

Chapter 6 Basin Plan Environmental Outcomes Monitoring for Fish (2014/15 – 2019/20): Macquarie-Castlereagh Water Resource Planning Area



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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 Macquarie-Castlereagh Water Resource Planning Area (WRPA) shown in [Figure 6.1](#).

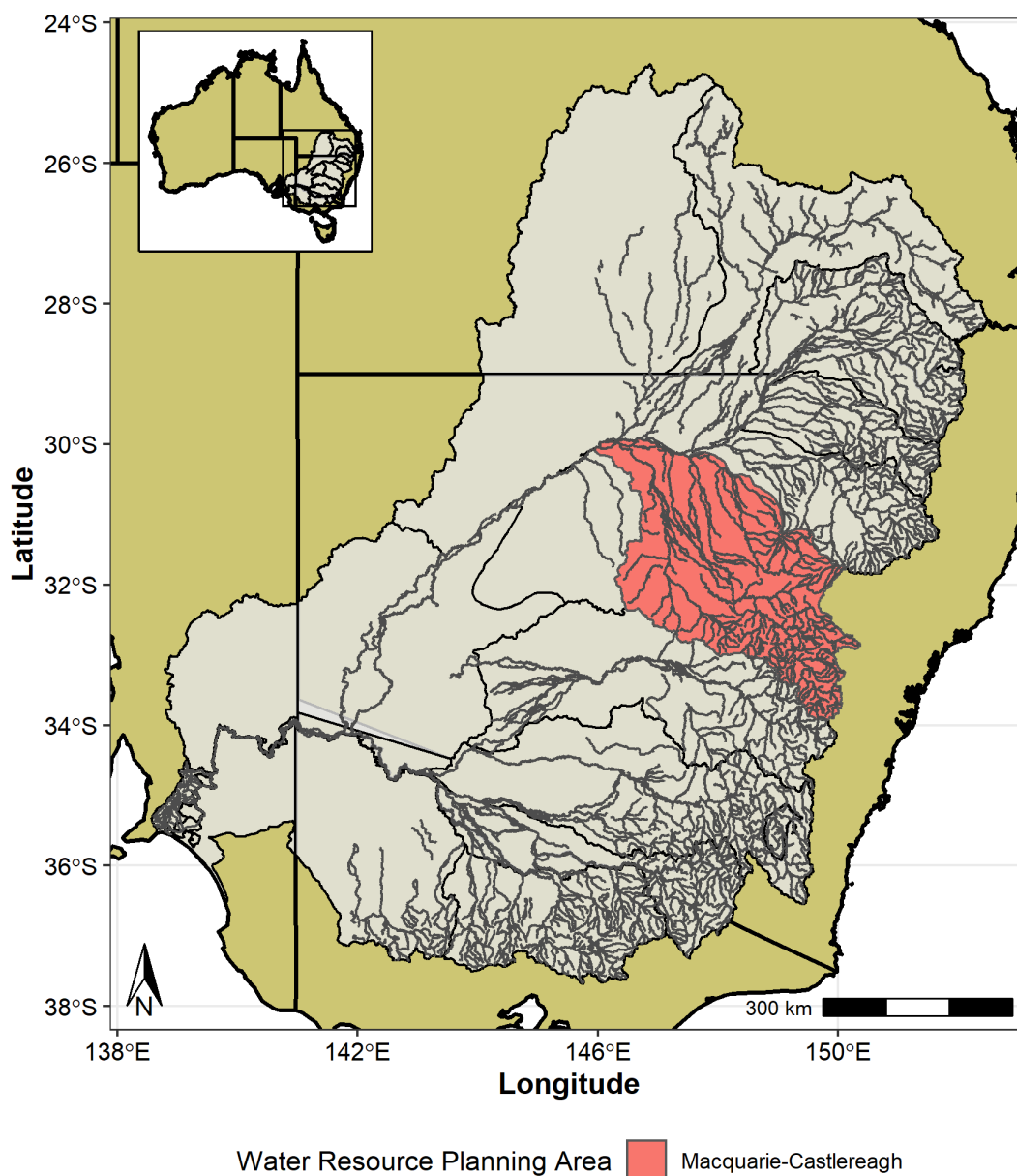


Figure 6.1: Murray-Darling Basin with the key region of this report highlighted. Inset map shows the whole of Australia with a box around the MDB.

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 Macquarie-Castlereagh 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 Macquarie-Castlereagh 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 Macquarie-Castlereagh WRPA and greater MDB (excluding the Macquarie-Castlereagh 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 Macquarie-Castlereagh 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 6.1). 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 6.1: 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	37 (1)
2015/2016	40 (7)
2016/2017	52 (1)
2017/2018	25 (15)
2018/2019	22 (14)
2019/2020	13 (4)

The sites sampled during the reporting period are shown in Figure 6.2. A breakdown of sites sampled each sampling season is shown in the Appendix (Figure 6.37).

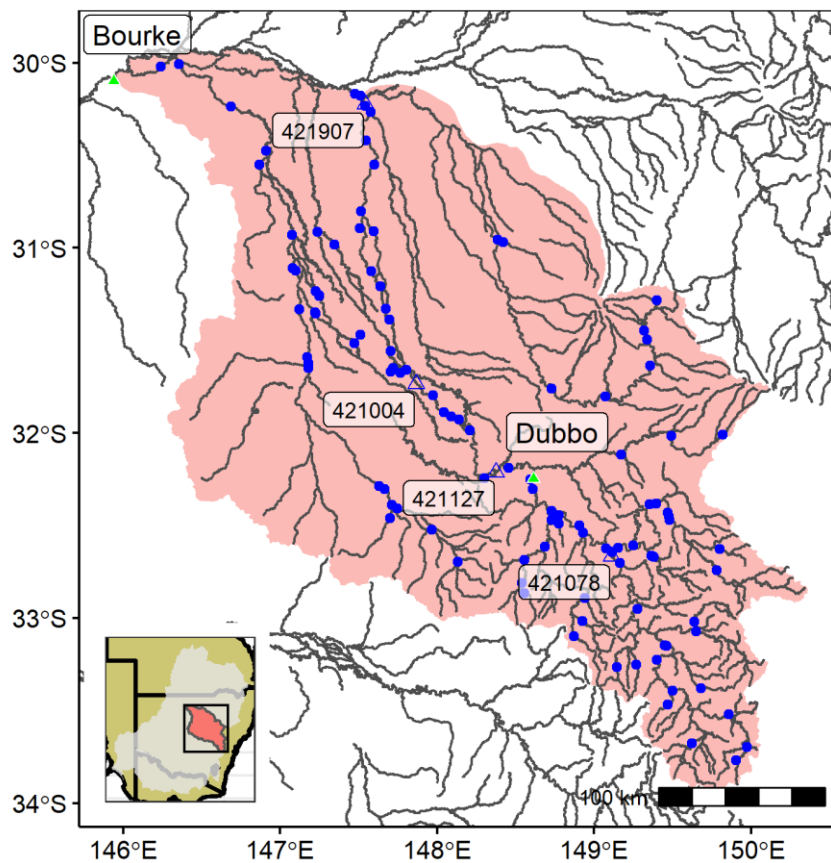


Figure 6.2: Sites (dots) sampled during the BPEOM-F program. Triangles show key flow gauges along with their gauge ID number. Dry sites are not shown.

Each sampling method has a different effectiveness at sampling each species. [Table 6.2](#) shows the total amount of each species caught by each method.

Table 6.2: 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	4	646	1
Golden perch	7	513	3
Freshwater catfish	5	87	0
Bony herring	66	1,667	11
Australian smelt	54	2,267	1
Common carp	728	4,934	704

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 6.3](#) shows the number of biological measurements taken each year for the six species. Note 2019/2020 had substantially less sites sampled than the other seasons ([Table 6.1](#)).

Table 6.3: 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	291	174	31	258	566	1,183
2015/2016	175	86	8	110	274	758
2016/2017	112	230	17	533	374	2,507
2017/2018	27	25	3	127	36	399
2018/2019	28	25	8	44	44	227
2019/2020	16	2	2	26	4	191

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 Macquarie-Castlereagh WRPA (Figure 6.3).

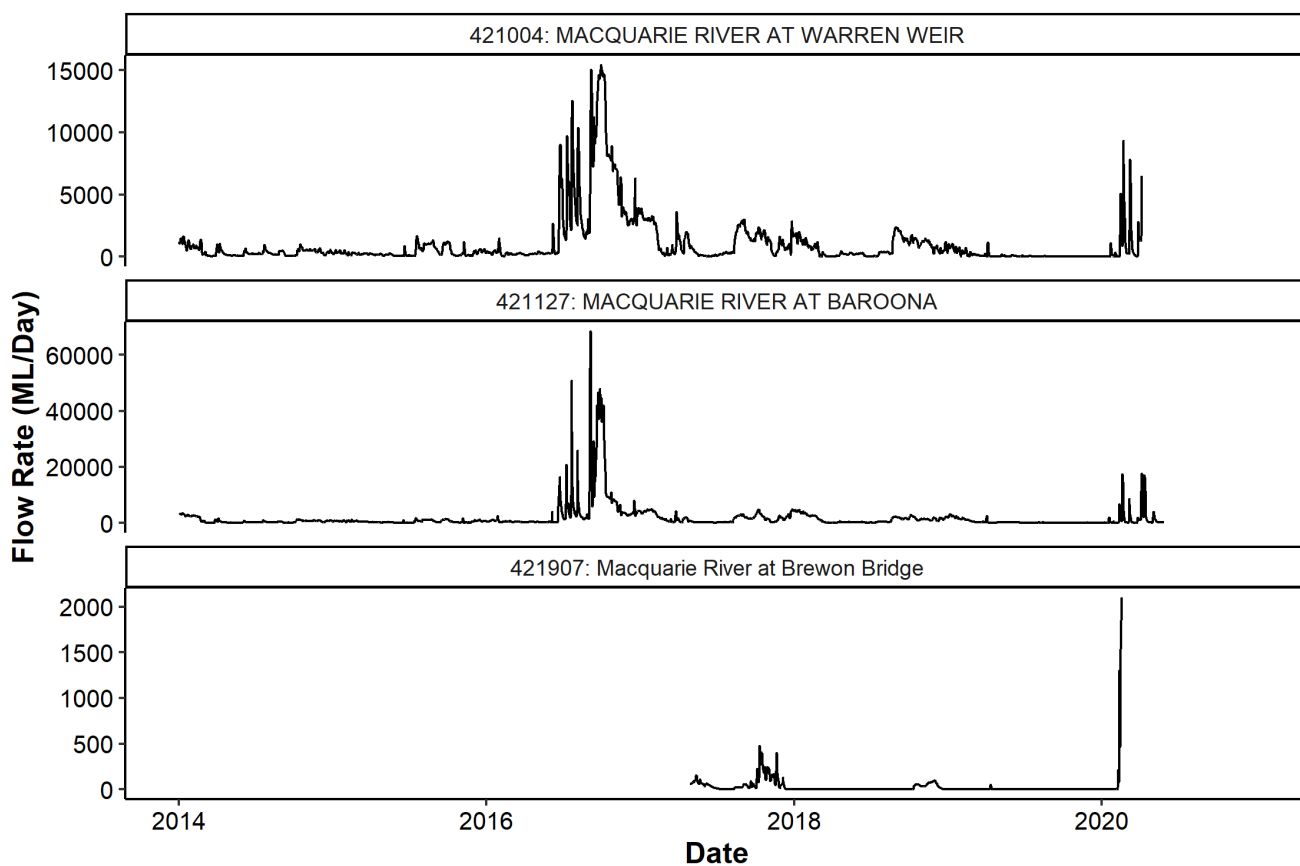


Figure 6.3: Flow data from various gauges in the Macquarie-Castlereagh WRPA over the reporting period. Gauge locations can be seen on Figure 6.2. Note the differing scales on the y-axis.

Water temperature data, where available, are also shown in Figure 6.4.

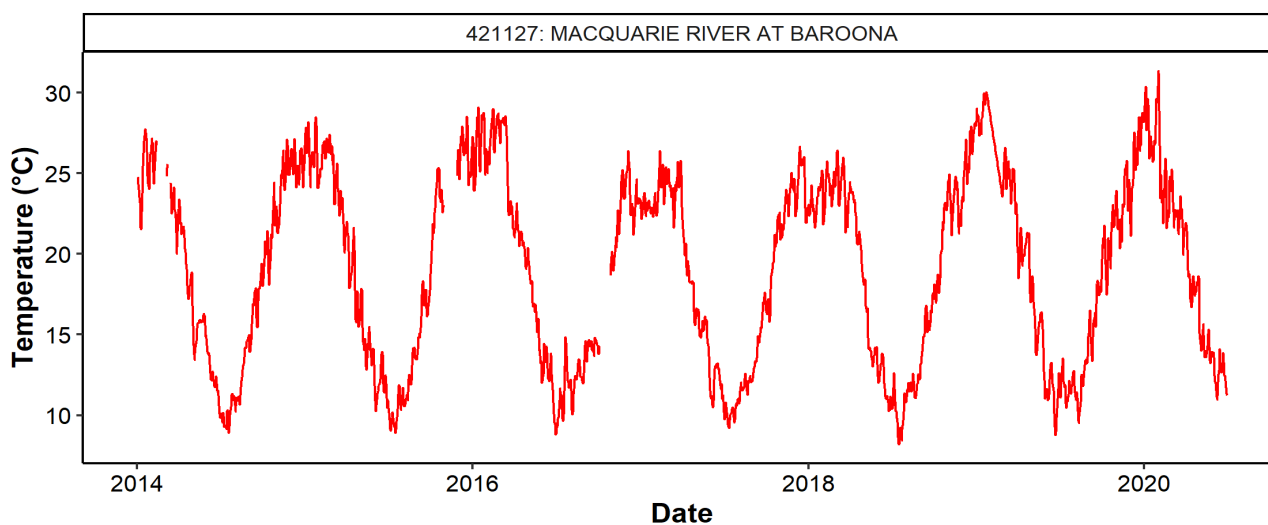


Figure 6.4: Water temperature data from various gauges in the Macquarie-Castlereagh WRPA over the reporting period. Gauge locations can be seen on Figure 6.2. Note the differing scales on the y-axis.

Species Diversity

A total of 23 fish species were observed across the Macquarie-Castlereagh WRPAs including six alien species. [Figure 6.5](#) shows the number of native and alien species found at each site. The full list of species caught and observed is in [Table 6.7](#).

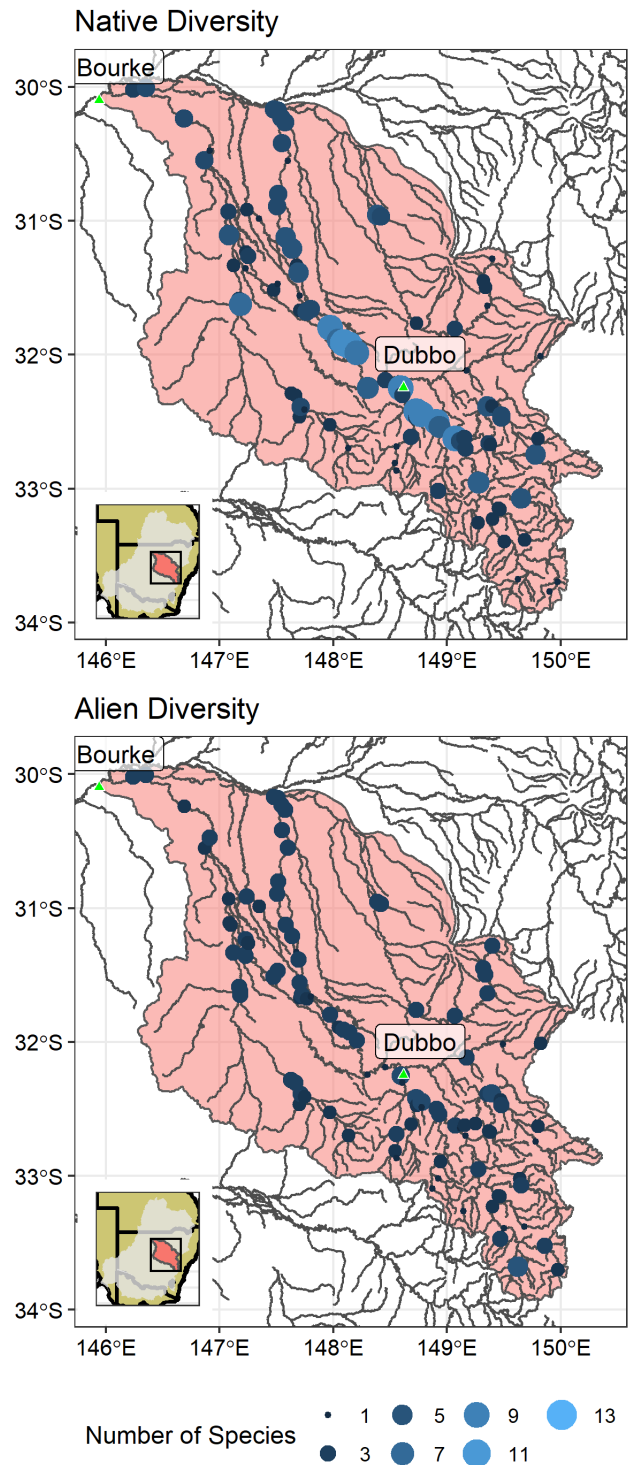


Figure 6.5: Diversity across all sampling sites. Bubble size represents the number of unique species observed at each site across all sampling methods and events. X represents a site that had water and was sampled, but no fish species were caught at all. Dry sites are excluded.

Summary Statement:

Native diversity was slightly higher in the central and northern areas of the Macquarie-Castlereagh WRPAs. The alien diversity was generally consistent across the region.

Murray cod



Population Structure

Figure 6.6 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 0 to 39, and 0% to 16% 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 13% (426 out of 3,201).

