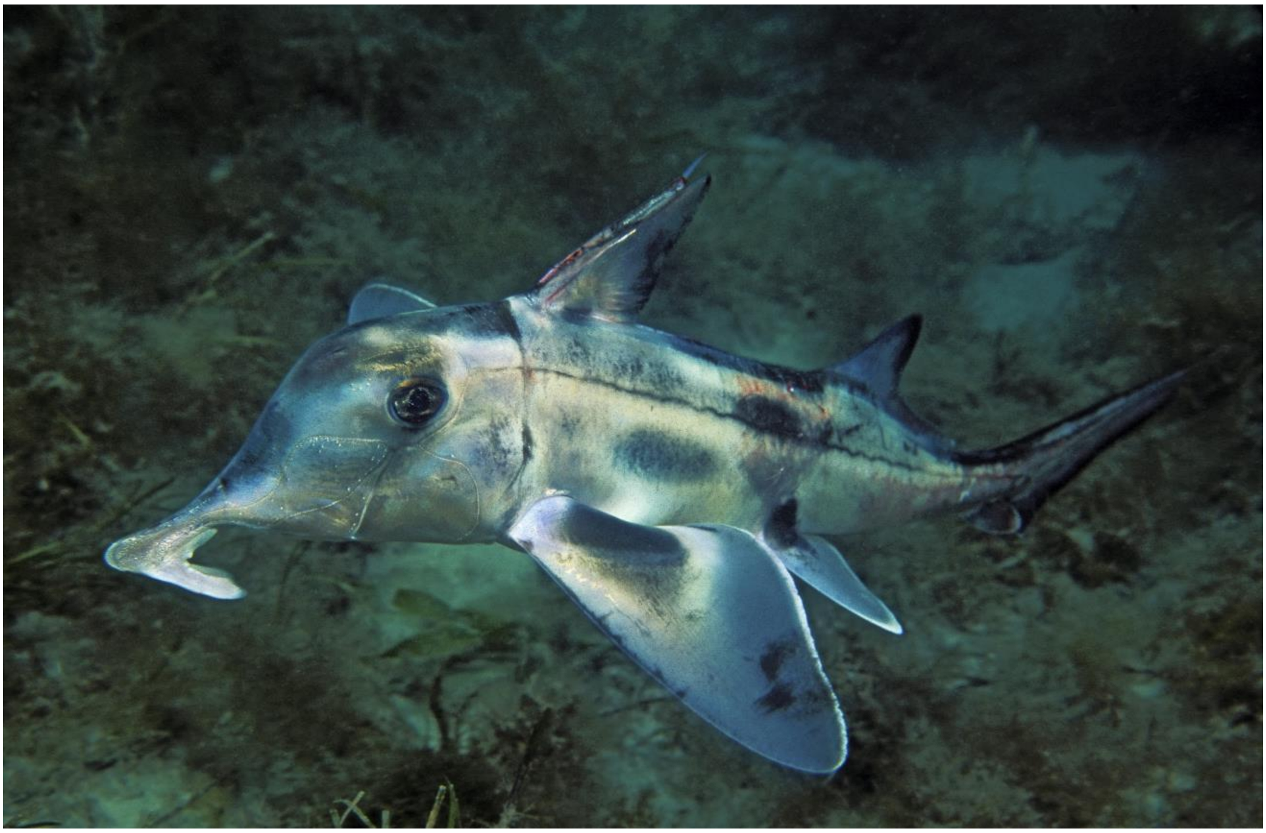
Characterising the status of the Western Port recreational fishery in relation to biodiversity values: Phase 1



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Executive Summary

Fishing as a form of harvesting was identified as a high priority research area in the recent Western Port Science Review (Keough et al. 2011a). The recreational fishing research data obtained from boat ramp interviews over a 15 year period has detailed information on numbers and lengths of species caught, as well as location, depth and habitat of capture. In this study the data was analysed with a view to increasing knowledge on the ecology and biodiversity of key fish species in Western Port. The results also form the base-line information for a stock assessment of important recreational fishing species in Western Port to be conducted in Phase 2 of the project.

The spatial distribution of catch rates (an indicator of abundance) was visualised using Geographical Information System (GIS) mapping for key species. Spatial information was supplemented with data on habitat and depth fished. Some species, such as King George Whiting, Southern Calamari and Southern Sea Garfish had higher catch rates (indicating greater abundance) in areas of higher seagrass cover. Fishing for these species tended to be in relatively shallow depths and habitats that included seagrass. In contrast, species such as Snapper and Gummy Shark had higher catch rates in the deeper reef habitats of the Western Entrance Segment and the Lower North Arm. An area of high catch rates for most species was the Rhyll Segment, a broad subtidal sedimentary plain with habitats such as seagrass, macroalgae and sedentary invertebrate isolates. The Rhyll Segment is also strongly influenced by water quality and sedimentation entering the north-east of the bay from the catchment, so catchment management to maintain water quality entering the bay is likely to be critical to maintaining fish biodiversity and sustaining recreational fishing in the bay.

