Department of Primary Industries
Department of Regional NSW

Chapter 11 Basin Plan Environmental Outcomes Monitoring for Fish (2014/15 – 2019/20): New South Wales Murray Water Resource Planning Area

Citation Details *464*
Acknowledgements *465*
Introduction *466*
What This Report Includes 467
Sampling Methods 468
Climate Overview *471*
Flow Data *472*
Species Diversity *474*
Murray cod *475*
Population Structure 476
Temporal Trends in Abundance 478
Health 479
Distribution 480
Golden perch *481*
Population Structure 482
Temporal Trends in Abundance 484
Health 485
Distribution 486
Freshwater catfish *487*
Population Structure 488
Temporal Trends in Abundance 489
Health 490
Distribution 491
Bony herring *492*
Population Structure 493
Temporal Trends in Abundance 494
Health 495
Distribution 496
Australian smelt *497*
Population Structure 498
Temporal Trends in Abundance 499
Health 500
Distribution 501
Common carp *502*
Population Structure 503
Temporal Trends in Abundance 504
Health 505
Distribution 506
Threatened Species *507*
Appendix *513*

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: David Crook (NSW DPI); 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) Murray Water Resource Planning Area (WRPA) shown in Figure 11.1.

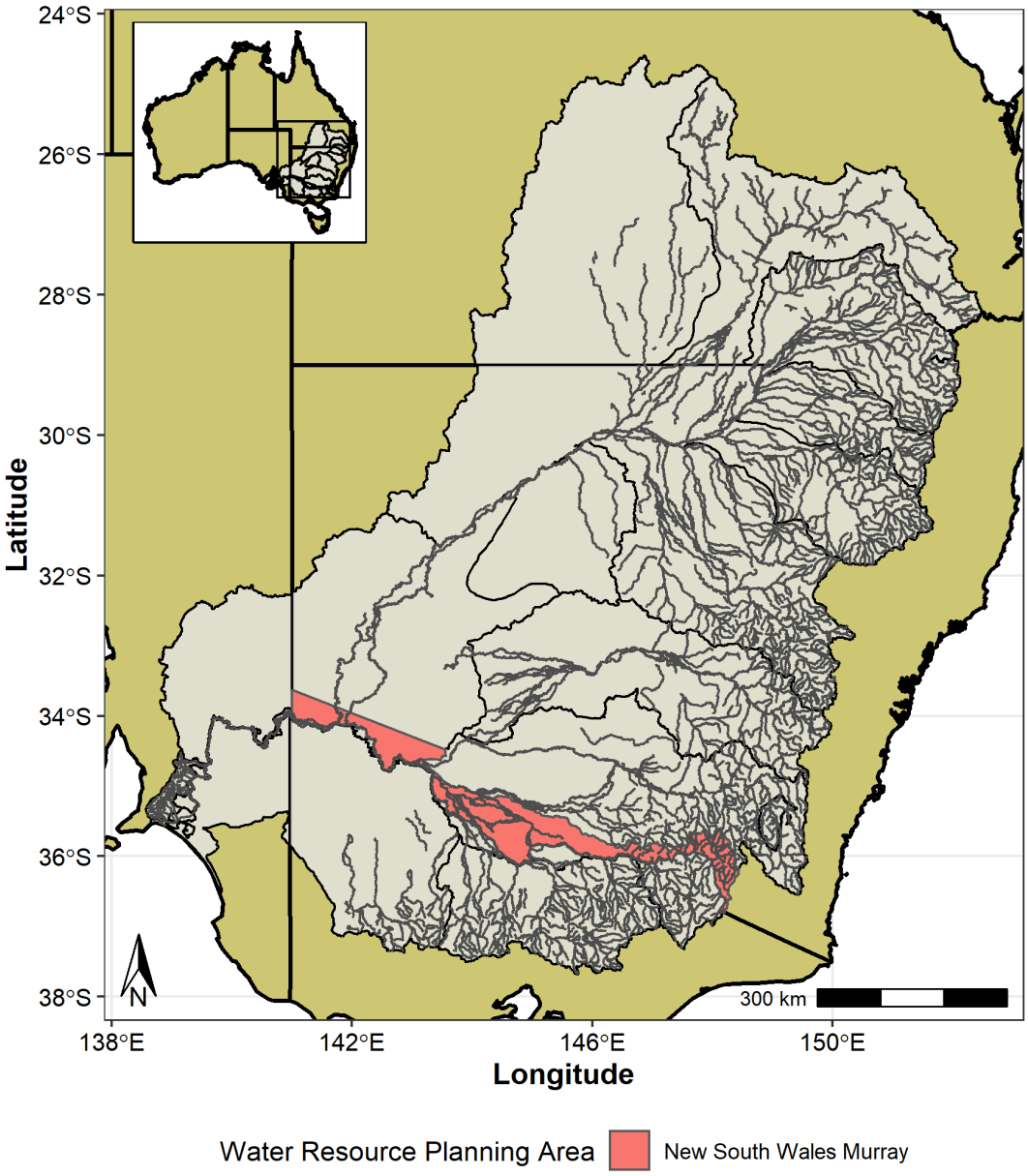

Figure 11.1: Murray-Darling Basin with the key region of this report highlighted. Inset map shows the whole of Australia with a box around the MDB.

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 Murray 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 Murray 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 Murray WRPA and greater MDB (excluding the NSW Murray 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 Murray 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 11.1). 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 11.1: 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	19 (0)
2015/2016	29 (1)
2016/2017	37 (1)
2017/2018	38 (7)
2018/2019	36 (2)
2019/2020	35 (0)

The sites sampled during the reporting period are shown in Figure 11.2. A breakdown of sites sampled each sampling season is shown in the Appendix (Figure 11.37).

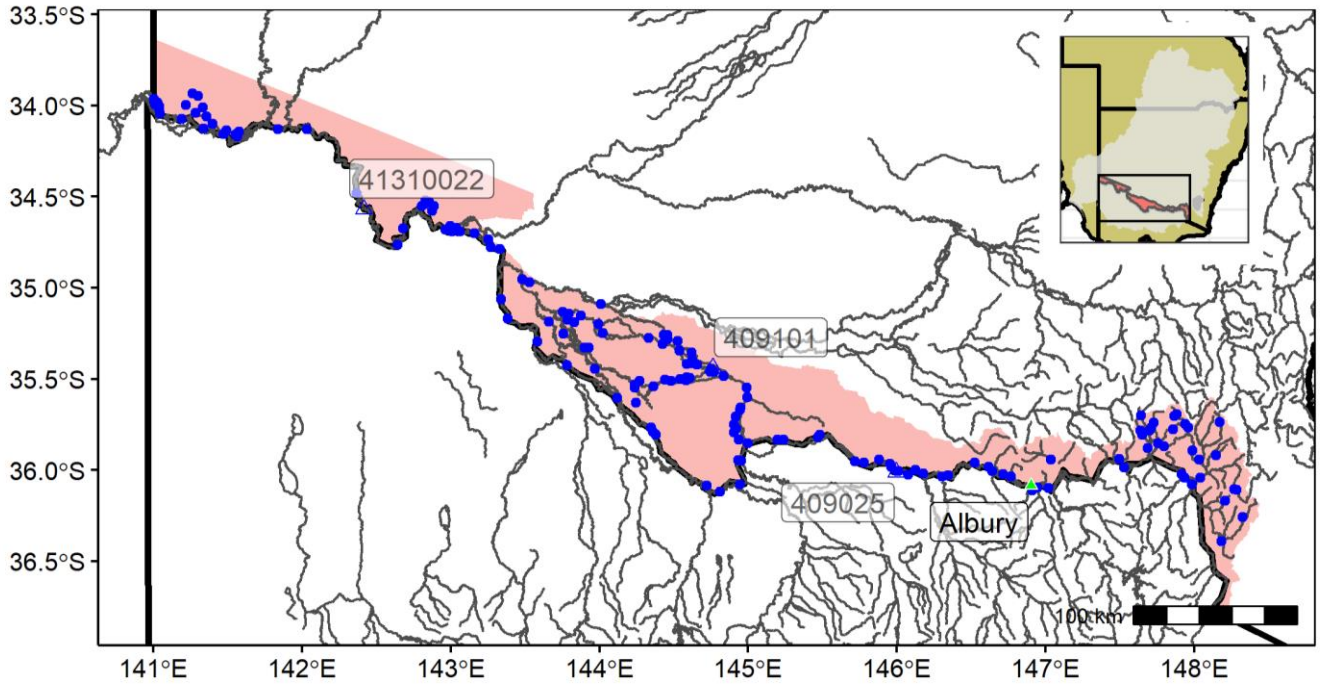

Figure 11.2: Sites (dots) sampled during the BPEOM-F program. Triangles show key flow gauges along with their gauge ID number. Dry sites are not shown.

Each sampling method has a different effectiveness at sampling each species. Table 11.2 shows the total amount of each species caught by each method.

Table 11.2: 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	3	253	0
Golden perch	0	158	0
Freshwater catfish	0	3	0
Bony herring	17	4,192	7
Australian smelt	43	8,513	5
Common carp	790	790	597

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 11.3 shows the number of biological measurements taken each year for the six species.

Table 11.3: 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	36	15	1	247	511	143
2015/2016	71	29	1	289	826	388
2016/2017	38	25	0	432	1,363	1903
2017/2018	48	52	1	457	793	773
2018/2019	40	19	0	416	645	737
2019/2020	23	18	0	289	407	188

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 Murray WRPA (Figure 11.3).

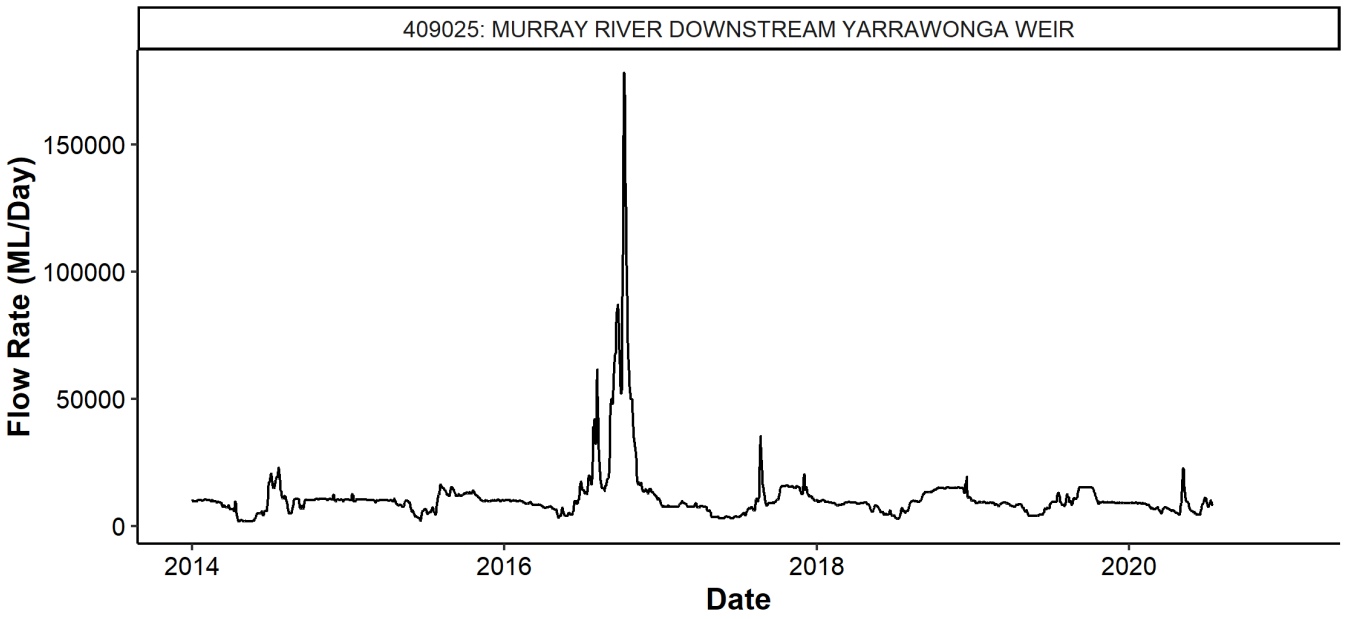

Figure 11.3: Flow data from various gauges in the NSW Murray WRPA over the reporting period. Gauge locations can be seen on Figure 11.2. Note the differing scales on the y-axis.

Water temperature data, where available, are also shown in Figure 11.4.

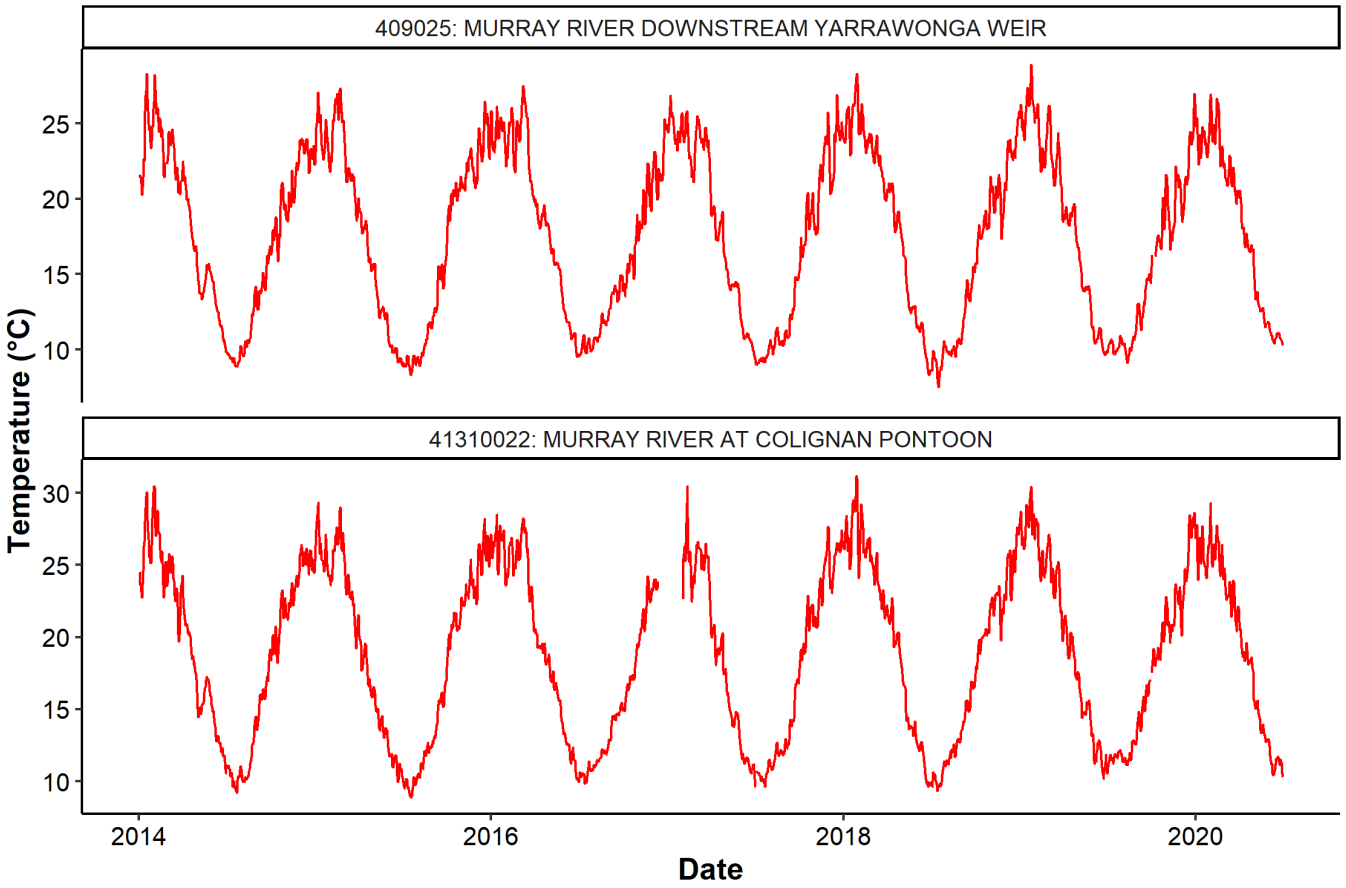

Figure 11.4: Water temperature data from various gauges in the NSW Murray WRPA over the reporting period. Gauge locations can be seen on Figure 11.2. Note the differing scales on the y-axis.

Species Diversity

A total of 25 fish species were observed across the NSW Murray WRPA including seven alien species. Figure 11.5 shows the number of native and alien species found at each site. The full list of species caught and observed is in Table 11.7.

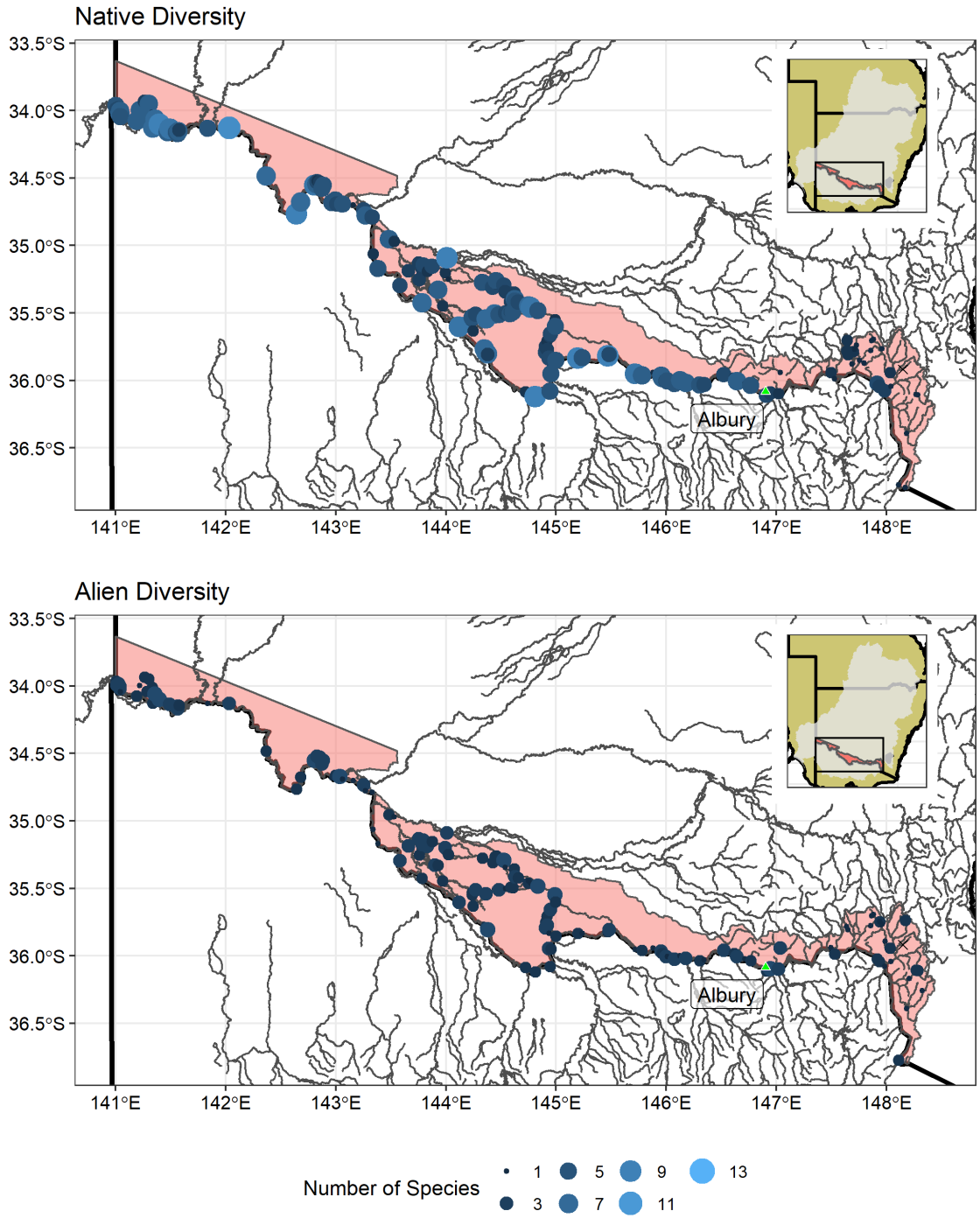

Figure 11.5: Diversity across all sampling sites. Bubble size represents the number of unique species observed at each site across all sampling methods and events. X represents a site that had water and was sampled, but no fish species were caught at all. Dry sites are excluded.