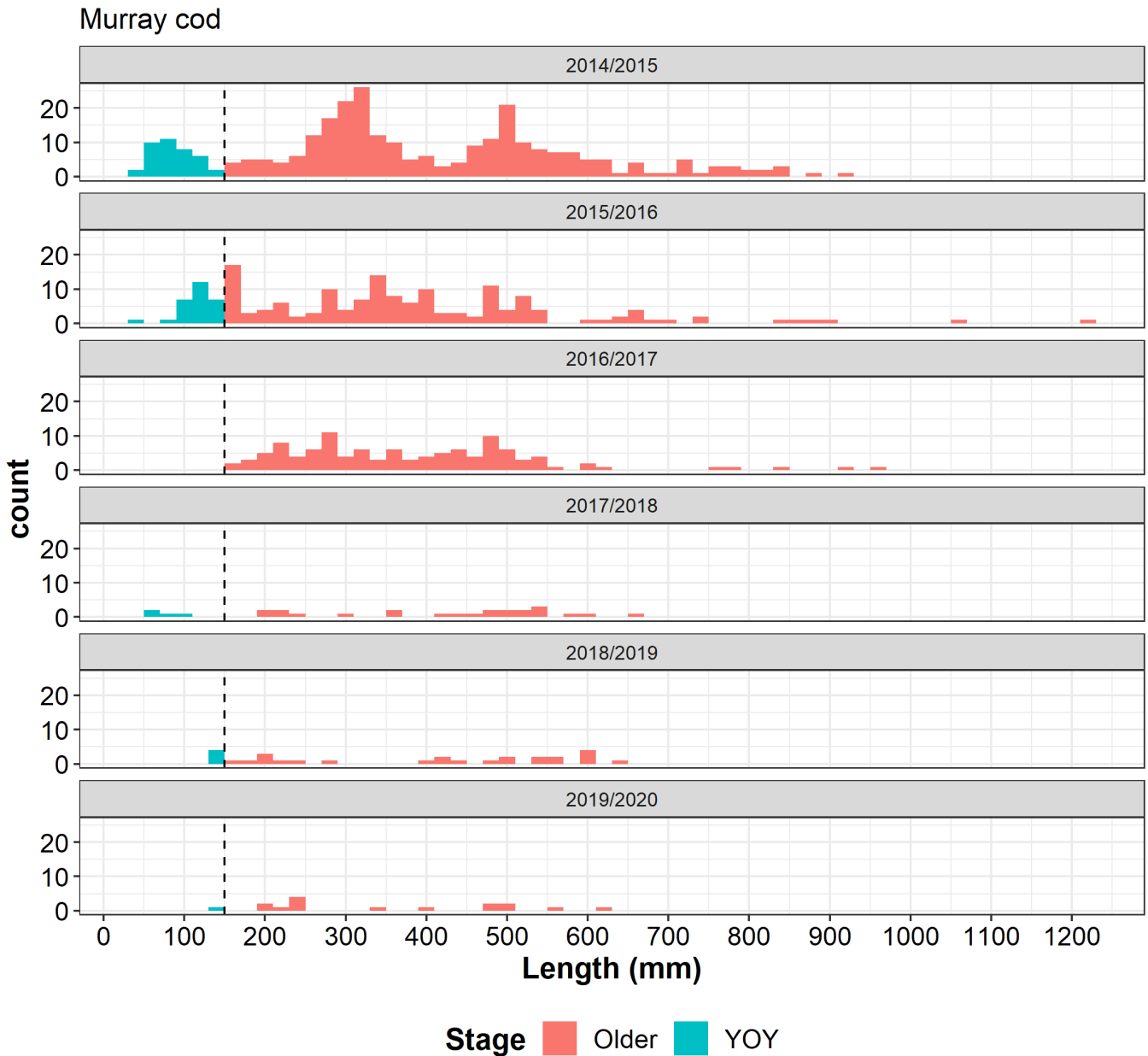


Figure 6.6: Length frequency plots for Murray cod by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Good recruitment 2014/15 and 2015/16 but limited to no recruitment in more recent years. From 2017/18 onwards there have also been few large (600mm) fish observed, although sampling effort was reduced (See [Table 6.1](#)).

Stocking

A total of 708,043 Murray cod were stocked into the waterways of the Macquarie-Castlereagh WRPAs during the reporting period. Of these fish, 509,231 (72%) were stocked into impoundments while 198,812 (28%) were stocked into rivers or creeks. [Table 6.4](#) shows the detailed breakdown of stocking by season, location and life stage while [Figure 6.7](#) shows the locations of stocking.

Table 6.4: 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	83,000
2014/2015	River/Creek	Fingerling	1,666
2014/2015	River/Creek	Fry	35,759
2015/2016	Impoundment	Fry	59,000
2015/2016	River/Creek	Fry	38,154
2016/2017	Impoundment	Fingerling	48,957
2016/2017	Impoundment	Fry	197,000
2016/2017	River/Creek	Fingerling	30,229
2016/2017	River/Creek	Fry	10,000
2017/2018	Impoundment	Fry	14,274
2017/2018	River/Creek	Fry	37,629
2018/2019	Impoundment	Fry	47,000
2018/2019	River/Creek	Fry	31,583
2019/2020	Impoundment	Fry	60,000
2019/2020	River/Creek	Fry	13,792

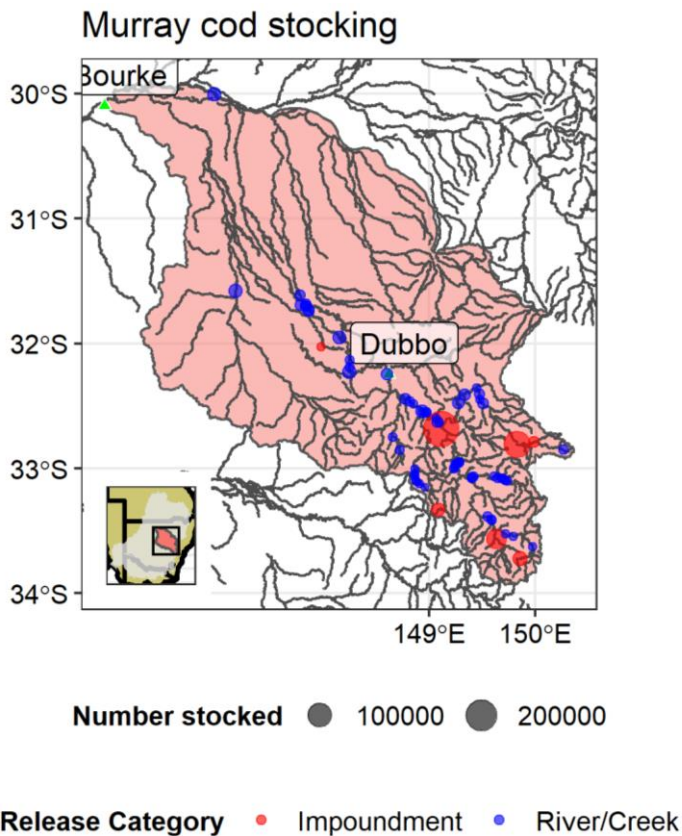


Figure 6.7: Locations of Murray cod stocking. Colours show whether a site was a river/creek site or an impoundment while the size of the point reflects the total number of fish stocked over the reporting period.

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 6.8](#) shows the abundance trend for the Macquarie-Castlereagh WRPA and the right-hand panel shows the overall trend across the NSW MDB.

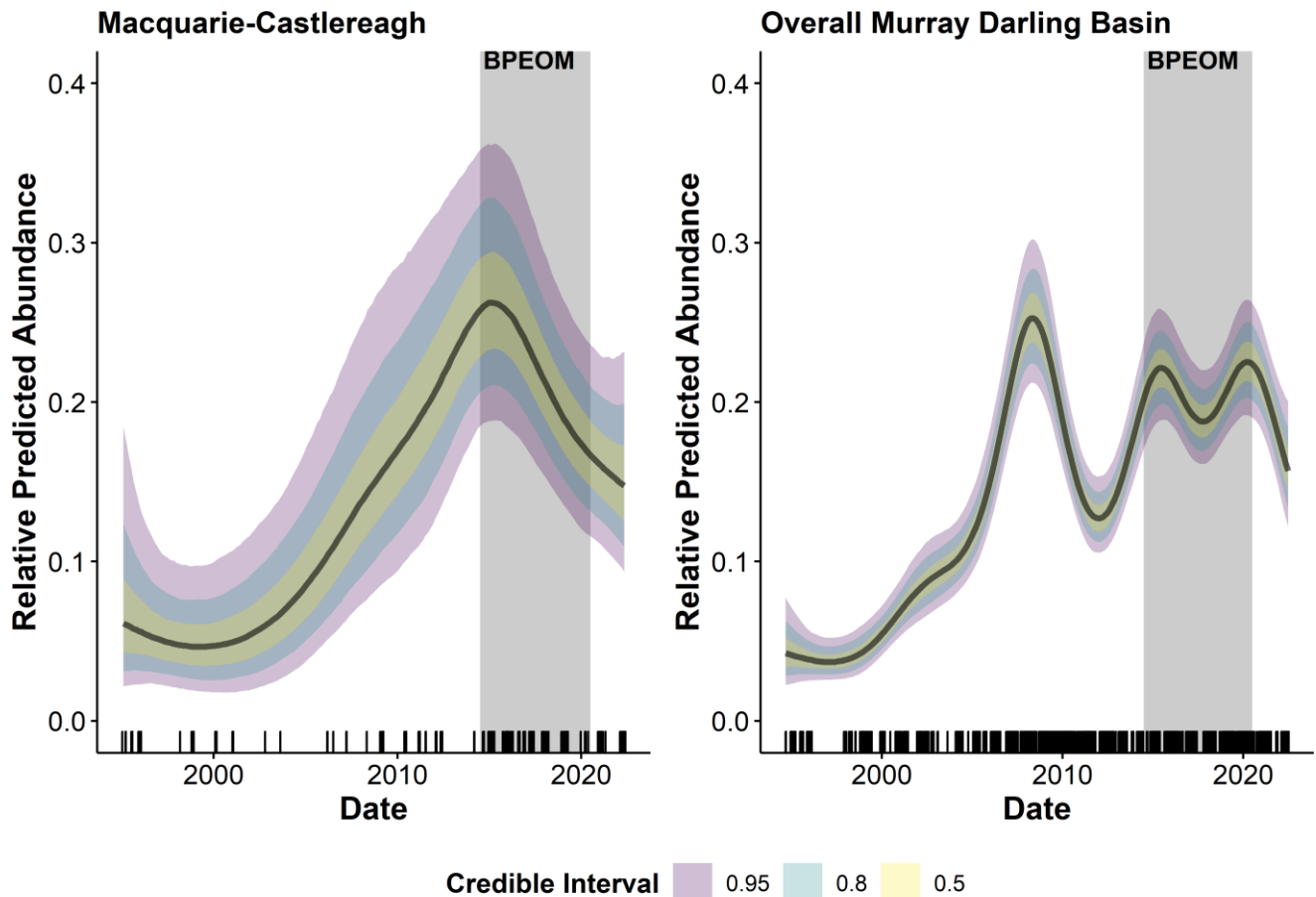


Figure 6.8: Relative abundance of Murray cod in both the Macquarie-Castlereagh WRPA and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and are the output of Bayesian generalised additive mixed models. The grey shaded 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:

Abundance has increased overall since the 1990s but has recently declined from a peak in approximately 2016. Current relative abundance slightly lower than the overall abundance across the NSW MDB.

Health

The prevalence of any health issues ranged from 22% of sampled fish in 2017/2018 to 42% of sampled fish in 2014/2015 (Figure 6.9). The most common health issue for Murray cod in the Macquarie-Castlereagh WRPAs was *Lernea*, which was observed in a total of 182 fish, corresponding to 28% of all Murray cod measured.

Across the other NSW MDB WRPA, 14% of Murray cod (443 out of 3,201 Murray cod) showed a health condition (excludes the Macquarie-Castlereagh WRPAs).

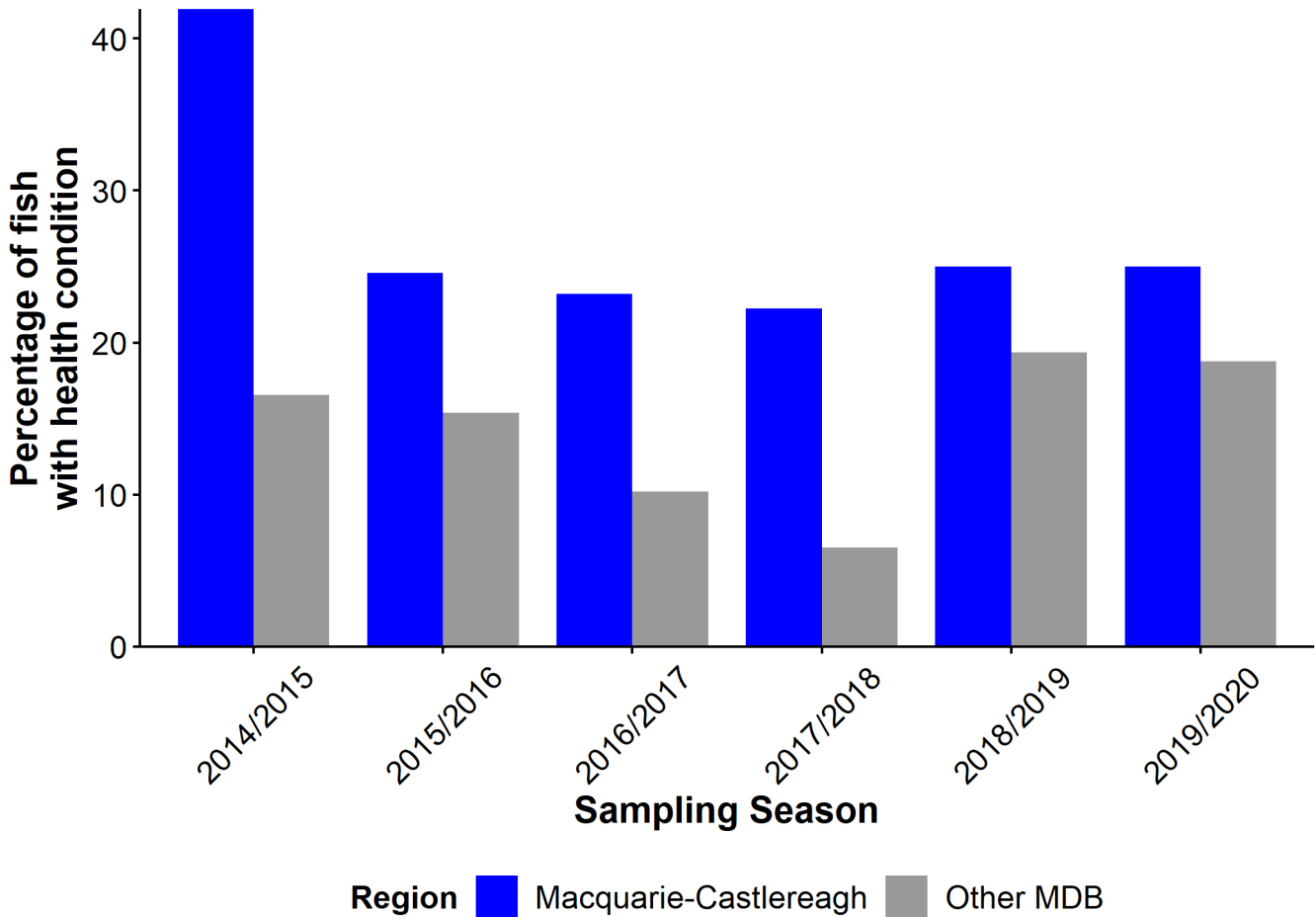


Figure 6.9: Timeseries showing the prevalence of health conditions in Murray cod. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA.

Summary Statement:

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

Distribution

Murray cod were recorded at 30 out of 108 sites in the Macquarie-Castlereagh WRPA. The maximum observed relative abundance at a site was 1.5 fish caught per 90 seconds of electrofishing. [Figure 6.10](#) shows the distribution and relative abundance of Murray cod across the Macquarie-Castlereagh WRPA.

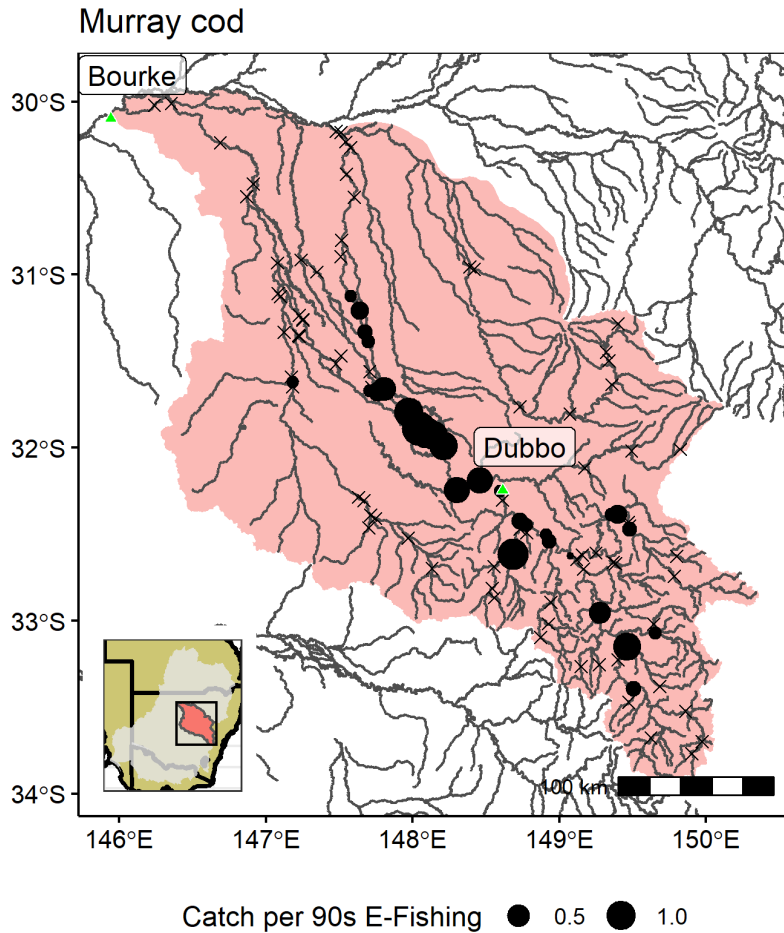


Figure 6.10: Distribution of Murray cod. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Murray cod were recorded across the central and south-eastern areas of the Macquarie-Castlereagh WRPA but most abundant in the mid-reaches.