In terms of changes to catch rates and length distributions over the survey period, there was a common pattern for a number of species of strong fluctuations at the scale of a few years. For species such as King George Whiting and Snapper, research has shown that these fluctuations are related to variability in recruitment that is driven by environmental fluctuations. Long term trends were also evident for some species across the survey period. Snapper showed an increasing trend that was most likely related to a series of successful recruitment years in Port Phillip Bay in the 2000’s following poor recruitment in the 1990’s. Flathead showed a slightly decreasing trend in catch rate that may be related to the much more significant decrease in Sand Flathead catch rates in Port Phillip Bay over the same period. This decline is also thought to be mainly driven by a period of poor recruitment related to environmental conditions. Although catch rates of Elephant Fish were relatively stable across the survey period, a contraction of the spatial distribution in the catch rates to the Rhyll Segment may be a cause for concern because decline in the population is masked by increased aggregation.

Overall the study provided new information on the spatial distribution and habitat use of important fish populations in Western Port that will inform management of the marine environment in relation to catchment inputs, coastal development, recreational fishing and marine protected areas. The results suggested that variation in catches by recreational fishers was

primarily influenced by the environmental drivers of recruitment of young fish to the Western Port ecosystem.

Introduction

Project Background

Western Port is a key biodiversity region as well as supporting important fisheries (Jenkins 2011; Keough *et al.* 2011a). Western Port is a RAMSAR wetland of international significance (Kellogg *et al.* 2010) and includes three of Victoria's 13 Marine National Parks (Keough *et al.* 2011a). Western Port supports large areas of habitat, particularly the seagrass *Zostera,* supporting a rich and diverse fish community (Jenkins 2011; Keough *et al.* 2011a). However, seagrass in Western Port, and *Zostera* in particular, has been subject to large losses, most markedly in the mid-1970s (Shepherd *et al.* 1989; Walker 2011).

The recent report to Melbourne Water *Understanding the Western Port Environment. A summary of current knowledge and priorities for future research*, otherwise referred to as the 'Western Port Science Review' (Keough *et al.* 2011a), identified harvesting as a key threat for Western Port (Keough *et al.* 2011b). Fishing is a primary form of harvesting that has the potential to impact fish populations and other biodiversity values and was identified as a high priority research area (Keough *et al.* 2011b). With the cessation of commercial netting in 2008, the primary form of harvesting of fish is by recreational fishing. While the removal of commercial fishing would have reduced the overall pressure from harvesting; recreational fisheries are generally more complex to manage because the quality of fishery-dependent data (catch, effort etc.) is more difficult to obtain. A priority research area under the harvesting theme was therefore to support the continued monitoring of recreational fishing, and extend this to include fishery independent surveys.

Monitoring of the recreational fishery in Western Port through boat ramp surveys and angler diarists has been undertaken for the past 15 years; however, to date there has not been a detailed analysis of this data to understand the ecological and biodiversity information available in the data set. This provides an opportunity for a research project related to the harvesting priority to undertake this detailed analysis and characterise the status of the present recreational fishery and also the biodiversity information available in the data set. In particular, the data can indicate the trends in recreational fishing catch rate over time and in space. It can further provide information on the areas and habitats producing particular species over time, and the trends in recruitment of key species. This spatial and temporal analysis of biodiversity value based on recreational fishing research data can be compared with the spatial distribution of marine protected areas, marine asset areas currently being defined by DEPI, and also freshwater inputs and other sites potentially affecting water quality.

Project Objectives

1. To undertake an analysis of recreational fishing research data sets with a view to increasing our knowledge of fish biodiversity and habitat relationships in Western Port.

2. To provide base-line information for a stock assessment of important recreational fishing species in Western Port to be conducted in Phase 2 of the project

Project Outcome

An increased understanding of fish species distribution and critical habitats will help inform natural resources managers about important areas of Western Port for fish biodiversity and assist in more targeted efforts in both the catchment and marine environment to protect and improve the environmental health of Western Port.

Materials and Methods

Study Area

Western Port has been subdivided into segments based on physical characteristics (Marsden *et al.* 1979): the Lower North Arm, Upper North Arm, Corinella Segment, Rhyll Segment and Western Entrance Segment (Figure 1). Western Port has a large area of intertidal mudflats (~ 1/3 of area) dissected by dendritic channels (depth to 30 m) with strong tidal currents (Figure 2). The tidal range of 2 to 3 metres means that a large volume of water is exchanged between the bay and the offshore waters on each tidal cycle. Most of the freshwater input is in the north-east of the bay (Figure 1), and entrainment of sediments from the catchment leads to increased suspended sediments in this area (Lee 2011). The dominant biogenic habitat in Western Port is seagrass; the major species are *Zostera capricornii* on the intertidal flats, *Zostera tasmanica* / *Zostera nigricaulis* in lower intertidal and shallow sub-tidal areas, and *Amphibolis antarctica* in the oceanic Western Entrance Segment (Walker 2011). The most recent seagrass mapping for the entire Western Port (Figure 3) was in 1999 (Blake and Ball 2001). At this point, seagrass cover was increasing after a major loss in the 1970s and 1980s (Blake and Ball 2001). Seagrass cover is likely to have fluctuated over the period of the recreational fishing survey; however, the basic distribution of seagrass in Western Port tends to be relatively consistent (Blake and Ball 2001).

