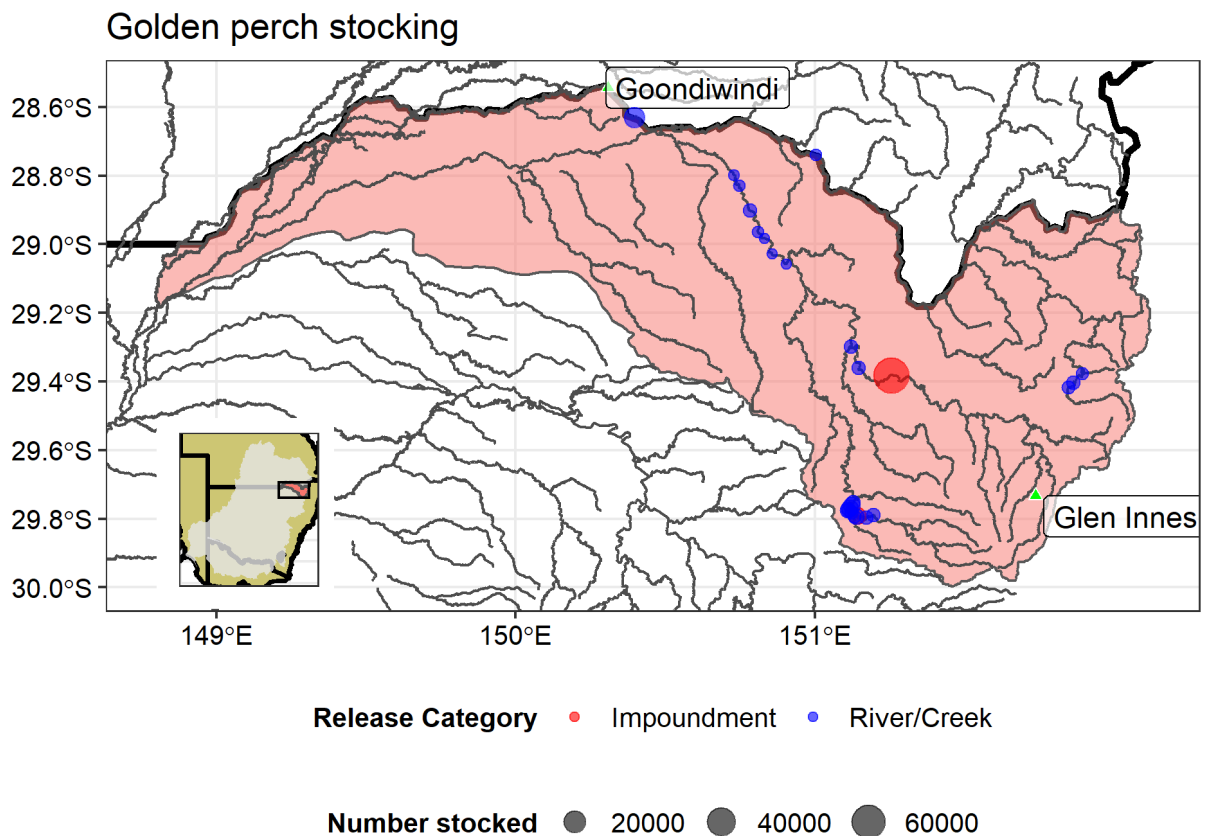


Figure 9.12: Locations of Golden perch stocking. Colours show whether a site was a river/creek site or an impoundment while the size of the point reflects the total number of fish stocked over the reporting period.

Temporal Trends in Abundance

We have modelled the relative abundance of Golden perch since 1994 based on all suitable boat electrofishing data. The left-hand panel of [Figure 9.13](#) shows the abundance trend for the NSW Border Rivers WRPA and the right-hand panel shows the overall trend across the NSW MDB.

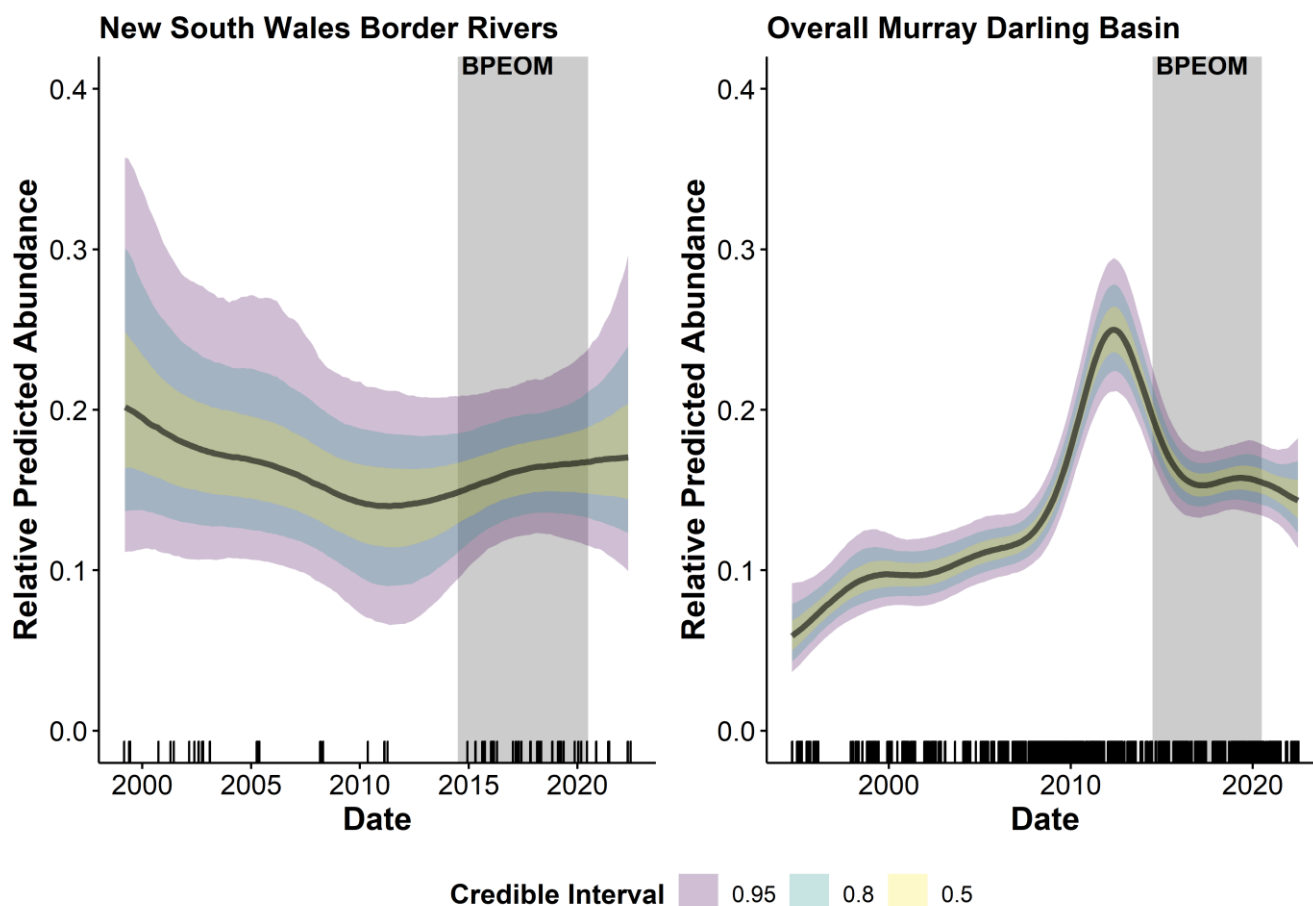


Figure 9.13: Relative abundance of Golden perch in both this valley and the overall Murray-Darling Basin. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region represents the period during which the BPEOM-F program was run. The black lines on the x-axis represent data coverage while the colours on the figure show various levels of confidence. Note when overlapping, the colours look slightly different due to the transparency and the y-axes vary between chapters of this report.

Summary Statement:

Current abundance similar to late 1990s with no significant change over time. Relative abundance is similar to the overall abundance across the MDB, which peaked around 2012.

Health

The prevalence of any health issues ranged from 0% of sampled fish in 2014/2015 to 27% of sampled fish in 2016/2017 (Figure 9.14). The most common health issue for Golden perch in the NSW Border Rivers water resource planning area was *Lernaeae*, which was observed in a total of 31 fish, corresponding to 8% of all Golden perch measured.

Across the other WRPAs, 37% of Golden perch (718 out of 1,933 Golden perch) showed a health condition (excludes NSW Border Rivers).

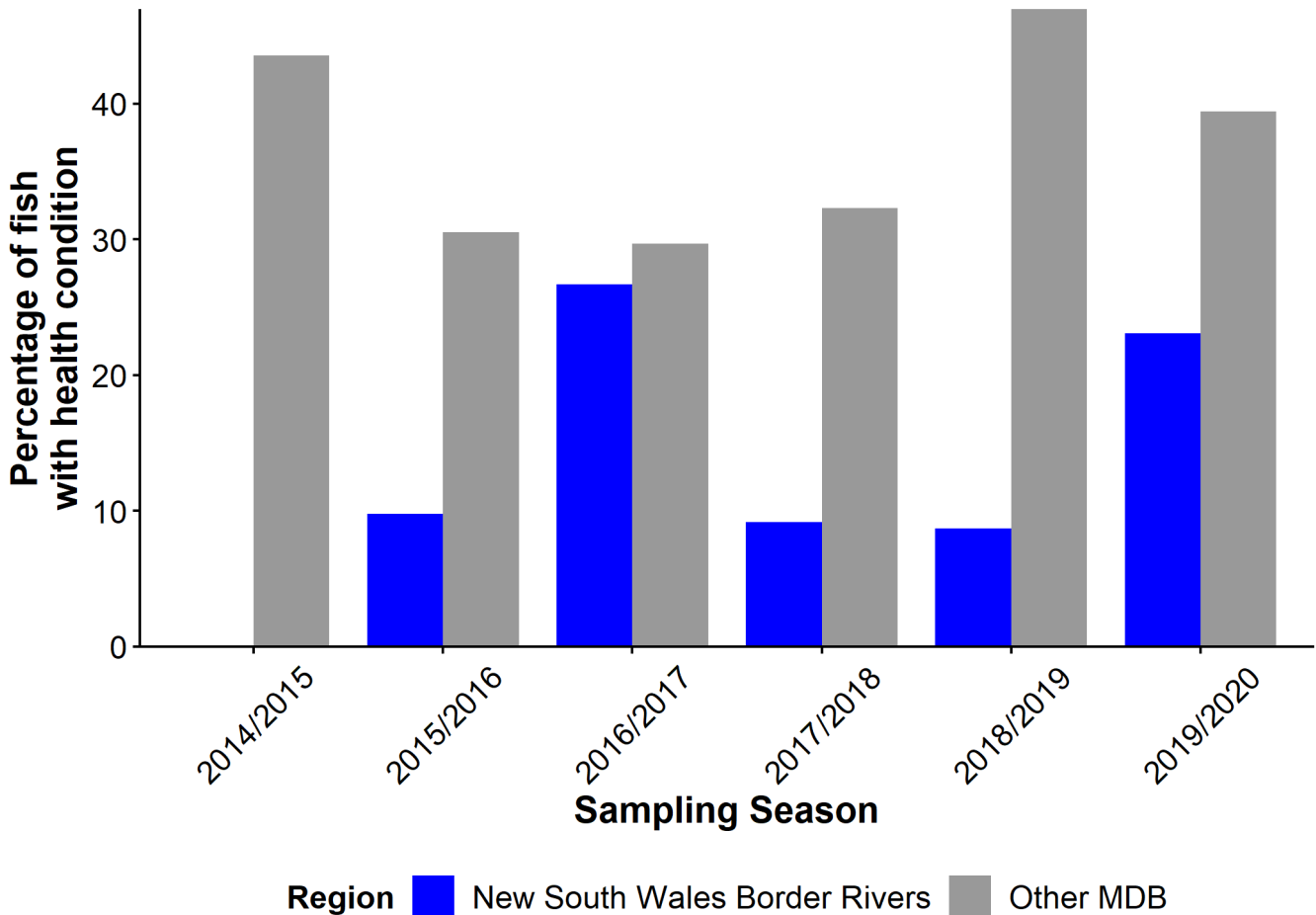


Figure 9.14: Timeseries showing the prevalence of health conditions in Golden perch. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA.

Summary Statement:

The presence of observable health conditions for Golden perch in the NSW Border Rivers was low to moderate, and consistently lower than the overall NSW MDB.

Distribution

Golden perch were recorded at 41 out of 83 sites in the NSW Border Rivers WRPA. The maximum observed relative abundance at a site was 0.7 fish caught per 90 seconds of electrofishing. [Figure 9.15](#) shows the distribution and relative abundance of Golden perch across the NSW Border Rivers WRPA.