Golden perch



Population Structure

Figure 6.11 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 96, and 0% 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 Golden perch was 9% (167 out of 1,759).

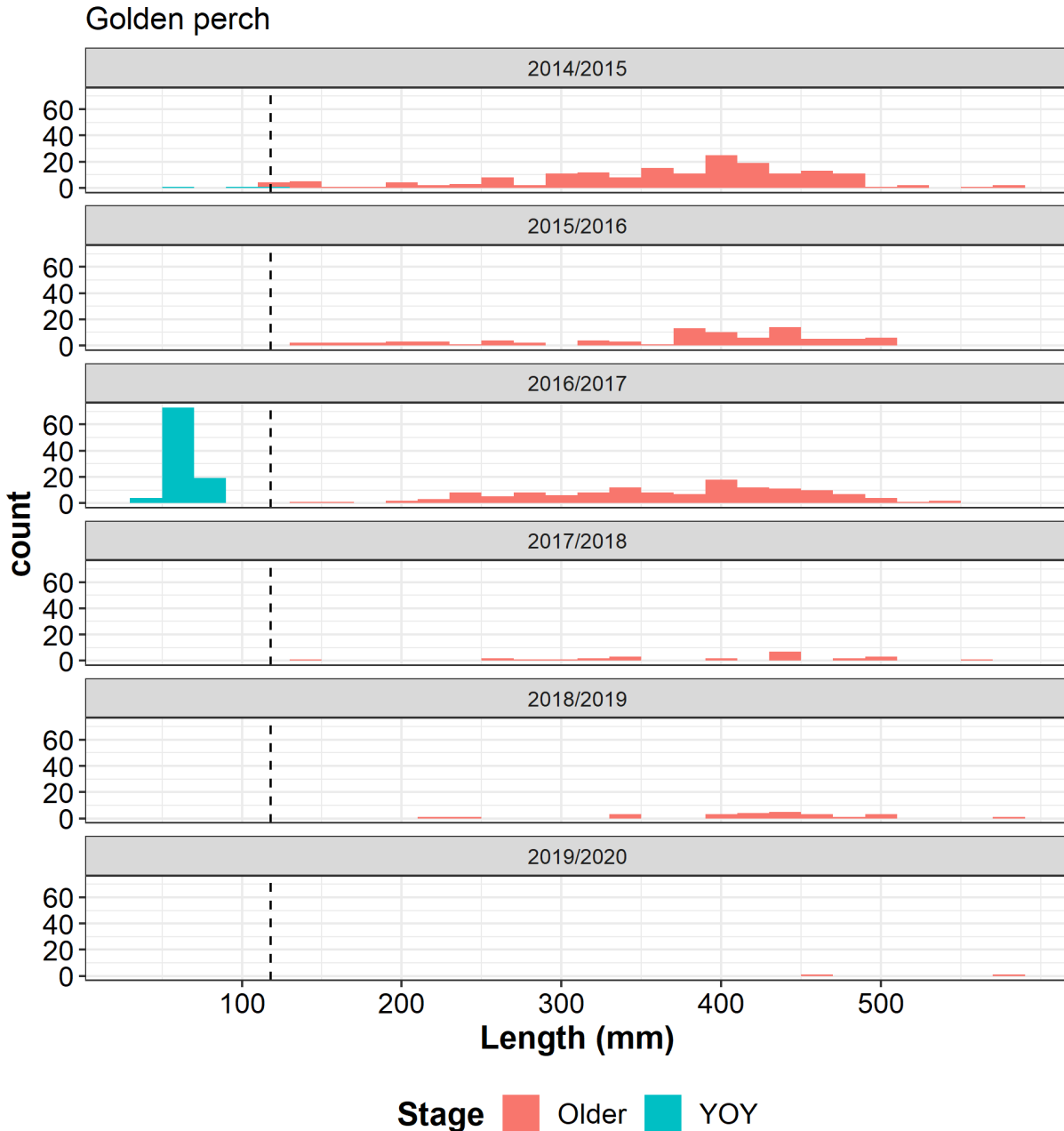


Figure 6.11: Length frequency plots for Golden perch by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Limited or poor recruitment in most years with young of the year only observed in 2014/15 and 2016/17. Suggests recruitment limitation in most years. Population structure dominated by larger (older) fish. A large reduction in sampling effort occurred in the recent years (Table 6.1).

Stocking

A total of 816,125 Golden perch were stocked into the waterways of the Macquarie-Castlereagh WRPAs during the reporting period. Of these fish, 595,921 (73%) were stocked into impoundments while 220,204 (27%) were stocked into rivers or creeks. [Table 6.5](#) shows the detailed breakdown of stocking by season, location and life stage while [Figure 6.12](#) shows the locations of stocking.

Table 6.5: 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	162,363
2014/2015	River/Creek	Fry	50,963
2015/2016	Impoundment	Fry	104,058
2015/2016	River/Creek	Fry	64,807
2016/2017	Impoundment	Fry	103,500
2016/2017	River/Creek	Fingerling	26,393
2017/2018	Impoundment	Fry	135,000
2017/2018	River/Creek	Fry	5,000
2018/2019	Impoundment	Fry	91,000
2018/2019	River/Creek	Fry	9,375
2019/2020	River/Creek	Fry	63,666

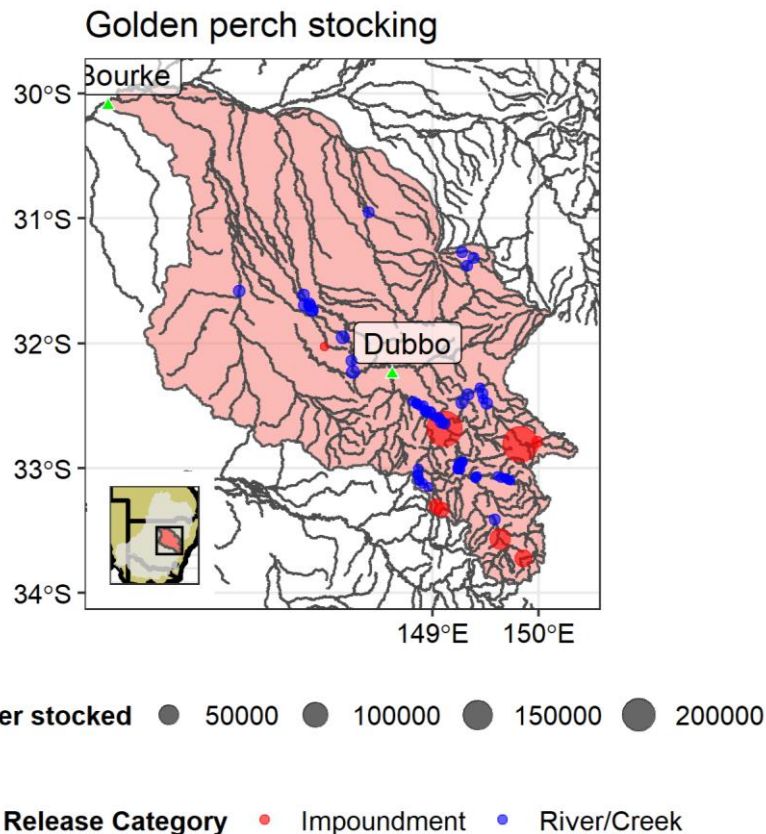


Figure 6.12: Locations of Golden perch stocking. Colours show whether a site was a river/creek site or an impoundment while the size of the point reflects the total number of fish stocked over the reporting period.

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 6.13](#) shows the abundance trend for the Macquarie-Castlereagh WRPA and the right-hand panel shows the overall trend across the NSW MDB.

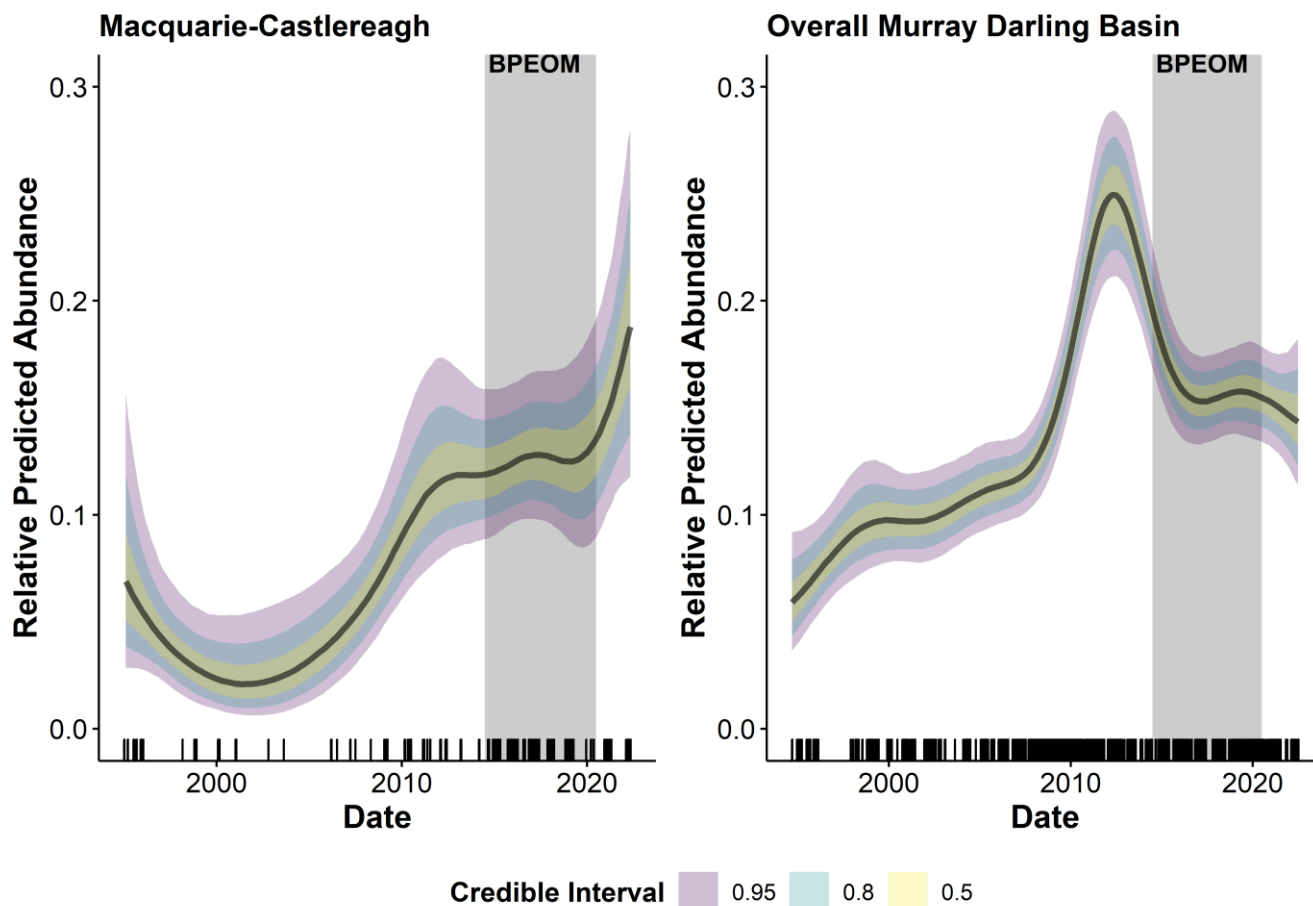


Figure 6.13: Relative abundance of Golden perch in both this valley and the overall Murray-Darling Basin. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region 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 higher than 1994 levels. Abundance was stable during the BPEOM period but has since increased. Relative abundance is slightly higher than the overall abundance across the MDB, which peaked around 2012.

Health

The prevalence of any health issues ranged from 16% of sampled fish in 2017/2018 to 50% of sampled fish in 2019/2020 (Figure 6.14). The most common health issue for Golden perch in the Macquarie-Castlereagh water resource planning area was Lerneae, which was observed in a total of 101 fish, corresponding to 19% of all Golden perch measured.

Across the other WRPAs, 34% of Golden perch (598 out of 1,759 Golden perch) showed a health condition (excludes Macquarie-Castlereagh).

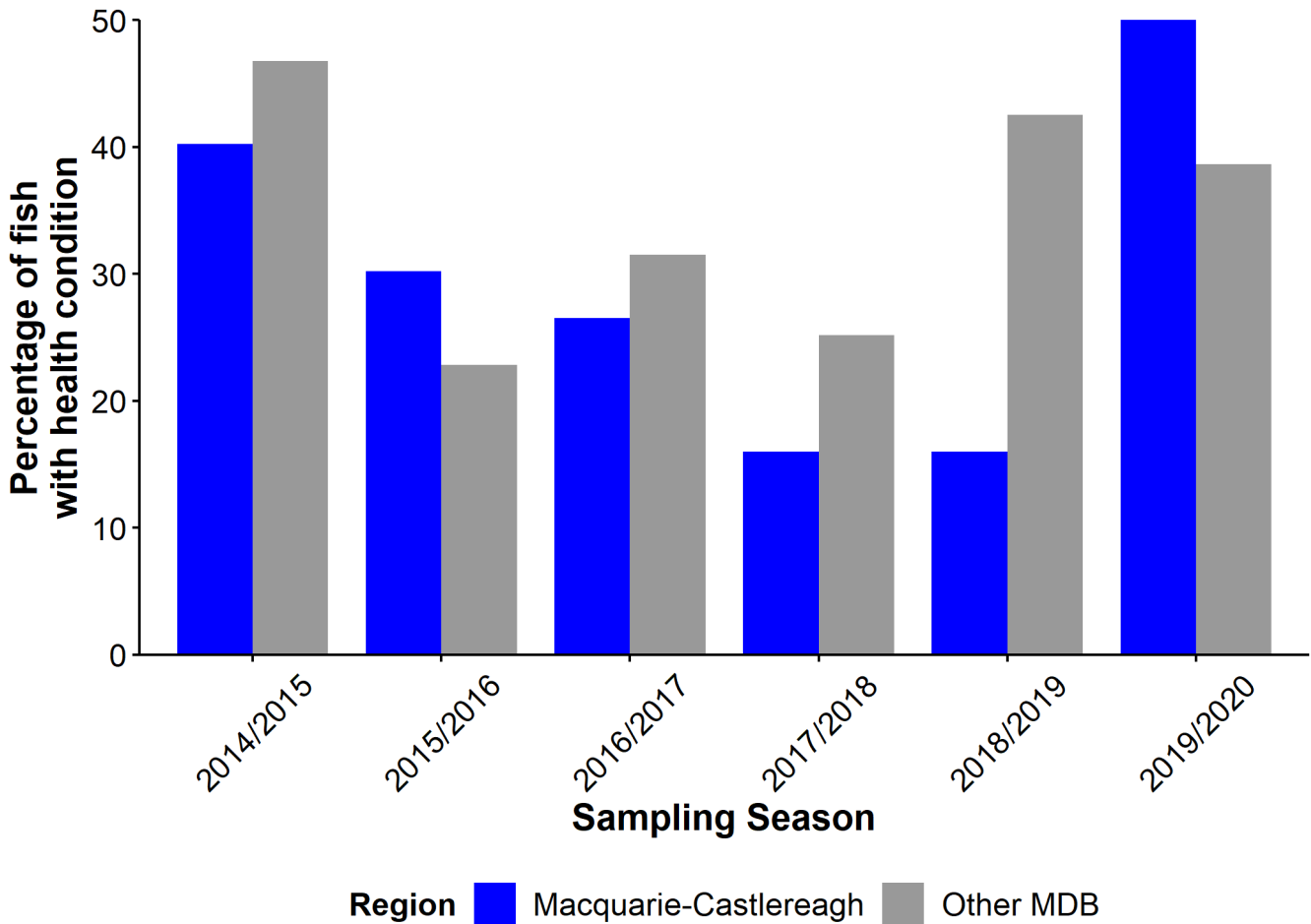


Figure 6.14: Timeseries showing the prevalence of health conditions in Golden perch. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

The presence of observable health conditions for Golden perch in the Macquarie-Castlereagh WRPAs was moderate to high, and generally slightly lower than the overall NSW MDB (except 2019/20).

Distribution

Golden perch were recorded at 44 out of 108 sites in the Macquarie-Castlereagh WRP. The maximum observed relative abundance at a site was 0.9 fish caught per 90 seconds of electrofishing. Figure 6.15 shows the distribution and relative abundance of Golden perch across the Macquarie-Castlereagh WRP.