Summary Statement:

Native diversity was highest in the western area of the NSW Murray WRPA region while the alien diversity was generally consistent across the region.

Murray cod

Population Structure

Figure 11.6 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 24, and 5% to 34% 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 12% (438 out of 3,594).

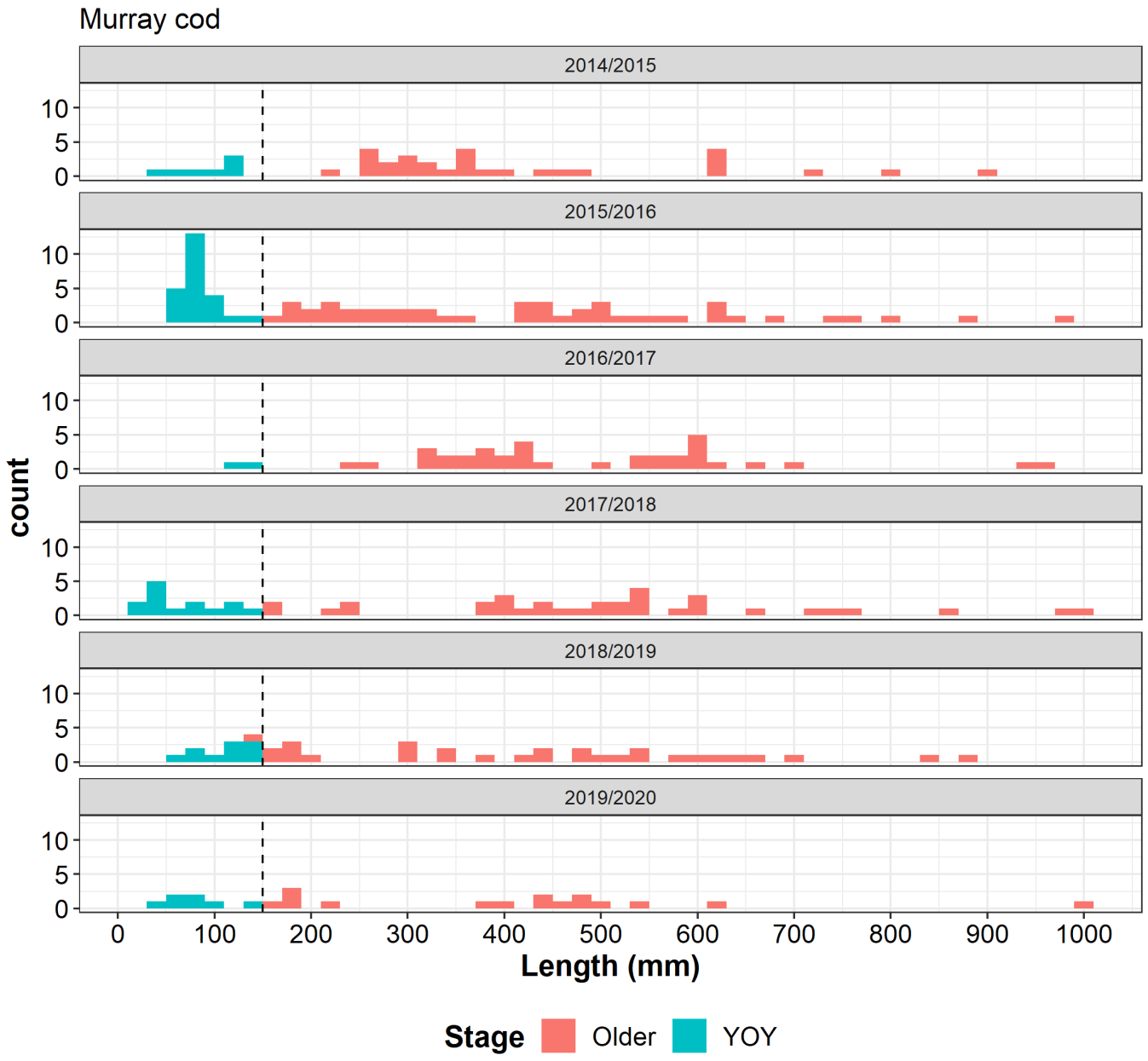

Figure 11.6: Length frequency plots for Murray cod by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Regular recruitment but variable numbers of YOY, with a good range of size classes.

Stocking

A total of 431,422 Murray cod were stocked into the waterways of the NSW Murray WRPA during the reporting period. Of these fish, 37,120 (9%) were stocked into impoundments while 394,302 (91%) were stocked into rivers or creeks. Table 11.4 shows the detailed breakdown of stocking by season, location and life stage while Figure 11.7 shows the locations of stocking.

Table 11.4: 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	2,000
2014/2015	River/Creek	Fry	80,741
2015/2016	Impoundment	Fry	1,000
2015/2016	River/Creek	Fry	67,532
2016/2017	Impoundment	Fingerling	12,120
2016/2017	Impoundment	Fry	8,000
2016/2017	River/Creek	Fingerling	111,068
2017/2018	River/Creek	Fry	1,377
2017/2018	River/Creek	Fry	37,420
2018/2019	Impoundment	Fry	9,000
2018/2019	River/Creek	Fry	54,131
2019/2020	Impoundment	Fry	5,000
2019/2020	River/Creek	Fry	42,033

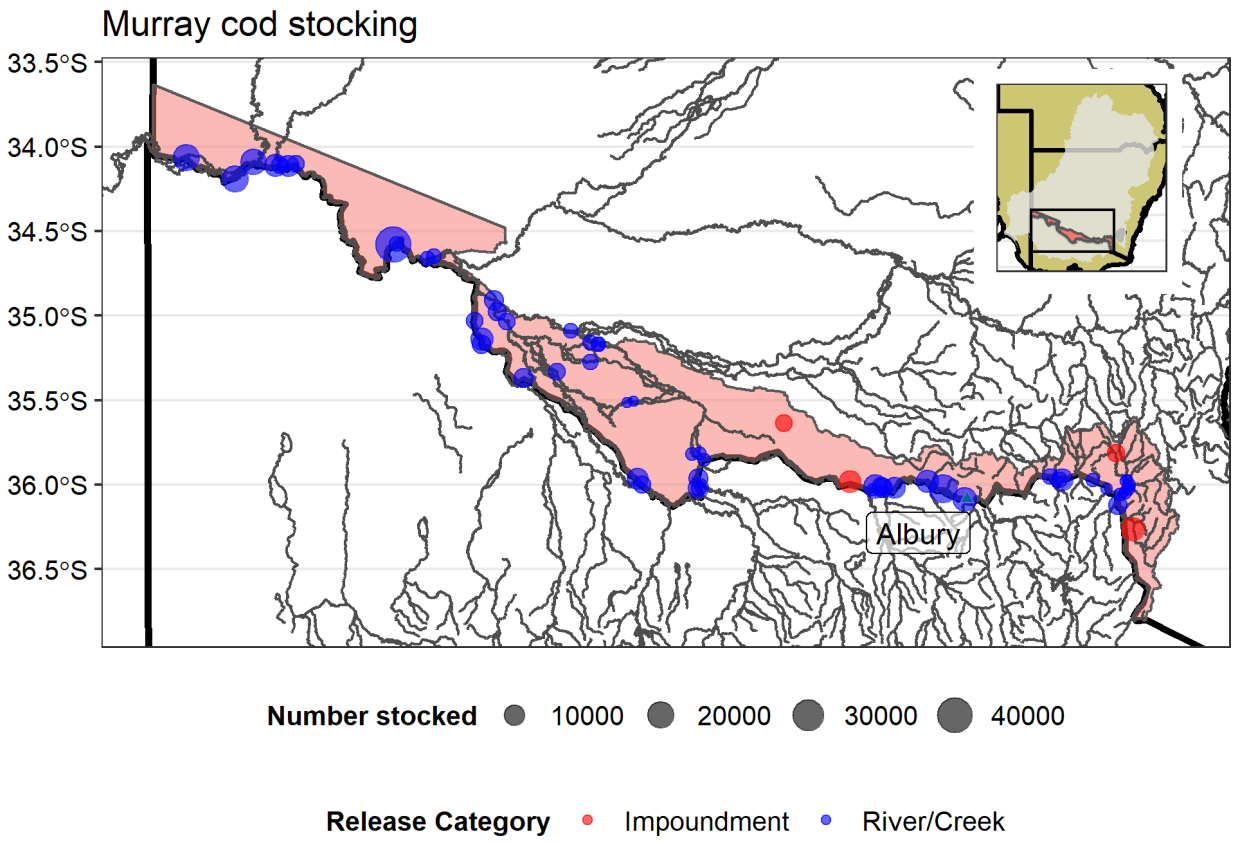

Figure 11.7: Locations of Murray cod stocking. Colours show whether a site was a river/creek site or an impoundment while the size of the point reflects the total number of fish stocked over the reporting period.

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 11.8 shows the abundance trend for the NSW Murray WRPA and the right-hand panel shows the overall trend across the NSW MDB.

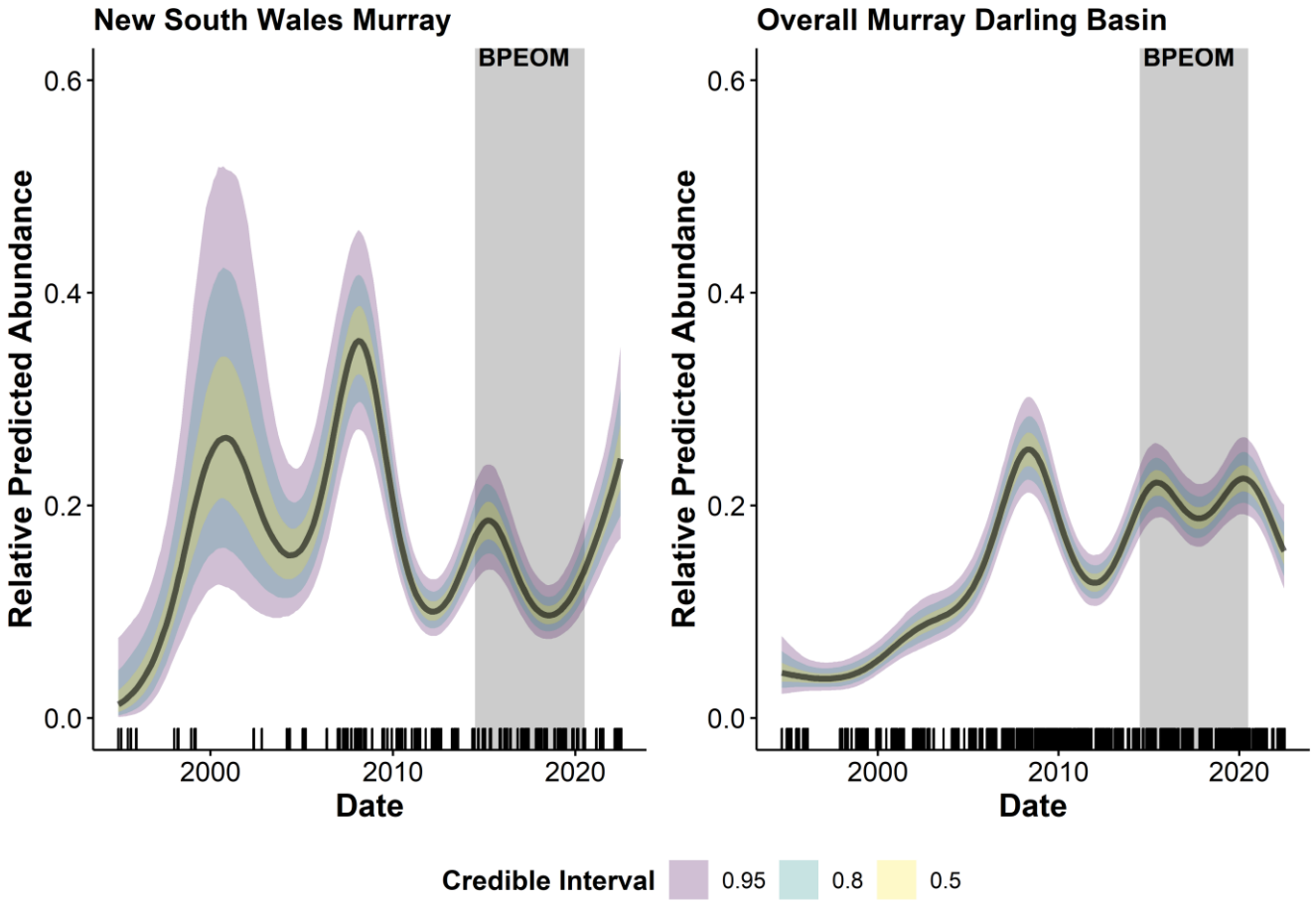

Figure 11.8: Relative abundance of Murray cod in both the NSW Murray WRPA and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and are the output of Bayesian generalised additive mixed models. The grey shaded region 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:

An overall increase in abundance since the 1990s until the early 2000s followed by fluctuations in abundance. Currently on an upward trend. Relative abundance approximately equal to overall abundance across the NSW MDB but was lower during the BPEOM-F program.

Health

The prevalence of any health issues ranged from 13% of sampled fish in 2019/2020 to 40% of sampled fish in 2018/2019 (Figure 11.9). The most common health issue for Murray cod in the NSW Murray WRPA was Lerneae, which was observed in a total of 33 fish, corresponding to 13% of all Murray cod measured.

Across the other NSW MDB WRPAs, 17% of Murray cod (599 out of 3,594 Murray cod) showed a health condition (excludes the NSW Murray WRPA).

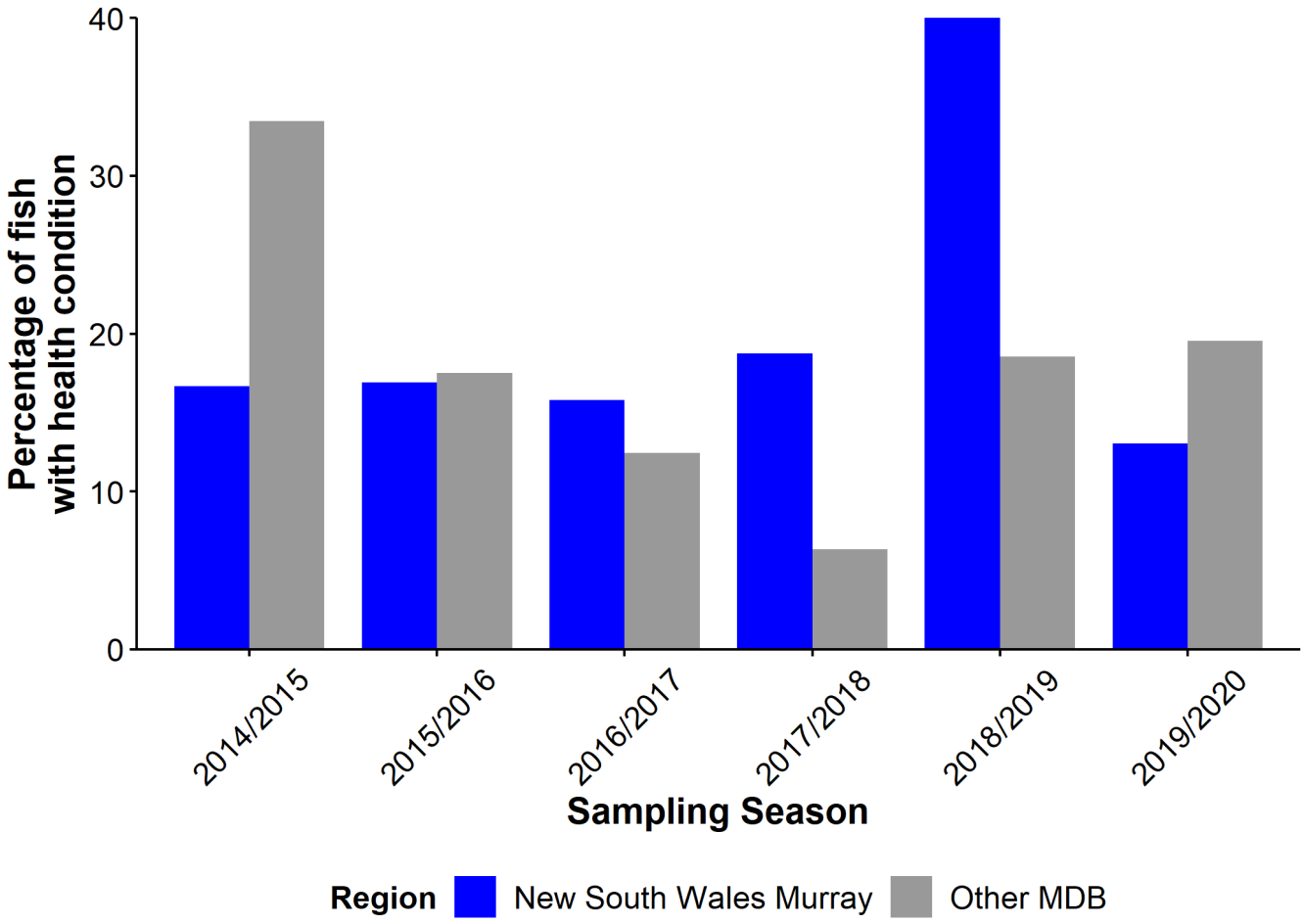

Figure 11.9: Timeseries showing the prevalence of health conditions in Murray cod. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

Presence of observable health conditions was variable across years but generally similar to the rest of the Murray-Darling Basin. 2018/19 showed a substantially higher presence of health issues than other seasons.