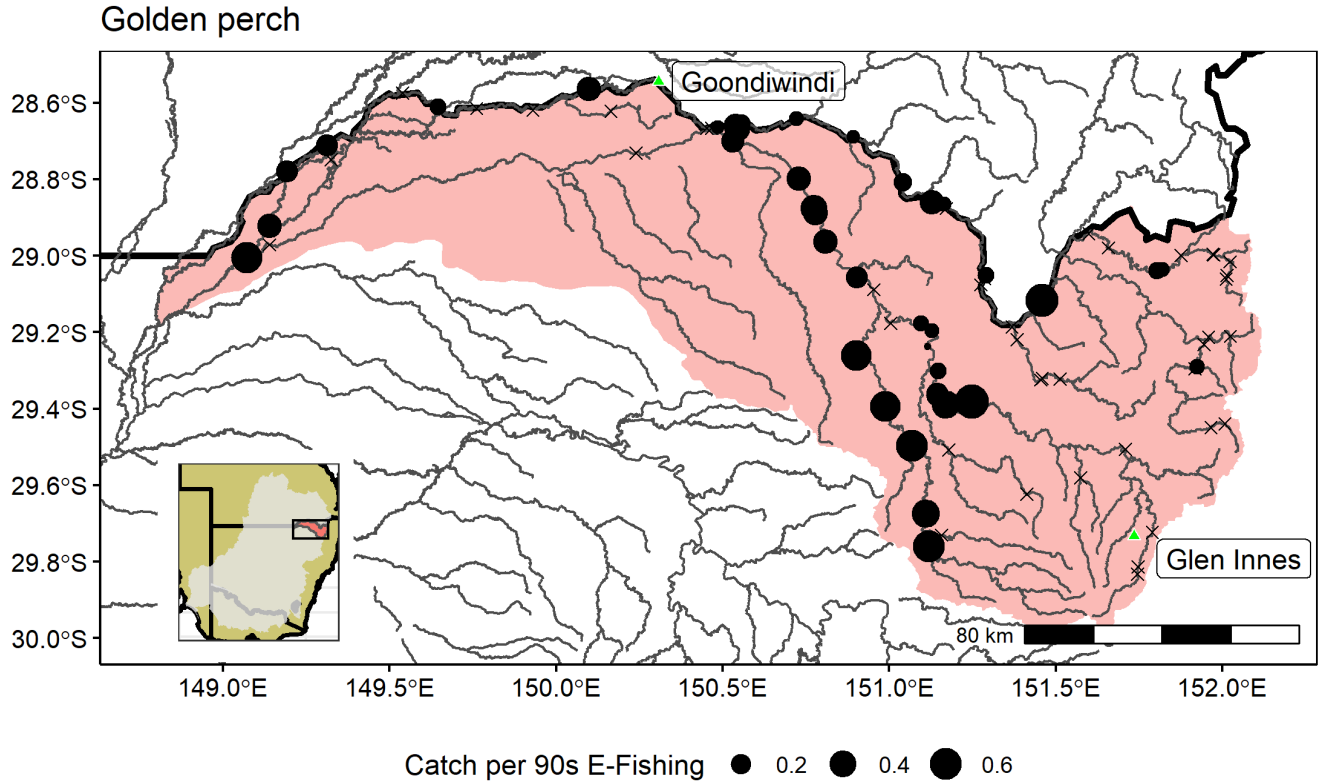


Figure 9.15: Distribution of Golden perch. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Golden perch were distributed across the NSW Border Rivers WRPA excluding some eastern upland reaches.

Freshwater catfish



Population Structure

Figure 9.16 shows the observed length frequency plot for Freshwater catfish for each of the sampling seasons. The observed numbers of Young of the Year (YOY) ranged from 0 to 46, and 0% to 60% of measured fish within a season.

Overall, during the BPEOM-F program, across all the MDB water resource planning areas, the percentage YOY for Freshwater catfish was 50% (190 out of 380).

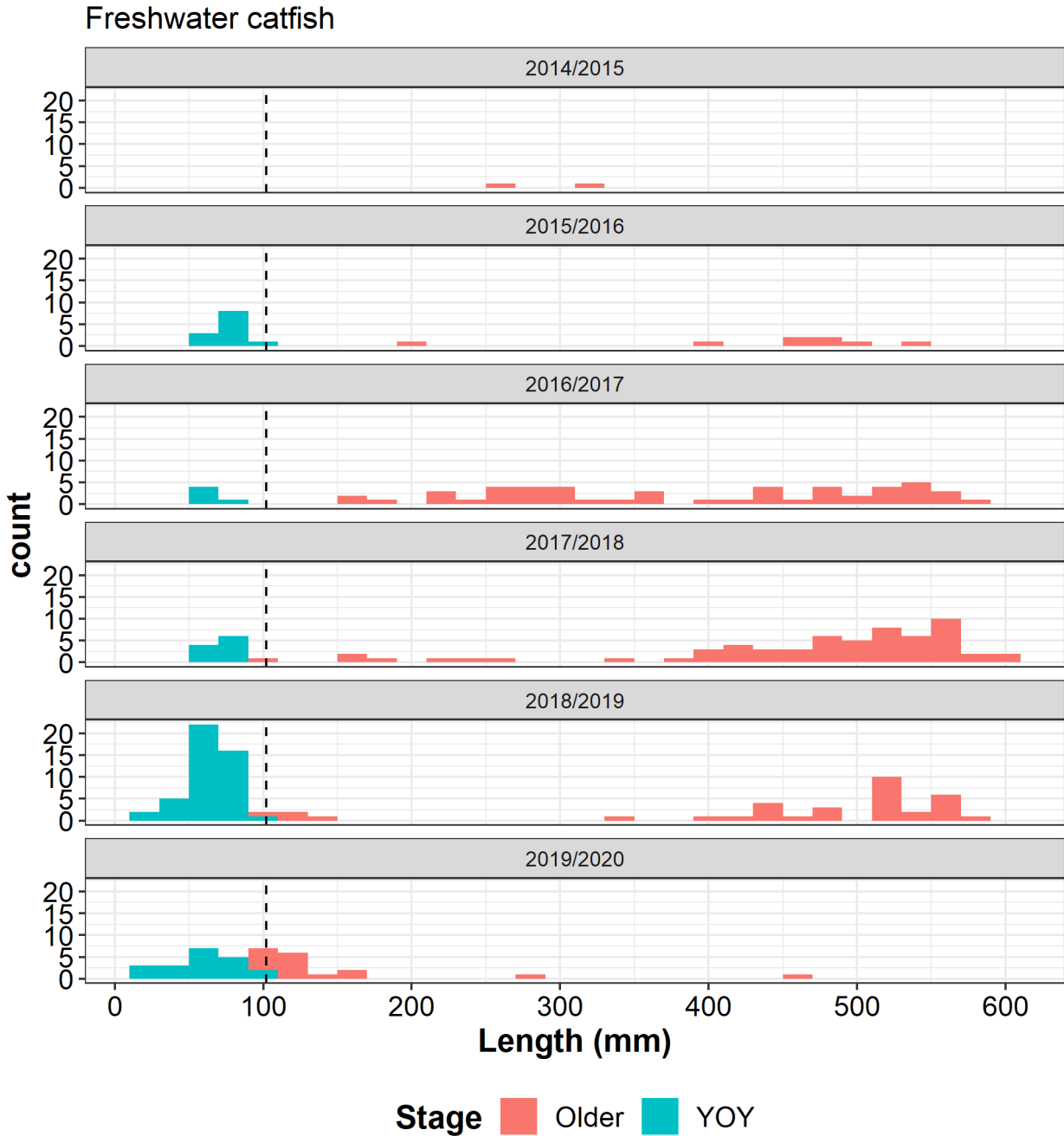


Figure 9.16: Length frequency plots for Freshwater catfish by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Recruitment was observed in all years except 2014/15. Very few larger fish were observed in 2014/15 and 2019/20.

Temporal Trends in Abundance

We have modelled the relative abundance of Freshwater catfish since 1994 based on all suitable boat and backpack electrofishing data. The left-hand panel of [Figure 9.17](#) shows the abundance trend for the NSW Border Rivers WRPA and the right-hand panel shows the overall trend across the NSW MDB.

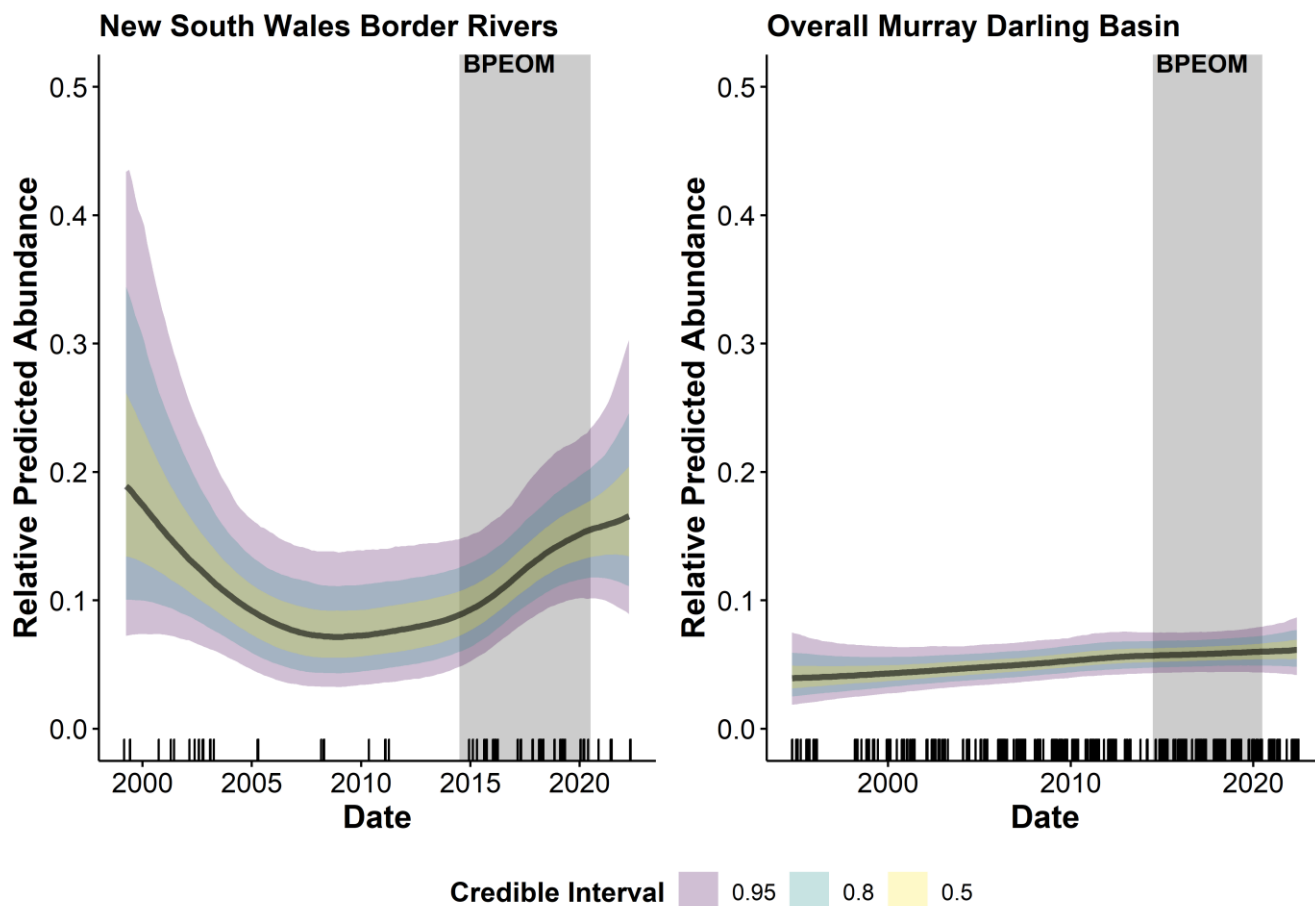


Figure 9.17: Relative abundance of Freshwater catfish in both this valley and the overall Murray-Darling Basin. Note there was insufficient data to model the abundance of Freshwater catfish, hence the empty plot. These are model estimates based upon all electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region represents the period during which the BPEOM-F program was run. The black lines on the x-axis represent data coverage while the colours on the figure show various levels of confidence. Note when overlapping, the colours look slightly different due to the transparency and the y-axes vary between chapters of this report.

Summary Statement:

The abundance of Freshwater catfish in the NSW Border Rivers declined in the early 2000s but has since recovered to late 1990s abundances and is currently higher than the overall NSW MDB abundance.

Health

No health issues were observed in Freshwater catfish in the NSW Border Rivers WRPA (Figure 9.18).

Across the other WRPAs, 2% of Freshwater catfish (8 out of 380 Freshwater catfish) showed a health condition (excludes NSW Border Rivers).