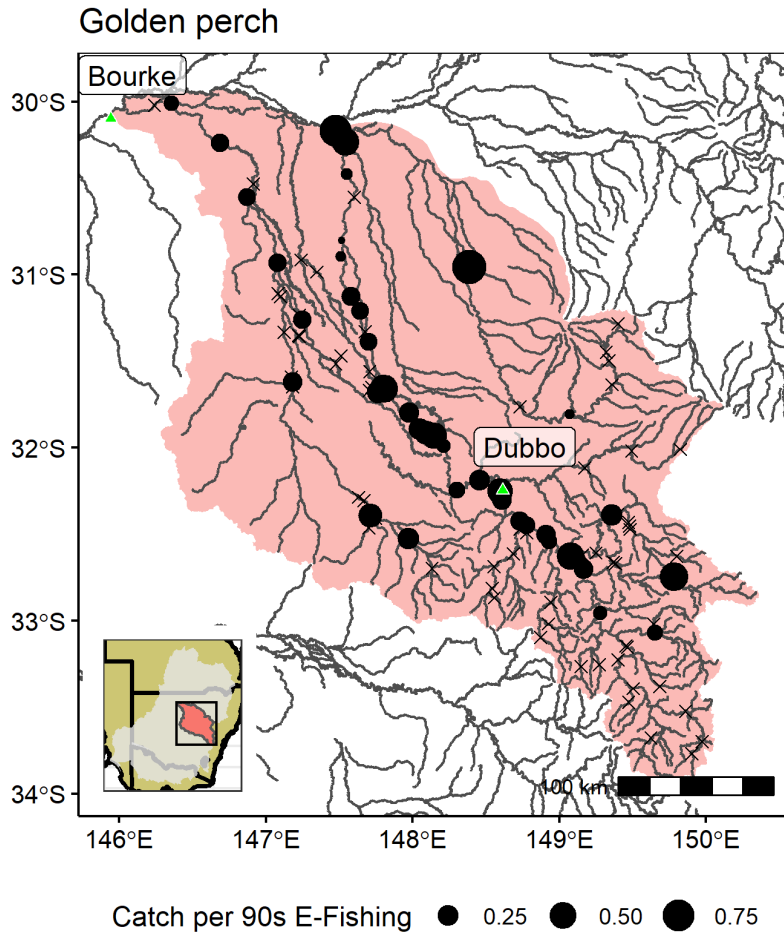


Figure 6.15: Distribution of Golden perch. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Golden perch were distributed across the Macquarie-Castlereagh WRP excluding some south-eastern upland reaches.

Freshwater catfish



Population Structure

Figure 6.16 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 9, and 0% to 29% 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 47% (268 out of 575).

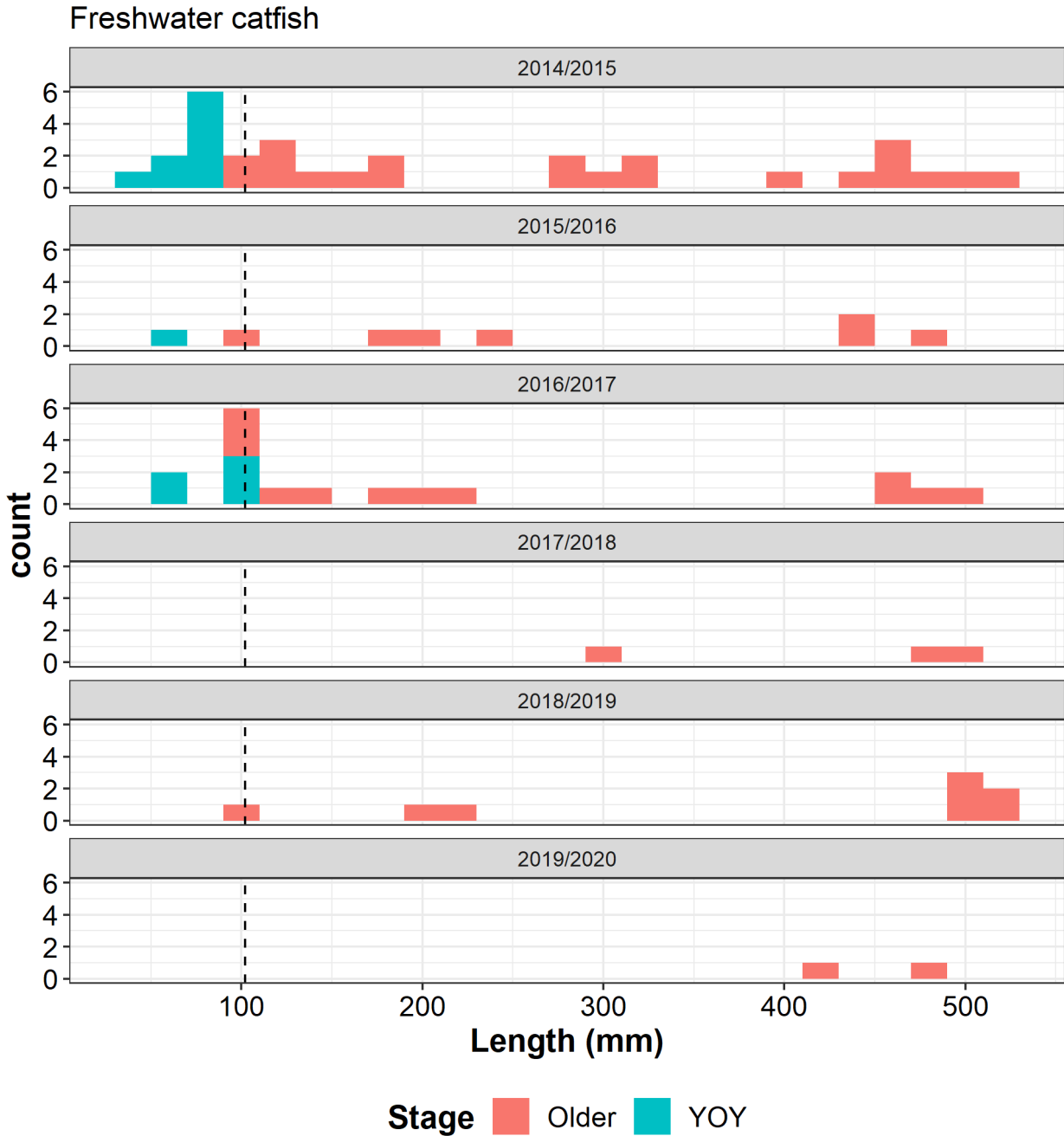


Figure 6.16: Length frequency plots for Freshwater catfish by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Recruitment was observed in prior to 2017 but no recruitment was observed since (although sampling effort was reduced; [Table 6.1](#)), suggesting recruitment failure in recent 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 6.17](#) shows the abundance trend for the Macquarie-Castlereagh WRPA and the right-hand panel shows the overall trend across the NSW MDB.

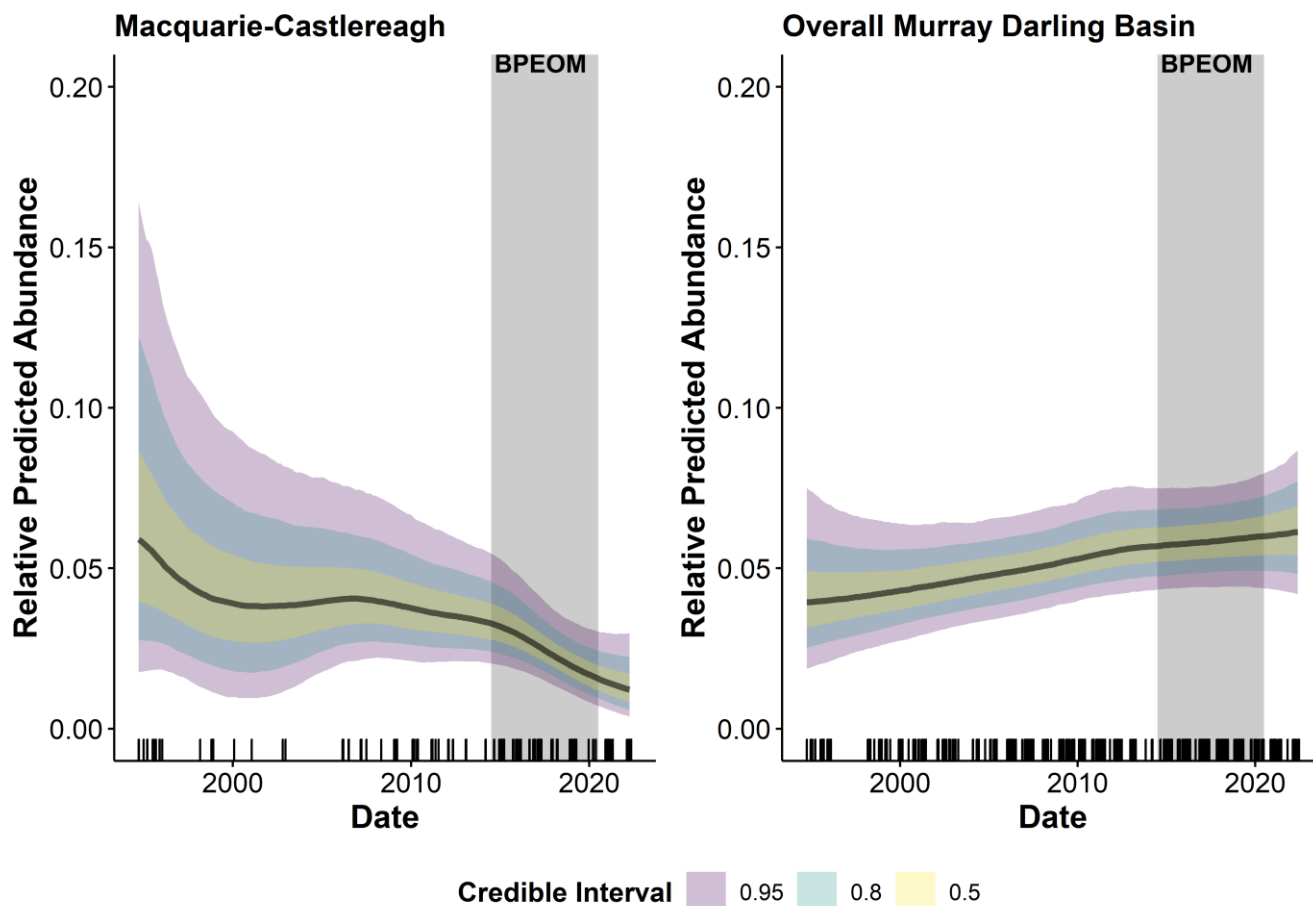


Figure 6.17: Relative abundance of Freshwater catfish in both this valley and the overall Murray-Darling Basin. Note there was insufficient data to model the abundance of Freshwater catfish, hence the empty plot. These are model estimates based upon all electrofishing data within the NSW DPI Freshwater 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 Macquarie-Castlereagh WRPA has declined since the 1990s and is currently lower than the overall NSW MDB abundance.

Health

The prevalence of any health issues ranged from 0% of sampled fish in 2015/2016 to 13% of sampled fish in 2014/2015 (Figure 6.18). The most common health issue for Freshwater catfish in the Macquarie-Castlereagh water resource planning area was Lerneae, which was observed in a total of 4 fish, corresponding to 6% of all Freshwater catfish measured.

Across the other WRPA's, 0.5% of Freshwater catfish (3 out of 575 Freshwater catfish) showed a health condition (excludes Macquarie-Castlereagh).

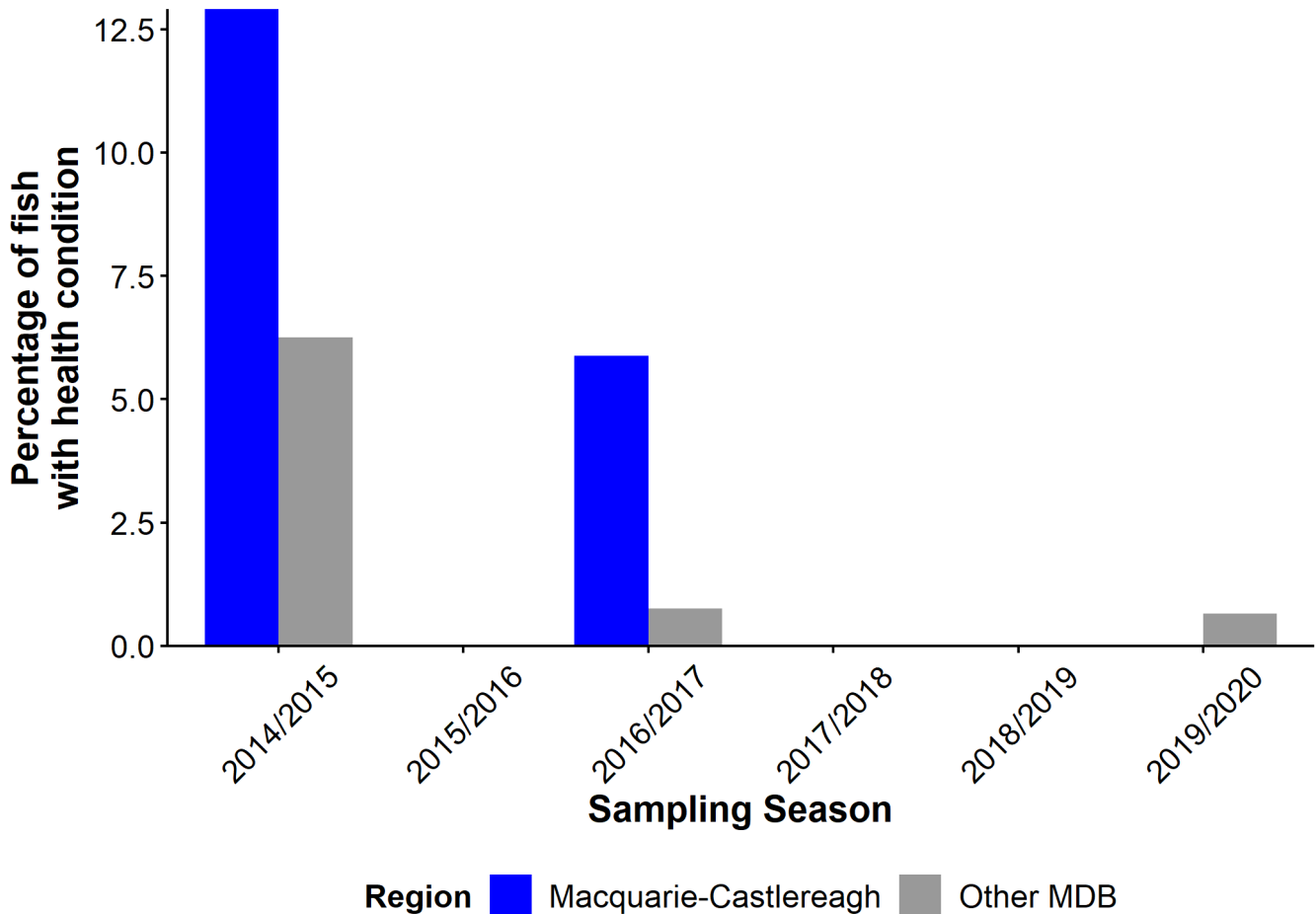


Figure 6.18: Timeseries showing the prevalence of health conditions in Freshwater catfish. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA's.

Summary Statement:

The presence of health issues for Freshwater Catfish is sporadic and occurs at moderate levels in some years while in other years no health issues are recorded. Overall, in the NSW MDB Freshwater catfish have few observed health issues.

Distribution

Freshwater catfish were recorded at 14 out of 108 sites in the Macquarie-Castlereagh WRPA. The maximum observed relative abundance at a site was 0.7 fish caught per 90 seconds of electrofishing. [Figure 6.19](#) shows the distribution and relative abundance of Freshwater catfish across the Macquarie-Castlereagh WRPA.

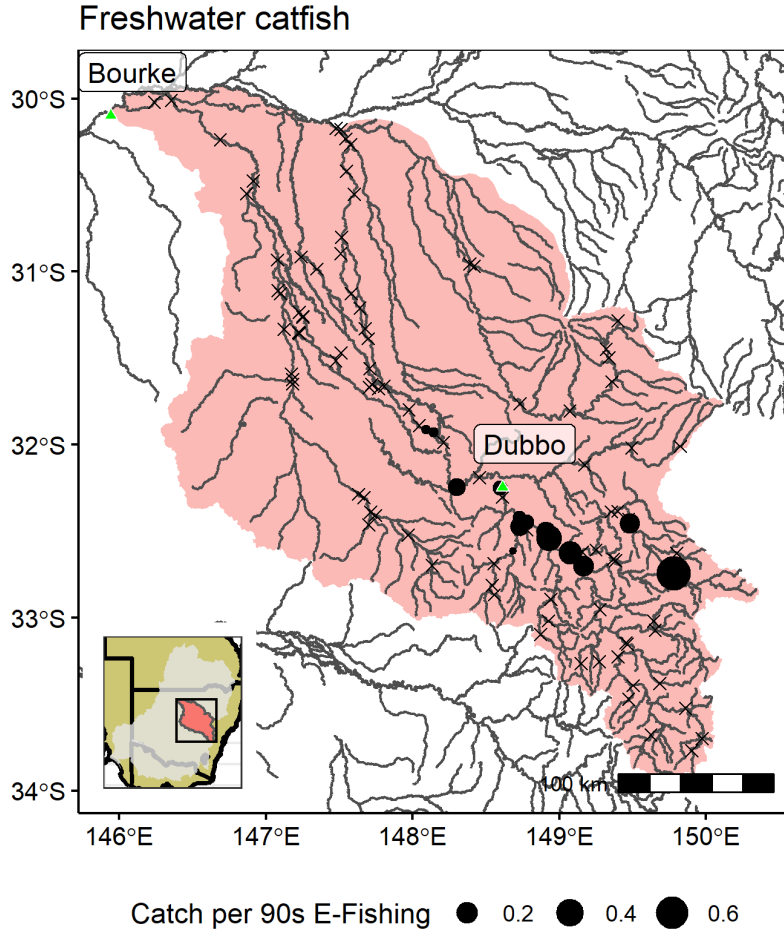


Figure 6.19: Distribution of Freshwater catfish. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Freshwater catfish appear to be in very low abundance and restricted the area south-east of Dubbo.

Bony herring



Population Structure

Figure 6.20 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 12 to 73, and 7% to 65% 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 % (4,784 out of 15,300). Bony herring are not a stocked species.