Distribution

Murray cod were recorded at 67 out of 166 sites in the NSW Murray WRPA. The maximum observed relative abundance at a site was 27 fish caught per 90 seconds of electrofishing. Figure 11.10 shows the distribution and relative abundance of Murray cod across the NSW Murray WRPA.

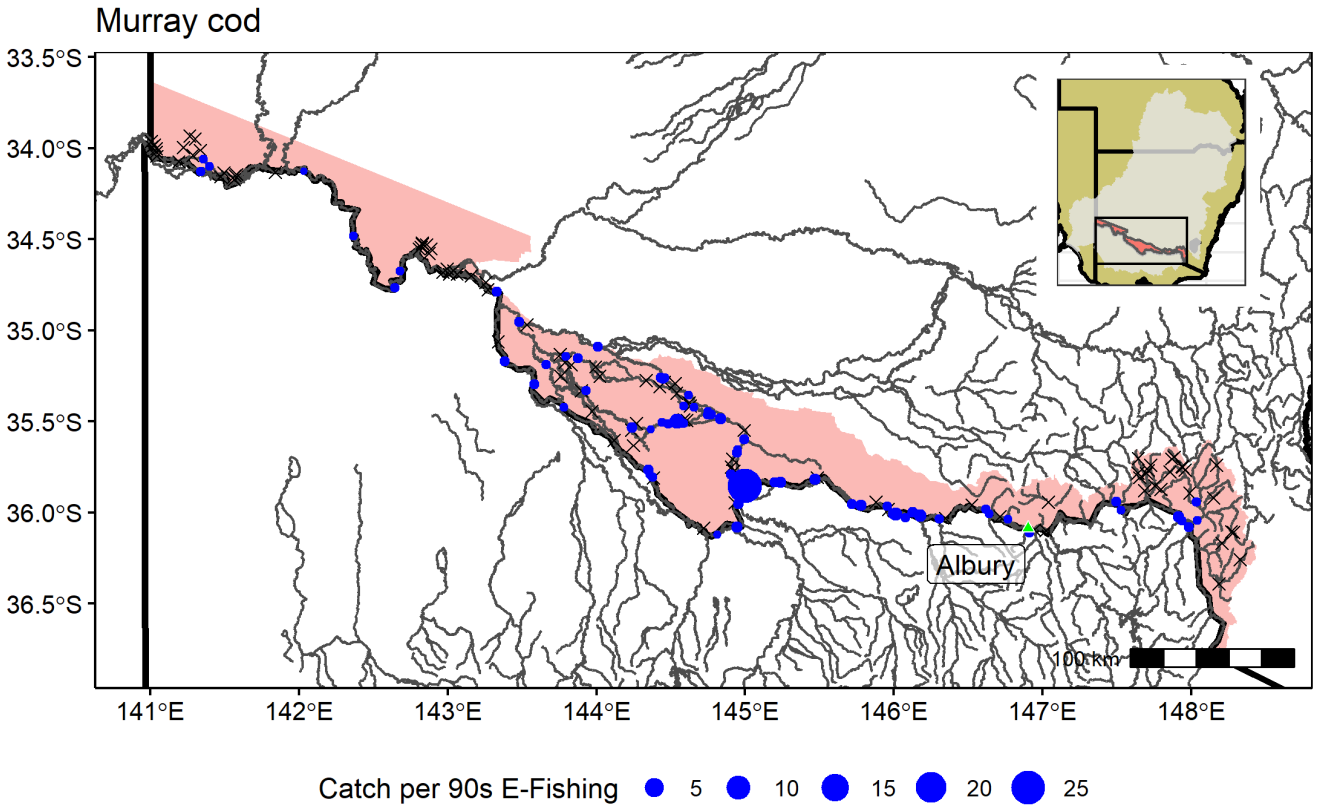

Figure 11.10: Distribution of Murray cod. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Murray cod were recorded across the NSW Murray WRPA but most abundant in the mid-reaches.

Golden perch

Population Structure

Figure 11.11 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 2, and 0% to 4% 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 12% (264 out of 2,143).

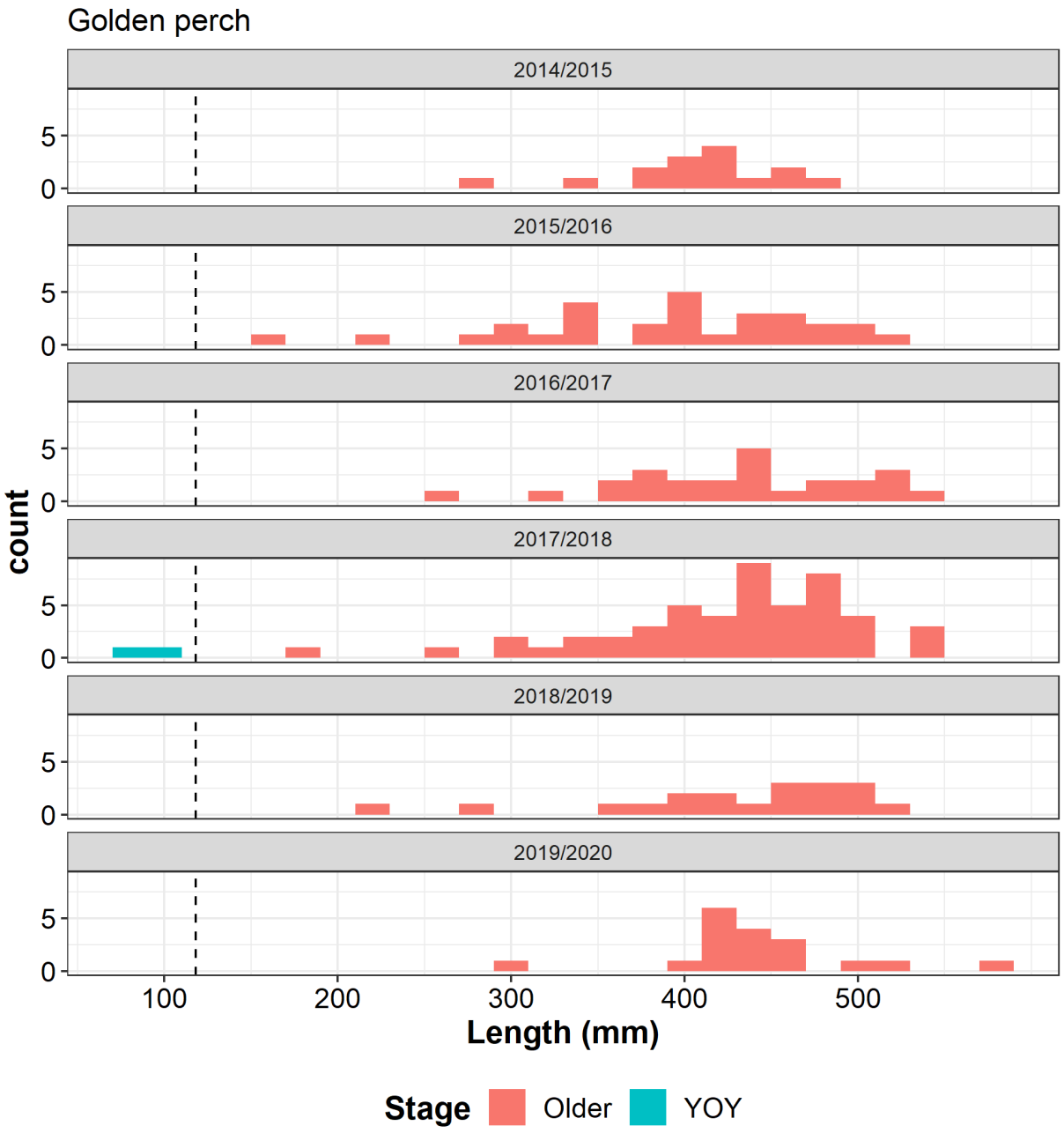

Figure 11.11: Length frequency plots for Golden perch by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Limited or poor recruitment in most years with young of the year only observed in 2017/18 suggesting recruitment limitation in most years.

Stocking

A total of 826,293 Golden perch were stocked into the waterways of the NSW Murray WRPA during the reporting period. Of these fish, 290,500 (35%) were stocked into impoundments while 535,793 (65%) were stocked into rivers or creeks. Table 11.5 shows the detailed breakdown of stocking by season, location and life stage while Figure 11.12 shows the locations of stocking.

Table 11.5: 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	27,000
2014/2015	River/Creek	Fry	159,723
2015/2016	Impoundment	Fry	46,000
2015/2016	River/Creek	Fry	59,107
2016/2017	Impoundment	Fingerling	500
2016/2017	Impoundment	Fry	87,000
2016/2017	River/Creek	Fingerling	76,992
2017/2018	Impoundment	Fry	65,000
2017/2018	River/Creek	Fry	2,857
2017/2018	River/Creek	Fry	128,092
2018/2019	Impoundment	Fry	60,000
2018/2019	River/Creek	Fry	43,031
2019/2020	Impoundment	Fry	5,000
2019/2020	River/Creek	Fry	65,991

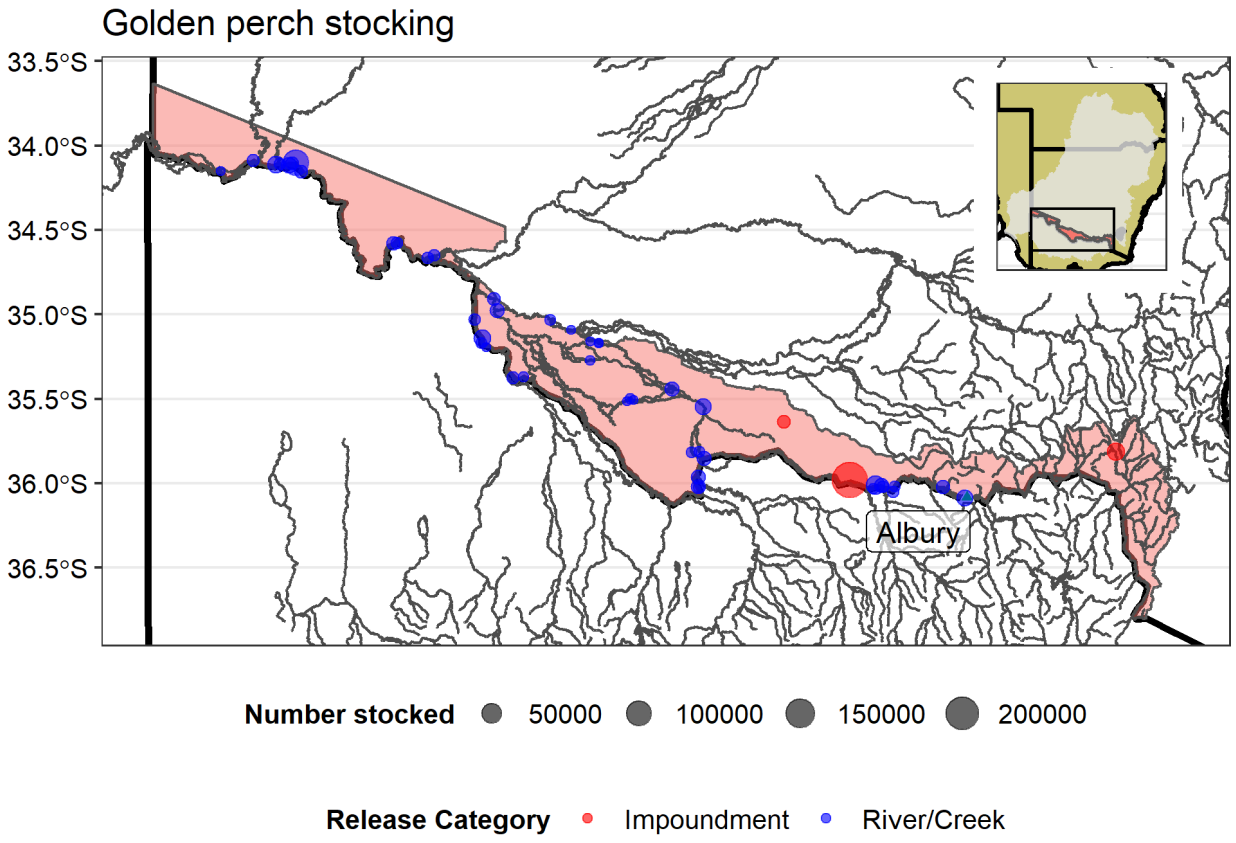

Figure 11.12: Locations of Golden perch stocking. Colours show whether a site was a river/creek site or an impoundment while the size of the point reflects the total number of fish stocked over the reporting period.

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 11.13 shows the abundance trend for the NSW Murray WRPA and the right-hand panel shows the overall trend across the NSW MDB.

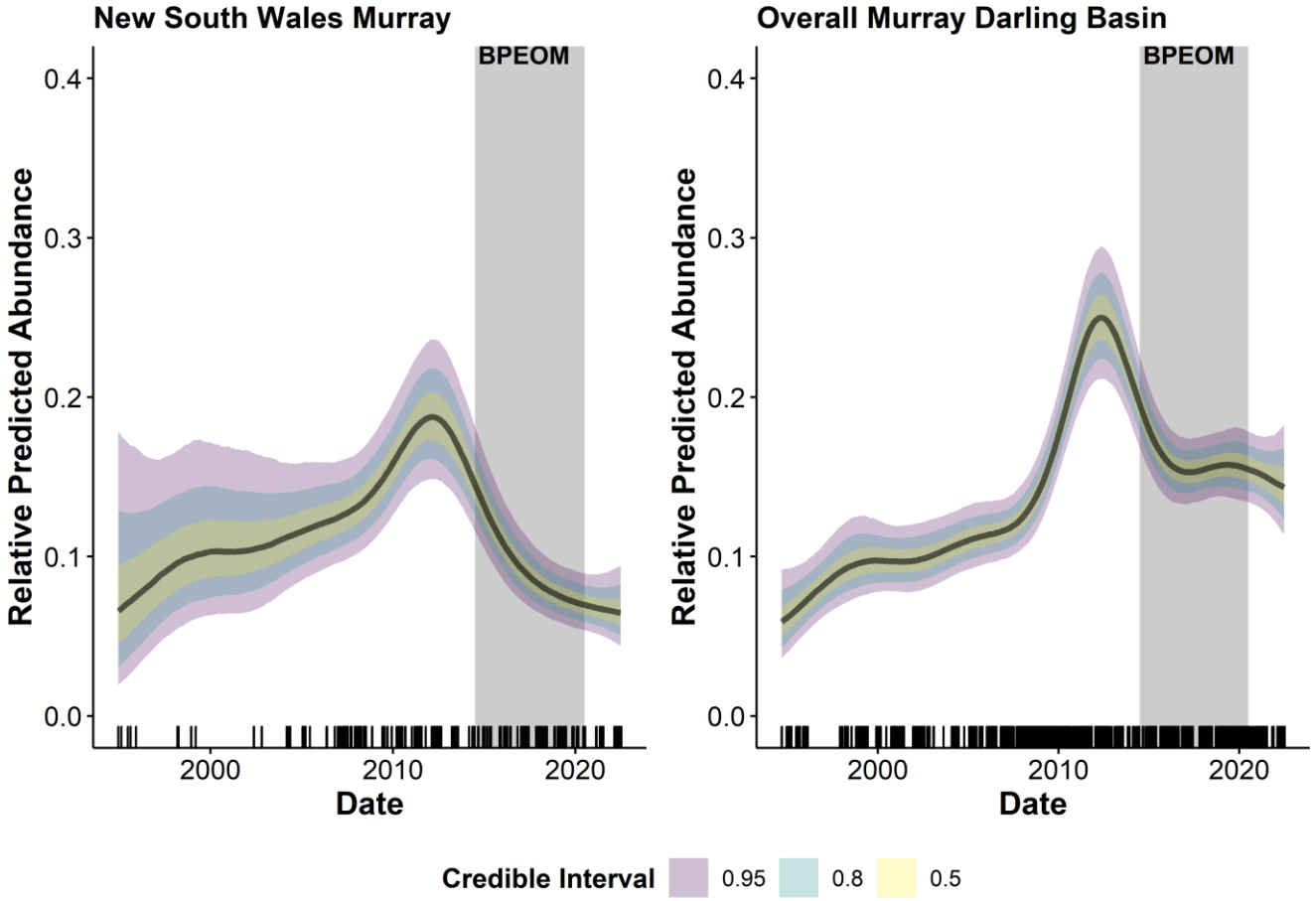

Figure 11.13: Relative abundance of Golden perch in both this valley and the overall Murray-Darling Basin. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region 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 approximately equal to 1994 levels. Abundance previously peaked around 2012 but has since declined. Relative abundance is lower than the overall abundance across the MDB, which also peaked around 2012.

Health

The prevalence of any health issues ranged from 20% of sampled fish in 2014/2015 to 67% of sampled fish in 2019/2020 (Figure 11.14). The most common health issue for Golden perch in the NSW Murray water resource planning area was Lerneae, which was observed in a total of 23 fish, corresponding to 15% of all Golden perch measured.

Across the other WRPAs, 33% of Golden perch (707 out of 2,143 Golden perch) showed a health condition (excludes NSW Murray).