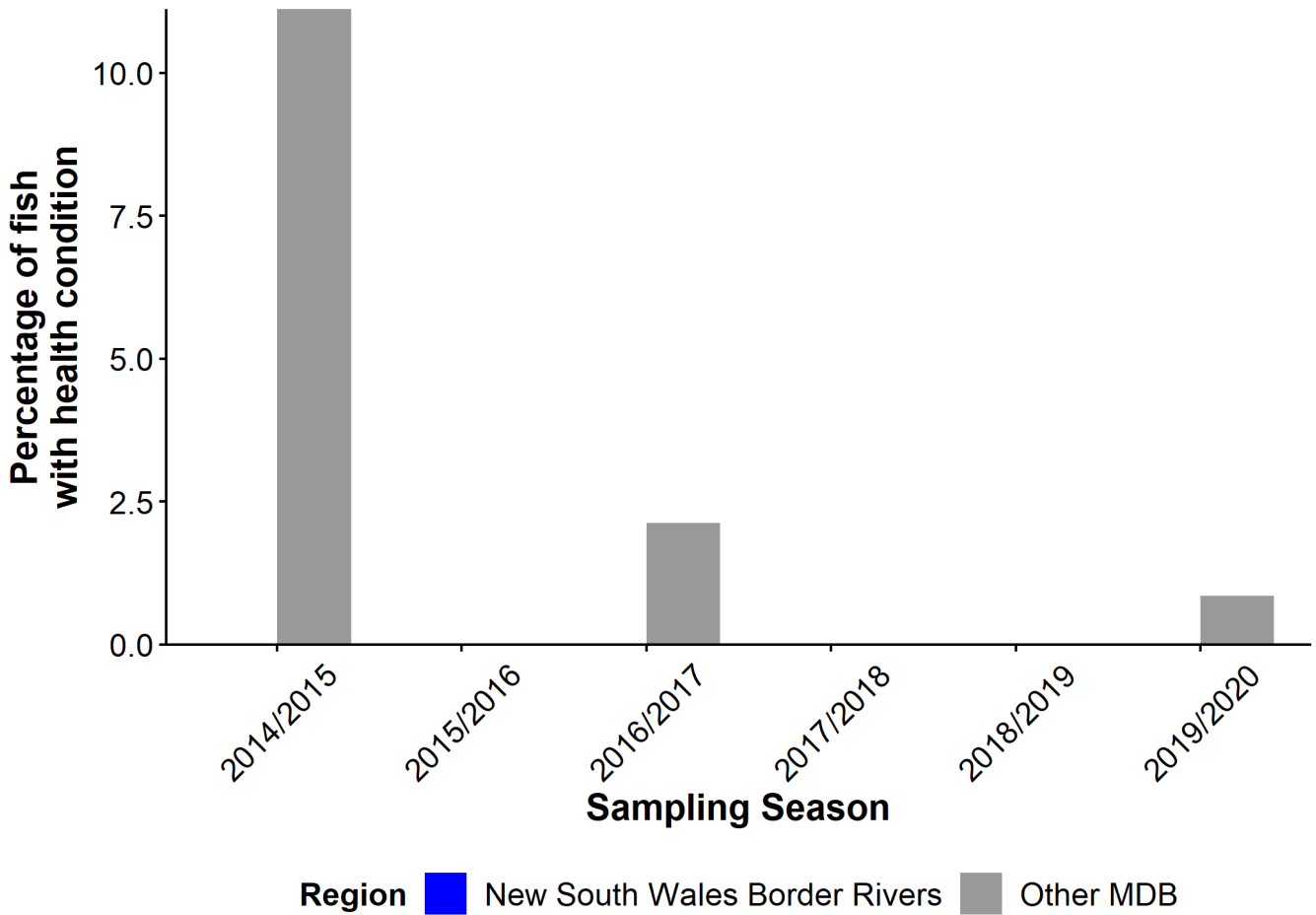


Figure 9.18: Timeseries showing the prevalence of health conditions in Freshwater catfish. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

No health issues were observed in Freshwater catfish in the NSW Border Rivers WRPA.

Distribution

Freshwater catfish were recorded at 39 out of 83 sites in the NSW Border Rivers WRPAs. The maximum observed relative abundance at a site was 1.4 fish caught per 90 seconds of electrofishing. [Figure 9.19](#) shows the distribution and relative abundance of Freshwater catfish across the NSW Border Rivers WRPAs.

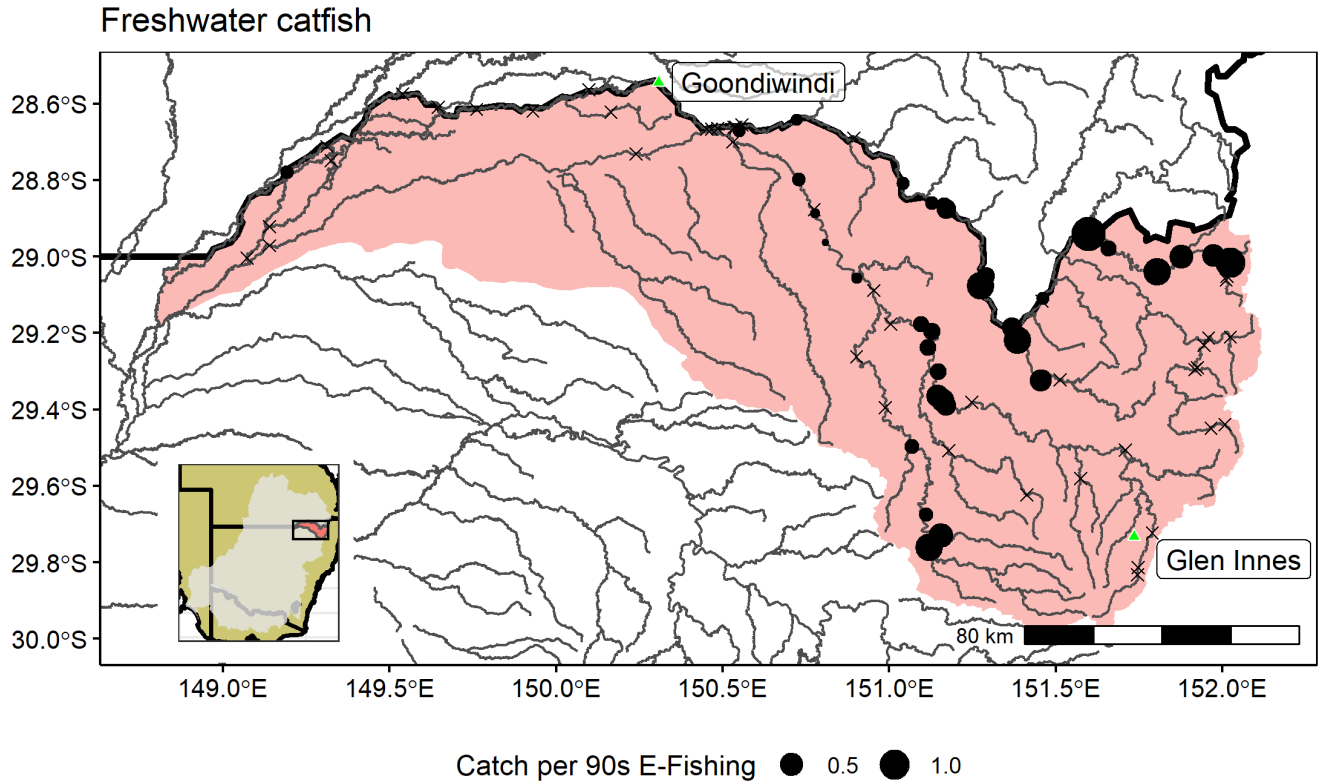


Figure 9.19: Distribution of Freshwater catfish. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Freshwater catfish were restricted to the region east of Goondiwindi and most abundant in the mid-elevation reaches. Freshwater catfish were not recorded in the south-eastern region around Glen Innes.

Bony herring



Population Structure

Figure 9.20 shows the observed length frequency plot for Bony herring for each of the sampling seasons. The observed numbers of Young of the Year (YOY) ranged from 19 to 388, and 5% to 42% of measured fish within a season.

Overall, during the BPEOM-F program, across all the MDB water resource planning areas, the percentage YOY for Bony herring was 31% (4,331 out of 13,865). Bony herring are not a stocked species.

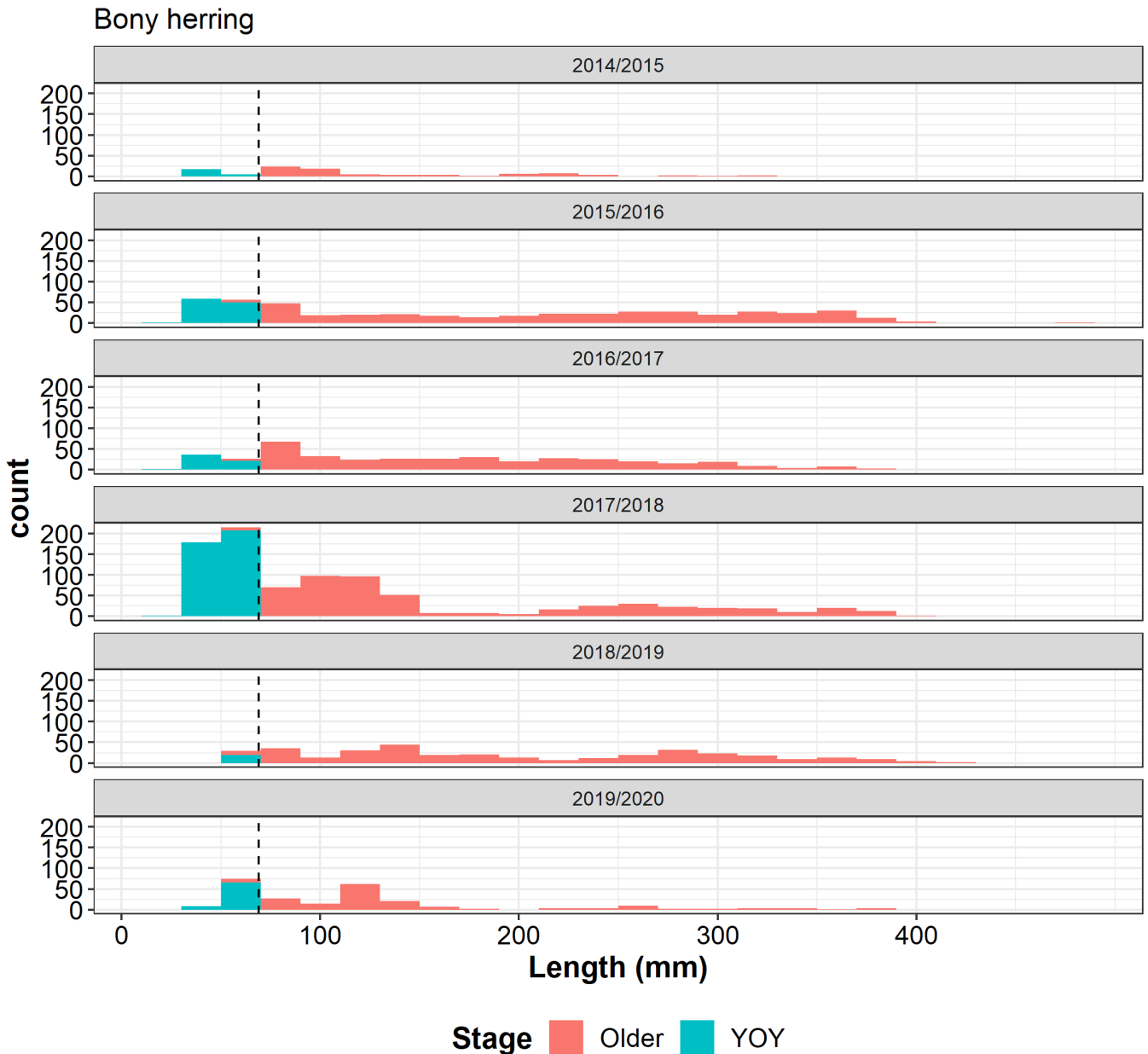


Figure 9.20: Length frequency plots for Bony herring by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Recruitment observed in all years although few YOY in 2018/19. Possible decline in larger fish in 2019/20.

Temporal Trends in Abundance

We have modelled the relative abundance of Bony herring since 1994 based on all suitable boat electrofishing data. The left-hand panel of [Figure 9.21](#) shows the abundance trend for the NSW Border Rivers WRPAs and the right-hand panel shows the overall trend across the NSW MDB.

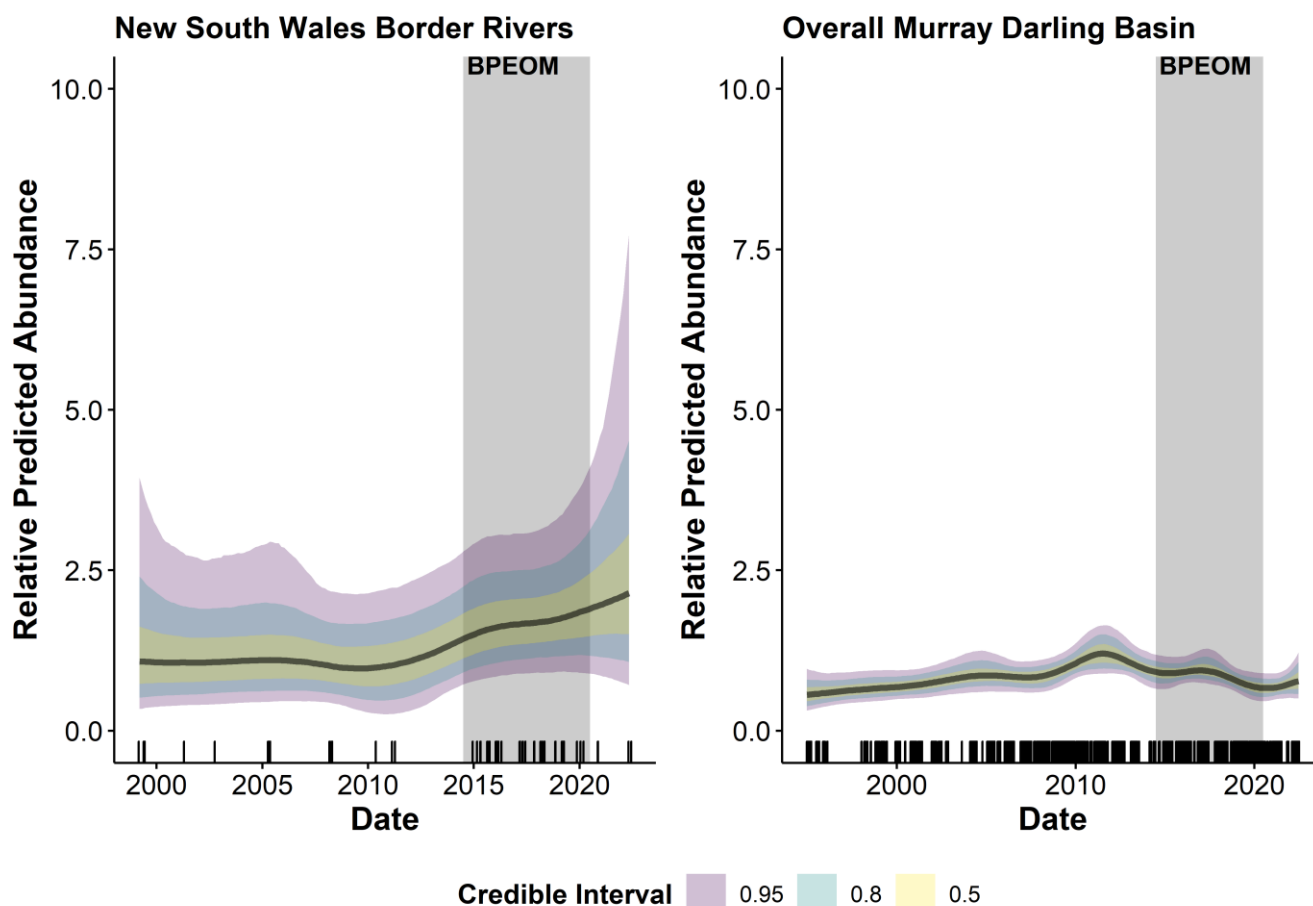


Figure 9.21: Relative abundance of Bony herring in both the Macquarie-Castlereagh WRPAs and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region represents the period during which the BPEOM-F program was run. The black lines on the x-axis represent data coverage while the colours on the figure show various levels of confidence. Note when overlapping, the colours look slightly different due to the transparency and the y-axes vary between chapters of this report.