Recreational Fishing Survey

The data analysed in the report came from the Victorian Fisheries Recreational Survey conducted in Western Port from November 1998 to 2013. Interviews were conducted by Fisheries Victoria staff with boat-based fishers returning from fishing trips. Interviews were conducted on weekends from approximately October - November to April - June each year. Nearly 11,000 interviews were conducted at 10 ramps, with most information coming from Corinella, Cowes, Hastings, Newhaven, Rhyll, Stony Point, Tooradin and Warneet (Figure 4). The number of interviews per year (largely dependent on funding) decreased from the beginning of the survey to 2003/04, increased in 2004/05 and then generally decreased to the end of the survey (Figure 4). Information provided included number of fishers, hours fished, fisher avidity, fishing method/bait, species caught and released, and fish length. The information included the area fished based on the catch cells previously used for commercial log book recording (Figure 5). Information on the depth of the fishing location was included in 2007/08 and information on the bottom habitat type was included in 2010/11. Because of potential unreliability of the information recorded by one interviewer, interviews for the south-eastern (Corinella, Newhaven, Rhyll, and Cowes) from 2005/06 were not included in the analysis.

Angler Diary Survey

Volunteer angler diarists have been operating in Victoria since 1997. Experienced volunteer anglers in Western Port contributed to the angler diary program. All anglers recorded: time spent fishing, fishing location, species targeted and caught, and gear/bait type used. All catches, including under-size fish, were recorded in diaries, and all fish caught were measured. Otolith samples were collected for ageing.

Data Analysis

Spatial distribution of Catch Rates

To analyse the spatial information contained in the Recreational Fishing Survey data, the catch rate was determined for individual species for each fishing trip (number of fish caught/released per angler hr effort). The catch rate data was allocated to the area fished based on the catch cells (Figure 5). Where more than one catch cell was fished on a trip we applied the calculated catch rate to each cell equally. The catch rate was chosen as the appropriate variable because it represents an index of abundance. For analysing temporal changes in spatial distribution of catch rate we divided the analysis into two seasons: “spring” (October to January) and “autumn” (February to May). We also divided the data into three sampling periods; 1998-2003, 2004-2008, and 2009-2013. The start of the third period coincided with the cessation of commercial netting in Western Port. We only included catch cells in the analysis if more there were more than 10 interviews represented in the data. ARCMAP GIS software was selected for the mapping process. For major angling species we filtered the data to include only trips where the species was targeted, while for less preferred species we included all interviews. We analysed both kept and released fish with the exception of Southern Calamari and Southern Sea Garfish where few fish are released. Most of released fish were under the legal minimum size limit and therefore can be used as a proxy recruitment index when examining temporal trends, although in some cases fish may have been released because the legal bag limit had been reached (particularly the case for Gummy Shark and Elephant Fish that have low bag limits). Nearly all Elephant Fish were caught in the “autumn” period only so the data analysis was restricted to this period.

Annual Catch Rates

The average annual catch rate was determined based on the total catch and effort for an interviewing day (per day catch rate) averaged across the financial year. Plots of standardised annual catch rate for the Angler Diary Program were also included for key species. Finally, annual catch rates (as well as catch and effort) from the commercial fishery up until the cessation of netting are included in Appendix A.

Length Frequency Distributions

Length frequency distributions were plotted by financial year for key species based on fork length (FL). Where fish were measured for total length, the data was converted to FL using linear regression. It was not possible to plot length frequencies for Elephant Fish and Gummy Shark because many measurements were recorded as partial length, but it was not clear what body dimension partial length represented in many cases.

Depth and Habitat of Fishing

The depth and habitat of fishing were plotted in terms of the number of trips a species was caught (or released) at each depth and in each habitat. Depth data was restricted to interviews where only one location (catch cell) was fished.

Figure 1. Segments of Western Port based on physical characteristics (Marsden *et al.* 1979)