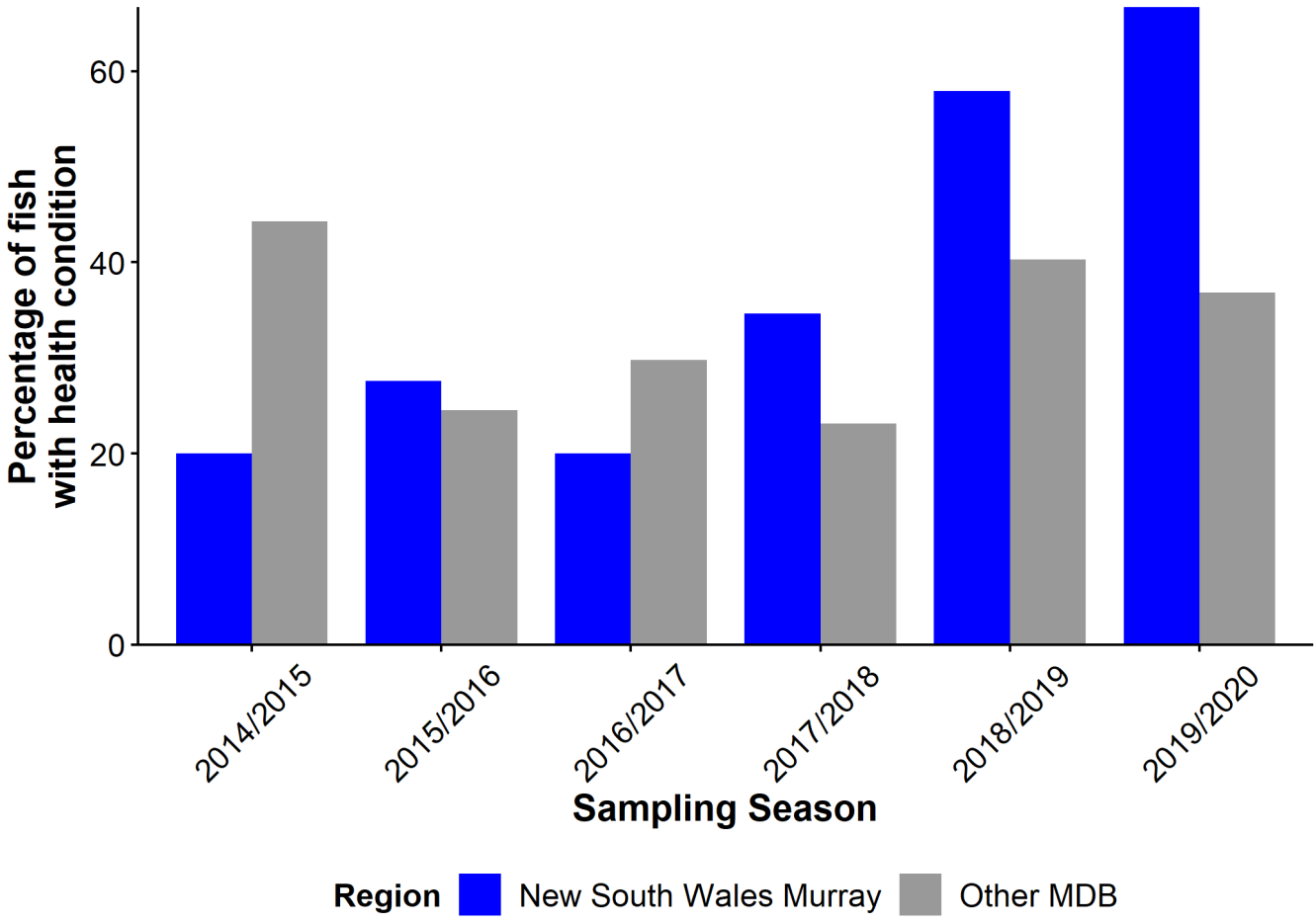

Figure 11.14: Timeseries showing the prevalence of health conditions in Golden perch. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

The presence of observable health conditions for Golden perch in the NSW Murray was moderate to high with an increasing trend over time. Recent years have had a higher prevalence of health issues compared to the wider NSW MDB.

Distribution

Golden perch were recorded at 60 out of 166 sites in the NSW Murray WRPA. The maximum observed relative abundance at a site was 13.5 fish caught per 90 seconds of electrofishing. Figure 11.15 shows the distribution and relative abundance of Golden perch across the NSW Murray WRPA.

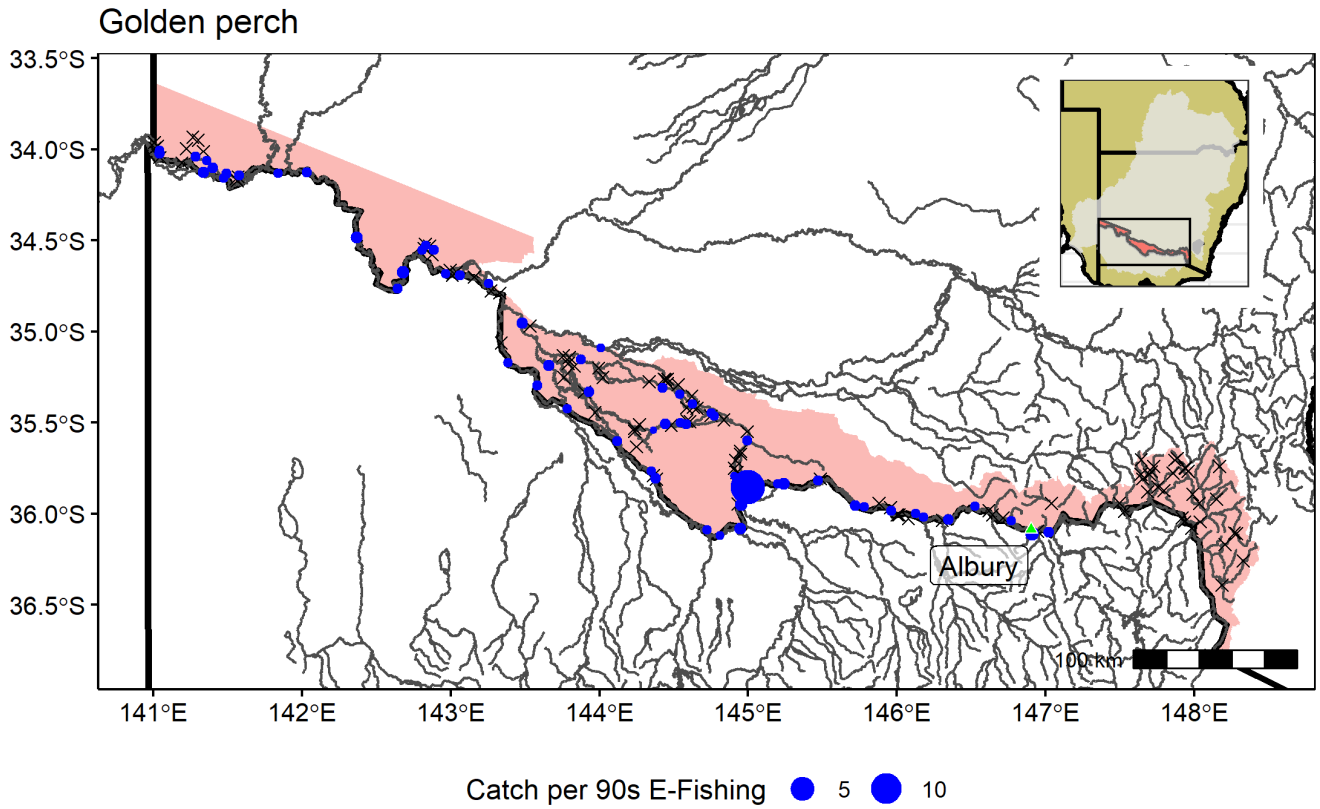

Figure 11.15: Distribution of Golden perch. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Golden perch were distributed across the NSW Murray WRPA with the exception of upland areas in the east.

Freshwater catfish

Population Structure

Figure 11.16 shows the observed length frequency plot for Freshwater catfish for each of the sampling seasons. Only 3 individuals were observed (one in 2014/15, one in 2015/16 and one in 2017/18) and all were of mature size.

Overall, during the BPEOM-F program, across all the MDB water resource planning areas, the percentage YOY for Freshwater catfish was 44% (285 out of 641).

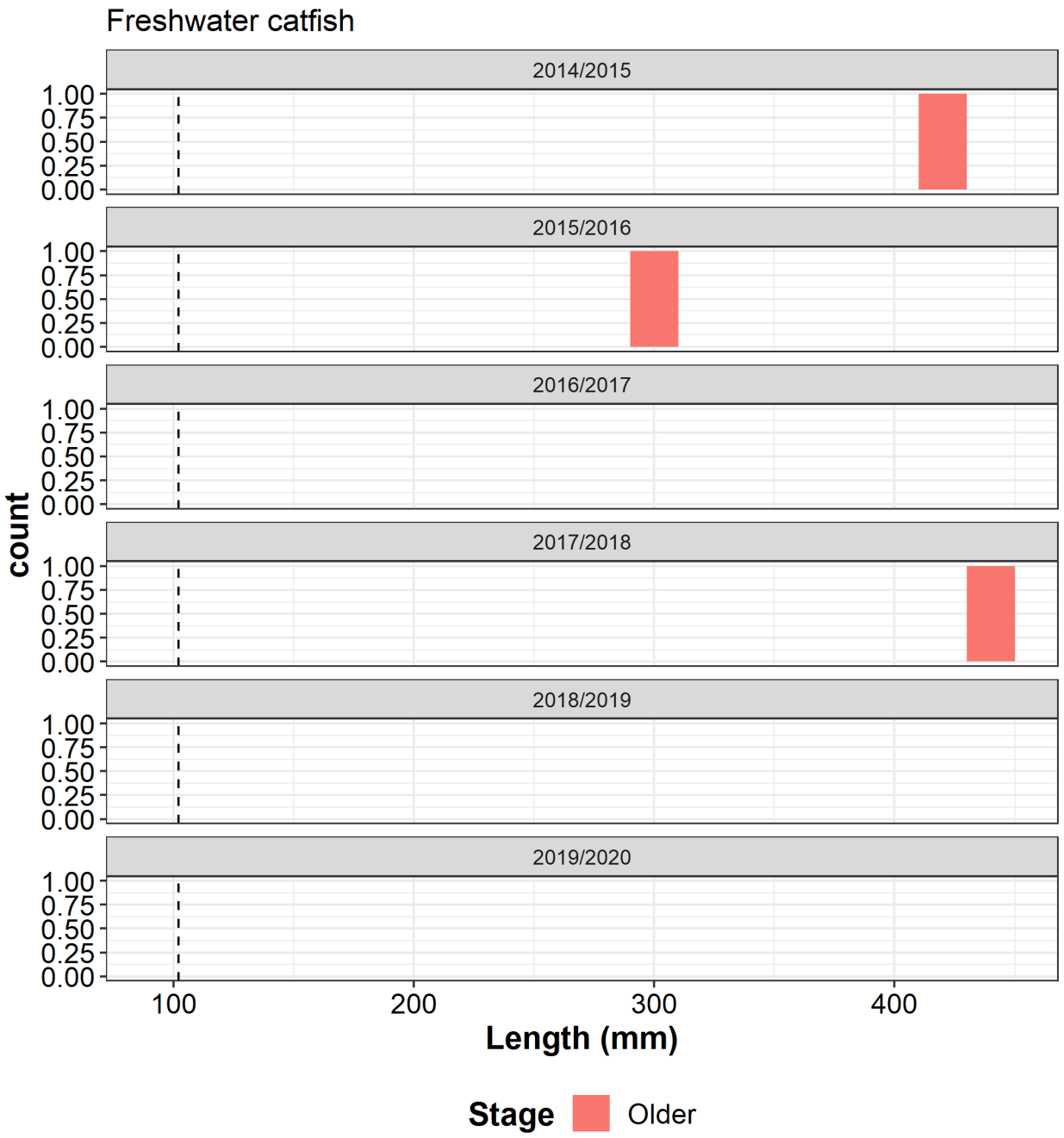

Figure 11.16: Length frequency plots for Freshwater catfish by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Only 3 adult Freshwater catfish were caught, suggesting very low abundance and limited recruitment. Freshwater catfish were not observed by other sampling programs in other years.

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 11.17 shows the abundance trend for the NSW Murray WRPA and the right-hand panel shows the overall trend across the NSW MDB.

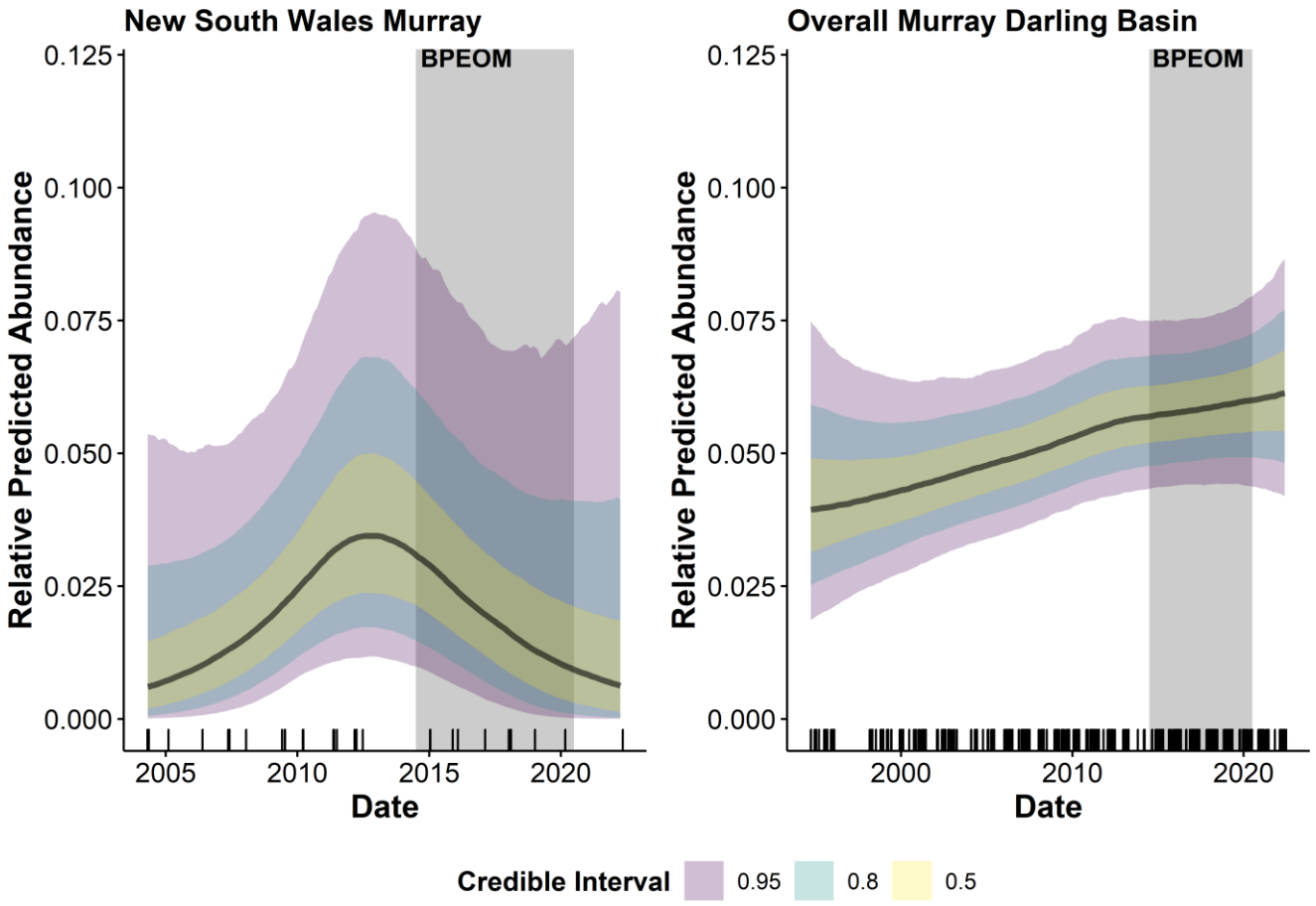

Figure 11.17: Relative abundance of Freshwater catfish in both this valley and the overall Murray-Darling Basin. These are model estimates based upon all electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded 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:

No major changes in abundance since the 1990s but there are large error bars around the abundance estimates. Abundance is likely to be considerably lower than the overall NSW MDB.

Health

No health issues were observed in the three Freshwater catfish sampled in the NSW Murray WRPA (Figure 11.18).

Across the other WRPAs, 1% of Freshwater catfish (8 out of 643 Freshwater catfish) showed a health condition (excludes NSW Murray).

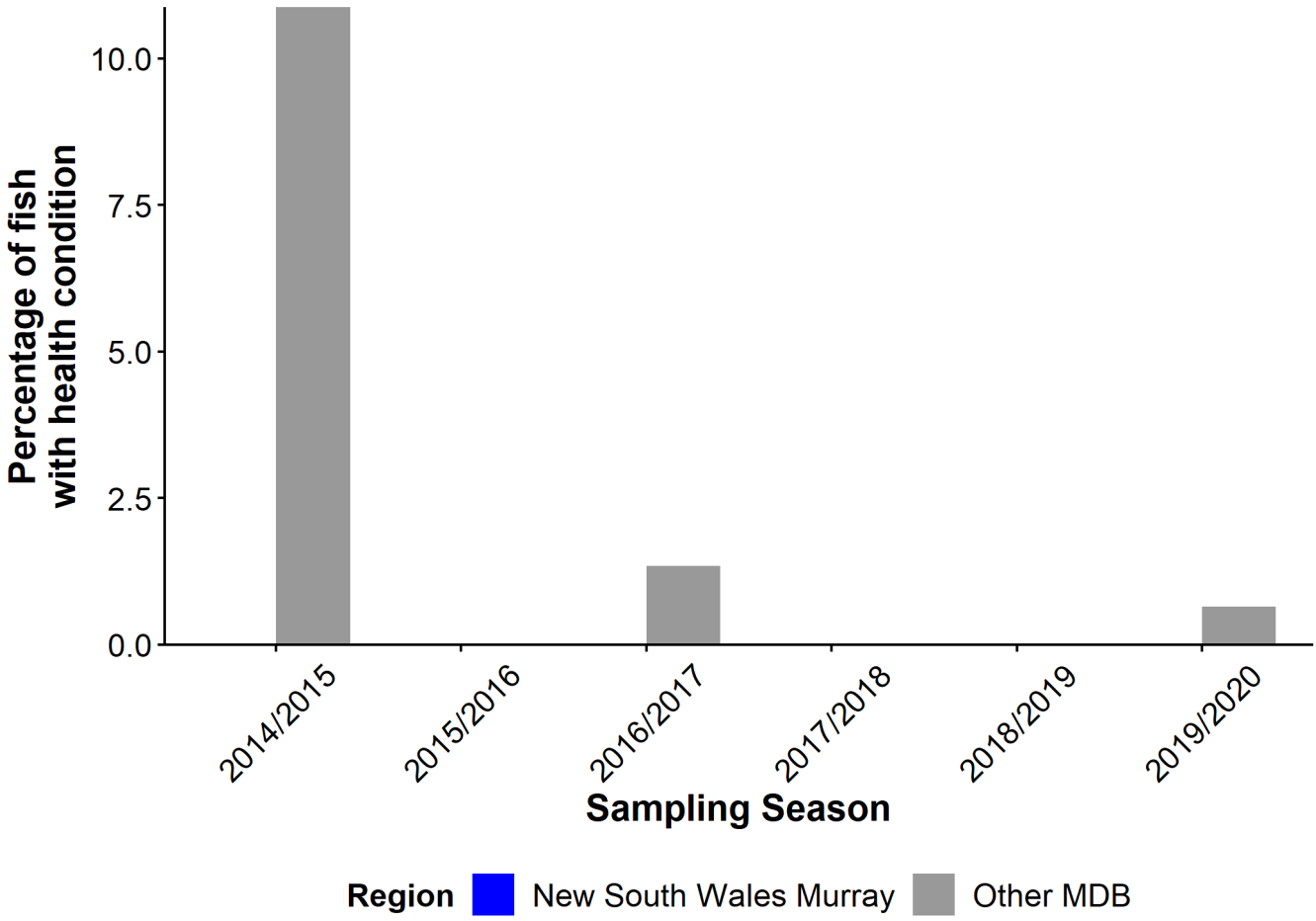

Figure 11.18: Timeseries showing the prevalence of health conditions in Freshwater catfish. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

No health issues were observed in the three Freshwater catfish caught. Overall, in the NSW MDB Freshwater catfish have few observed health issues.

Distribution

Freshwater catfish were recorded at 2 out of 166 sites in the NSW Murray WRPA. The maximum observed relative abundance at a site was 0.1 fish caught per 90 seconds of electrofishing. Figure 11.19 shows the distribution and relative abundance of Freshwater catfish across the NSW Murray WRPA.