Summary Statement:

Abundance likely to be slightly higher than the late 1990s. Abundance is currently higher than the overall NSW MDB.

Health

The prevalence of any health issues ranged from 0% of sampled fish in 2016/2017 to 10% of sampled fish in 2014/2015 (Figure 9.22). The most common health issue for Bony herring in the NSW Border Rivers WRPAs was Fungus, which was observed in a total of 7 fish, corresponding to <1% of all Bony herring measured.

Across the other NSW MDB WRPA, 1% of Bony herring (162 out of 13,865 Bony herring) showed a health condition (excludes the NSW Border Rivers WRPAs).

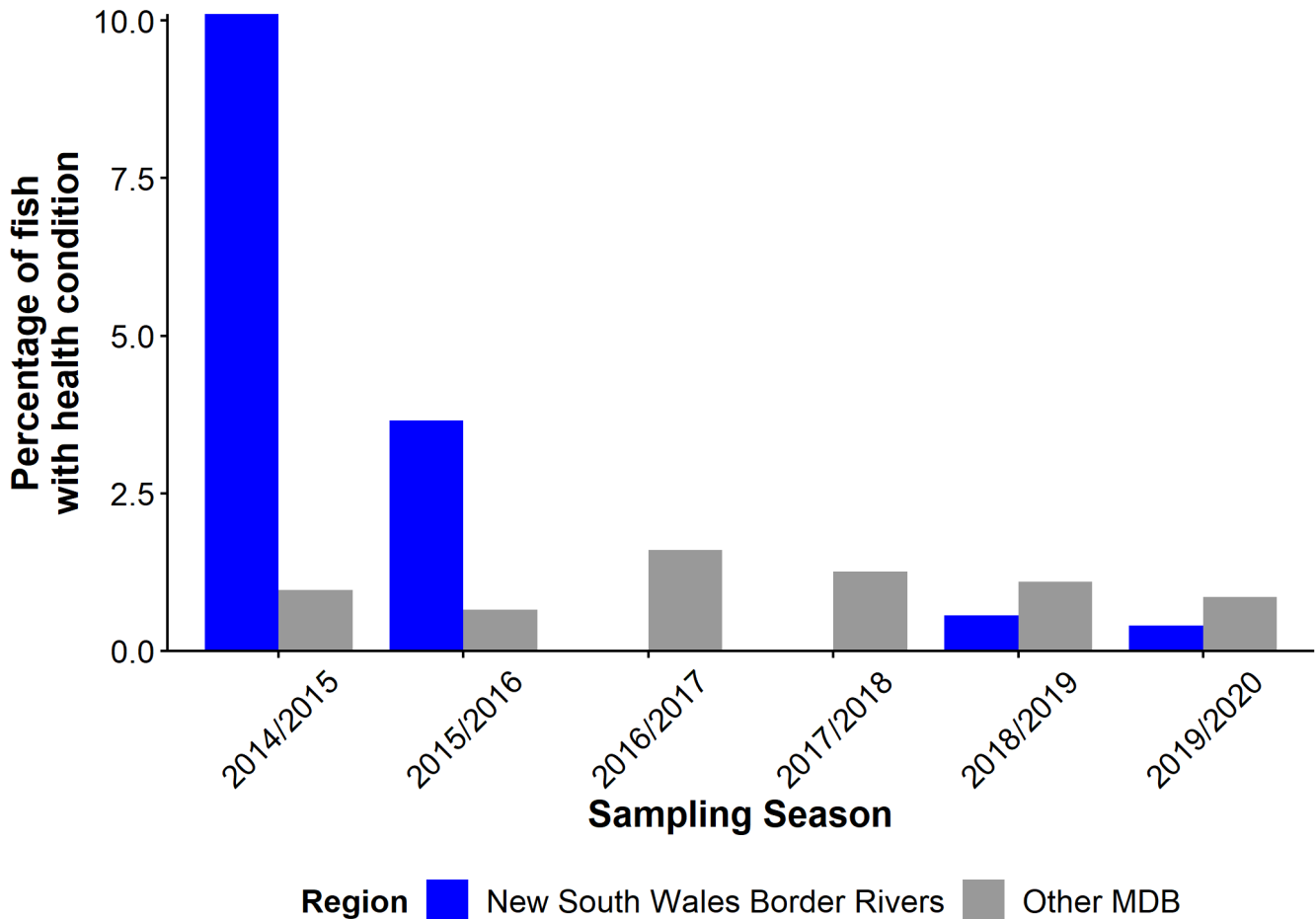


Figure 9.22: Timeseries showing the prevalence of health conditions in Bony herring. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA.

Summary Statement:

Presence of observable health conditions was low to moderate but lower than the rest of the NSW MDB since 2016/17. 2014/15 and 2015/16 had substantially higher rates of health conditions than the other years and in comparison to the wider NSW MDB.

Distribution

Bony herring were recorded at 32 out of 83 sites in the NSW Border Rivers WRP. The maximum observed relative abundance at a site was 65 fish caught per 90 seconds of electrofishing. [Figure 9.23](#) shows the distribution and relative abundance of Bony herring across the NSW Border Rivers WRP.

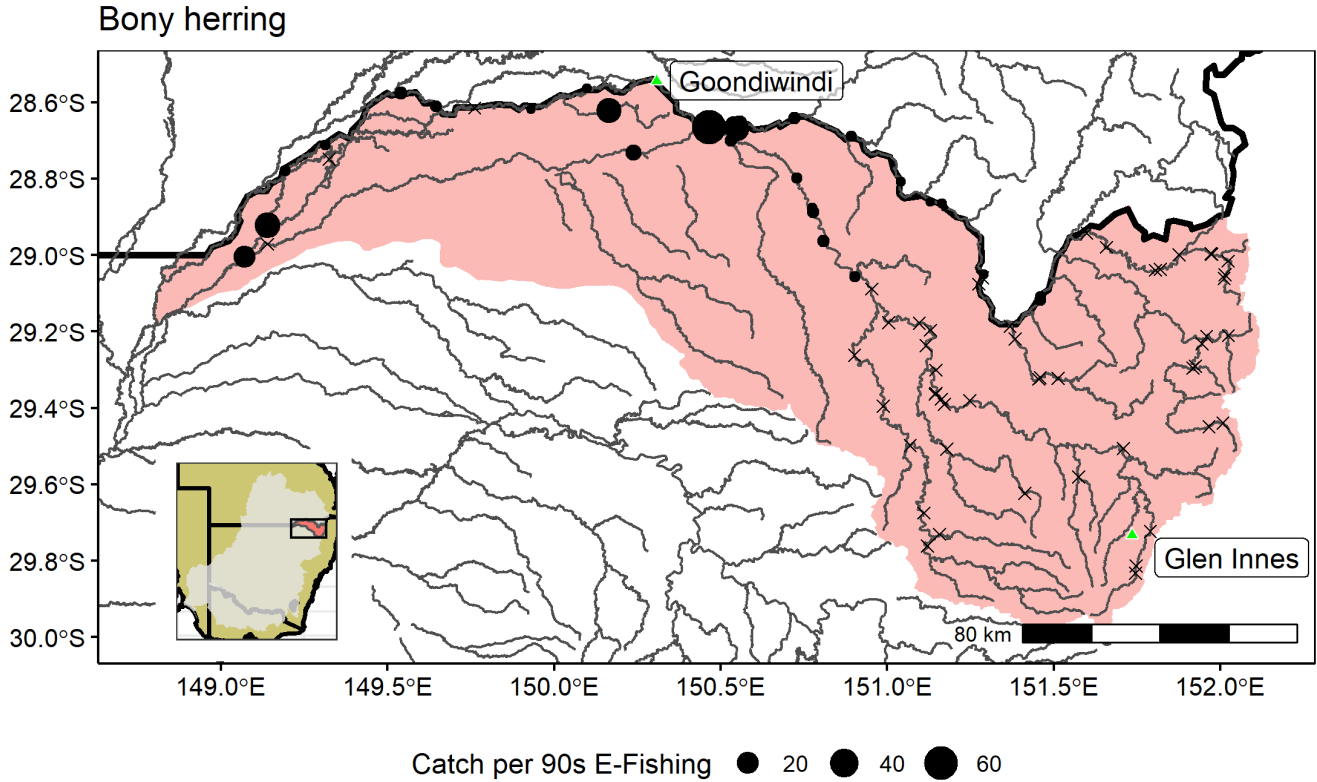


Figure 9.23: Distribution of Bony herring. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Bony herring were recorded in lowland reaches across the central and western region of the NSW Border Rivers WRP and were absent in eastern and upland sites.

Australian smelt



Population Structure

Figure 9.24 shows the observed length frequency plot for Australian smelt for each of the sampling seasons. The observed numbers of Young of the Year (YOY) ranged from 3 to 72, and 10% to 76% of measured fish within a season.

Overall, during the BPEOM-F program, across all the MDB water resource planning areas, the percentage YOY for Australian smelt was 42% (3,385 out of 8,054). Australian smelt are not a stocked species.

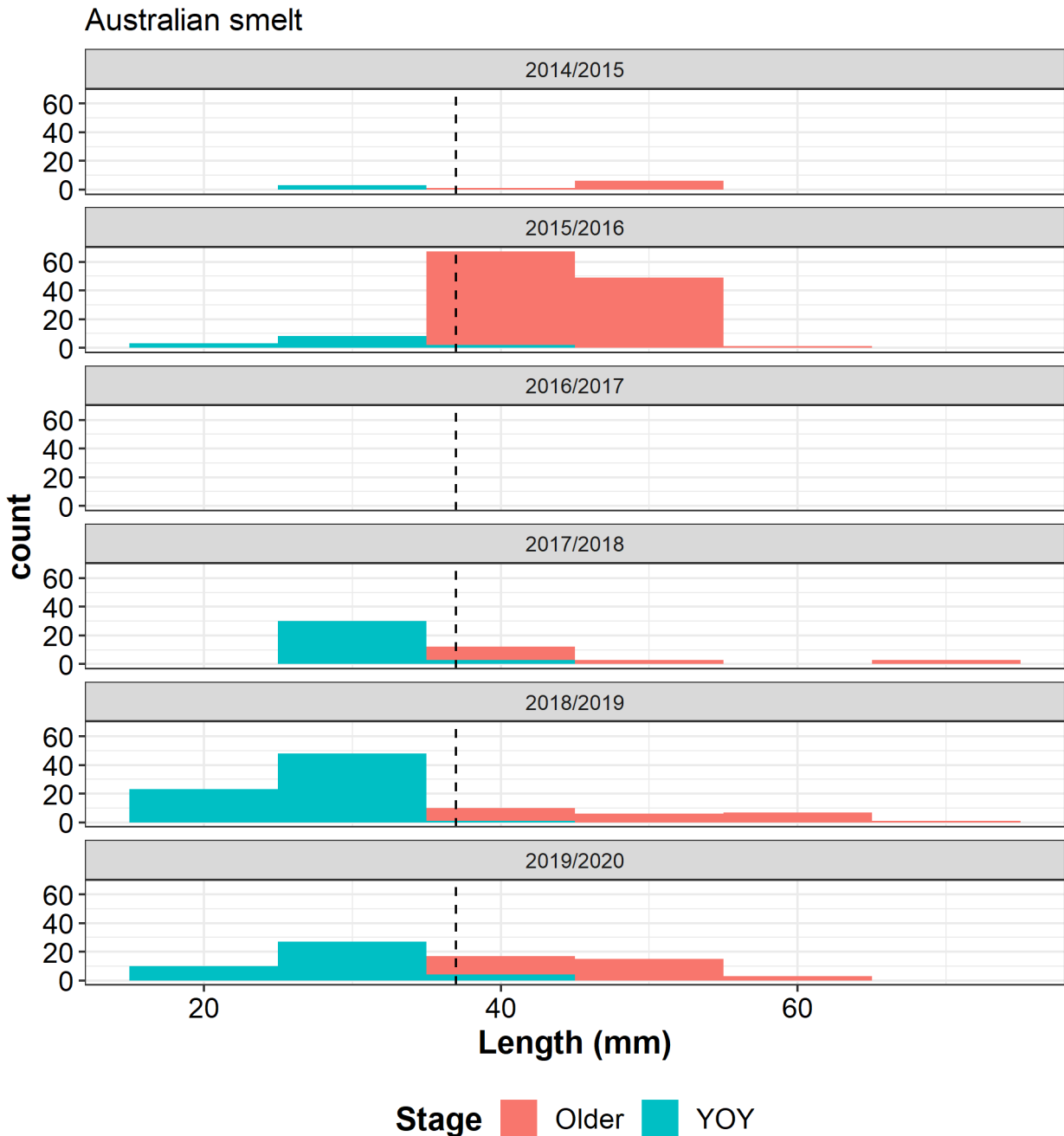


Figure 9.24: Length frequency plots for Australian smelt by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Young of the Year and adult Australian smelt were observed in all years except 2016/17 when no Australian smelt were observed suggesting a possible recruitment failure in 2016/17. Only one individual was observed across all NSW DPI sampling programs in 2016/17 in this region.