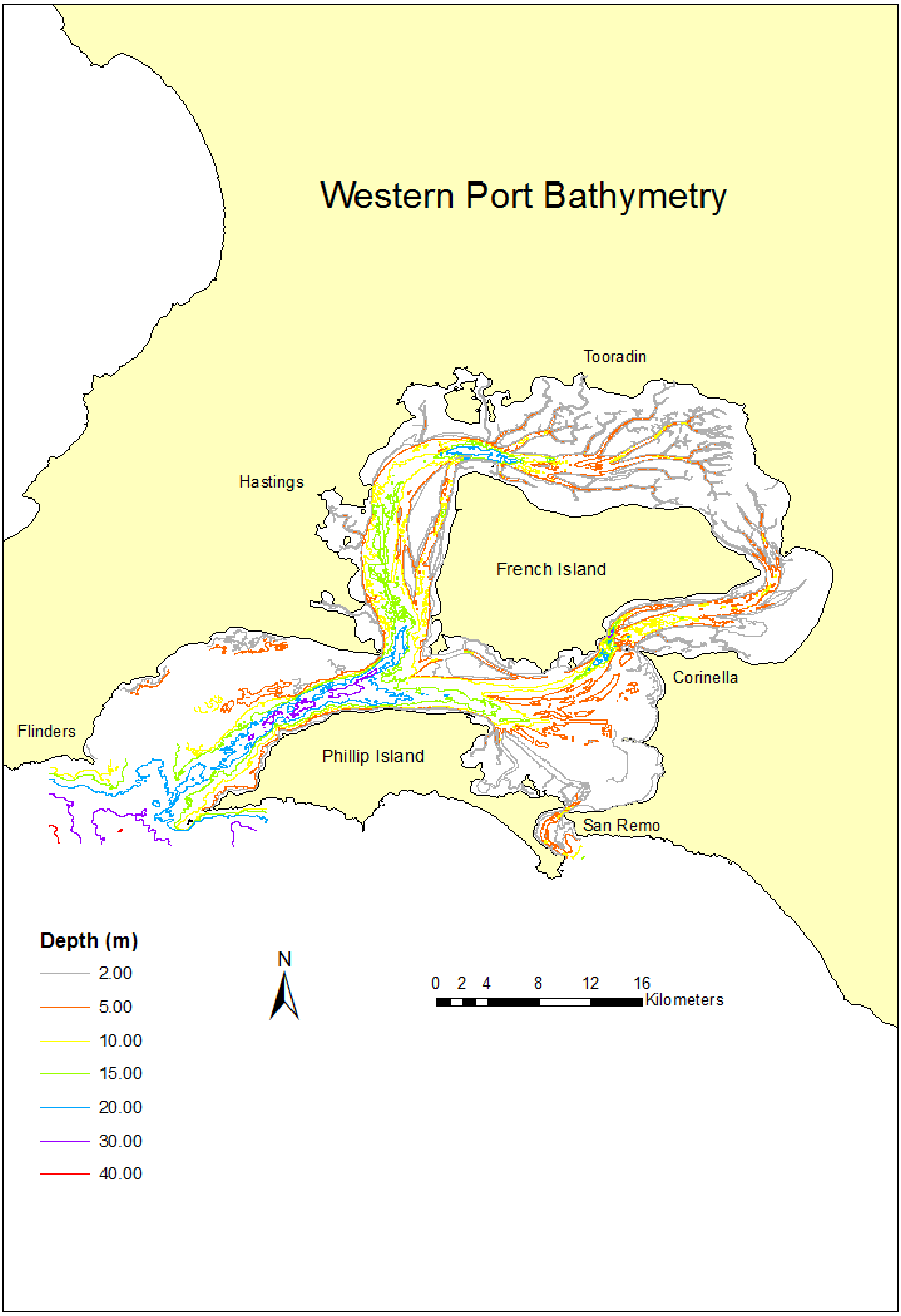


Figure 2. GIS mapping layer of Western Port bathymetry

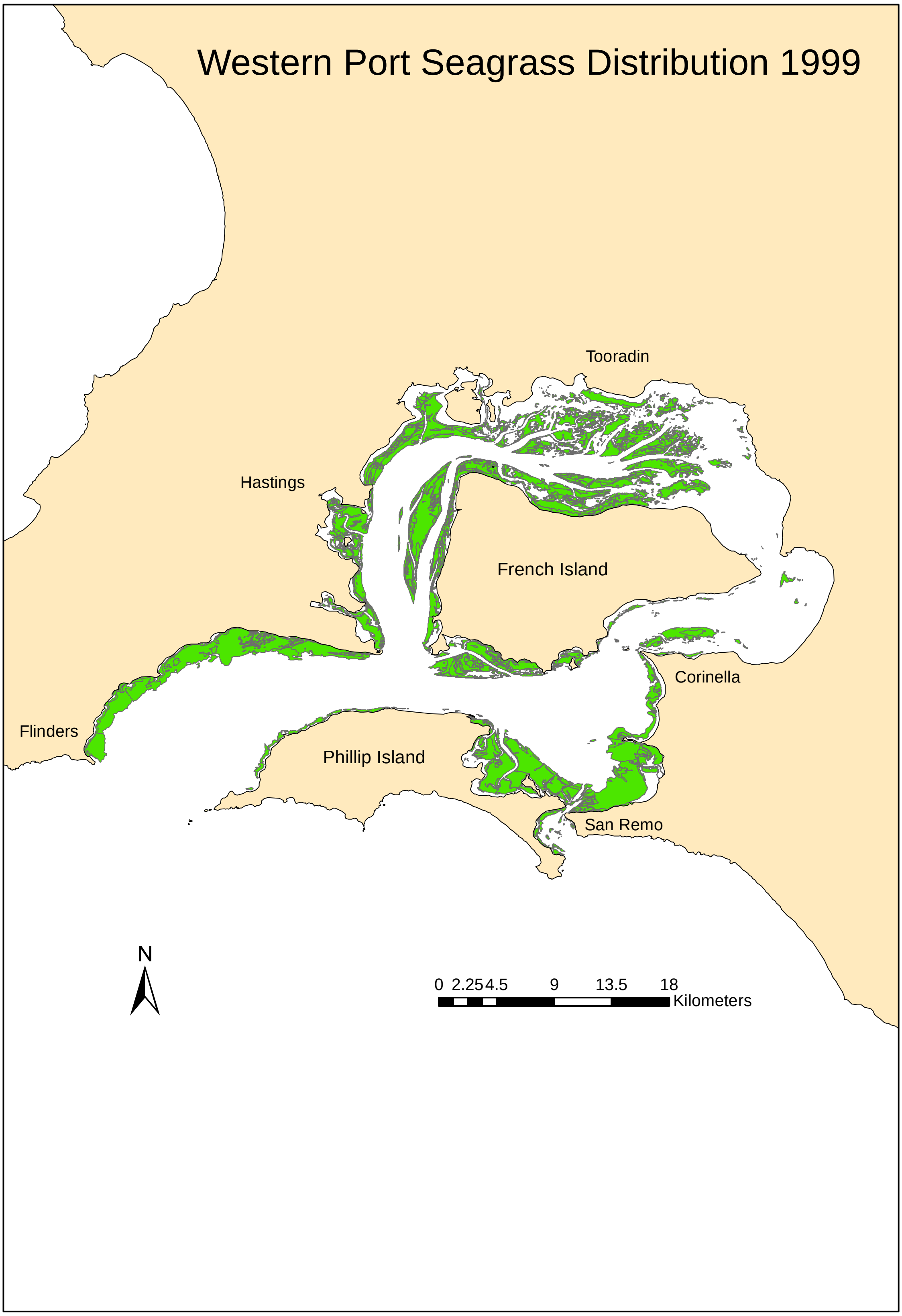


Figure 3. GIS mapping layer of distribution of seagrass in Western Port mapped in 1999