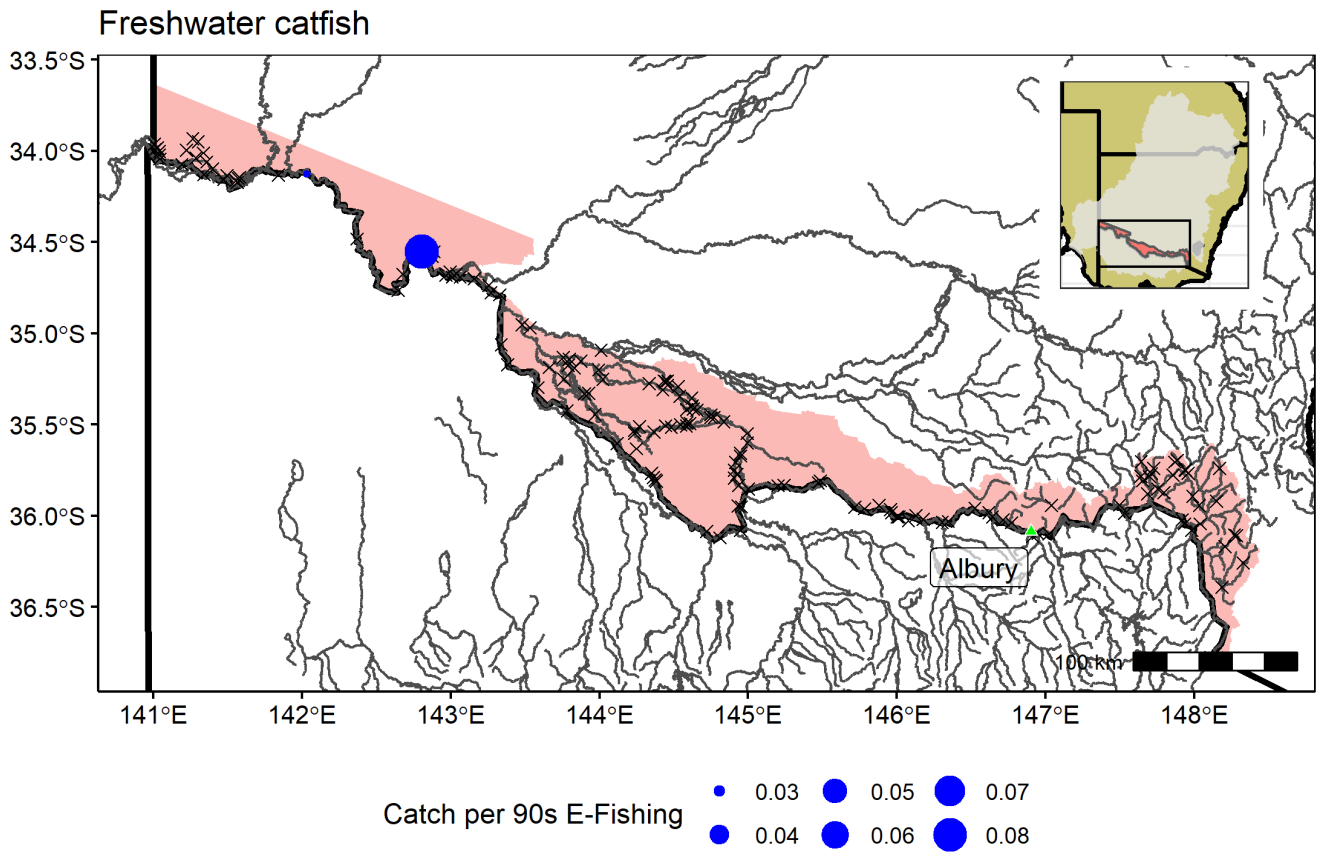

Figure 11.19: Distribution of Freshwater catfish. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Freshwater catfish appear to be in very low abundance and restricted to the central western region of the NSW Murray WRPA, being absent in most of the region.

Bony herring

Population Structure

Figure 11.20 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 66 to 206, and 24% 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 Bony herring was 30% (4,252 out of 14,268). Bony herring are not a stocked species.

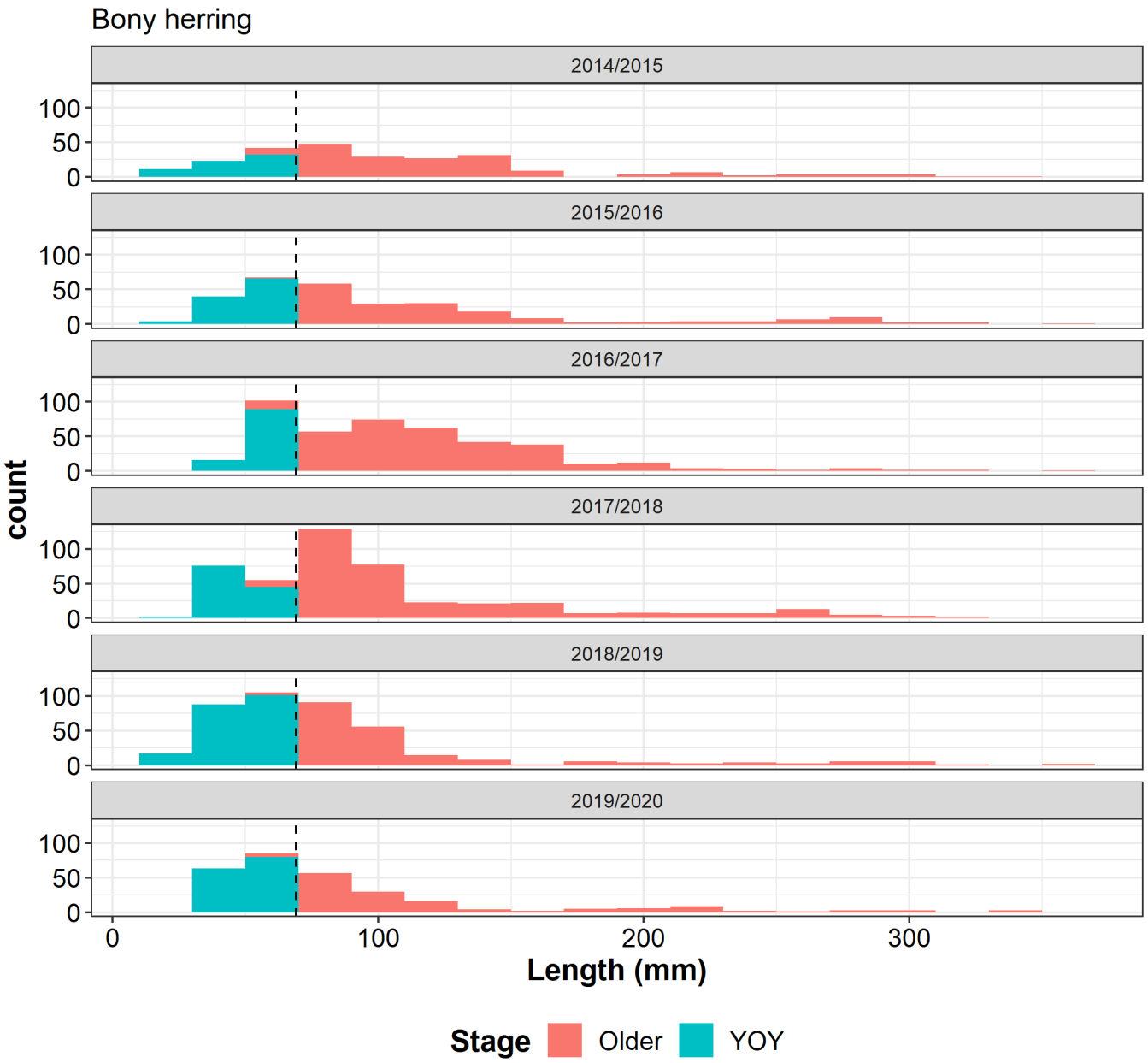

Figure 11.20: Length frequency plots for Bony herring by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Strong evidence for recruitment in all years with a good range of size classes.

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 11.21 shows the abundance trend for the NSW Murray WRPA and the right-hand panel shows the overall trend across the NSW MDB.

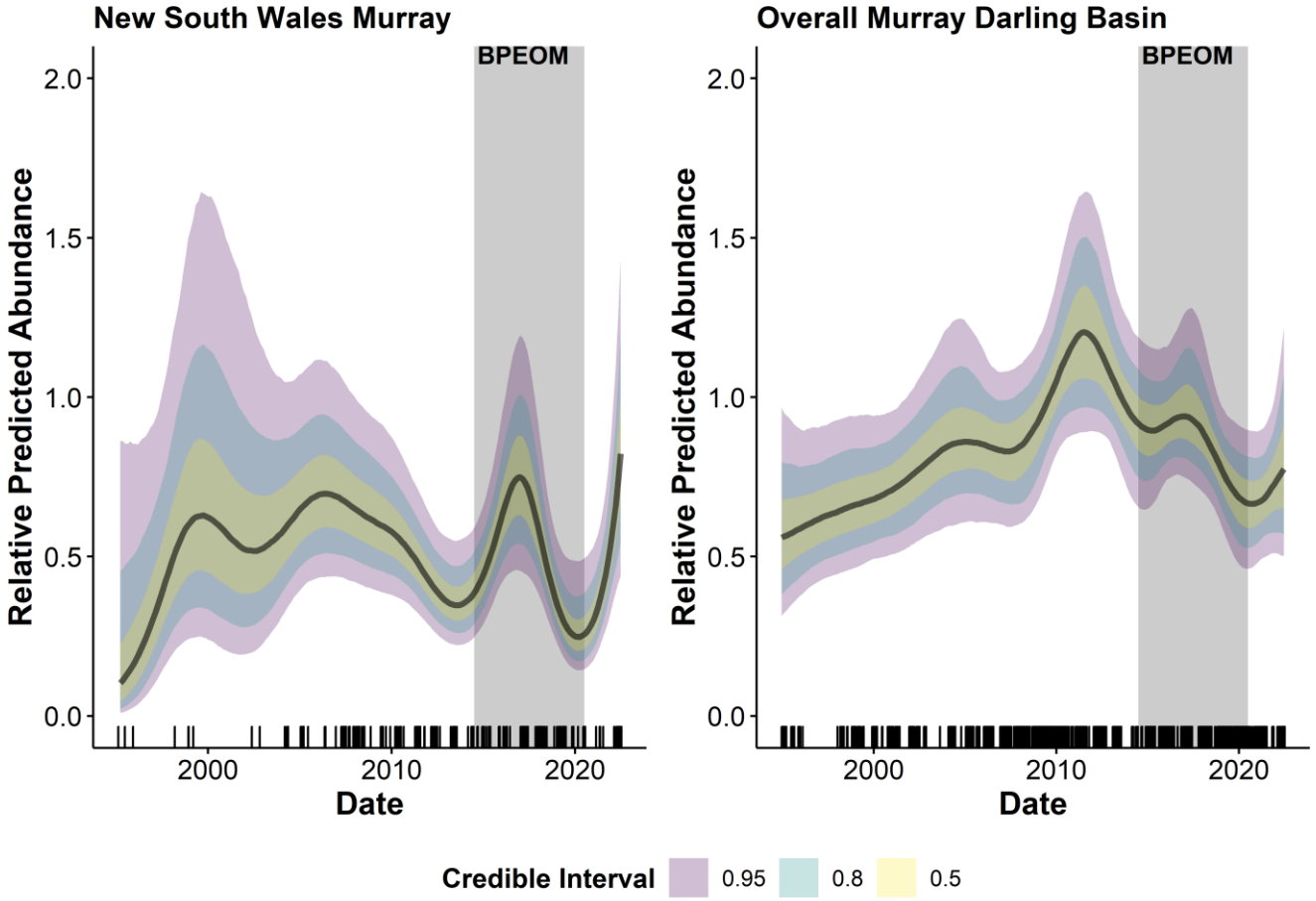

Figure 11.21: Relative abundance of Bony herring in both the NSW Murray WRPA and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region 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 1994 levels but recent years have seen large fluctuations. Abundance is currently approximately equal to the overall NSW MDB but was lower than the NSW MDB in the BPEOM-F period.

Health

The prevalence of any health issues ranged from 0% of sampled fish in 2014/2015 to 1% of sampled fish in 2018/2019 (Figure 11.22). The most common health issue for Bony herring in the NSW Murray WRPA was Lerneae, which was observed in a total of 4 fish, corresponding to <1% of all Bony herring measured.

Across the other NSW MDB WRPAs, 1% of Bony herring (184 out of 14,268 Bony herring) showed a health condition (excludes the NSW Murray WRPA).

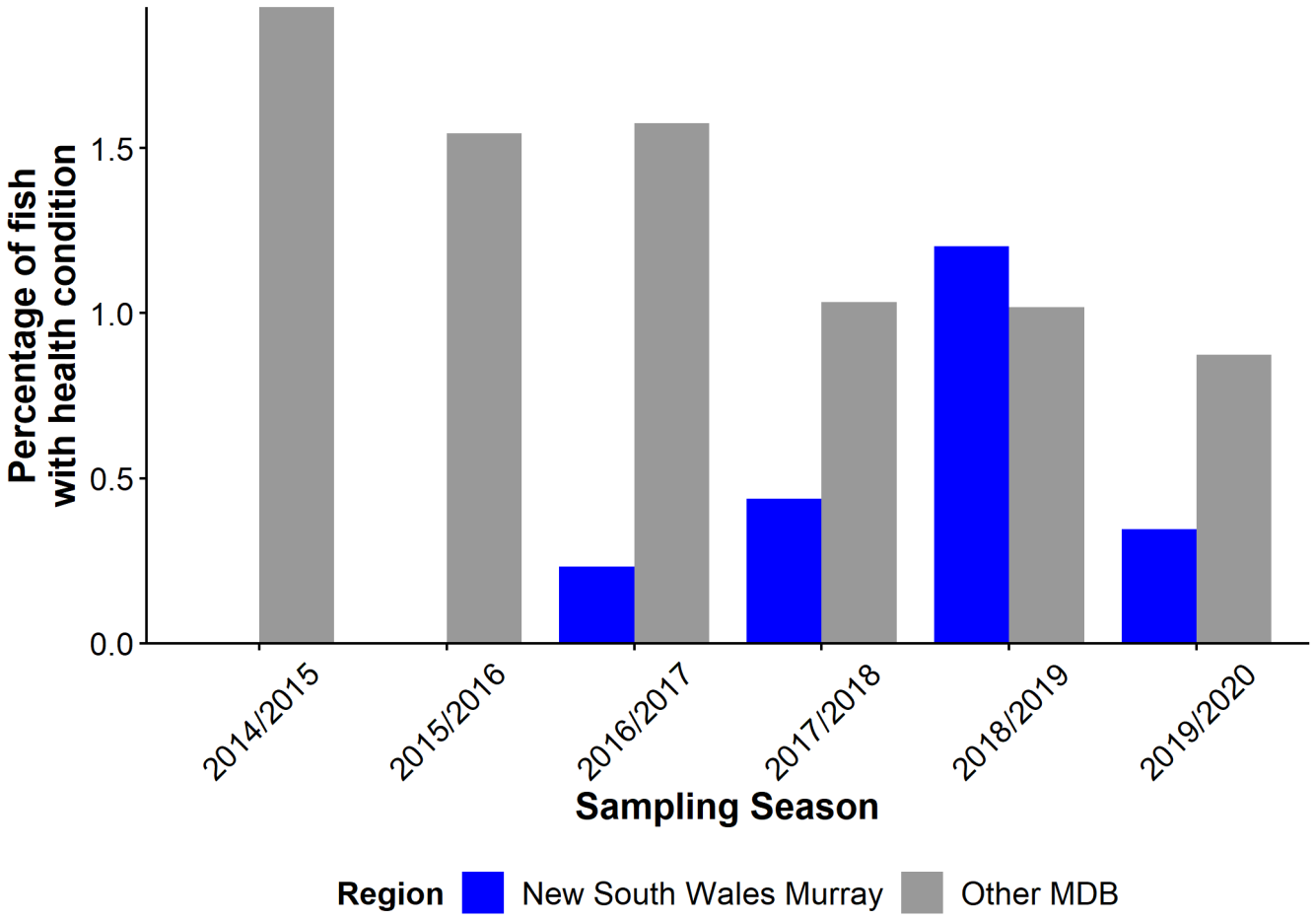

Figure 11.22: Timeseries showing the prevalence of health conditions in Bony herring. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

Presence of observable health conditions was low overall and lower or equal to the rest of the NSW MDB.

Distribution

Bony herring were recorded at 60 out of 166 sites in the NSW Murray WRPA. The maximum observed relative abundance at a site was 31.8 fish caught per 90 seconds of electrofishing. Figure 11.23 shows the distribution and relative abundance of Bony herring across the NSW Murray WRPA.

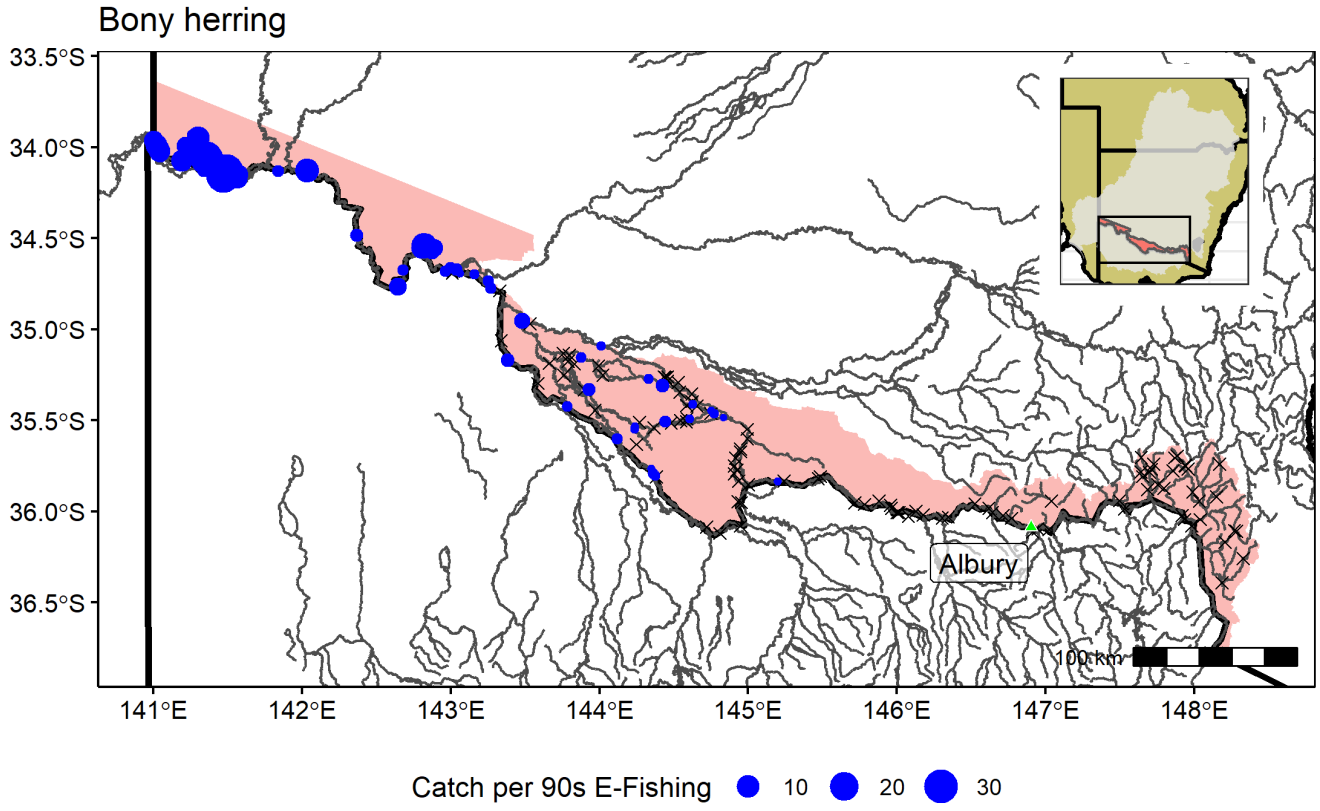

Figure 11.23: Distribution of Bony herring. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Bony herring were recorded across western half of the NSW Murray WRPA but absent in eastern and upland sites. Abundance was highest in the downstream reaches.