Temporal Trends in Abundance

We have modelled the relative abundance of Australian smelt since 1994 based on all suitable boat electrofishing data. The left-hand panel of [Figure 9.25](#) shows the abundance trend for the NSW Border Rivers WRPAs and the right-hand panel shows the overall trend across the NSW MDB.

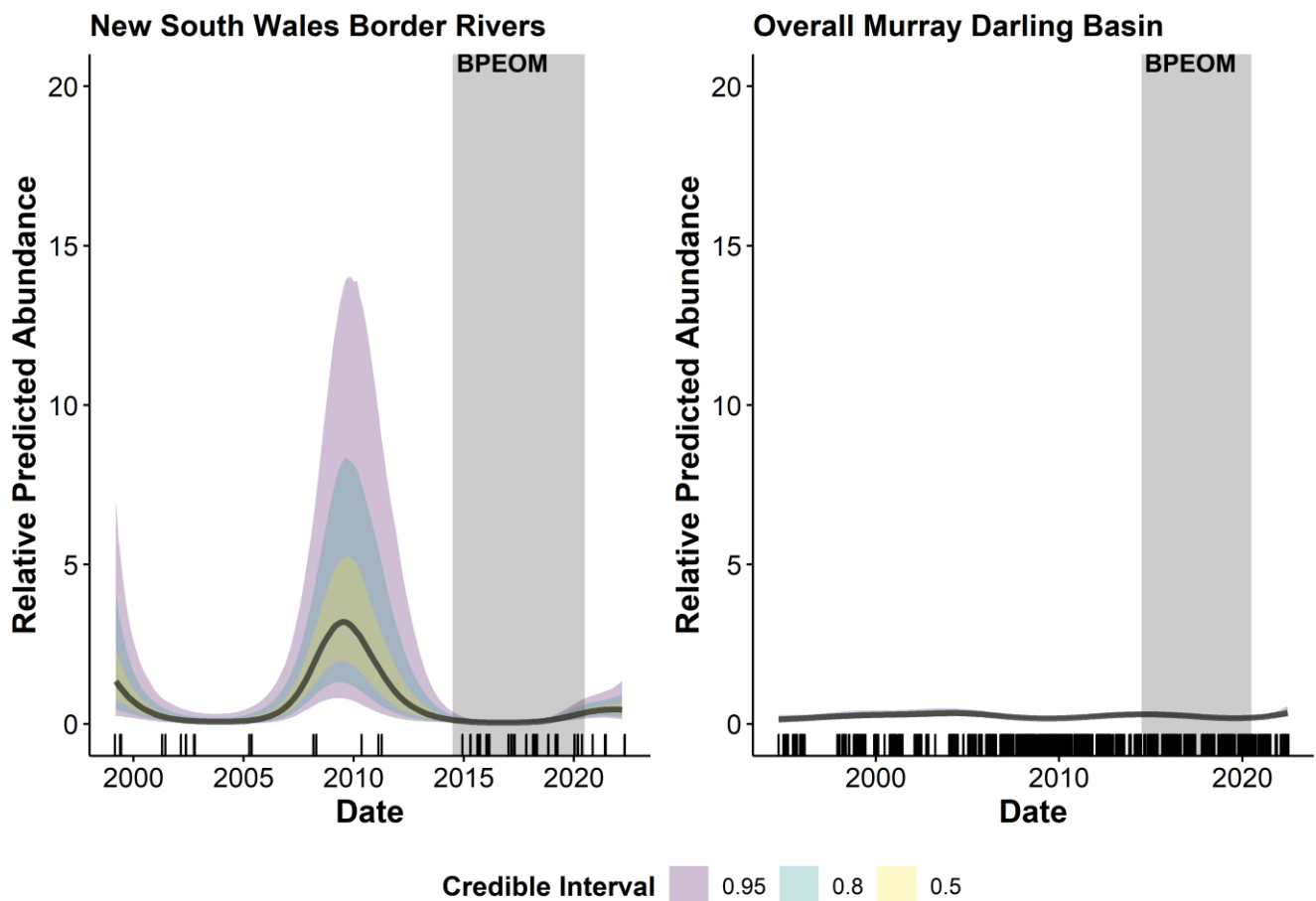


Figure 9.25: Relative abundance of Australian smelt in both the NSW Border Rivers WRPAs and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region represents the period during which the BPEOM-F program was run. The black lines on the x-axis represent data coverage while the colours on the figure show various levels of confidence. Note when overlapping, the colours look slightly different due to the transparency and the y-axes vary between chapters of this report.

Summary Statement:

Abundance peaked in approximately 2009 but has since declined back to late 1990s levels. Current relative abundance is approximately equal to the overall NSW MDB.

Health

The prevalence of any health issues ranged from 0% of sampled fish in most seasons to 10% of sampled fish to 2014/2015 (Figure 9.26). The most common health issue for Australian smelt in the NSW Border Rivers WRPAs was *Lerneae*, which was observed in a total of 1 fish, corresponding to <1% of all Australian smelt measured.

Across the other NSW MDB WRPA, 1% of Australian smelt (52 out of 8,054 Australian smelt) showed a health condition (excludes the NSW Border Rivers WRPAs).

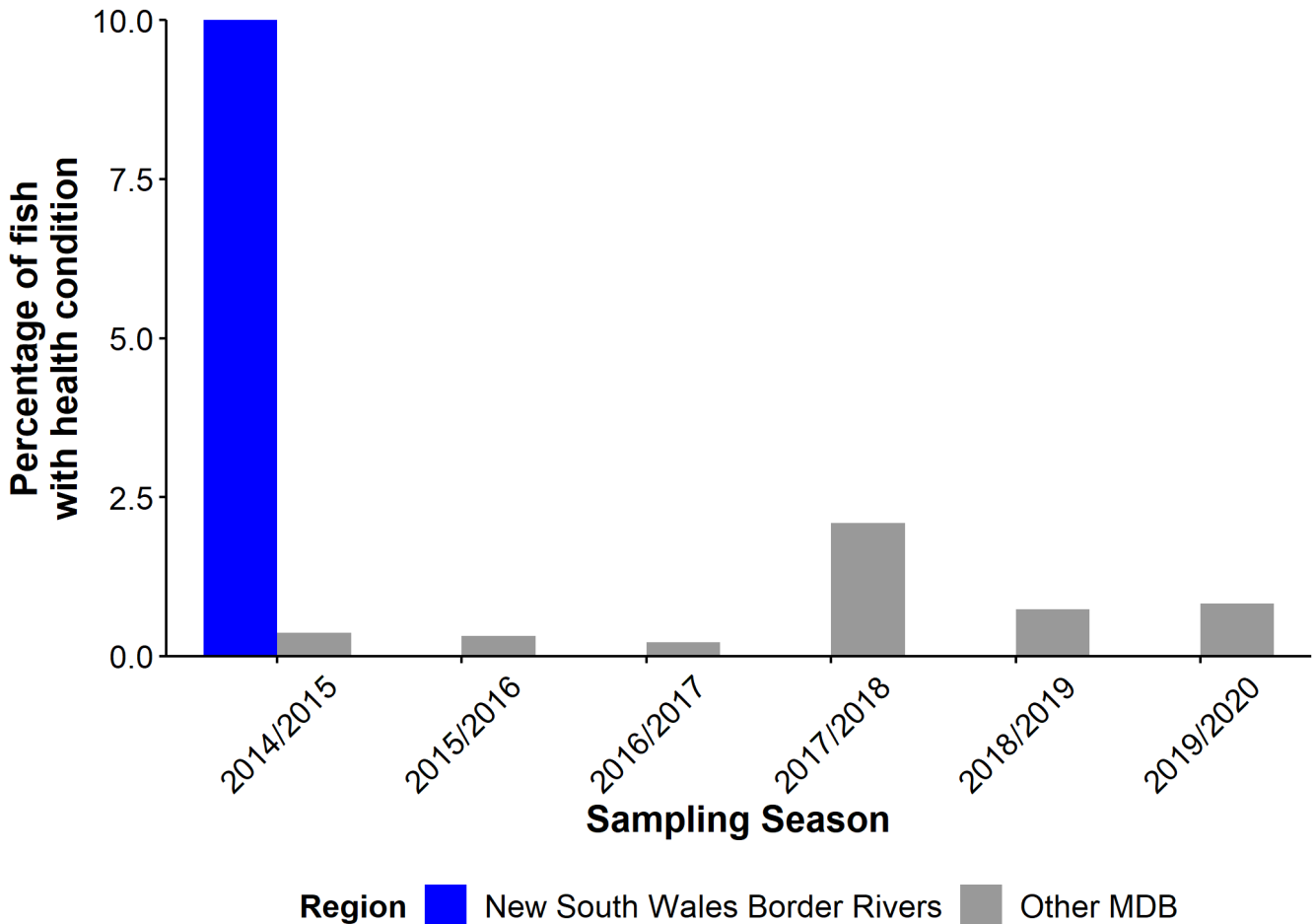


Figure 9.26: Timeseries showing the prevalence of health conditions in Australian smelt. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA.

Summary Statement:

Health conditions were only observed in 2014/15 when they occurred at much higher rates than the wider NSW MDB.

Distribution

Australian smelt were recorded at 26 out of 83 sites in the NSW Border Rivers WRPA. The maximum observed relative abundance at a site was 4.9 fish caught per 90 seconds of electrofishing. [Figure 9.27](#) shows the distribution and relative abundance of Australian smelt across the NSW Border Rivers WRPA.

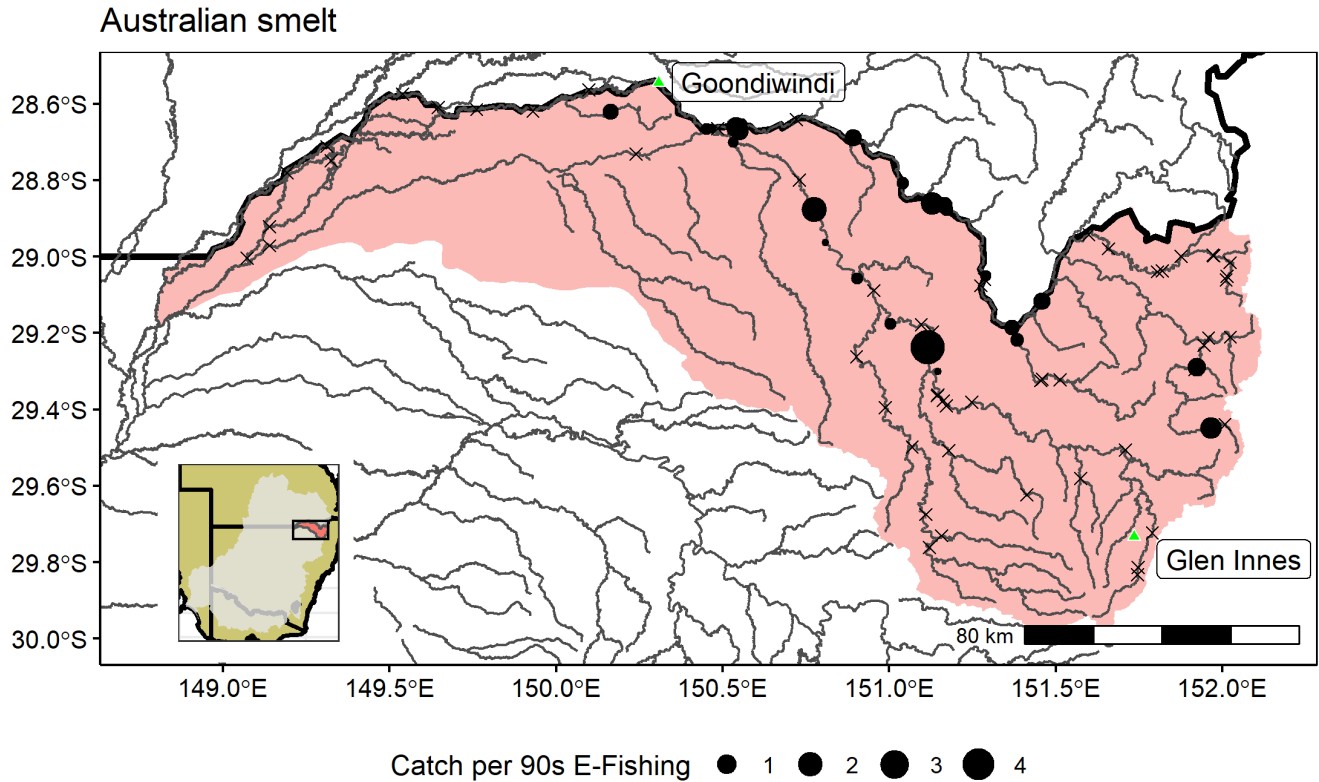


Figure 9.27: Distribution of Australian smelt. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Australian smelt were recorded across the central and eastern reaches of the NSW Border Rivers WRPA although the distribution in the east was patchy. They were not recorded in the western region of the WRPA.