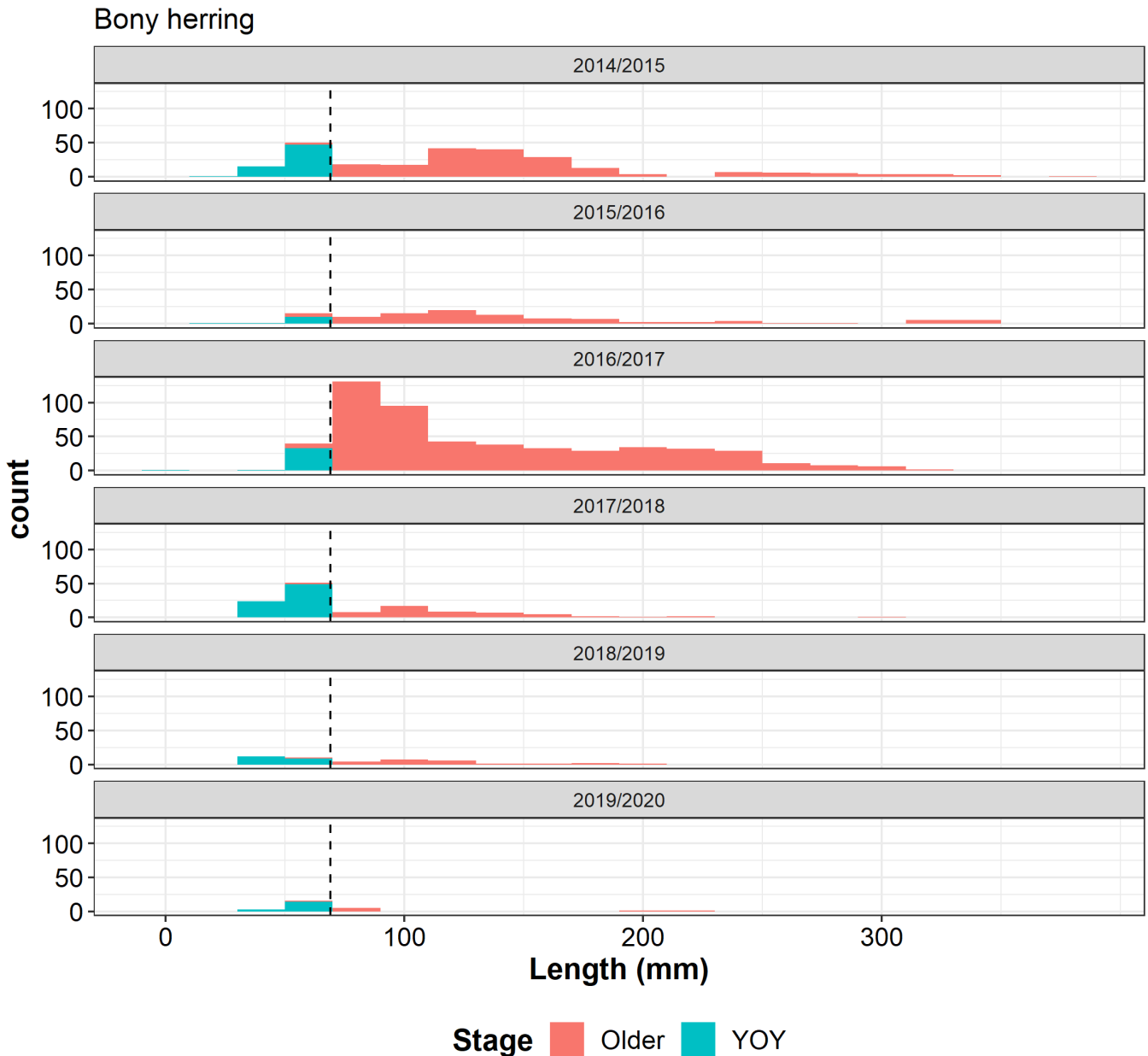


Figure 6.20: Length frequency plots for Bony herring by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Variable recruitment with among years. Decline in larger fish after 2016/17 although this also corresponds to reduced sampling effort (Table 6.1).

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 6.21](#) shows the abundance trend for the Macquarie-Castlereagh WRPA and the right-hand panel shows the overall trend across the NSW MDB.

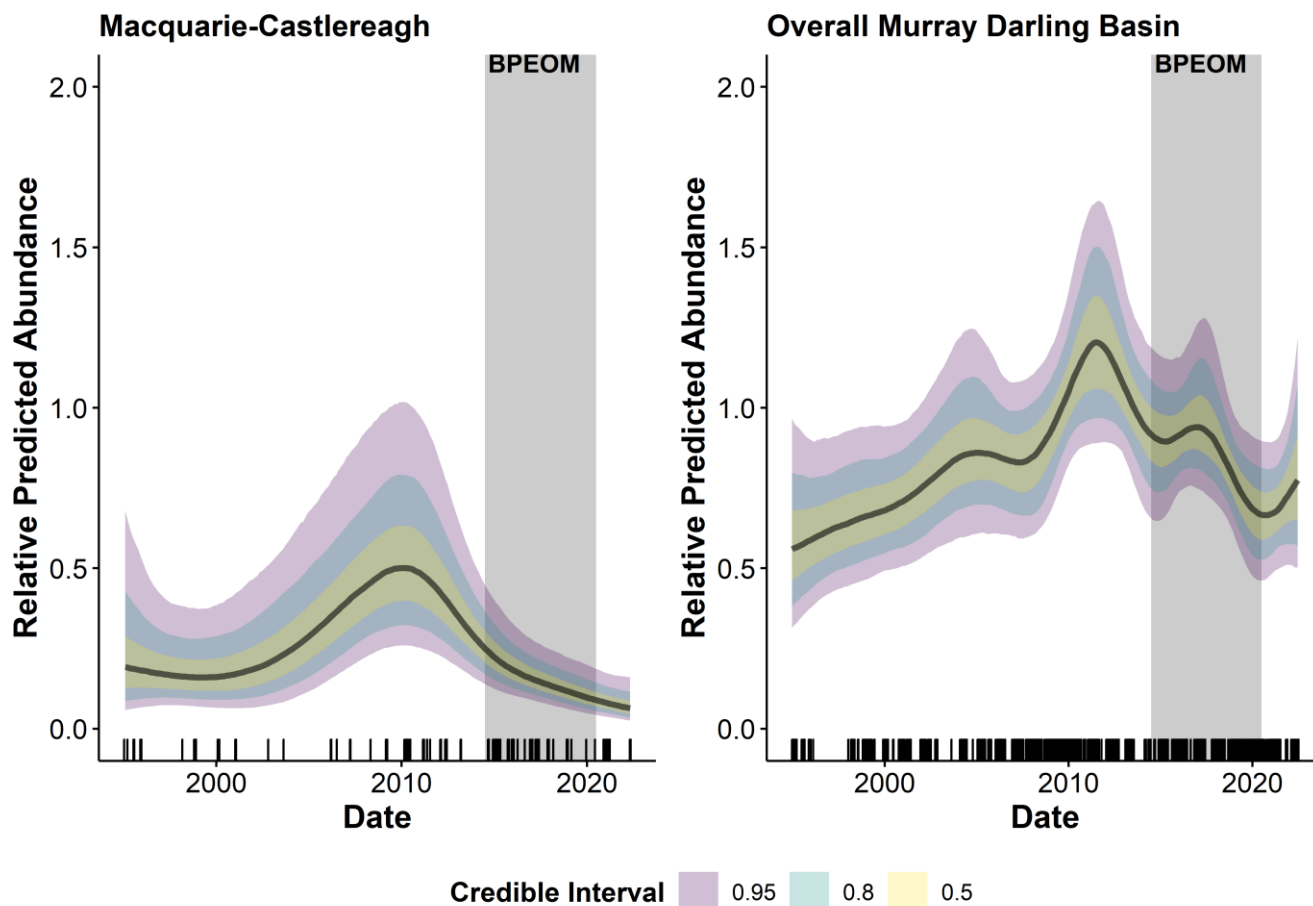


Figure 6.21: Relative abundance of Bony herring in both the Macquarie-Castlereagh WRPA and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded 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 lower than 1994 levels and has declined since 2010. Abundance is currently lower than the overall NSW MDB.

Health

The prevalence of any health issues ranged from 0% of sampled fish in 2017/2018 to 6% of sampled fish in 2016/2017 (Figure 6.22). The most common health issue for Bony herring in the Macquarie-Castlereagh WRPAs was Wounds, which was observed in a total of 14 fish, corresponding to 1% of all Bony herring measured.

Across the other NSW MDB WRPA, 1% of Bony herring (154 out of 15,300 Bony herring) showed a health condition (excludes the Macquarie-Castlereagh WRPAs).

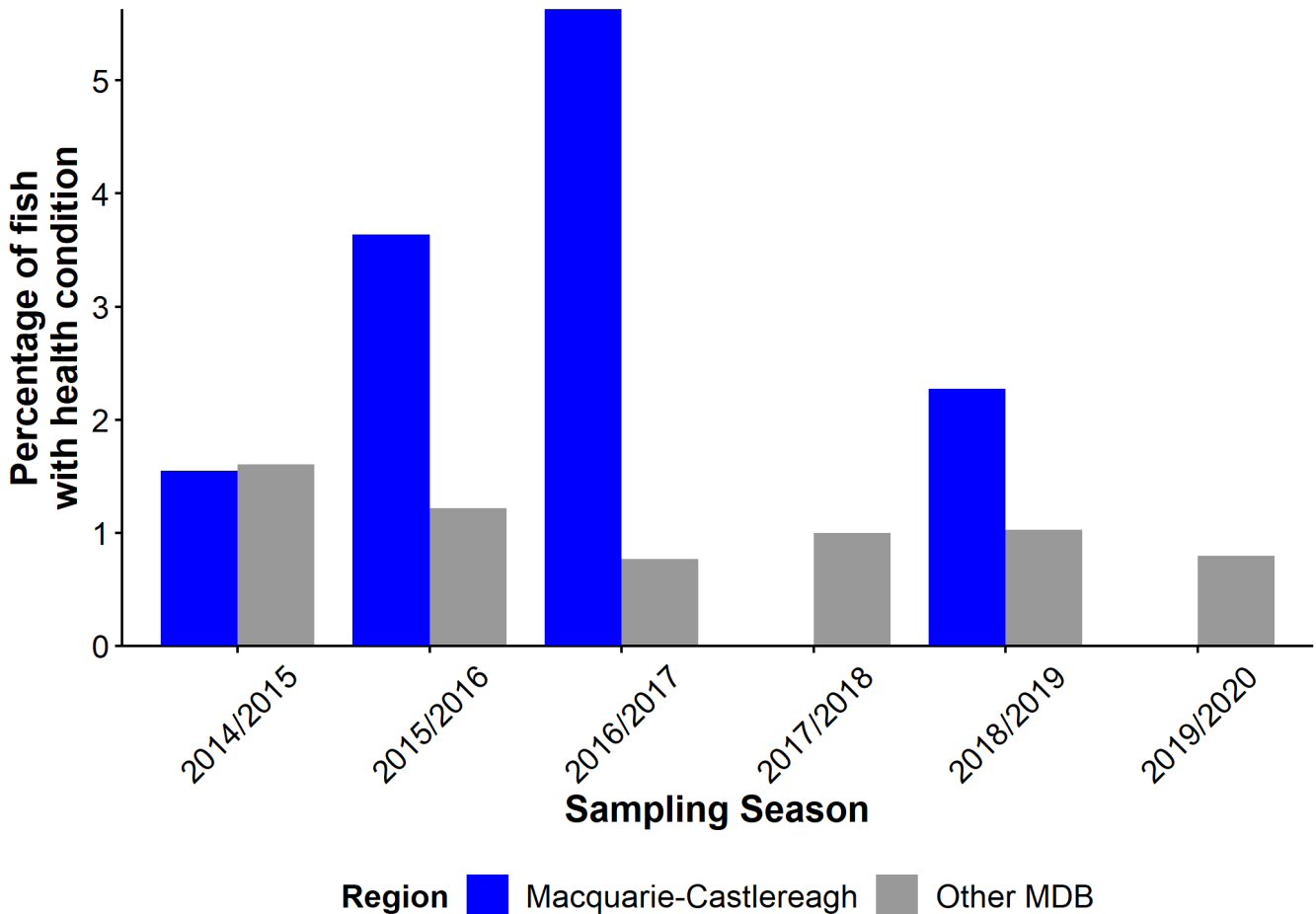


Figure 6.22: Timeseries showing the prevalence of health conditions in Bony herring. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA.

Summary Statement:

Presence of observable health conditions was low to moderate, but higher than the rest of the NSW MDB in some years.

Distribution

Bony herring were recorded at 31 out of 108 sites in the Macquarie-Castlereagh WRP. The maximum observed relative abundance at a site was 23 fish caught per 90 seconds of electrofishing. [Figure 6.23](#) shows the distribution and relative abundance of Bony herring across the Macquarie-Castlereagh WRP.

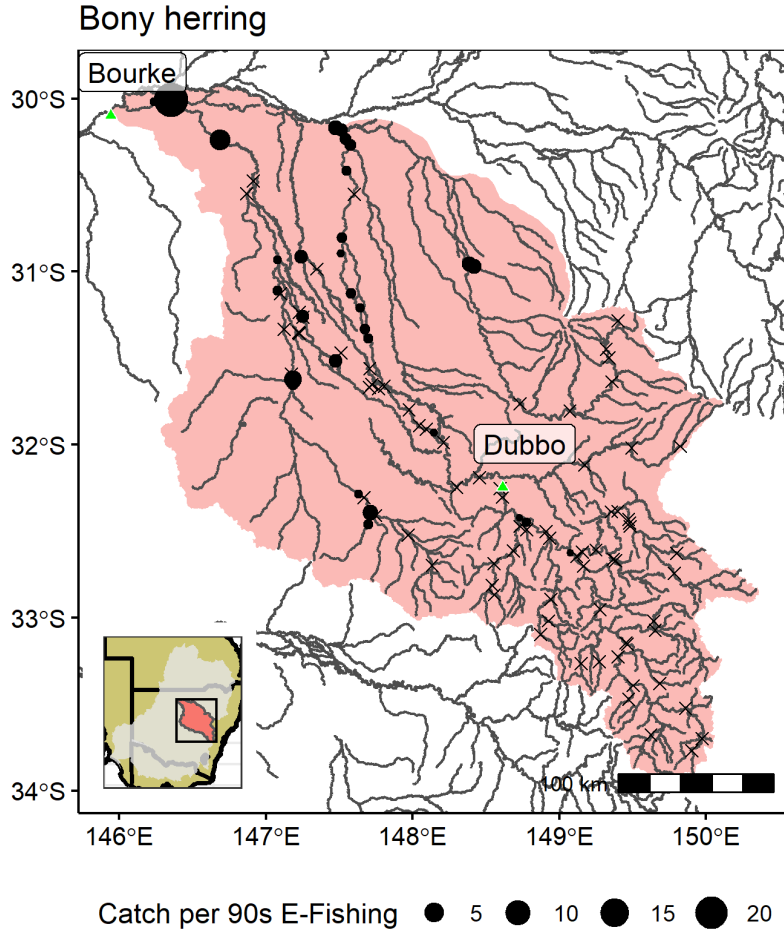


Figure 6.23: Distribution of Bony herring. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Bony herring were recorded across the northwest of the Macquarie-Castlereagh WRP but absent in eastern and upland sites.

Australian smelt



Population Structure

Figure 6.24 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 0 to 211, and 0% to 47% 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 43% (3,044 out of 7,109). Australian smelt are not a stocked species.

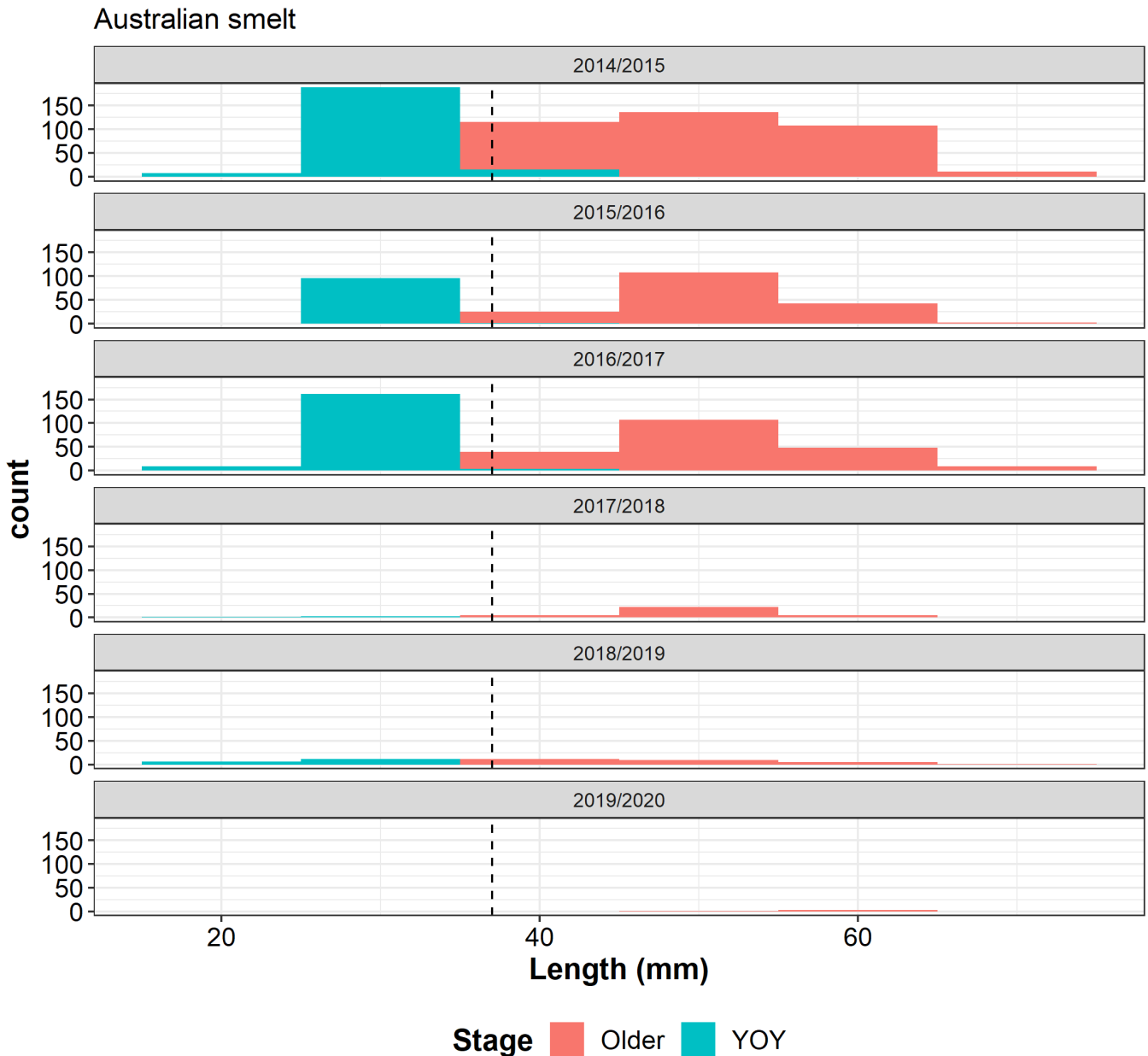


Figure 6.24: Length frequency plots for Australian smelt by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Evidence of variable recruitment in all years with a peak in 2015/16 and possibly recruitment limitation in 2014/15 and 2019/20. The overall reduction in fish after 2017 also corresponds to reduced sampling effort (Table 6.1).