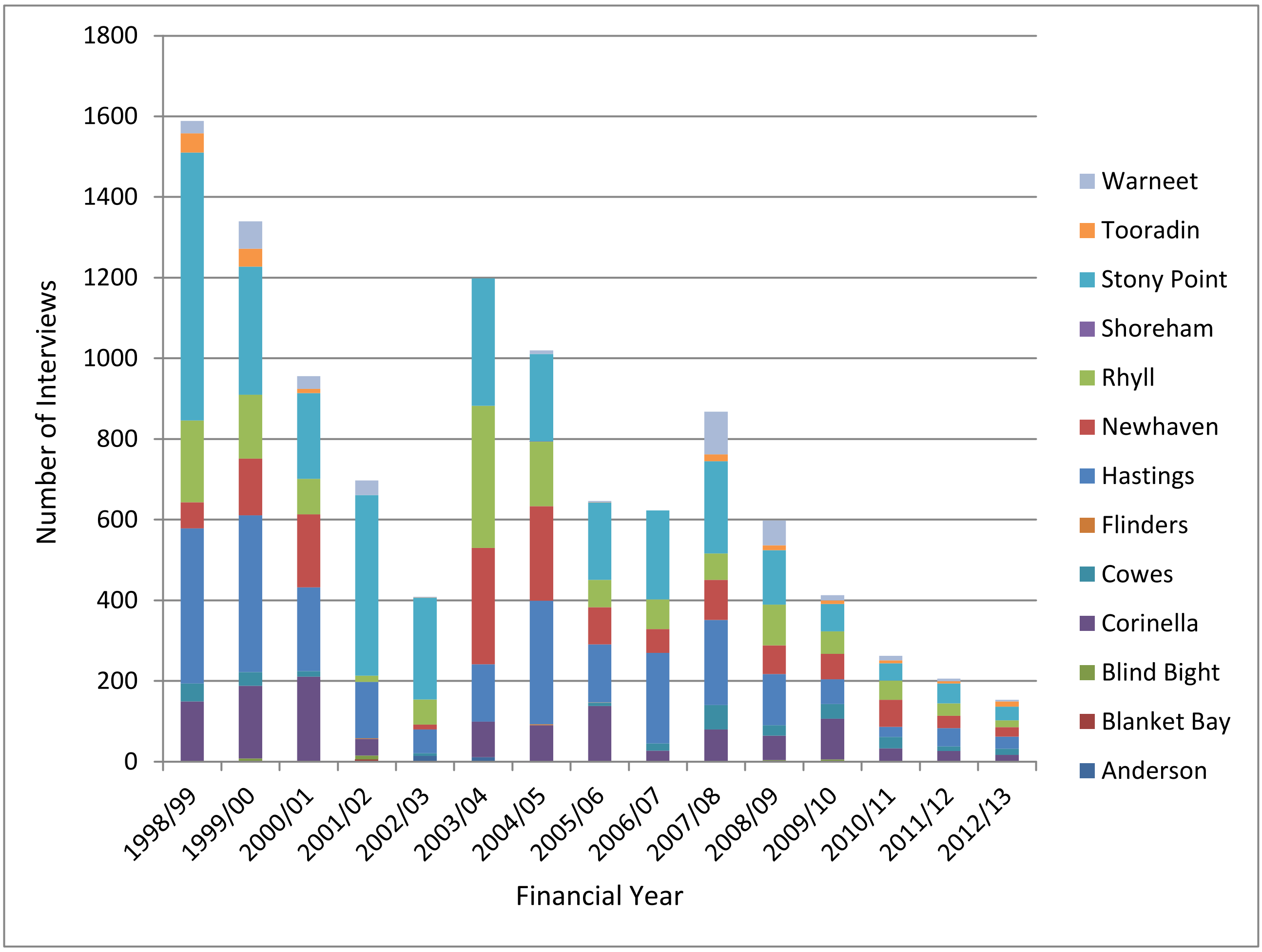


Figure 4. Number of interviews at each boat ramp for each financial year of the recreational creel survey

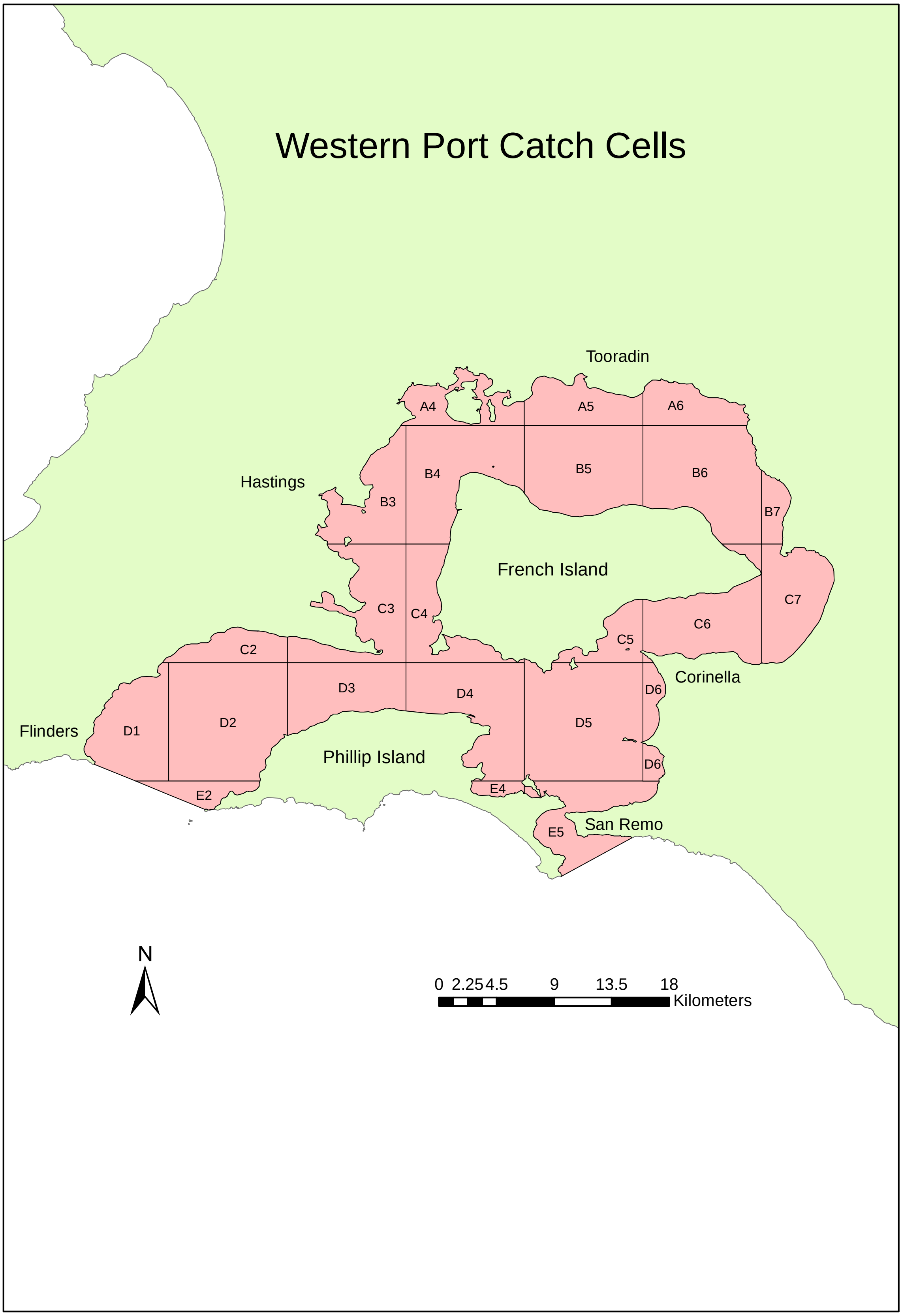


Figure 5. GIS mapping layer of catch cells used for spatial analysis in Western Port

Results

Spatial distribution of catch rates

King George Whiting

The catch rate of King George Whiting was highest north-west of French Island, in the Upper North Arm near Tooradin and in the Rhyll Segment (Figure 6A). Areas of highest catch rates were broadly similar for all three periods, with relatively high rates the Upper North Arm near Tooradin in Period 1(Figure 6B), along the east coast of the Rhyll Segment in Period 2 (Figure 6C), and to the north-west of French Island in Period 3 (Figure 6D). Seasonally, the catch rate increased in the Rhyll Segment relative to other areas from spring (Figure 7A) to autumn (Figure 7B). The catch rate of released King George whiting was highest in the Rhyll and Corinella segments and was also relatively high in the Upper North Arm from Hastings to Tooradin (Figure 7C). Areas of higher catch rates (Figure 6) broadly corresponded with areas of the bay with greatest seagrass cover (Figure 3).