Common carp



Population Structure

Figure 9.28 shows the observed length frequency plot for Common carp for each of the sampling seasons. The observed numbers of Young of the Year (YOY) ranged from 5 to 45, and 4% to 28% of measured fish within a season.

Overall, during the BPEOM-F program, across all the MDB water resource planning areas, the percentage YOY for Common carp was 59% (11,920 out of 20,083). Common carp are not a stocked species.

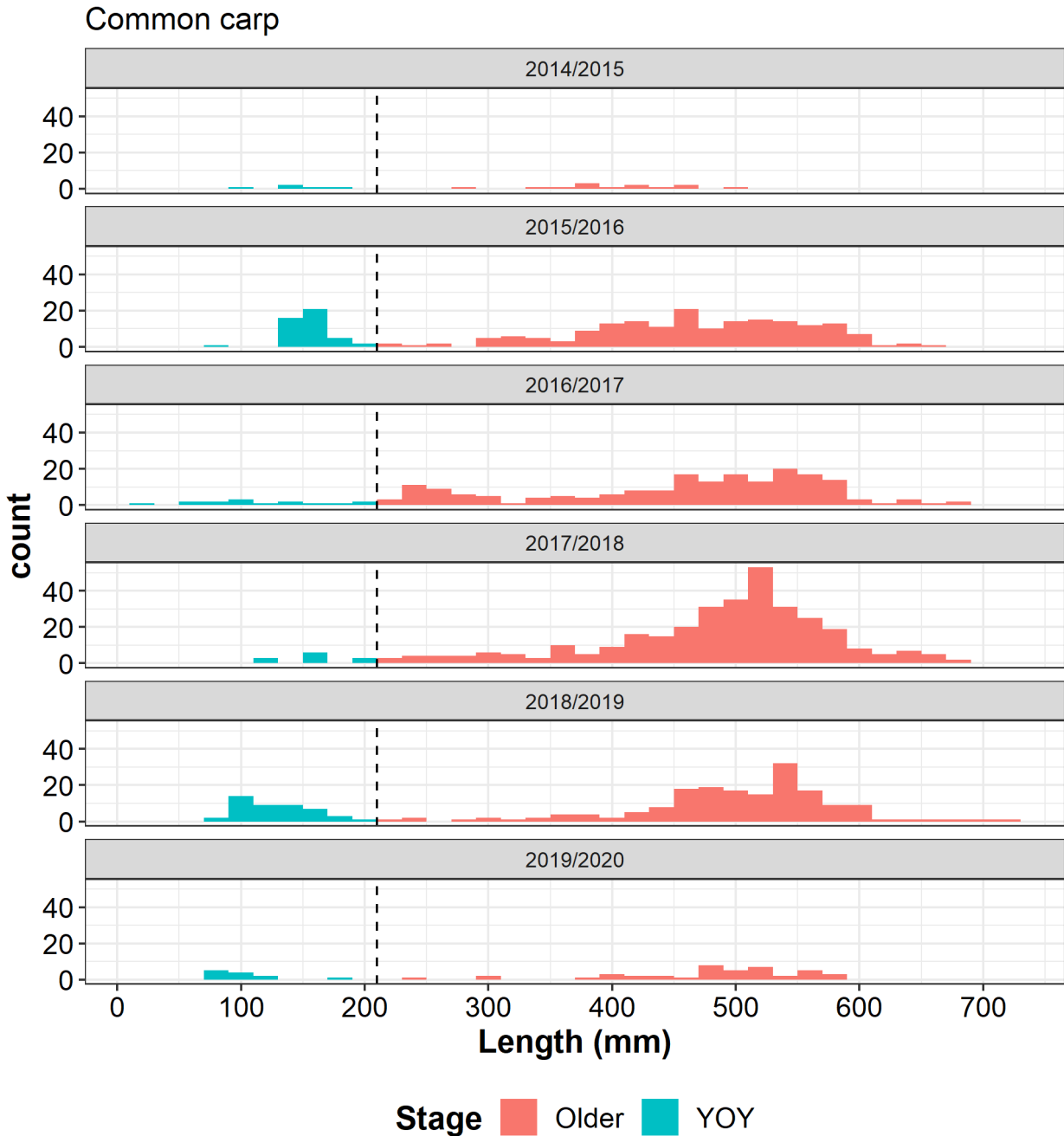


Figure 9.28: Length frequency plots for common carp by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Generally consistent recruitment and presence of large fish in all years.

Temporal Trends in Abundance

We have modelled the relative abundance of Common carp since 1994 based on all suitable boat and backpack electrofishing data. The left-hand panel of [Figure 9.29](#) shows the abundance trend for the NSW Border Rivers WRPA and the right-hand panel shows the overall trend across the NSW MDB.

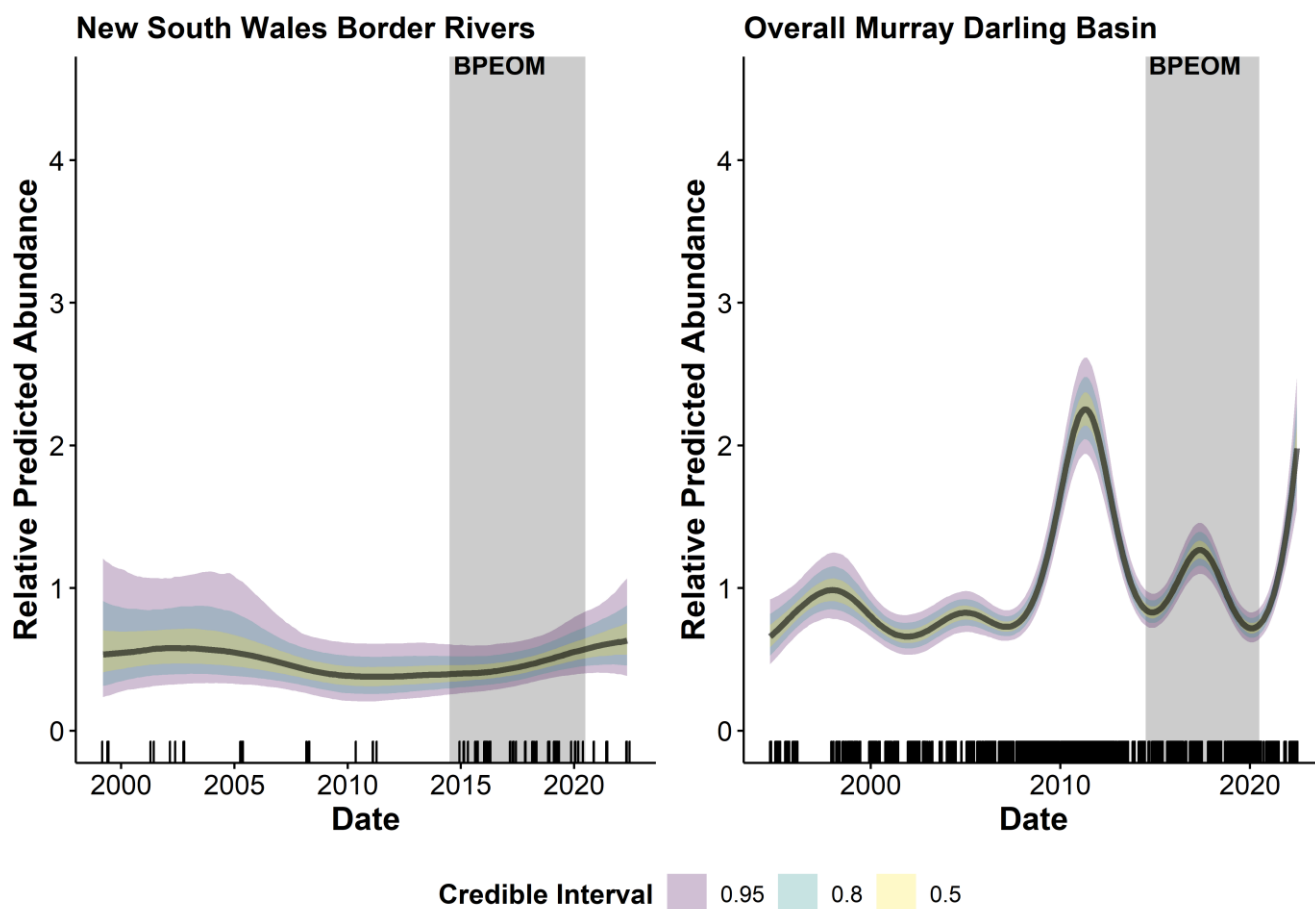


Figure 9.29: Relative abundance of Common carp in both this valley and the overall Murray-Darling Basin. These are model estimates based upon all electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region represents the period during which the BPEOM-F program was run. The black lines on the x-axis represent data coverage while the colours on the figure show various levels of confidence. Note when overlapping, the colours look slightly different due to the transparency and the y-axes vary between chapters of this report.

Summary Statement:

Current abundance similar to late 1990s levels. No substantial fluctuations in abundance over time. Current relative abundance lower than the overall NSW MDB.

Health

The prevalence of any health issues ranged from 1% of sampled fish in 2017/2018 to 6% of sampled fish in 2019/2020 (Figure 9.30). The most common health issue for Common carp in the NSW Border Rivers water resource planning area was *Lernea*, which was observed in a total of 9 fish, corresponding to 1% of all Common carp measured.

Across the other WRPA, 6% of Common carp (1,138 out of 20,084 Common carp) showed a health condition (excludes NSW Border Rivers).

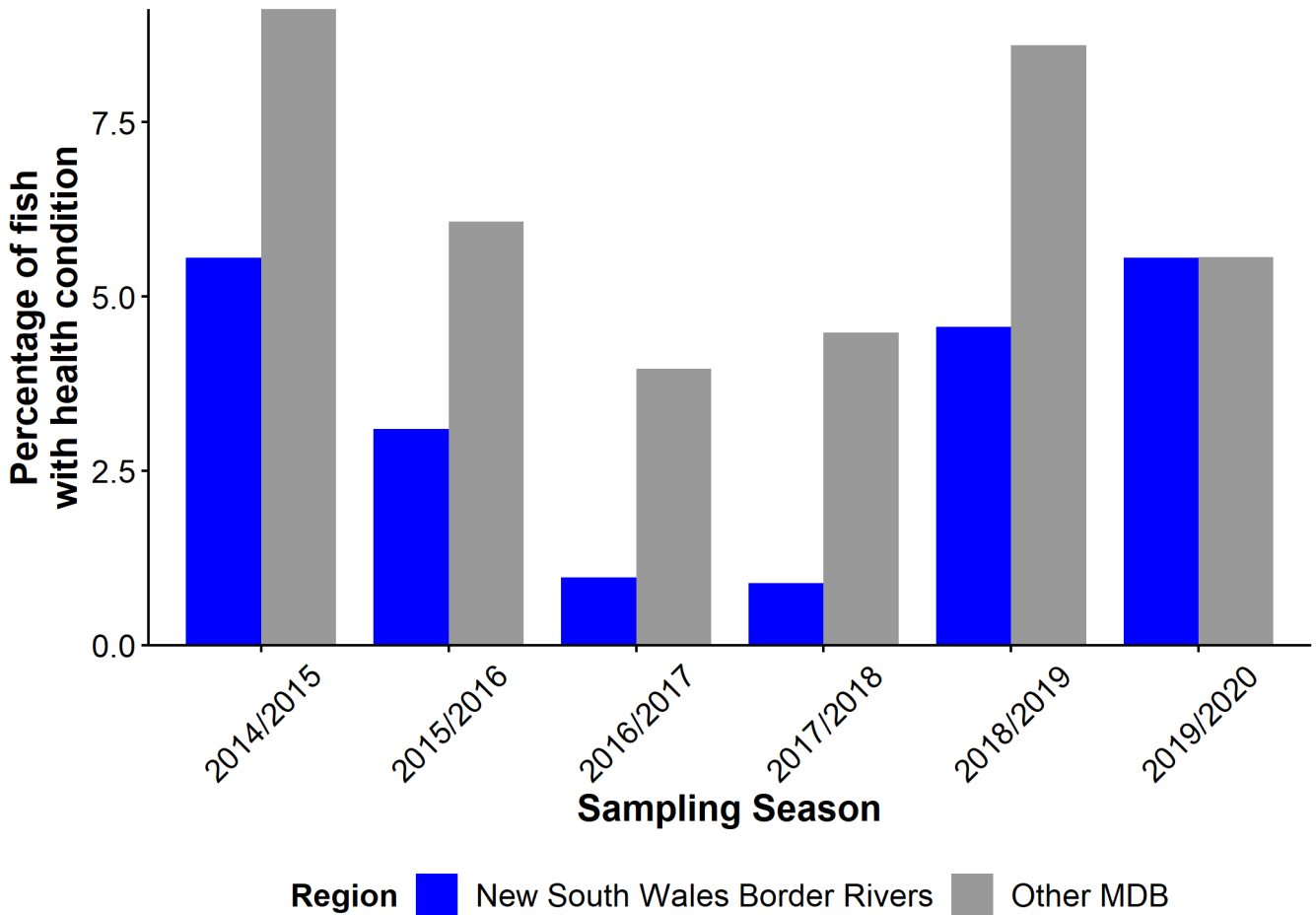


Figure 9.30: Timeseries showing the prevalence of health conditions in Common carp. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

Presence of observable health conditions in the NSW Border Rivers WRPA was low and generally lower than the rest of the NSW MDB.