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 6.25](#) shows the abundance trend for the Macquarie-Castlereagh WRPA and the right-hand panel shows the overall trend across the NSW MDB.

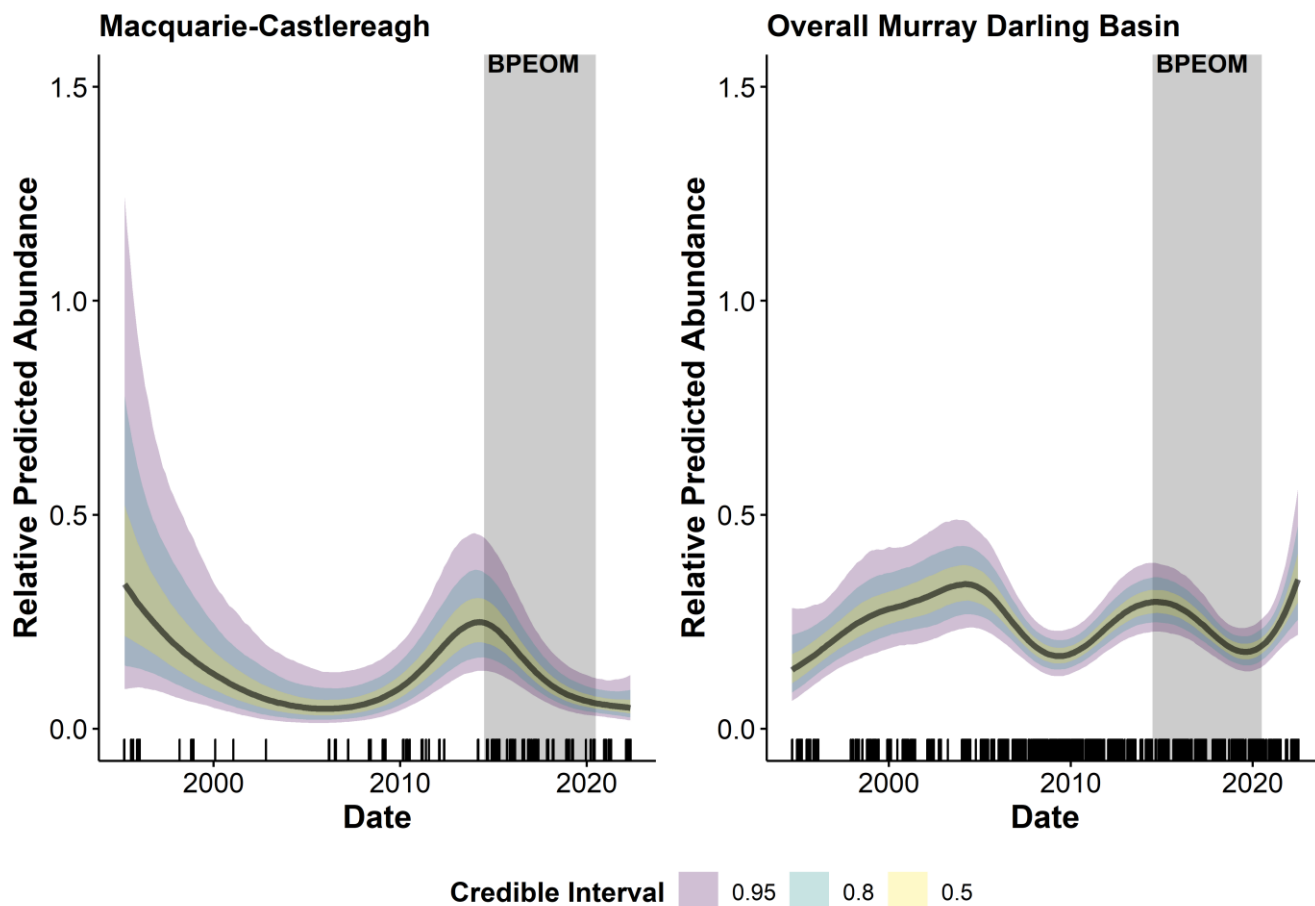


Figure 6.25: Relative abundance of Australian smelt in both the Macquarie-Castlereagh WRPA and the overall NSW MDB. These are model estimates based upon all boat electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey 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 declined since the 1990s. There was an increase in abundance prior from 2010 – 2014 but has since declined. Current relative abundance is lower than the overall NSW MDB.

Health

The prevalence of any health issues ranged from 0% of sampled fish in 2017/2018 to 1% of sampled fish to 2016/2017 (Figure 6.26). The most common health issue for Australian smelt in the Macquarie-Castlereagh WRPAs was Lesions, which was observed in a total of 3 fish, corresponding to <1% of all Australian smelt measured.

Across the other NSW MDB WRPA, 1% of Australian smelt (47 out of 7,109 Australian smelt) showed a health condition (excludes the Macquarie-Castlereagh WRPAs).

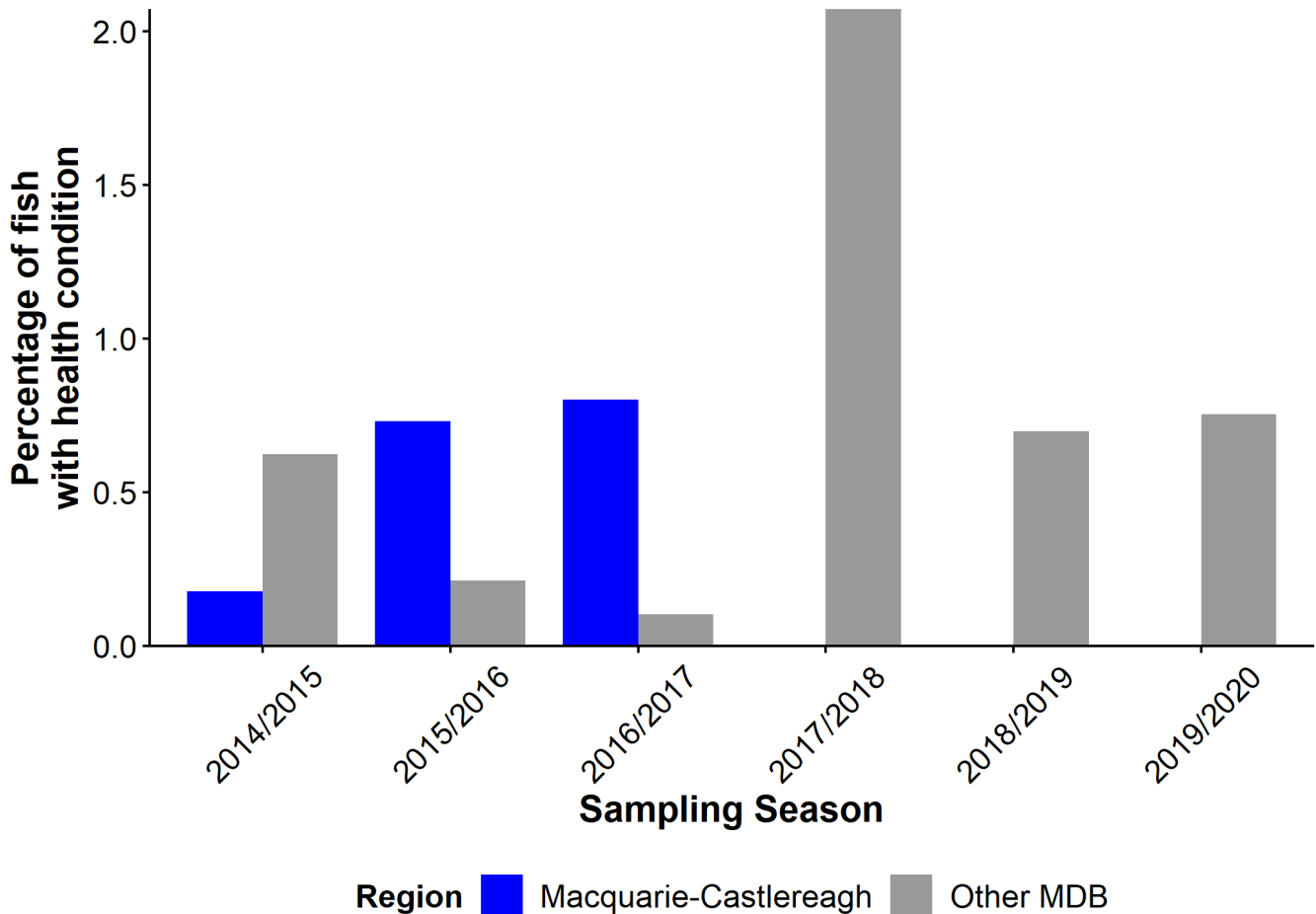


Figure 6.26: Timeseries showing the prevalence of health conditions in Australian smelt. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPA.

Summary Statement:

Presence of observable health conditions was low and generally comparable to the wider NSW MDB. No health issues observed in the Macquarie-Castlereagh WRPAs since 2016/17.

Distribution

Australian smelt were recorded at 31 out of 108 sites in the Macquarie-Castlereagh WRP. The maximum observed relative abundance at a site was 10.5 fish caught per 90 seconds of electrofishing. [Figure 6.27](#) shows the distribution and relative abundance of Australian smelt across the Macquarie-Castlereagh WRP.

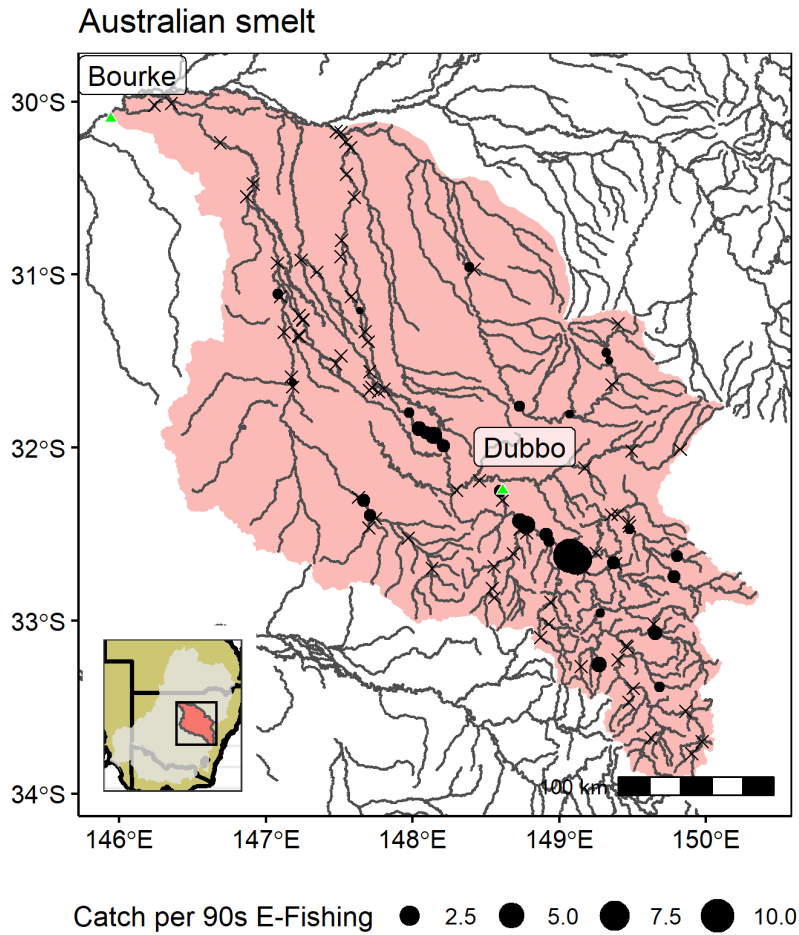


Figure 6.27: Distribution of Australian smelt. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Australian smelt were recorded across the southern half of the Macquarie-Castlereagh WRP with a few observations to the north.

Common carp



Population Structure

Figure 6.28 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 108 to 2,015, and 24% 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 56% (8,866 out of 15,878). Common carp are not a stocked species.

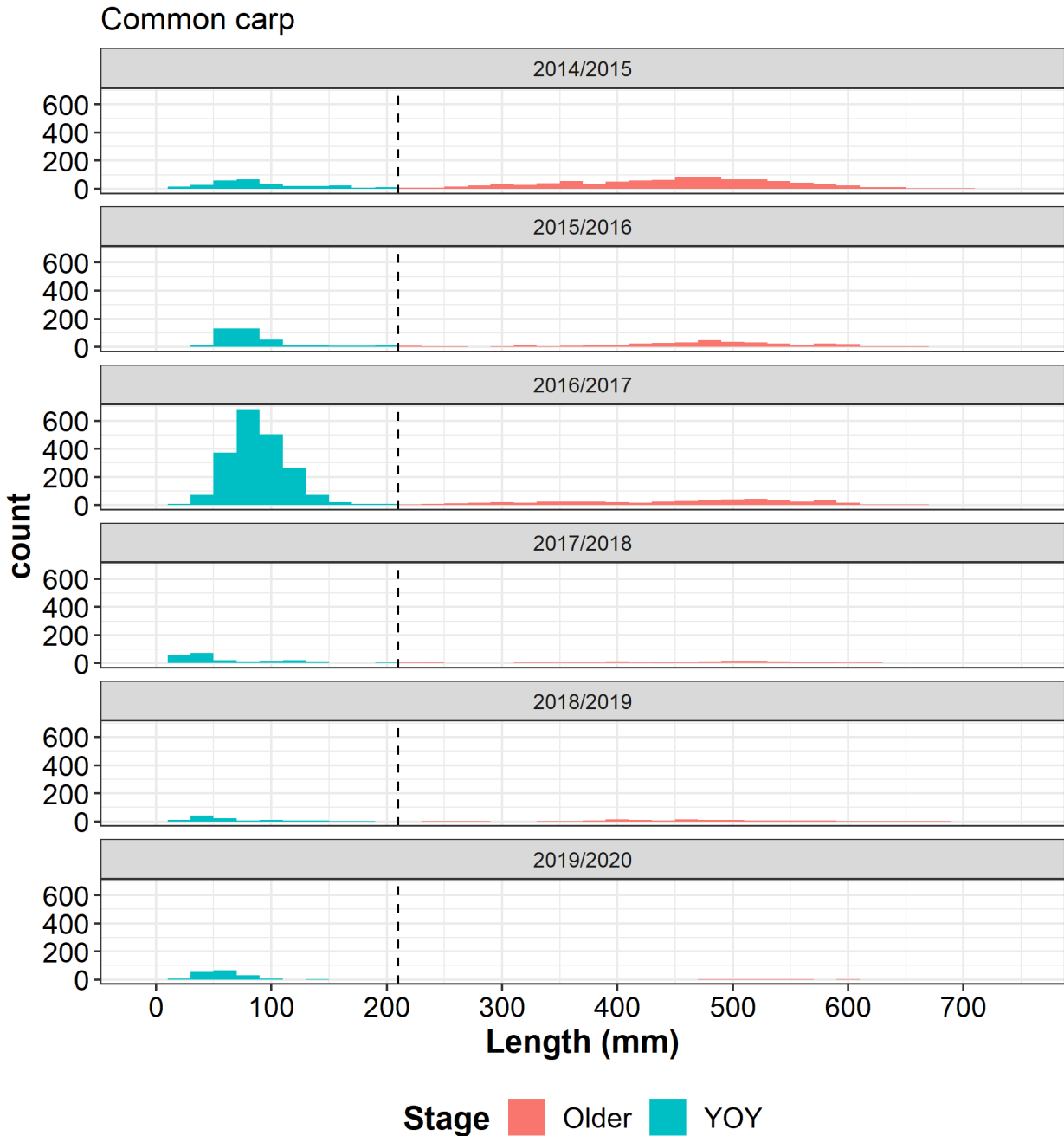


Figure 6.28: Length frequency plots for common carp by sampling season. YOY represents Young of the Year fish.

Summary Statement:

Variable recruitment among years with a very strong peak in 2016/17. No large fish observed in 2019/20 (although there was a strong presence of YOY). Sampling effort was reduced after 2017 (Table 6.1).

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 6.29](#) shows the abundance trend for the Macquarie-Castlereagh WRPA and the right-hand panel shows the overall trend across the NSW MDB.