Snapper

The catch rate of Snapper was highest in the Western Entrance Segment and in the Lower North Arm (Figure 8A), corresponding to the deepest areas of Western Port (Figure 2). Areas of highest catch rates were broadly similar for all three periods, with relatively high rates north of Phillip Island in Period 1 (Figure 8B), in the western entrance area and the south-west of the Lower North Arm in Period 2 (Figure 8C), and in the western entrance area in Period 3 (Figure 8D). Areas of highest catch rates were also similar in spring (Figure 9A) and autumn (Figure 9B), with minor differences such as an increased catch rate in the eastern entrance area in autumn. Areas of high catch rates of released snapper were similar to kept snapper but were also relatively high in the Rhyll Segment and Eastern Entrance (Figure 9C).

Flathead

The catch rate of kept Flathead was highest in the Lower North Arm, particularly in the section south of Hastings (Figure 10A). Areas of highest catch rates showed some variation over the three periods. Areas of high catch rates in Period 1 were similar to the total survey (Figure 10B) but in Period 2 also included high catch rates on the eastern coast of the Rhyll Segment (Figure 10C), and in Period 3 included high catch rates in the Eastern Entrance area and in the Upper North Arm near Tooradin (Figure 10D). The Lower North Arm was the area of highest catch rate in both seasons (Figure 11A,B), with relatively high catch rates also recorded in the Eastern Entrance in autumn (Figure 11B). Areas of highest catch rate of released flathead were also in the Lower North Arm extending south into the Western Entrance Segment (Figure 11C). A high catch rate of released flathead was also recorded in the north-west of the bay in catch cell A4 (Figure 5).

A) B)
C) D)