Australian smelt

Population Structure

Figure 11.24 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 191 to 834, and 37% to 61% 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 34 % (1,344 out of 3,997). Australian smelt are not a stocked species.

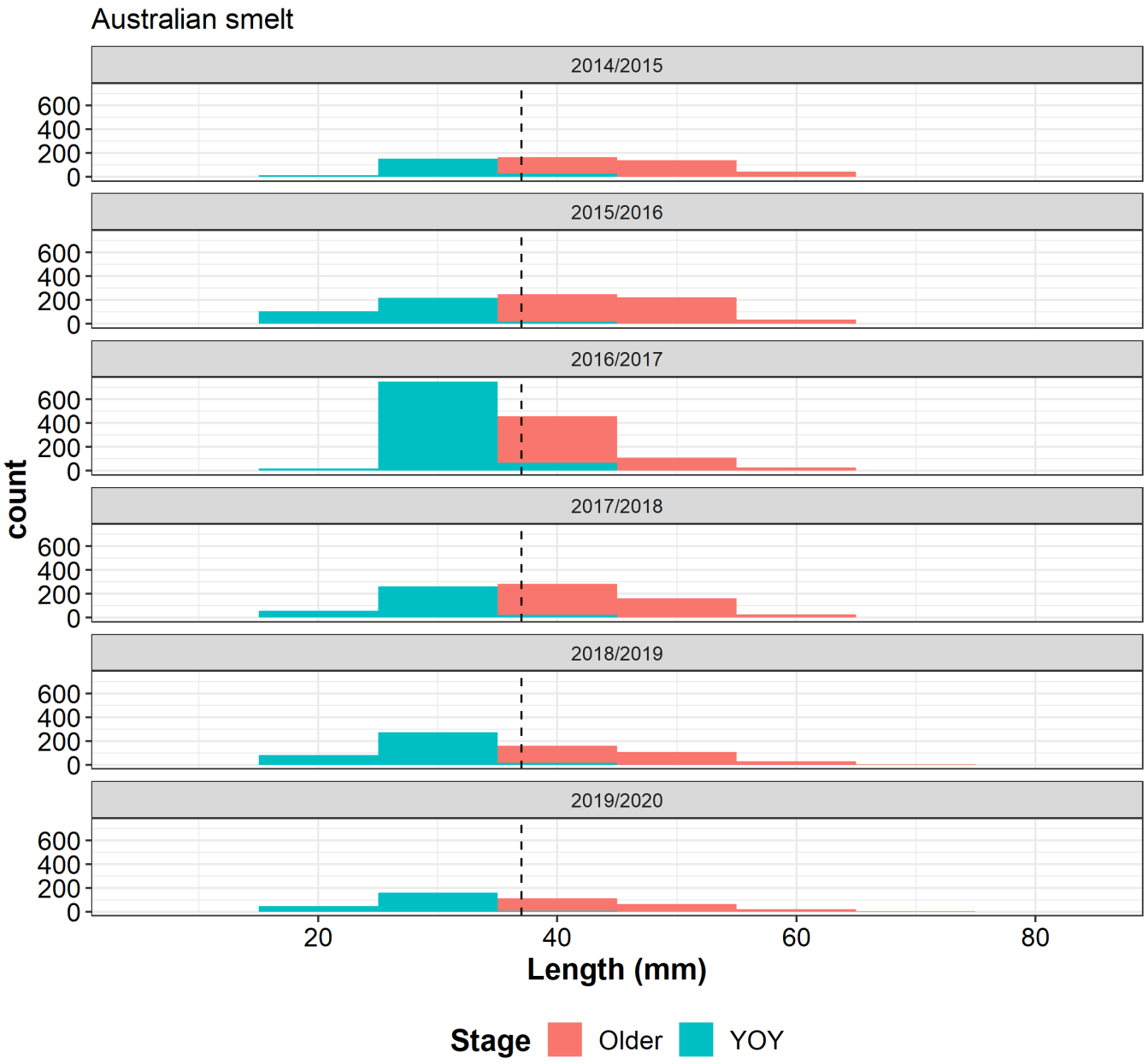

Figure 11.24: Length frequency plots for Australian smelt by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Evidence of recruitment in all years with a peak in 2016/17.

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 11.25 shows the abundance trend for the NSW Murray WRPA and the right-hand panel shows the overall trend across the NSW MDB.

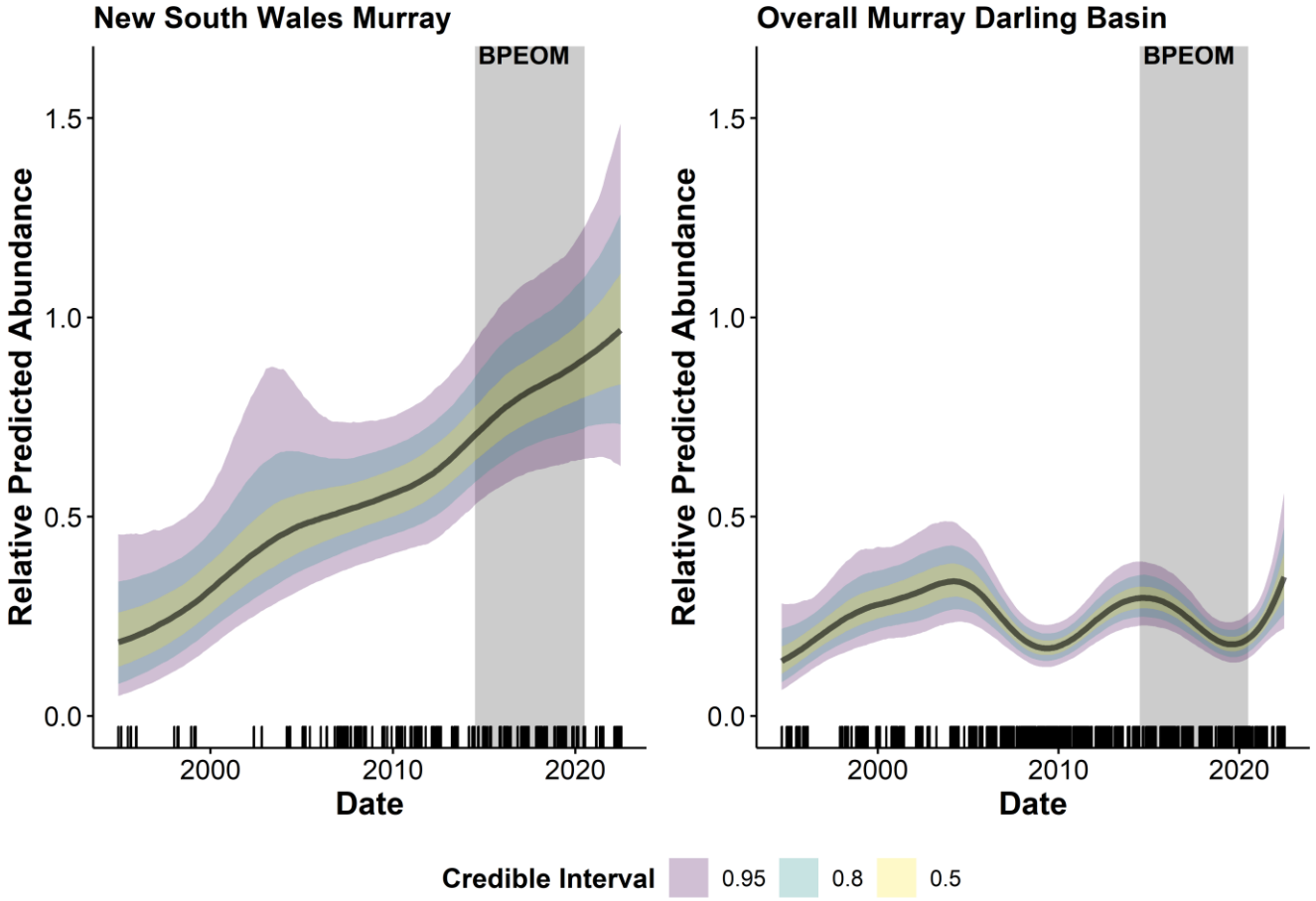

Figure 11.25: Relative abundance of Australian smelt in both the NSW Murray WRPA and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region 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 has increased substantially since the 1990s and 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 3% of sampled fish to 2017/2018 (Figure 11.26). The most common health issue for Australian smelt in the NSW Murray WRPA was Lerneae, which was observed in a total of 30 fish, corresponding to 1% of all Australian smelt measured.

Across the other NSW MDB WRPAs, <1% of Australian smelt (15 out of 3,997 Australian smelt) showed a health condition (excludes the NSW Murray WRPA).

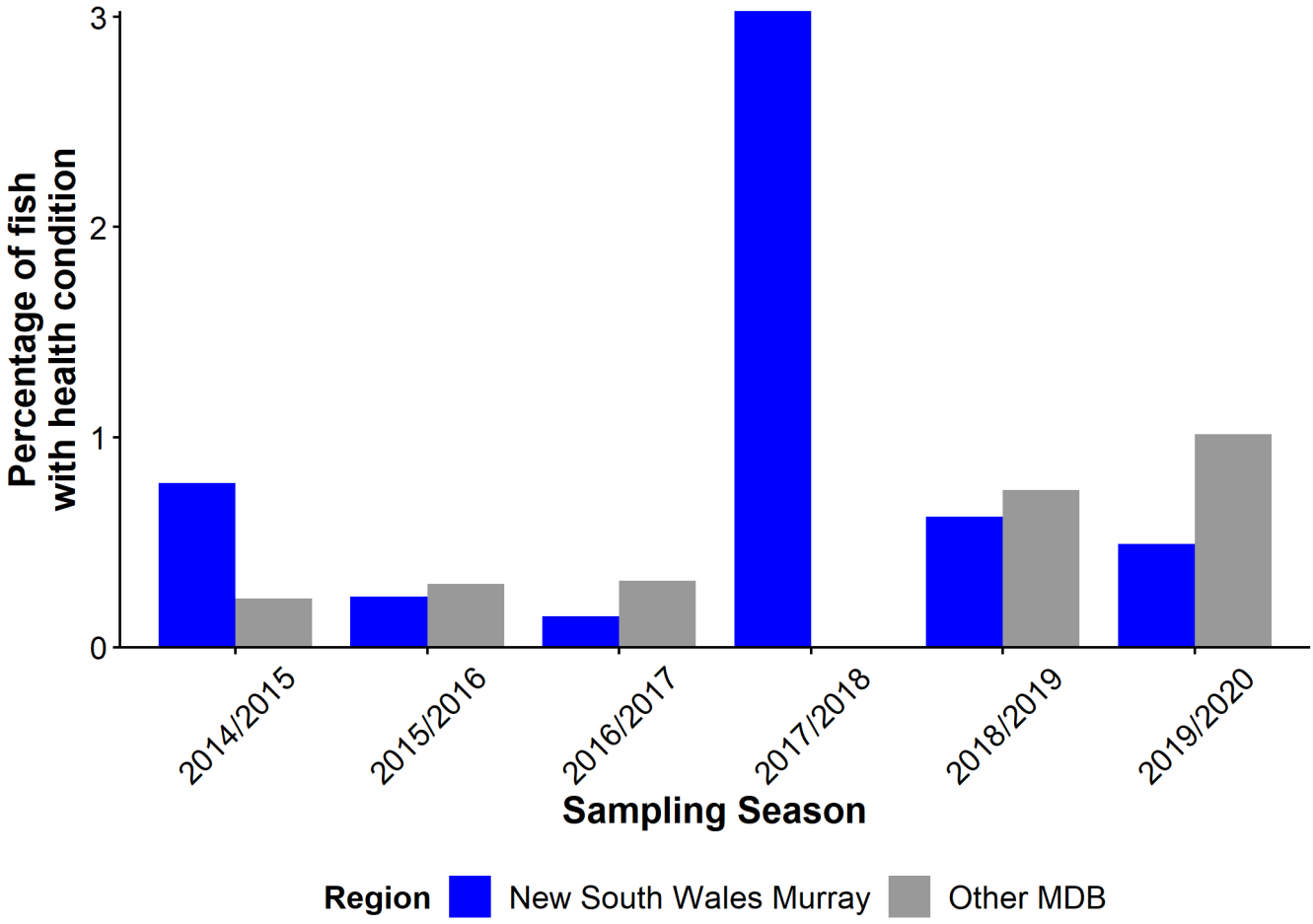

Figure 11.26: Timeseries showing the prevalence of health conditions in Australian smelt. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

Presence of observable health conditions was low and generally similar to the rest of the NSW MDB except for 2017/18 when it was the only WRPA to record health issues in Australian smelt.

Distribution

Australian smelt were recorded at 121 out of 166 sites in the NSW Murray WRPA. The maximum observed relative abundance at a site was 72 fish caught per 90 seconds of electrofishing. Figure 11.27 shows the distribution and relative abundance of Australian smelt across the NSW Murray WRPA.

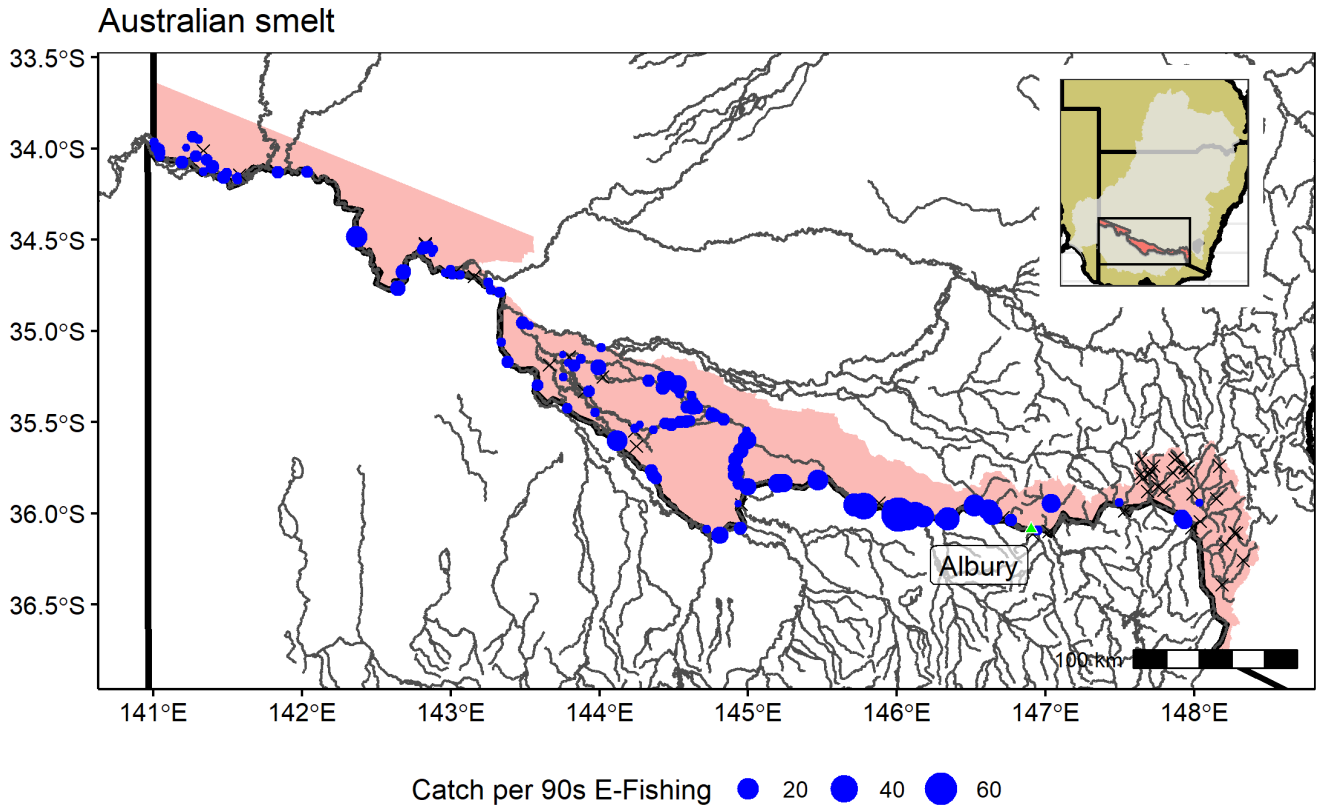

Figure 11.27: Distribution of Australian smelt. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Australian smelt were recorded across the NSW Murray WRPA but less abundant or absent in eastern upland sites.

Common carp

Population Structure

Figure 11.28 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 7 to 1,709, and 5% to 90% 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 53% (9,131 out of 17,071). Common carp are not a stocked species.