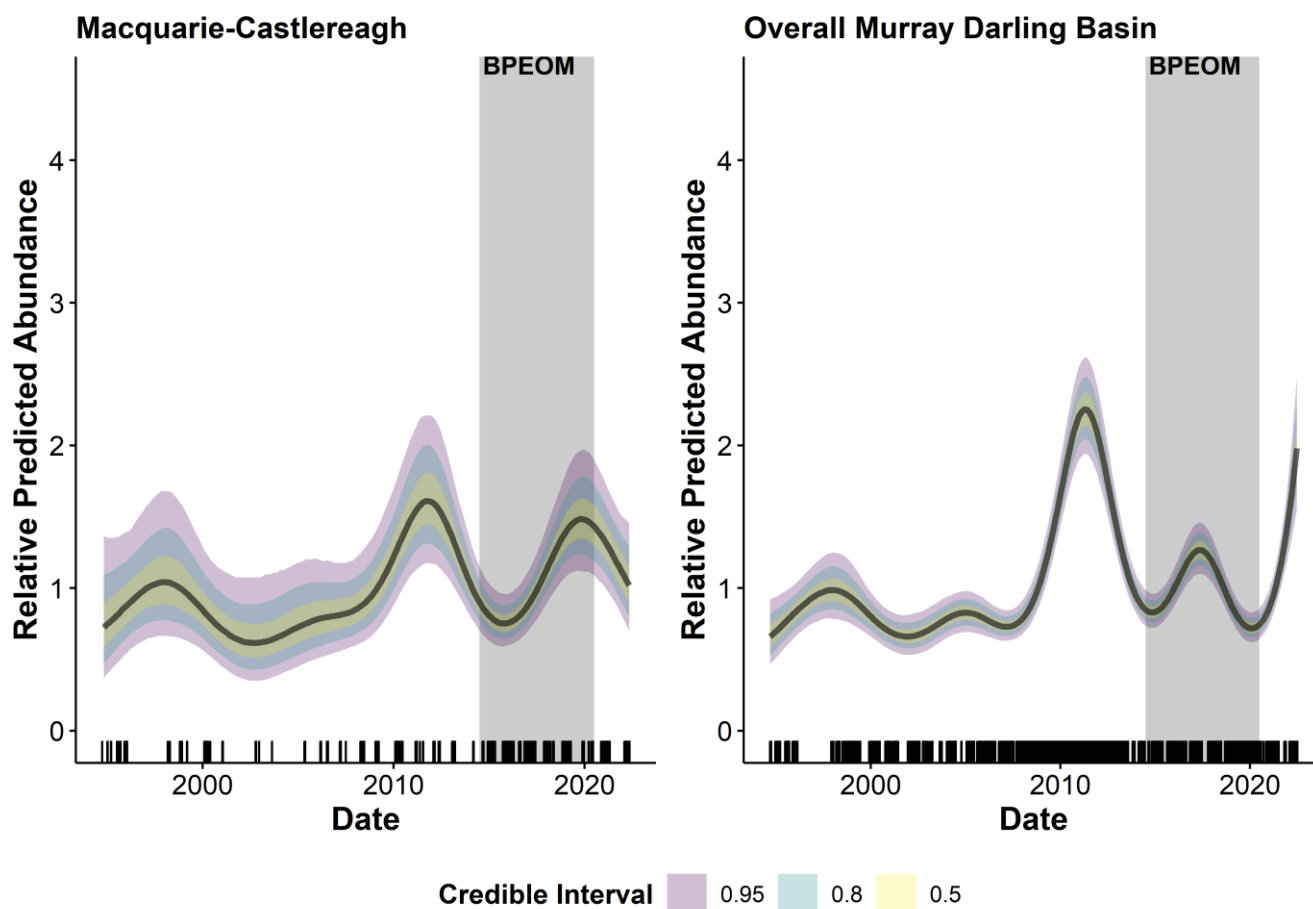


Figure 6.29: Relative abundance of Common carp in both this valley and the overall Murray-Darling Basin. These are model estimates based upon all electrofishing data within the NSW DPI Freshwater ecosystem database and the output of Bayesian generalised additive mixed models. The grey shaded region represents 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 slightly higher than 1994 levels. Abundance peaked in approximately 2011 and 2019. Current relative abundance lower than the overall NSW MDB.

Health

The prevalence of any health issues ranged from 3% of sampled fish in 2019/2020 to 15% of sampled fish in 2018/2019 (Figure 6.30). The most common health issue for Common carp in the Macquarie-Castlereagh water resource planning area was *Lernea*, which was observed in a total of 165 fish, corresponding to 3% of all Common carp measured.

Across the other WRPAs, 5% of Common carp (829 out of 15,879 Common carp) showed a health condition (excludes Macquarie-Castlereagh).

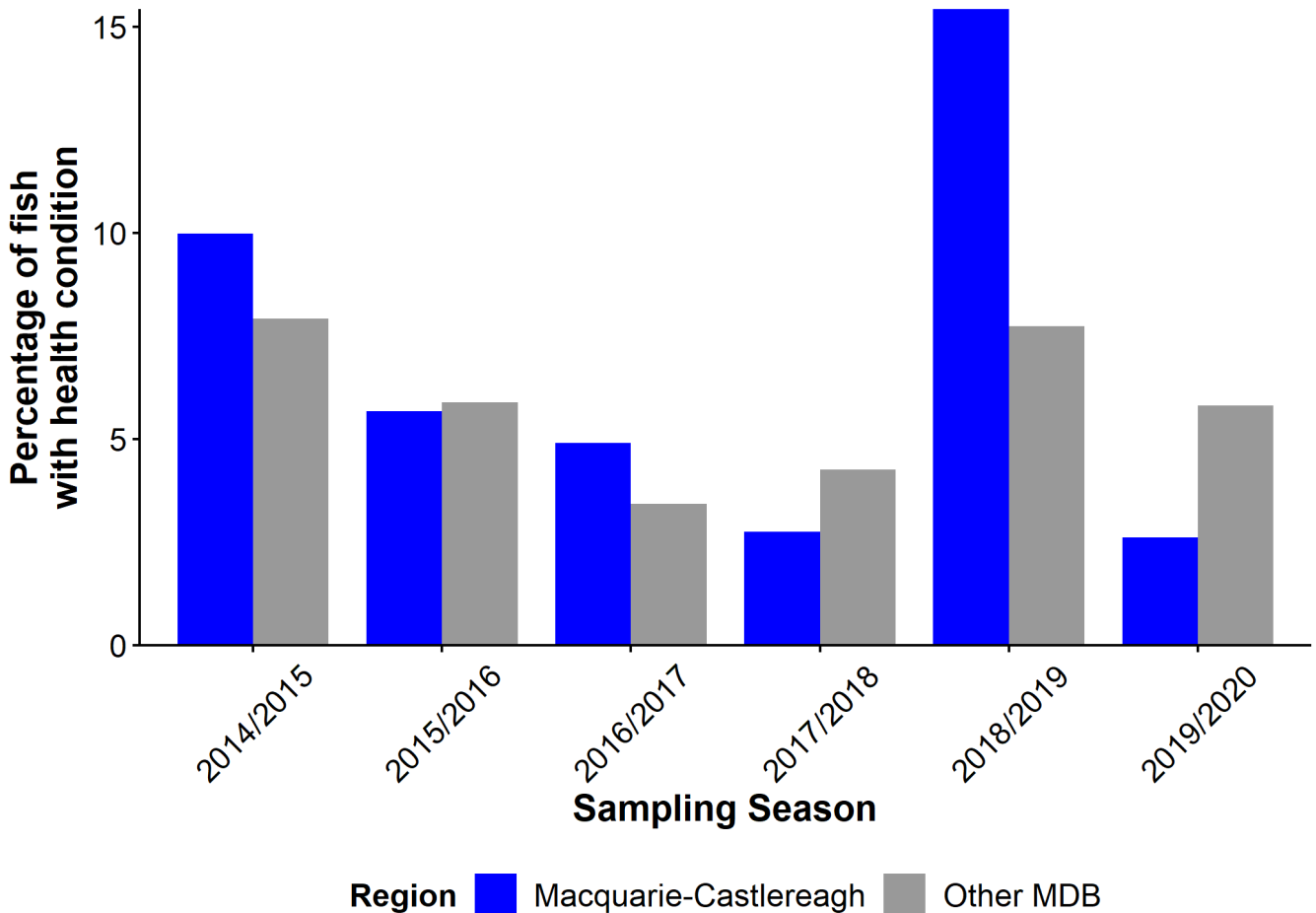


Figure 6.30: Timeseries showing the prevalence of health conditions in Common carp. Blue shows the region-specific data while the grey shows the average across the other NSW MDB WRPAs.

Summary Statement:

Presence of observable health conditions in the Macquarie-Castlereagh was low to moderate and generally similar to the rest of the NSW MDB except for 2018/19 when it was higher.

Distribution

Common carp were recorded at 96 out of 108 sites in the Macquarie-Castlereagh WSPA. The maximum observed relative abundance at a site was 22 fish caught per 90 seconds of electrofishing. [Figure 6.31](#) shows the distribution and relative abundance of Common carp across the Macquarie-Castlereagh WSPA.

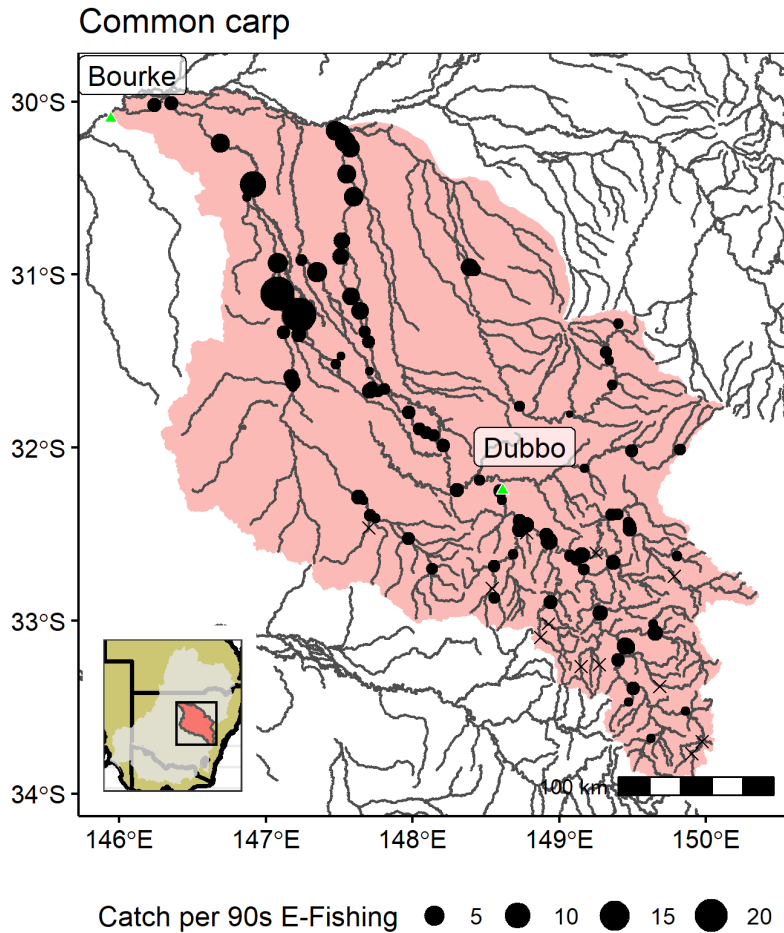


Figure 6.31: Distribution of Common carp. Filled circles show sites where the species was present, and the size of the circle represents relative abundance. Sites that were sampled with electrofishing but did not contain the species are shown with an X.

Summary Statement:

Present across the Macquarie-Castlereagh WSPA with higher abundances in the northwest downstream reaches.

Threatened Species

The following table (Table 6.6) 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 Macquarie-Castlereagh 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 6.9.

Table 6.6: 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*	26 (2)
<i>Bidyanus bidyanus</i>	Silver perch*#	10 (4)
<i>Maccullochella macquariensis</i>	Trout cod*#	7 (0)
<i>Maccullochella peelii</i>	Murray cod#	651 (185)
<i>Tandanus tandanus</i>	Freshwater catfish*	89 (15)

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

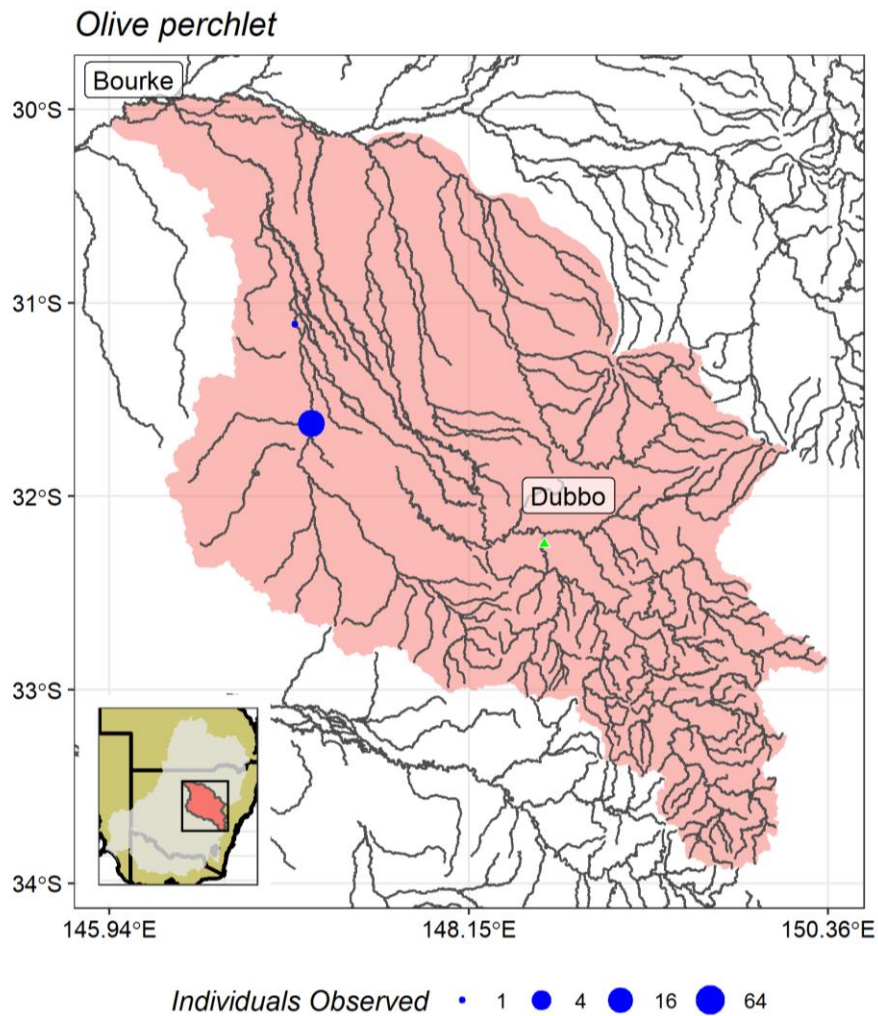


Figure 6.32: Distribution of Olive perchlet. Filled circles show sites where the species was present, and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 28 Olive perchlet were caught or observed across two sites (2015 – 2020) on the Bogan River.

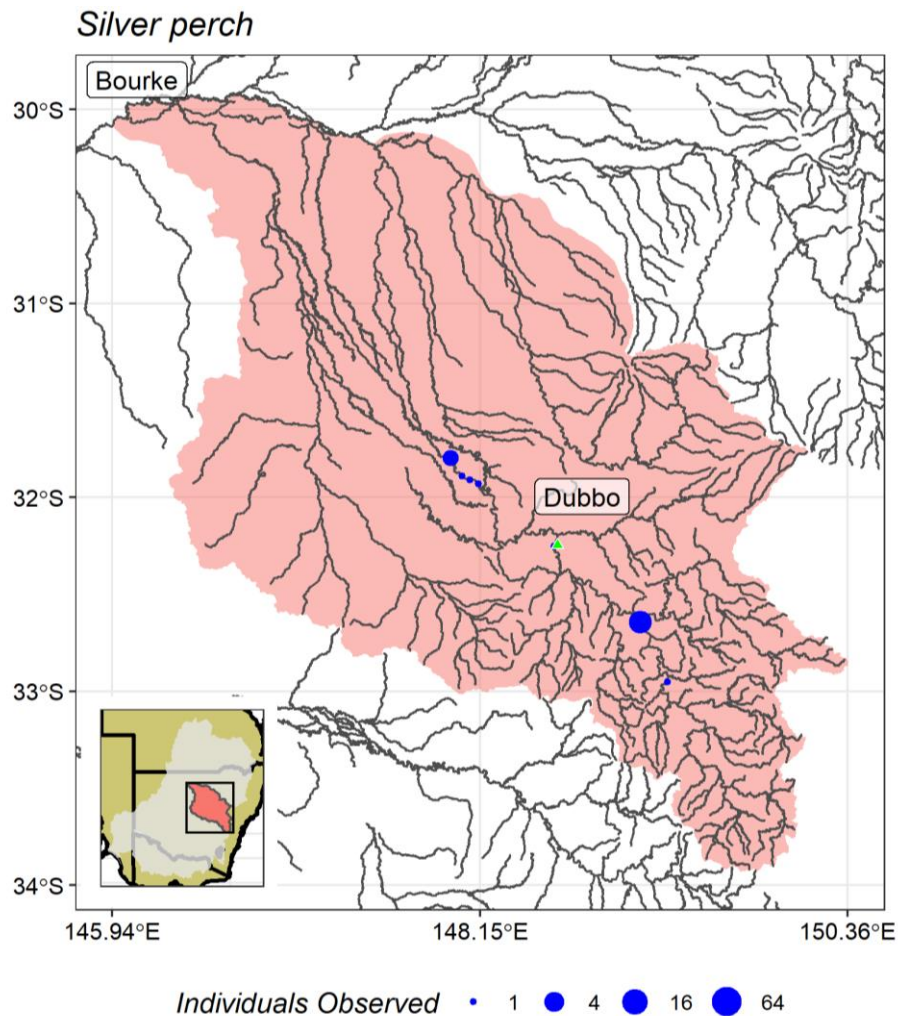


Figure 6.33: Distribution of Silver perch. Filled circles show sites where the species was present, and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 14 Silver perch were caught or observed across seven sites (2014 – 2018) on the Macquarie River.