Distribution

Common carp were recorded at 40 out of 83 sites in the NSW Border Rivers WRPA. The maximum observed relative abundance at a site was 3.9 fish caught per 90 seconds of electrofishing. [Figure 9.31](#) shows the distribution and relative abundance of Common carp across the NSW Border Rivers WRPA.

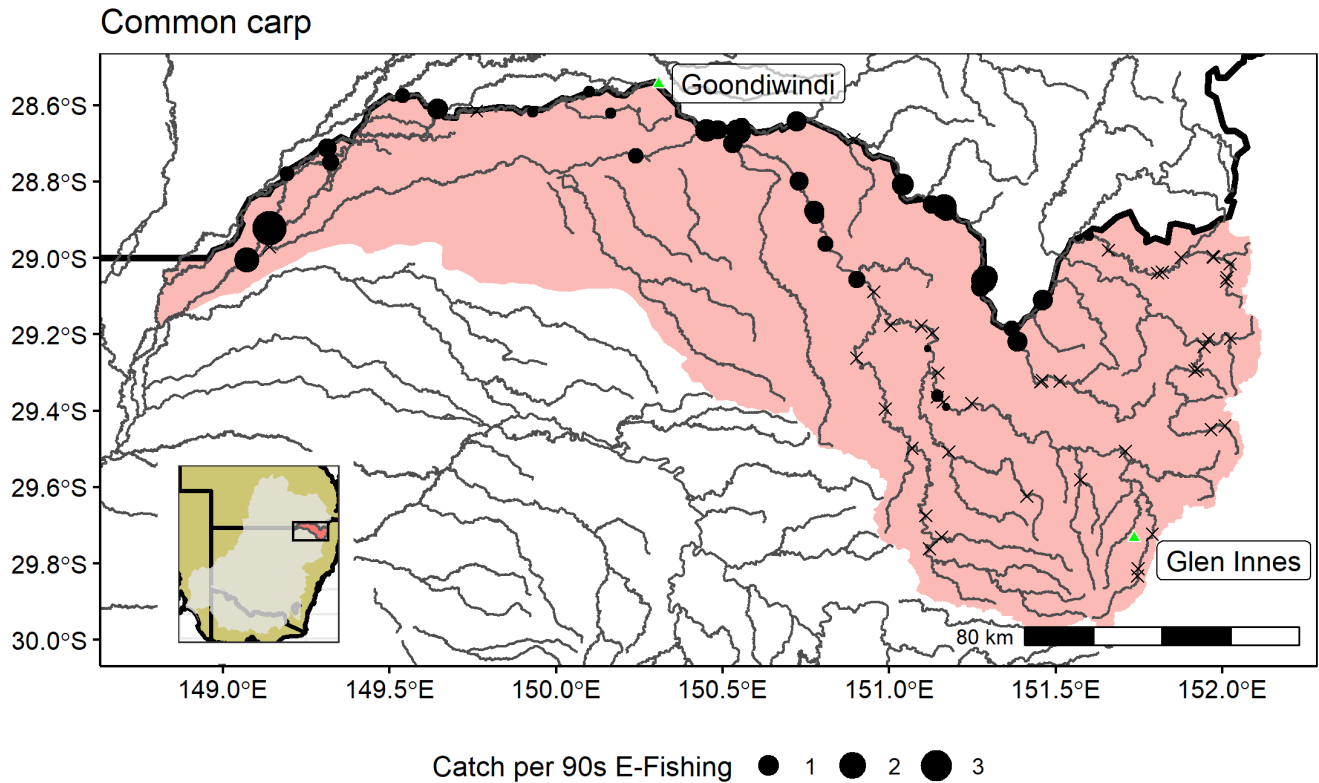


Figure 9.31: Distribution of Common carp. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Present across the western and central reaches of the NSW Border Rivers WRPA. Absent from the eastern upland regions.

Threatened Species

The following table (Table 9.6) shows the fish species listed under either the *NSW Fisheries Management Act 1994* (FMA) or the *Commonwealth Environmental Protection and Biodiversity Conservation Act 1999* (EPBC) which were observed in the NSW Border Rivers Water Resource Planning Area during the BPEOM program. A list of all threatened fish species observed by NSW DPI Fisheries (as part of any sampling program in any area) is provided in Table 9.9.

Table 9.6: Listed species which were observed in this region during the BPEOM-F program. (* = FMA, # = EPBC)

Species	Common name	Total caught (observed)
<i>Ambassis agassizii</i>	Olive perchlet*	129 (8)
<i>Bidyanus bidyanus</i>	Silver perch*#	29 (6)
<i>Maccullochella peelii</i>	Murray cod#	1,656 (829)
<i>Mogurnda adspersa</i>	Southern purple-spotted gudgeon*	7 (4)
<i>Tandanus tandanus</i>	Freshwater catfish*	264 (70)

The following pages provide more information on where each species was observed.

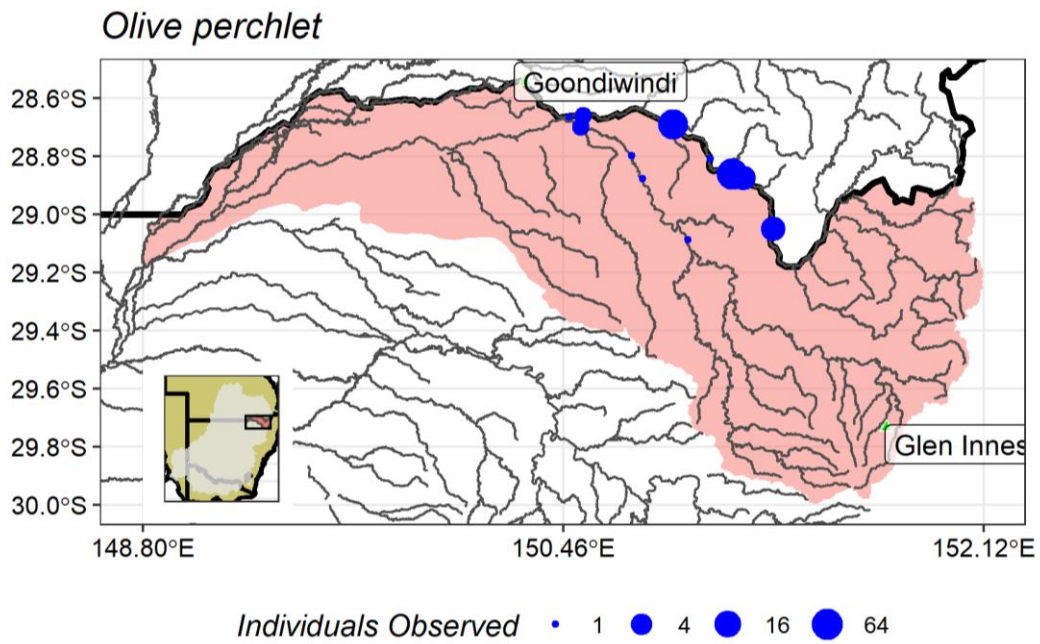


Figure 9.32: Distribution of Olive perchlet. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 137 Olive perchlet were caught or observed across 12 sites (2015 – 2020) on the McIntyre and Dumaresq Rivers.

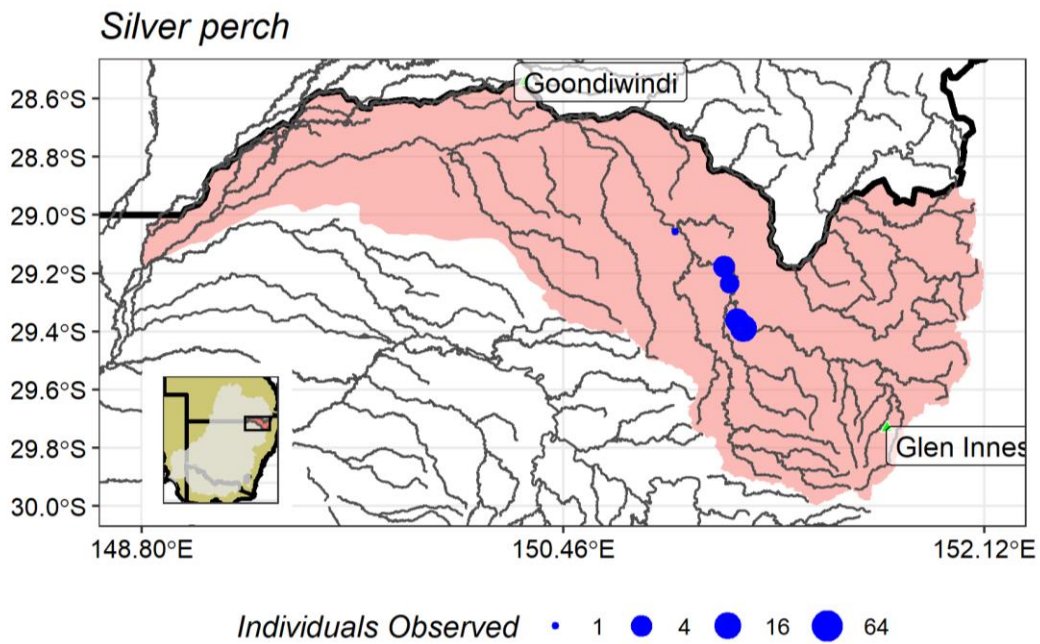


Figure 9.33: Distribution of Silver perch. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 35 Silver perch were caught or observed across seven sites (2015 – 2019), mostly in the Severn River (1 in the Macintyre River).

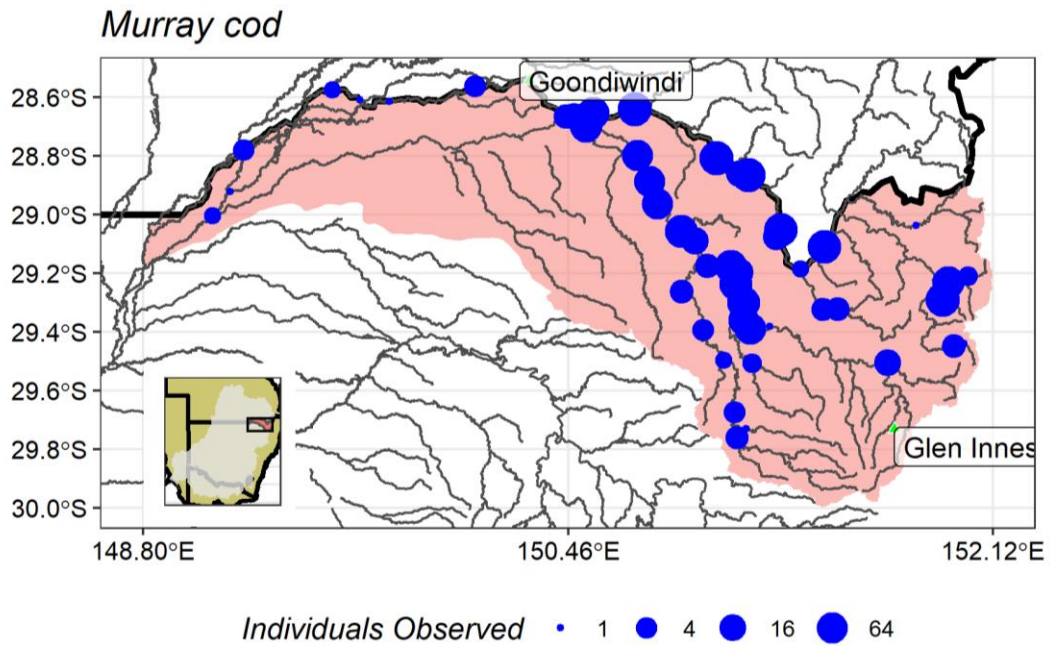


Figure 9.34: Distribution of Murray cod. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance. Note the bottom image shows a juvenile Murray cod.

Summary Statement:

A total of 2,485 Murray cod were caught or observed across 59 sites (2014 – 2020) across the whole NSW Border Rivers WRPA.

Southern purple-spotted gudgeon

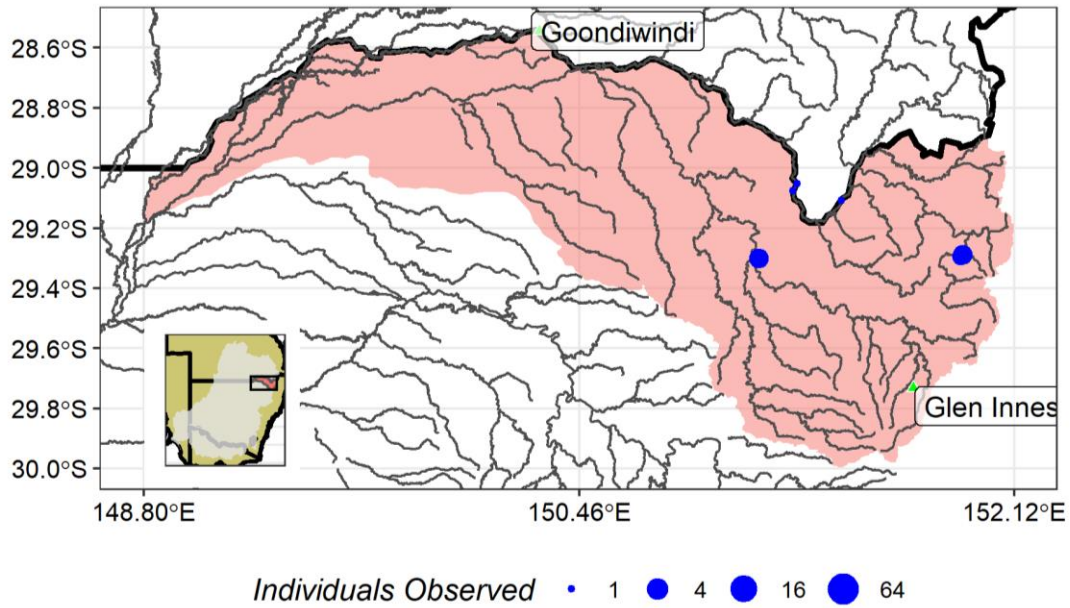


Figure 9.35: Distribution of Southern purple-spotted gudgeon. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance. Note the bottom image shows a juvenile Murray cod.