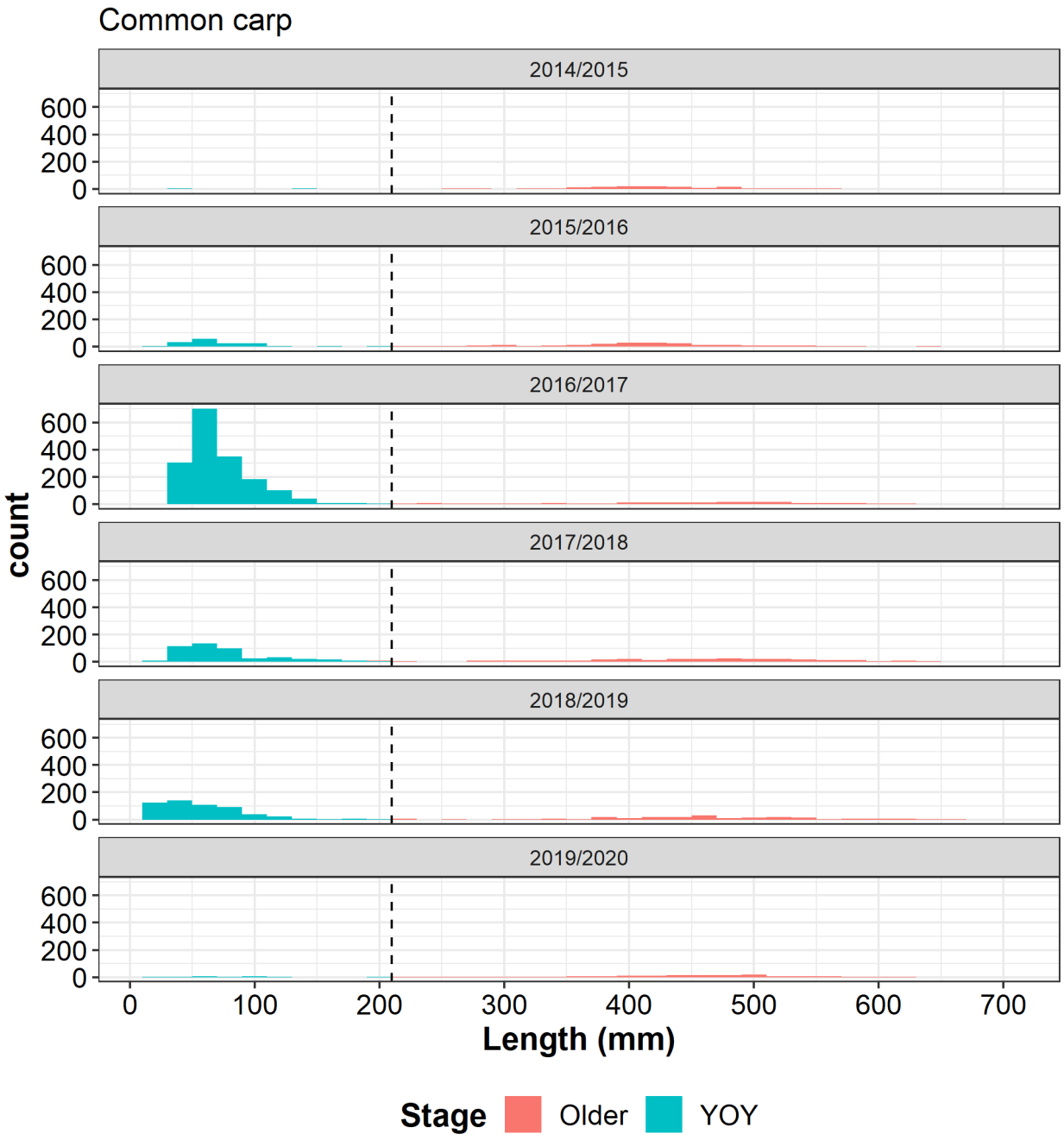

Figure 11.28: Length frequency plots for common carp by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Strong recruitment evident between 2016 and 2019 with a peak in 2016/17. Large fish present in all years but low recruitment in 2014/15 and 2019/20.

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 11.29 shows the abundance trend for the NSW Murray WRPA and the right-hand panel shows the overall trend across the NSW MDB.

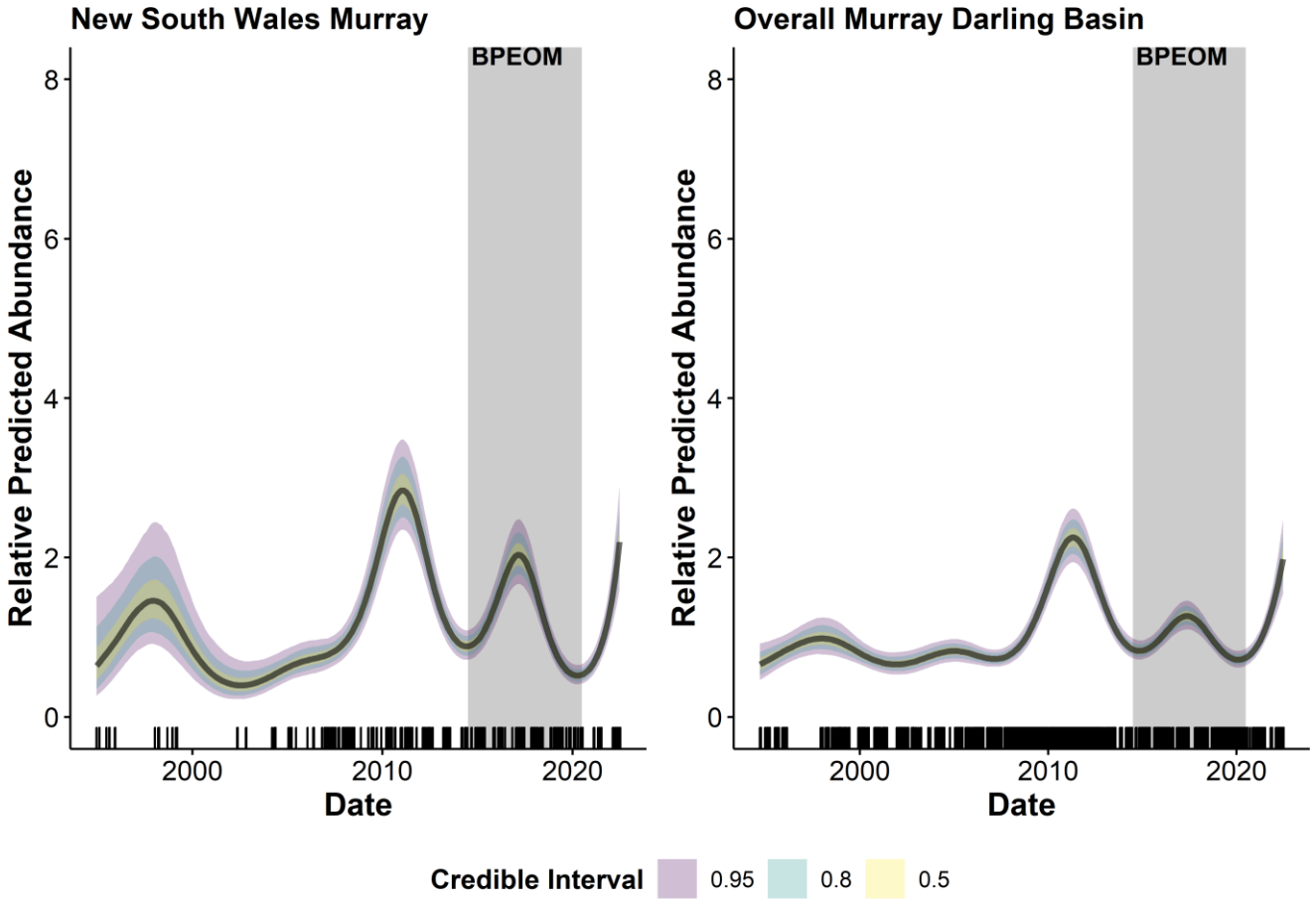

Figure 11.29: Relative abundance of Common carp in both this valley and the overall Murray-Darling Basin. These are model estimates based upon all electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region 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 higher than 1994 levels driven by an increase in recent years. Large fluctuations are evident across the time-series. Biomass has declined recently based on other modelling (NSW DPI unpubl.) suggesting the recent increase in abundance is driven by increased numbers of juveniles. Relative abundance approximately equal to the overall NSW MDB.

Health

The prevalence of any health issues ranged from 1% of sampled fish in 2016/2017 to 9% of sampled fish in 2019/2020 (Figure 11.30). The most common health issue for Common carp in the NSW Murray water resource planning area was Lerneae, which was observed in a total of 88 fish, corresponding to 2% of all Common carp measured.

Across the other WRPAs, 6% of Common carp (1,008 out of 17,072 Common carp) showed a health condition (excludes NSW Murray).

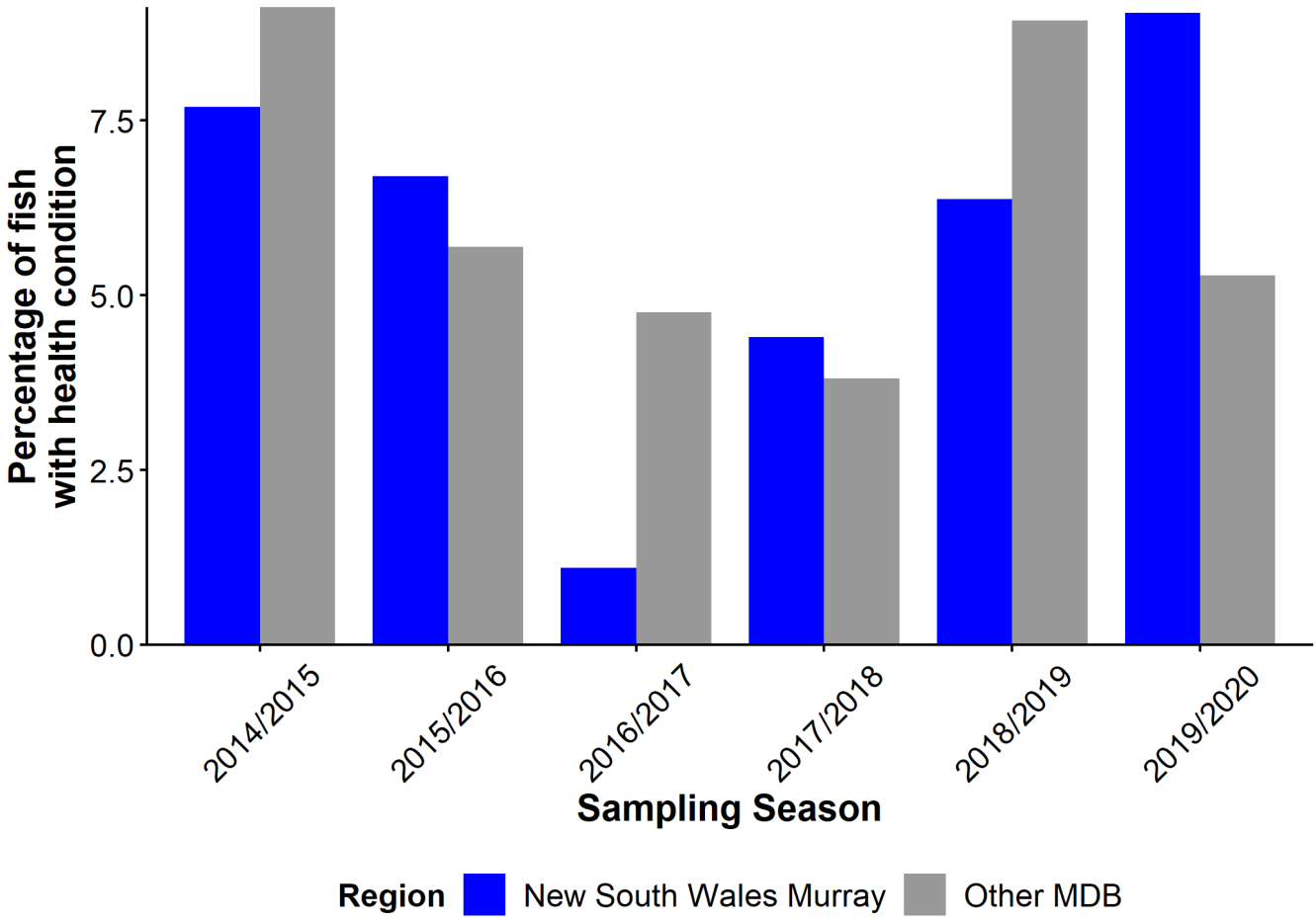

Figure 11.30: Timeseries showing the prevalence of health conditions in Common carp. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

Presence of observable health conditions in the NSW Murray was generally low and approximately equal to the rest of the NSW MDB.

Distribution

Common carp were recorded at 136 out of 166 sites in the NSW Murray WRPA. The maximum observed relative abundance at a site was 38.02 fish caught per 90 seconds of electrofishing. Figure 11.31 shows the distribution and relative abundance of Common carp across the NSW Murray WRPA.

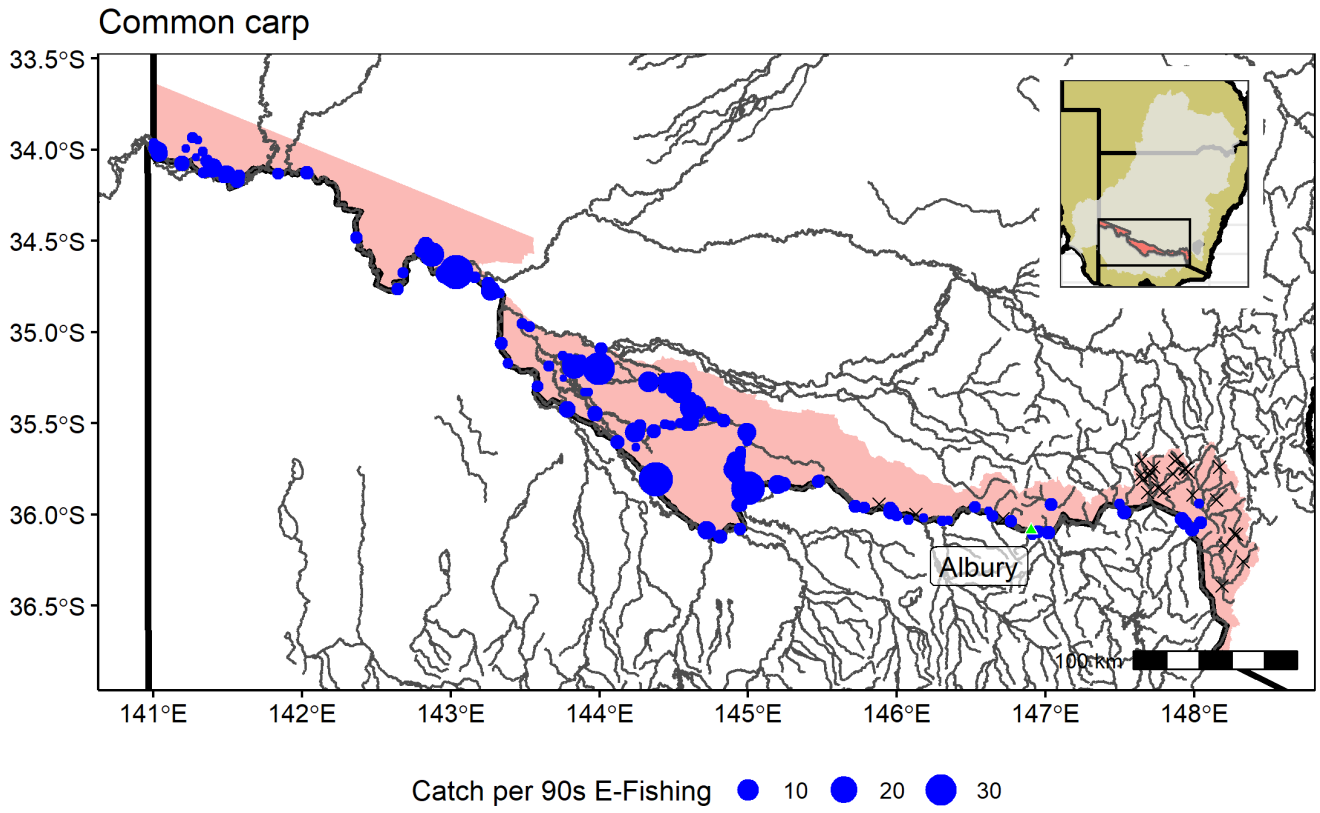

Figure 11.31: Distribution of Common carp. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Recorded across the western and central areas of the NSW Murray WRPA, but rare or absent in the upland eastern sites.

Threatened Species

The following table (Table 11.6) 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 Murray 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 11.9.

Table 11.6: Listed species which were observed in this region during the BPEOM-F program. (* = FMA, # = EPBC)

Species	Common name	Total caught (observed)
Bidyanus bidyanus	Silver perch*#	27 (4)
Maccullochella macquariensis	Trout cod*#	66 (2)
Maccullochella peelii	Murray cod#	256 (41)
Nannoperca australis	Southern pygmy perch*#	595 (197)
Tandanus tandanus	Freshwater catfish*	3 (1)

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

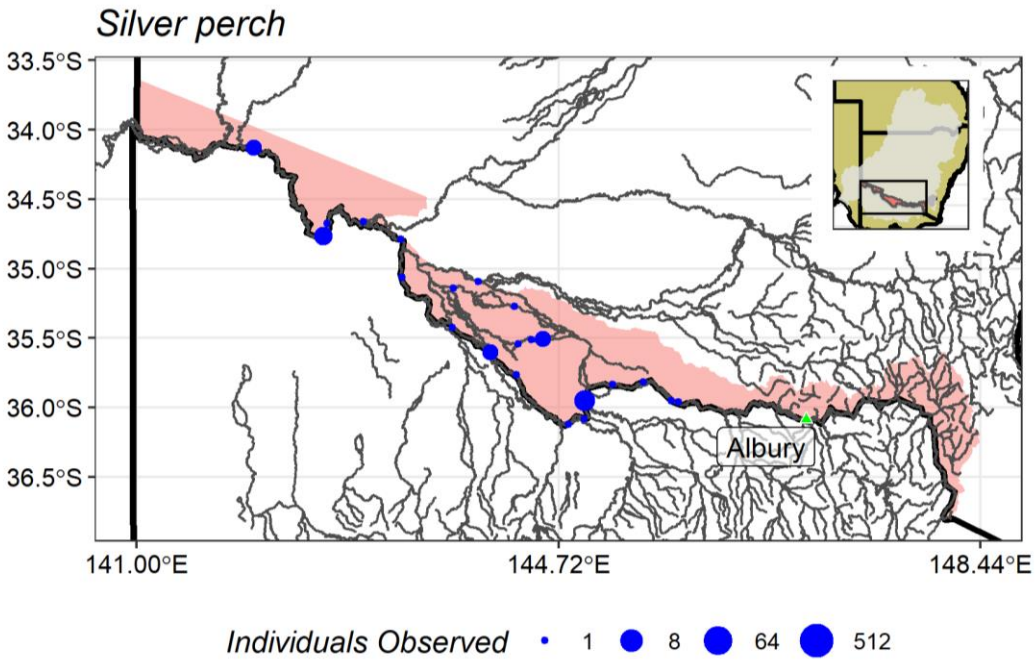

Figure 11.32: Distribution of Silver perch. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 31 Silver perch were caught or observed across 22 sites in the NSW Murray region.