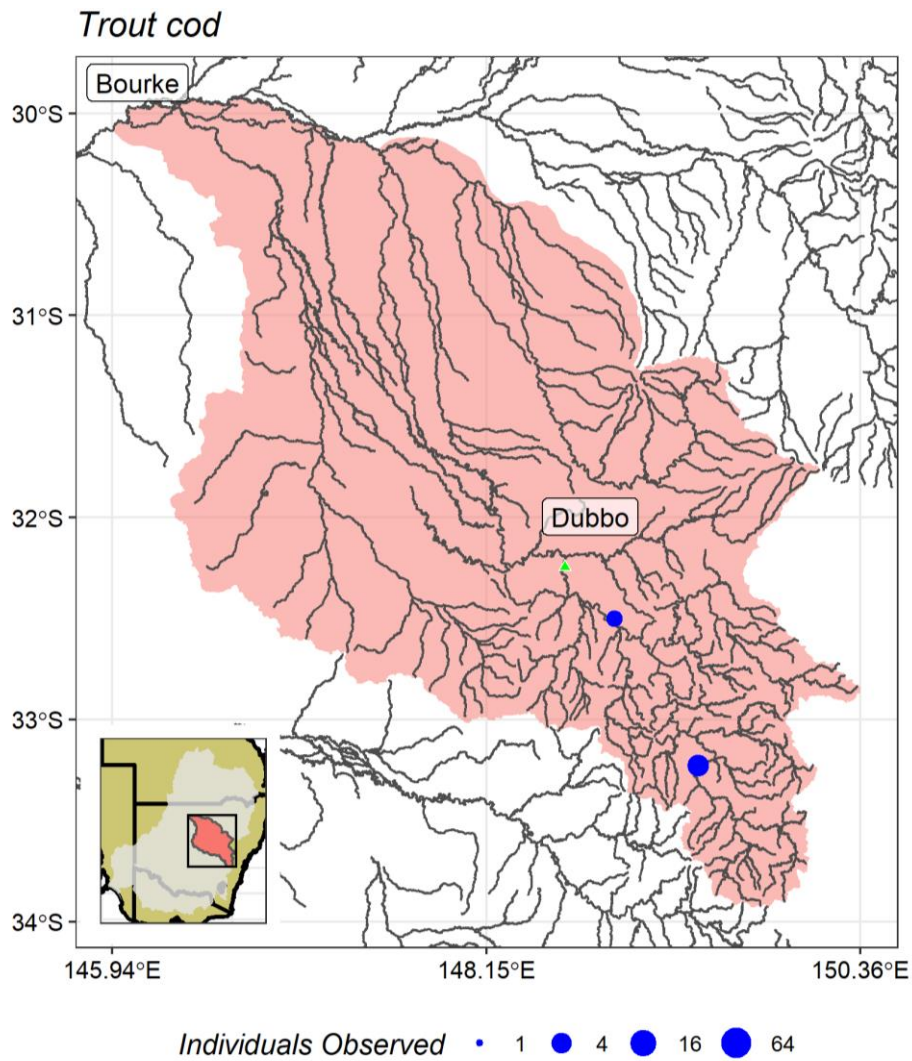


Figure 6.34: Distribution of Trout cod. Filled circles show sites where the species was present, and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of seven Trout cod were caught across two sites (2014 – 2016) on the upper Macquarie River.

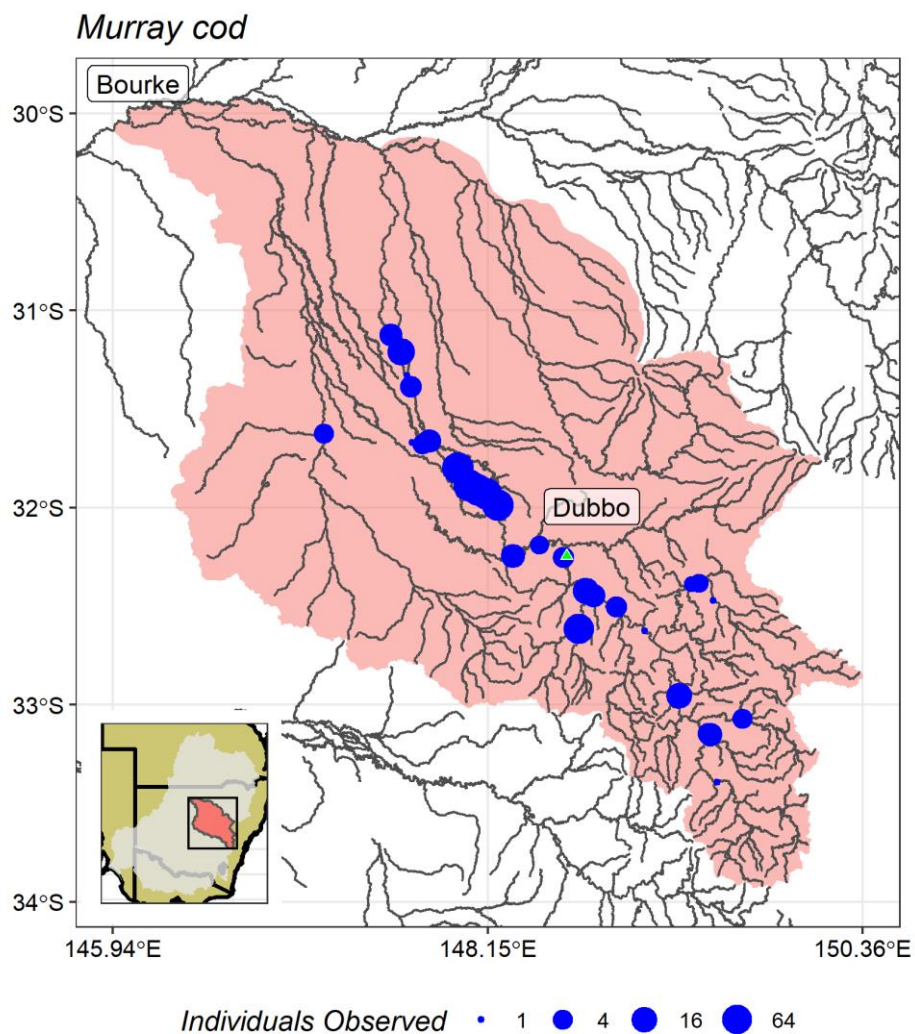


Figure 6.35: Distribution of Murray cod. Filled circles show sites where the species was present, and the size of the circle represents number of observed individuals abundance. Note the bottom image shows a juvenile Murray cod.

Summary Statement:

A total of 836 Murray cod were caught or observed across 30 sites across the Macquarie-Castlereagh WRPA.

Freshwater catfish

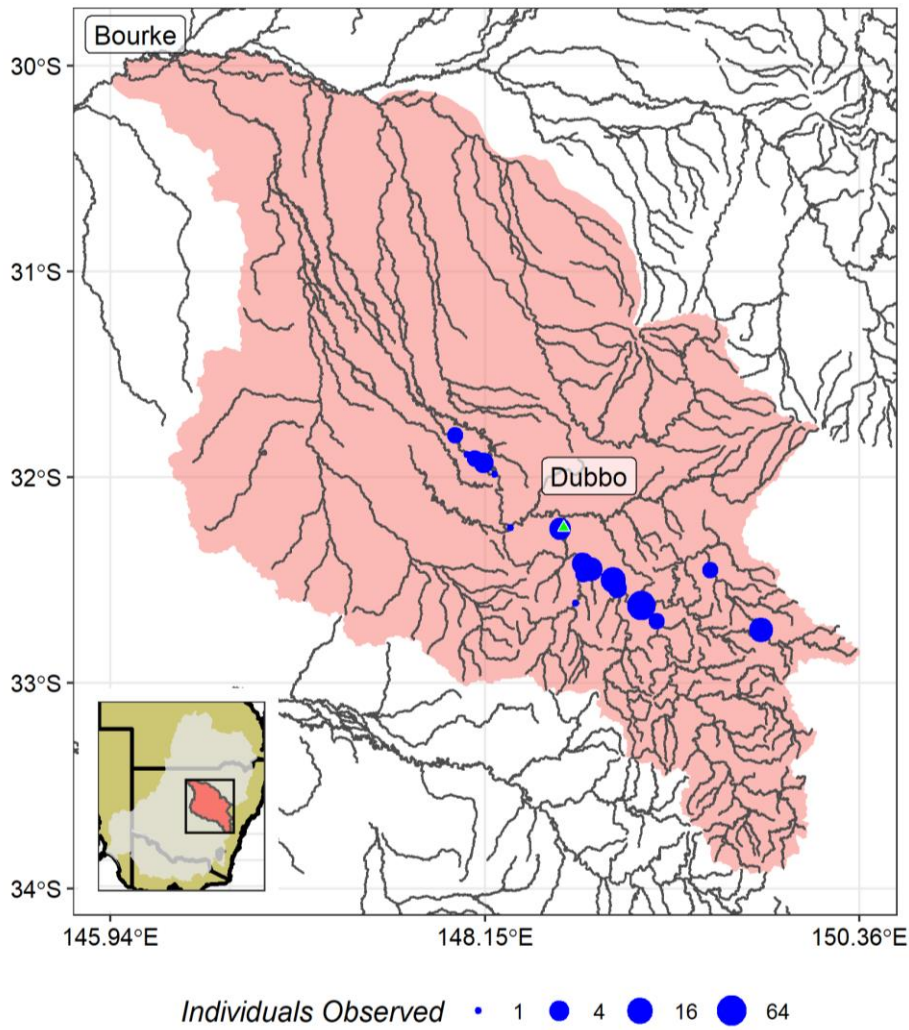


Figure 6.36: Distribution of Freshwater catfish. Filled circles show sites where the species was present, and the size of the circle represents number of observed individuals abundance.

Summary Statement:

A total of 104 Freshwater catfish were caught or observed across 17 sites (2014 – 2018) in the Macquarie-Castlereagh WRP.

Appendix

Figure 6.37 shows the locations of sites sampled in each sampling season.

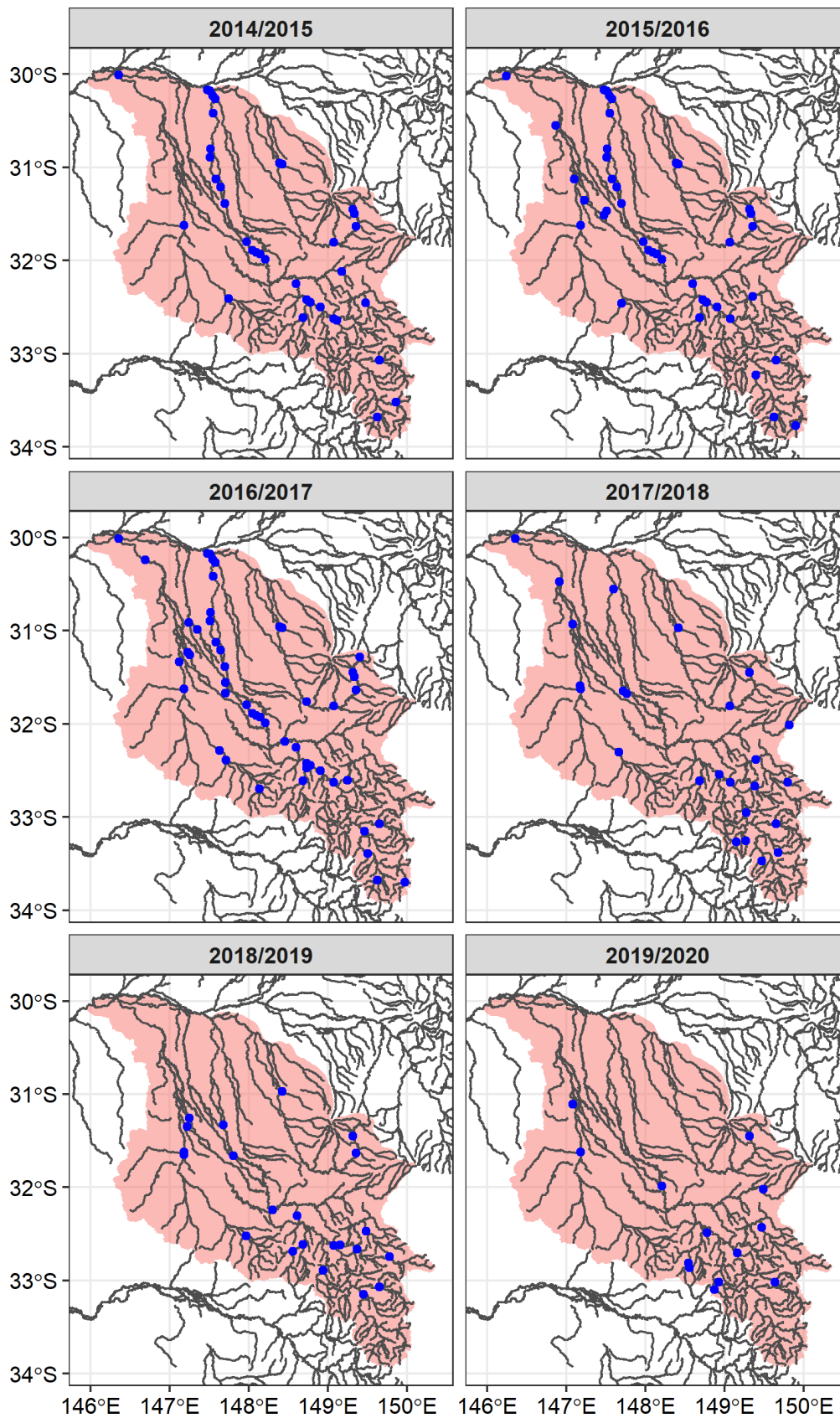


Figure 6.37: Sites sampled during the BPEOM-F program by Sampling Season. Dry sites are not shown.

Table 6.7 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 6.1. 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 Macquarie-Castlereagh WRPA were: Darling hardyhead, Flat-headed galaxias, Macquarie perch, Southern purple-spotted gudgeon, Southern pygmy perch, Hyrtl's catfish. 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 6.10.

Table 6.7: 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	898	370	970	36	44	4
Bony herring	YES	240	103	1,178	153	44	26
Brown trout	YES	1	1	12	0	0	0
Carp-gudgeon species complex	YES	1,235	1,176	1,267	1,035	992	172
Common carp	NA	1,203	682	3,392	482	227	380
Common carp - Goldfish hybrid	NA	1	0	0	0	3	0
Dwarf flathead gudgeon	YES	0	1	0	2	0	0
Eastern gambusia	NA	2,195	2,757	4,680	1,320	611	371
Flathead gudgeon	YES	712	115	218	23	108	17
Freshwater catfish	YES	51	8	17	3	8	2
Golden perch	YES	170	85	216	25	25	2
Goldfish	NA	129	147	4,386	239	52	55
Mountain galaxias	YES	36	106	16	81	4	2
Murray-Darling rainbowfish	YES	733	169	132	3	1	0
Murray cod	YES	292	176	112	27	28	16
Olive perchlet	YES	0	7	2	1	1	15
Rainbow trout	YES	1	22	13	0	0	0
Redfin	YES	2	17	216	28	78	0
River blackfish	NA	0	0	0	0	0	5
Silver perch	YES	5	2	2	1	0	0
Spangled perch	YES	34	21	80	9	2	0
Trout cod	YES	2	5	0	0	0	0
Unspecked hardyhead	YES	192	112	227	16	15	53

The following table summarises the sampling methods by which each fish species was caught (Table 6.8).

Table 6.8: Total catch of each species by sampling method.

Common name	Backpack Electrofishing	Bait Trap	Boat Electrofishing
Australian smelt	54	1	2,267
Bony herring	66	11	1,667
Brown trout	8	0	6
Carp-gudgeon species complex	1,808	3,700	369
Common carp	728	704	4,934
Common carp - Goldfish hybrid	0	0	4
Dwarf flathead gudgeon	2	0	1
Eastern gambusia	7,611	3,316	1,007
Flathead gudgeon	32	120	1,041
Freshwater catfish	2	0	87
Golden perch	7	3	513
Goldfish	334	45	4,629
Mountain galaxias	236	4	5
Murray-Darling rainbowfish	19	1	1,018
Murray cod	4	1	646
Olive perchlet	0	8	18
Rainbow trout	25	0	11
Redfin	33	18	290
River blackfish	5	0	0
Silver perch	0	0	10
Spangled perch	43	23	80
Trout cod	5	0	2
Unspecked hardyhead	5	5	605

Table 6.9: 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 6.10 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 Macquarie-Castlereagh WRPA were: Darling hardyhead, Flat-headed galaxias, Macquarie perch, Southern purple-spotted gudgeon, Southern pygmy perch. 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 6.7.

Table 6.10. 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	1,017	511	995	51	56	42
Bony herring	YES	240	103	1,349	153	44	26
Brown trout	YES	4	3	12	0	14	32
Carp-gudgeon species complex	YES	2,502	1,511	1,660	1,061	1,021	389
Common carp	NA	1,564	914	3,689	712	639	636
Common carp - Goldfish hybrid	NA	2	5	2	3	7	0
Dwarf flathead gudgeon	YES	0	1	0	2	0	0
Eastern Gambusia	NA	2,445	3,169	5,273	1,518	1,335	701
Flathead gudgeon	YES	784	228	260	192	127	90
Freshwater catfish	YES	57	27	26	6	10	2
Golden perch	YES	185	129	245	39	37	12
Goldfish	NA	130	147	4,760	239	61	72
Hyrtl's catfish	YES	0	0	1	0	0	0
Mountain galaxias	YES	93	126	40	130	147	348
Murray-Darling rainbowfish	YES	758	176	136	3	1	0
Murray cod	YES	432	286	199	101	97	39
Olive perchlet	YES	0	7	2	1	1	15
Rainbow trout	YES	4	27	13	4	117	67
Redfin	YES	222	156	840	67	111	49
River Blackfish	YES	0	0	0	0	0	5
Shrimp	NA	73	87	161	3	58	21
Silver perch	YES	6	4	2	2	0	0
Spangled perch	YES	35	21	119	9	2	0
Trout cod	YES	3	5	0	0	0	0
Unspecked hardyhead	YES	212	230	234	16	15	53