Summary Statement:

A total of 11 Southern purple-spotted gudgeon were caught or observed across six sites (2015 – 2020) in the Severn and Dumaresq Rivers.

Freshwater catfish

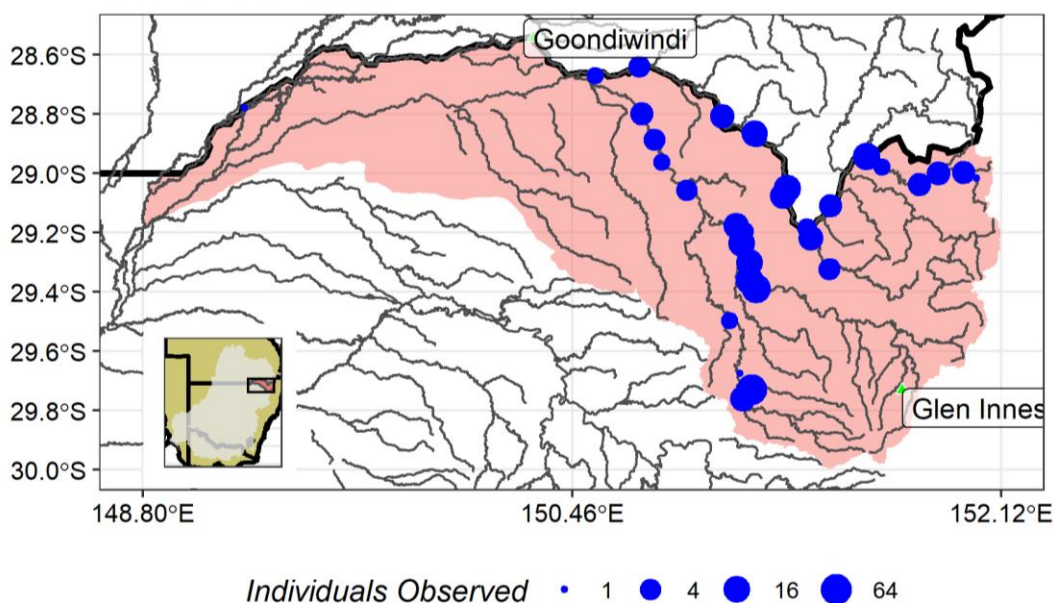


Figure 9.36: Distribution of Freshwater catfish. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 334 Freshwater catfish were caught or observed across 39 sites (2015 – 2020) across the eastern half of the NSW Border Rivers WRP (with a single occurrence to the west of Goondiwindi).

Appendix

Figure 9.37 shows the locations of sites sampled in each sampling season.

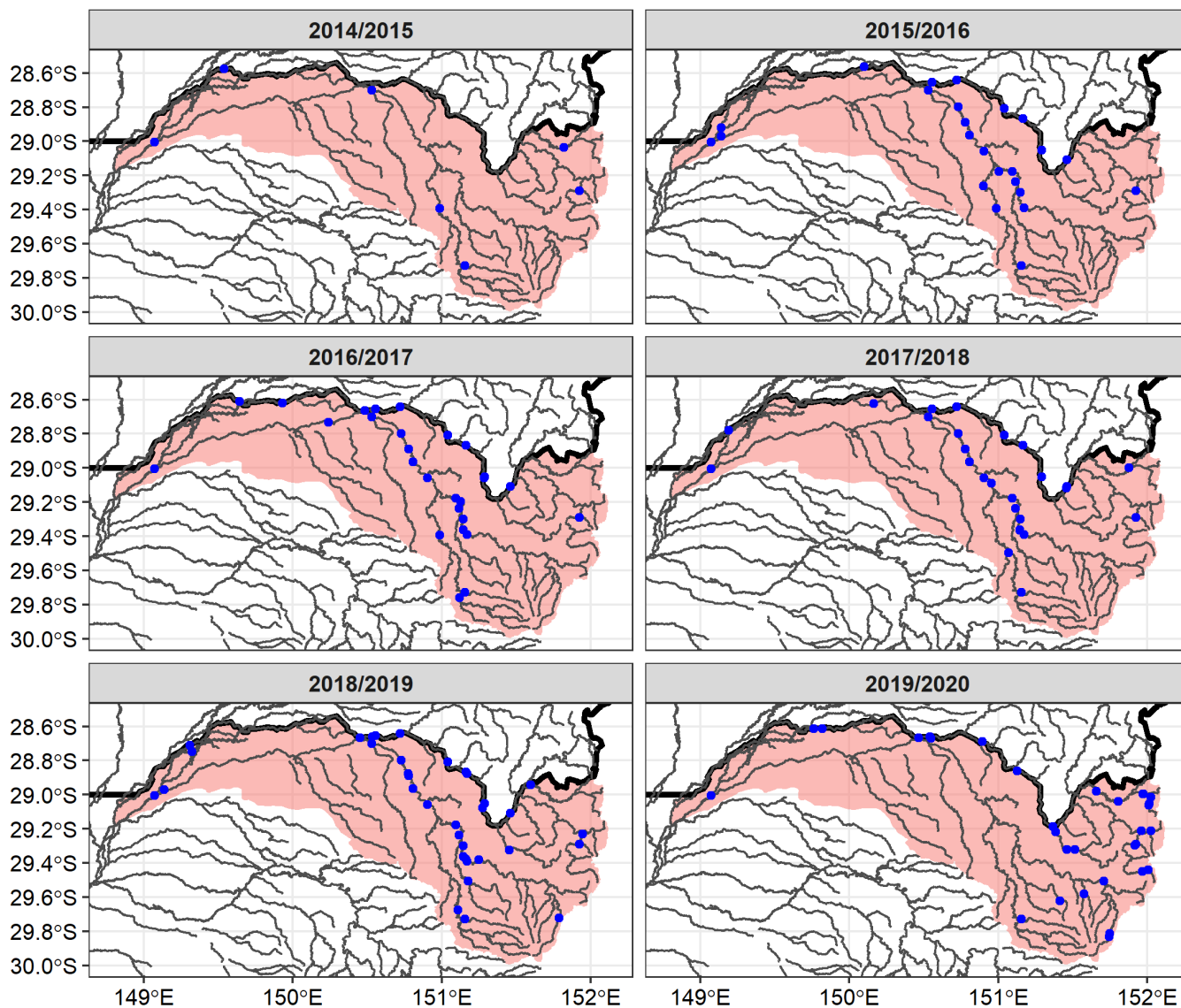


Figure 9.37: Sites sampled during the BPEOM-F program by Sampling Season. Dry sites are not shown.

Table 9.7 shows all fish species detected during this survey period as part of BPEOM-F. Note there are variations in effort between sampling seasons so this information should be considered in conjunction with Table 9.1. The Expected from modelling column identifies species which are possible to occur based upon MaxENT habitat modelling (likelihood threshold > 0.33; NA represents no modelling was undertaken). Species that were possible from the modelling but not observed during BPEOM sampling in the NSW Border Rivers WRPA were: River Blackfish, Mountain galaxias, Macquarie perch, Dwarf flathead gudgeon, Rainbow trout, Brown trout. It should be noted that the MaxENT modelling actually models habitat availability and is not always a reliable index of abundance, it merely indicates possible distribution based upon habitat. A full list of species observed during this period across all programs is in Table 9.10tbl-Table Species all programs.

Table 9.7: Total number caught of each species by sampling season.

Common name	Expected from modelling	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Australian smelt	YES	10	387	0	48	95	72
Bony herring	YES	341	919	499	1,909	386	1,295
Carp-gudgeon species complex	YES	154	2,632	840	4,763	49,77	3,919
Common carp	NA	18	226	206	337	219	54
Darling hardyhead	YES	0	11	4	2	5	7
Eastern gambusia	NA	62	239	61	270	820	432
Freshwater catfish	YES	2	20	55	71	80	36
Golden perch	YES	3	94	60	132	69	13
Goldfish	NA	41	12	30	58	115	43
Murray-Darling carp-gudgeon	NA	0	0	13	0	0	0
Murray-Darling rainbowfish	YES	25	178	274	413	212	55
Murray cod	YES	28	310	224	552	447	95
Olive perchlet	YES	2	3	4	2	13	105
Redfin	YES	0	0	0	0	38	3
Silver perch	YES	0	6	7	12	4	0
Southern purple-spotted gudgeon	YES	3	0	1	0	1	2
Spangled perch	YES	5	11	13	19	152	37
Unspecked hardyhead	YES	1	45	47	206	901	653

The following table summarises the sampling methods by which each fish species was caught (Table 9.8).

Table 9.8: Total catch of each species by sampling method.

Common name	Backpack Electrofishing	Bait Trap	Boat Electrofishing
Australian smelt	13	0	599
Bony herring	6	0	5,343
Carp-gudgeon species complex	946	12,149	4,190
Common carp	3	0	1,057
Darling hardyhead	20	0	9
Eastern gambusia	908	181	795
Freshwater catfish	77	1	186
Golden perch	0	3	368
Goldfish	29	13	257
Murray-Darling carp-gudgeon	0	13	0
Murray-Darling rainbowfish	14	11	1,132
Murray cod	155	0	1,501
Olive perchlet	0	66	63
Redfin	0	0	41
Silver perch	0	0	29
Southern purple-spotted gudgeon	4	1	2
Spangled perch	15	20	202
Unspecked hardyhead	104	17	1,732

Table 9.9: Listed threatened species recorded in the Murray-Darling Basin (from the NSW DPI Fisheries Freshwater Ecosystem research database). Species are listed under either the *NSW Fisheries Management Act 1994 (FMA)* or the *Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC)*

Genus, species	Common Name	EPBC Status	FMA Status
<i>Ambassis agassizii</i>	Agassiz's glassfish, olive perchlet, western New South Wales population	NA	Endangered Population
<i>Bidyanus bidyanus</i>	Silver Perch, Bidyan	Critically Endangered	Vulnerable
<i>Craterocephalus fluviatilis</i>	Murray Hardyhead	Endangered	Critically Endangered
<i>Galaxias rostratus</i>	Flathead Galaxias, Beaked Minnow, Flat-headed Galaxias, Flat-headed Jollytail, Flat-headed Minnow	Critically Endangered	Critically Endangered
<i>Galaxias tantangara</i>	Stocky Galaxias	NA	Critically Endangered
<i>Maccullochella macquariensis</i>	Trout Cod	Endangered	Endangered
<i>Maccullochella peelii</i>	Murray Cod	Vulnerable	NA
<i>Macquaria australasica</i>	Macquarie Perch	Endangered	Endangered
<i>Mogurnda adspersa</i>	Southern Purple Spotted Gudgeon	NA	Endangered
<i>Nannoperca australis</i>	Southern Pygmy Perch	Vulnerable	Endangered
<i>Tandanus tandanus</i>	Freshwater catfish, eel tailed catfish, Murray-Darling Basin population	NA	Endangered Population

Table 9.10 shows all fish species detected during this survey period across all programs and methods. Due to variations in project methods protocols, this data is presented only to give a complete list of species observed in the region. The Expected from Modelling column identifies species which are possible to occur based upon MaxENT habitat modelling (likelihood threshold > 0.33; NA represents no modelling was undertaken). Species that were possible from the modelling but not observed during BPEOM sampling in the NSW Border Rivers WRPA were: River blackfish, Mountain galaxias, Macquarie perch, Dwarf flathead gudgeon, Rainbow trout, Brown trout. It should be noted that the MaxENT modelling actually models habitat availability and is not always a reliable index of abundance, it merely indicates possible distribution based upon habitat. A list of species caught as part of BPEOM-F during this period is in Table 9.7.

Table 9.10. Total catch of each species by all sampling programs and all methods in the region. Note these include projects with sampling not representative of the community and the data should not be interpreted.

Common name	Expected from modelling	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Australian smelt	YES	11	575	1	48	103	822
Bony herring	YES	417	936	499	1,909	387	1,295
Carp-gudgeon species complex	YES	661	3,725	851	4,841	5,848	7,648
Common carp	NA	32	241	222	337	260	150
Darling hardyhead	YES	0	11	4	2	5	7
Eastern Gambusia	NA	74	625	69	307	1,498	649
Freshwater catfish	YES	9	30	57	76	81	39
Golden perch	YES	9	97	61	132	69	13
Goldfish	NA	45	13	31	58	115	50
Murray-Darling carp-gudgeon	NA	0	0	13	0	0	0
Murray-Darling rainbowfish	YES	30	314	285	420	226	71
Murray cod	YES	42	323	234	561	450	96
Olive perchlet	YES	2	7	4	2	13	352
Redfin	YES	0	0	0	0	38	3
Shrimp	NA	24	402	158	7	155	57
Silver perch	YES	0	6	7	12	4	0
Southern purple-spotted gudgeon	YES	3	0	1	0	4	3
Spangled perch	YES	8	12	13	19	152	37
Unspecked hardyhead	YES	43	258	55	227	938	2,333