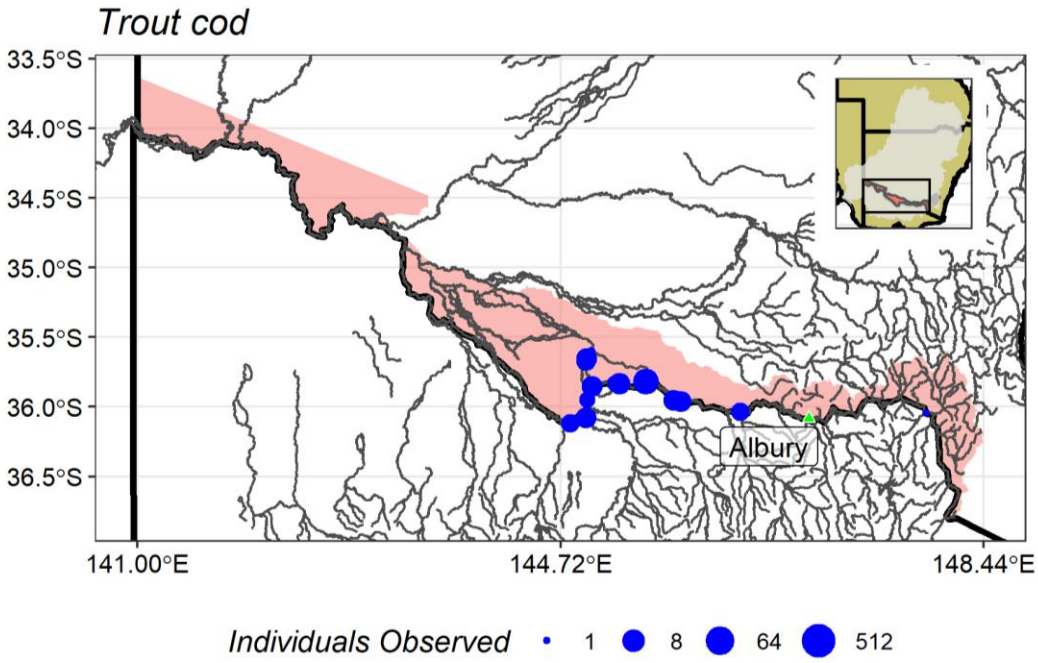

Figure 11.33: Distribution of Trout cod. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance.

Summary Statement:

68 Trout cod were caught or observed at 14 sites mostly between Echuca and Albury.

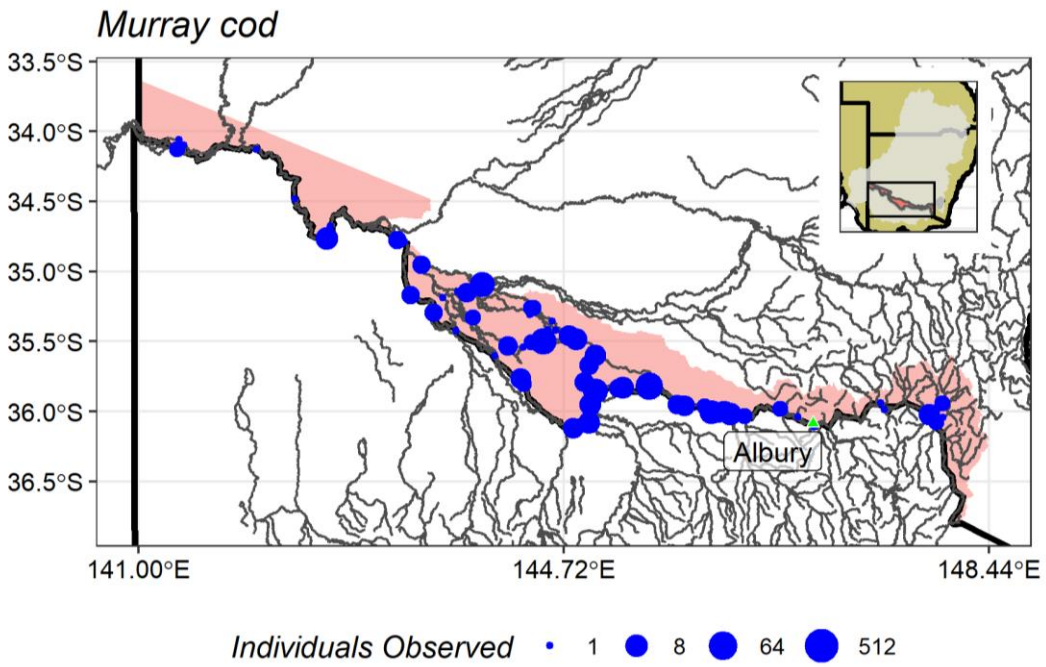

Figure 11.34: Distribution of Murray cod. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance. Note the bottom image shows a juvenile Murray cod.

Summary Statement:

A total of 297 Murray cod were caught across 70 sites in the NSW Murray WRPA, mostly in the central areas.

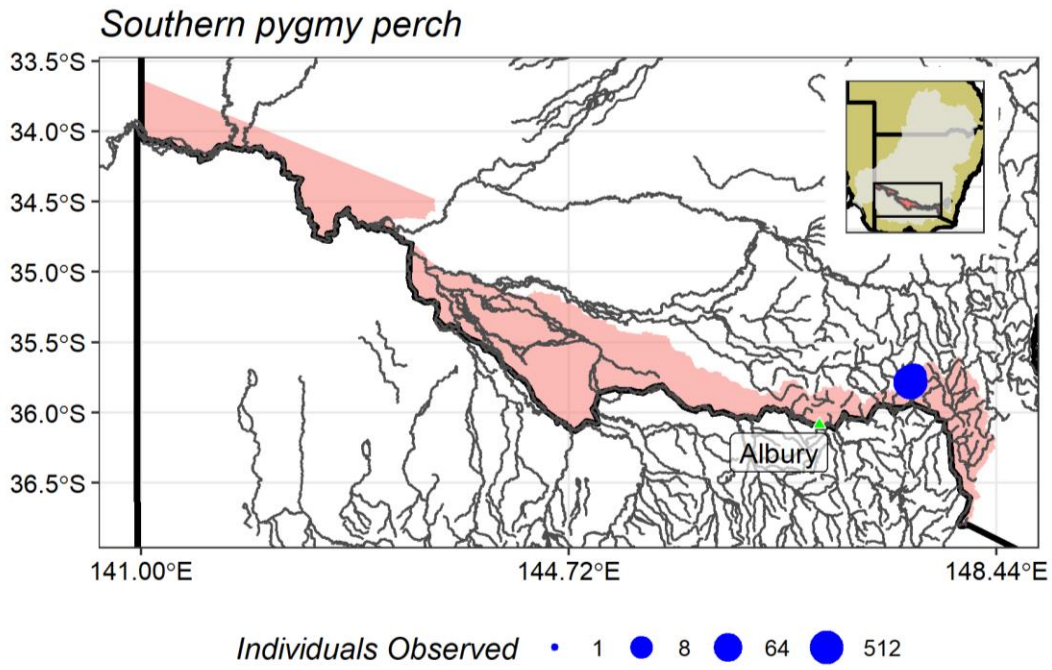

Figure 11.35: Distribution of Southern pygmy perch. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 792 Southern pygmy perch were observed at 2 sites in the Upper Murray.

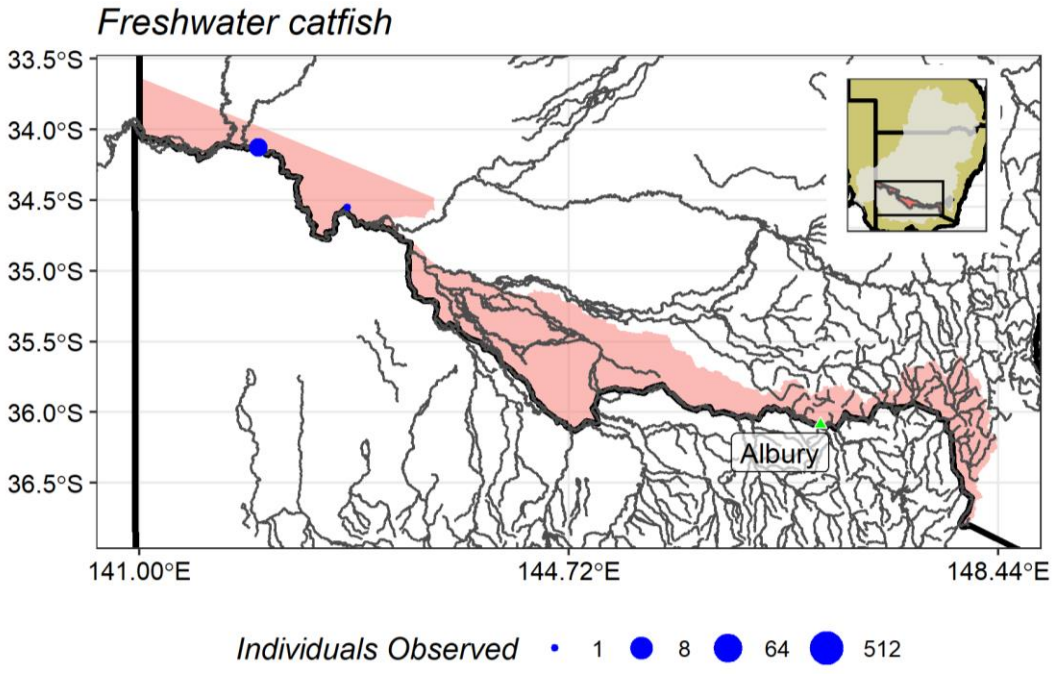

Figure 11.36: Distribution of Freshwater catfish. Filled circles show sites where the species was present and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 4 Freshwater catfish were caught or observed across two sites in 2015, 2016 and 2018.

Appendix

Figure 11.37 shows the locations of sites sampled in each sampling season.

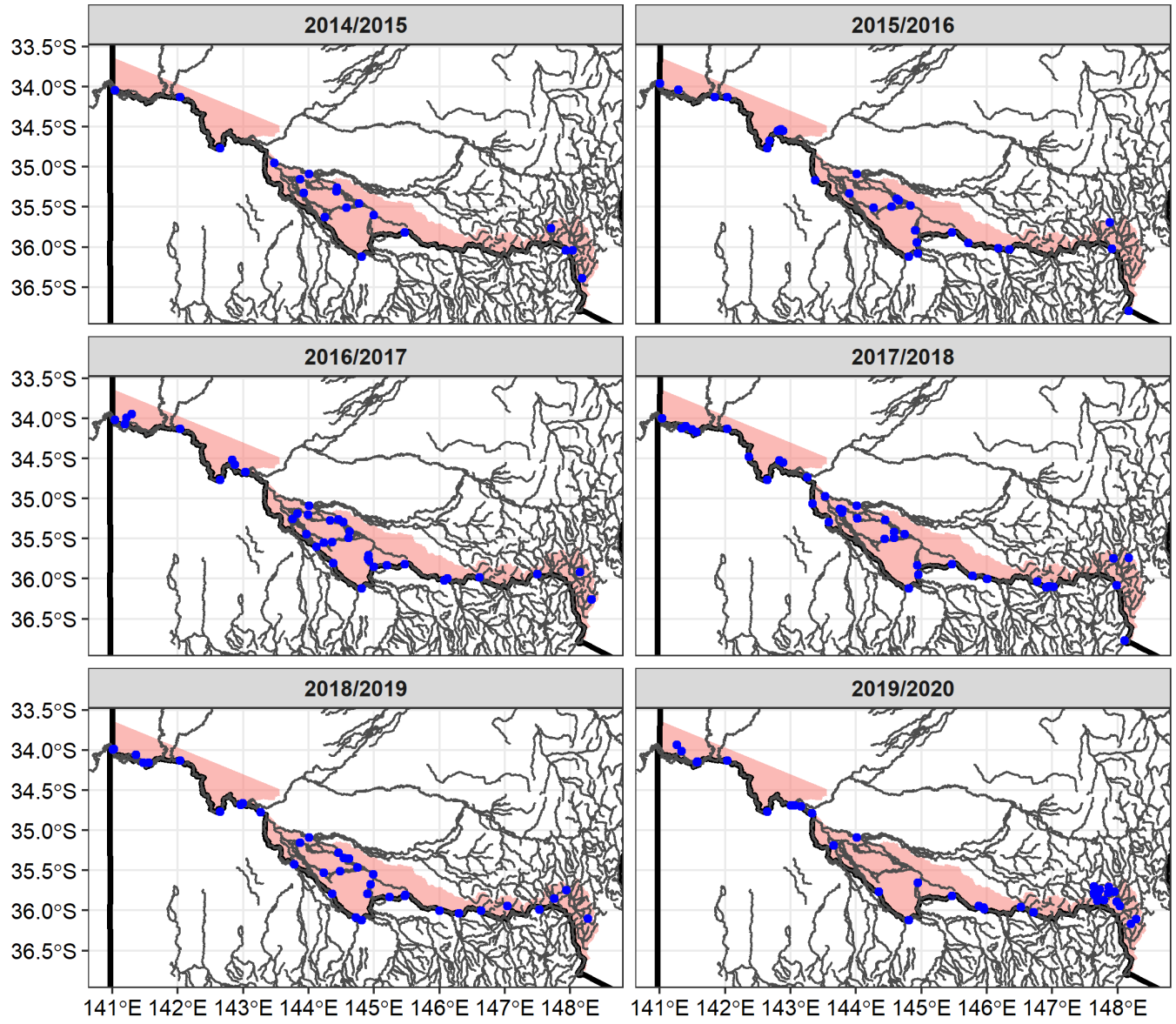

Figure 11.37: Sites sampled during the BPEOM-F program by Sampling Season. Dry sites are not shown.

Table 11.7 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 11.1. 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 Murray WRPA were: Olive perchlet, Darling hardyhead, Murray hardyhead, Riffle galaxias, Flat-headed galaxias, Macquarie perch, Southern purple-spotted gudgeon. 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 11.10.

Table 11.7: 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	624	1,578	2,697	2,021	922	719
Bony herring	YES	289	511	796	895	1055	670
Brown trout	YES	2	0	1	44	2	9
Carp-gudgeon species complex	YES	468	801	1,615	2227	1,286	1,021
Common carp	NA	143	388	3,927	839	830	188
Dwarf flathead gudgeon	YES	1	0	0	16	3	0
Eastern gambusia	NA	335	218	1198	161	277	117
Flathead gudgeon	YES	6	233	37	49	17	107
Freshwater catfish	YES	1	1	0	1	0	0
Galaxias spp	NA	0	0	0	0	0	7
Golden perch	YES	15	29	25	52	19	18
Goldfish	NA	5	60	487	261	98	11
Mountain galaxias	YES	0	246	0	7	73	160
Murray-Darling rainbowfish	YES	95	81	159	280	62	85
Murray cod	YES	36	71	38	48	40	23
Obscure galaxias	YES	0	0	0	0	1	0
Oriental weatherloach	NA	0	1	0	2	1	1
Rainbow trout	YES	0	0	3	6	5	21
Redfin	YES	0	9	4	22	48	32
River blackfish	YES	4	3	0	2	6	58
Silver perch	YES	3	3	7	7	4	3
Southern pygmy perch	YES	0	0	0	0	0	595
Trout cod	YES	5	16	7	9	21	8
Two-spined blackfish	NA	15	0	0	1	0	0
Unspecked hardyhead	YES	31	404	143	942	254	203

The following table summarises the sampling methods by which each fish species was caught (Table 11.8).

Table 11.8: Total catch of each species by sampling method.

Common name	Backpack Electrofishing	Bait Trap	Boat Electrofishing
Australian smelt	43	5	8,513
Bony herring	17	7	4,192
Brown trout	55	0	3
Carp-gudgeon species complex	787	3,380	3,251
Common carp	790	597	4,928
Dwarf flathead gudgeon	4	1	15
Eastern gambusia	1,262	475	569
Flathead gudgeon	15	46	388
Freshwater catfish	0	0	3
Galaxias spp	7	0	0
Golden perch	0	0	158
Goldfish	54	4	864
Mountain galaxias	453	26	7
Murray-Darling rainbowfish	1	2	759
Murray cod	3	0	253
Obscure galaxias	0	0	1
Oriental weatherloach	2	0	3
Rainbow trout	35	0	0
Redfin	8	4	103
River blackfish	62	0	11
Silver perch	1	0	26
Southern pygmy perch	583	12	0
Trout cod	0	0	66
Two-spined blackfish	16	0	0
Unspecked hardyhead	3	16	1,958

Table 11.9: 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
Ambassis agassizii	Agassiz's glassfish, olive perchlet, western New South Wales population	NA	Endangered Population
Bidyanus bidyanus	Silver Perch, Bidyan	Critically Endangered	Vulnerable
Craterocephalus fluviatilis	Murray Hardyhead	Endangered	Critically Endangered
Galaxias rostratus	Flathead Galaxias, Beaked Minnow, Flat-headed Galaxias, Flat-headed Jollytail, Flat-headed Minnow	Critically Endangered	Critically Endangered
Galaxias tantangara	Stocky Galaxias	NA	Critically Endangered
Maccullochella macquariensis	Trout Cod	Endangered	Endangered
Maccullochella peelii	Murray Cod	Vulnerable	NA
Macquaria australasica	Macquarie Perch	Endangered	Endangered
Mogurnda adspersa	Southern Purple Spotted Gudgeon	NA	Endangered
Nannoperca australis	Southern Pygmy Perch	Vulnerable	Endangered
Tandanus tandanus	Freshwater catfish, eel tailed catfish, Murray-Darling Basin population	NA	Endangered Population

Table 11.10 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 Murray WRPA were: Olive perchlet, Darling hardyhead, Murray hardyhead, Riffle galaxias, Flat-headed galaxias, Southern purple-spotted gudgeon. 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 11.7.

Table 11.10. 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	1,682	3,104	5,131	2,629	2,270	1,702
Bony herring	YES	507	564	946	1,222	1,166	675
Brown trout	YES	4	0	3	44	2	9
Carp-gudgeon species complex	YES	11,773	3,959	10,093	11,125	5,897	7,927
Common carp	NA	1,002	868	8,421	2,447	1564	391
Common carp - Goldfish hybrid	NA	1	0	0	0	0	0
Dwarf flathead gudgeon	YES	22	49	1	19	6	26
Eastern Gambusia	NA	2,195	787	1,710	1,226	625	388
Flathead gudgeon	YES	38	364	62	55	89	188
Freshwater catfish	YES	1	2	0	1	0	0
Galaxia spp	NA	0	0	0	0	0	7
Golden perch	YES	267	105	95	127	108	45
Goldfish	NA	264	135	1,165	470	497	61
Macquarie perch	YES	0	0	33	28	0	2
Mountain galaxias	YES	2	246	49	10	73	160
Murray-Darling rainbowfish	YES	689	315	795	782	860	176
Murray cod	YES	448	175	126	130	186	82
Obscure galaxias	YES	0	0	0	0	1	0
Oriental weatherloach	NA	54	1	7	13	5	2
Rainbow trout	YES	0	0	3	7	5	21
Redfin	YES	0	33	48	285	72	62
River blackfish	NA	42	3	60	37	6	59
Silver perch	YES	28	15	19	20	14	8
Southern pygmy perch	YES	3	0	0	0	0	595
Trout cod	YES	7	75	37	25	60	45
Two-spined blackfish	NA	15	15	3	1	0	0
Unspecked hardyhead	YES	194	580	697	1,138	406	239