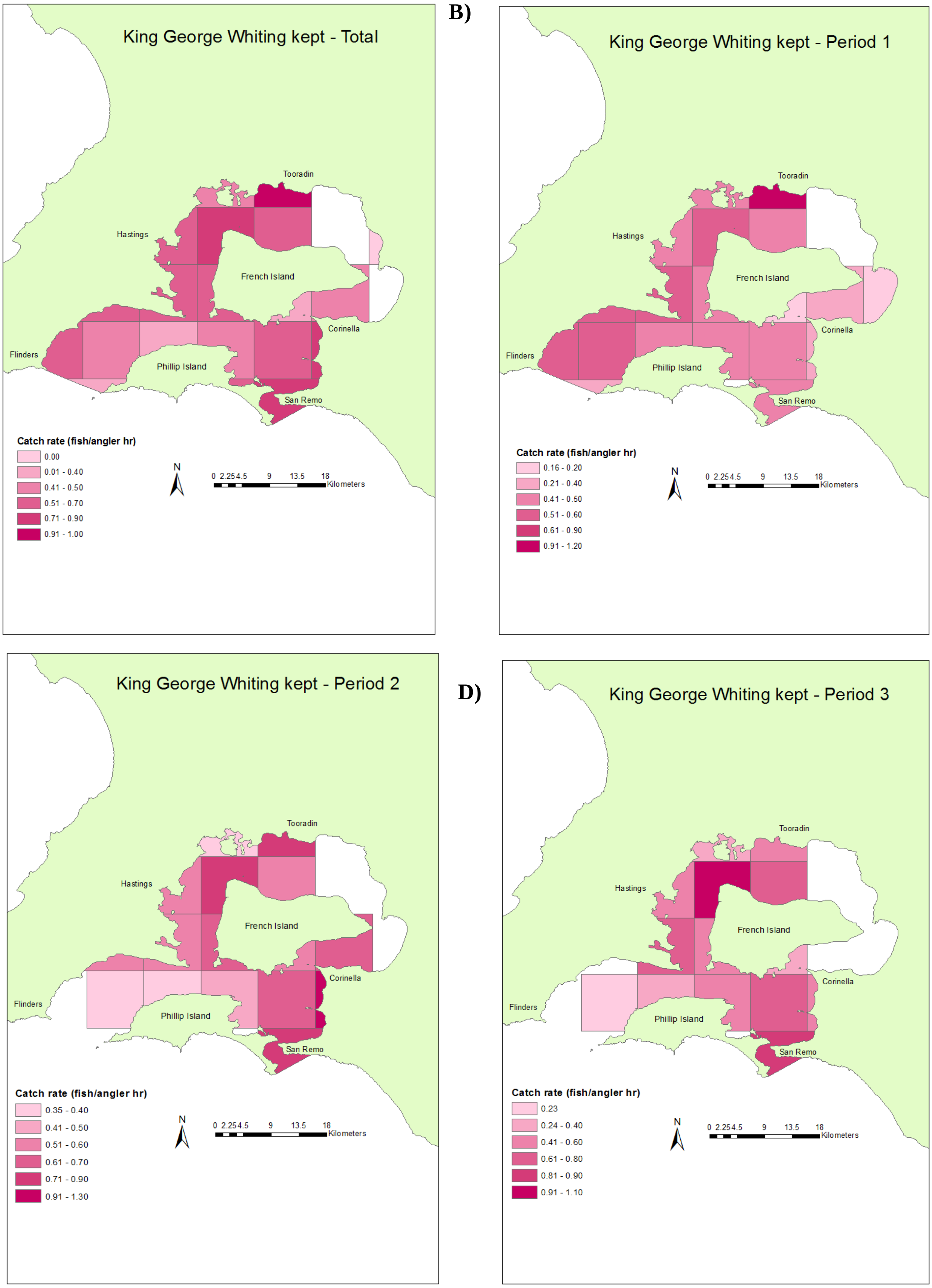


Figure 6. Catch rate of King George Whiting: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

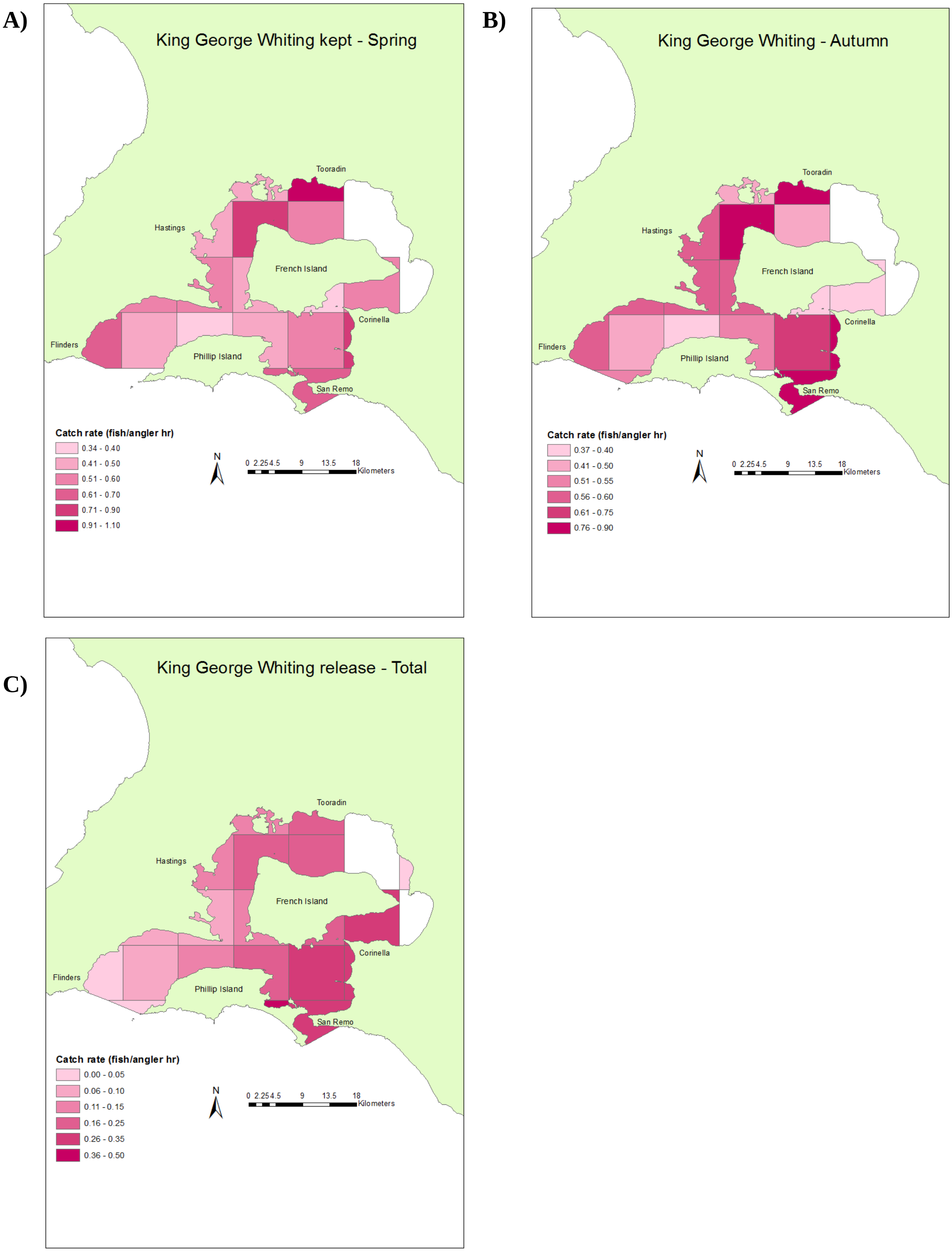


Figure 7. Catch rate of King George Whiting: (A) Spring, (B) Autumn, (C) Total released

A) B) C) D)

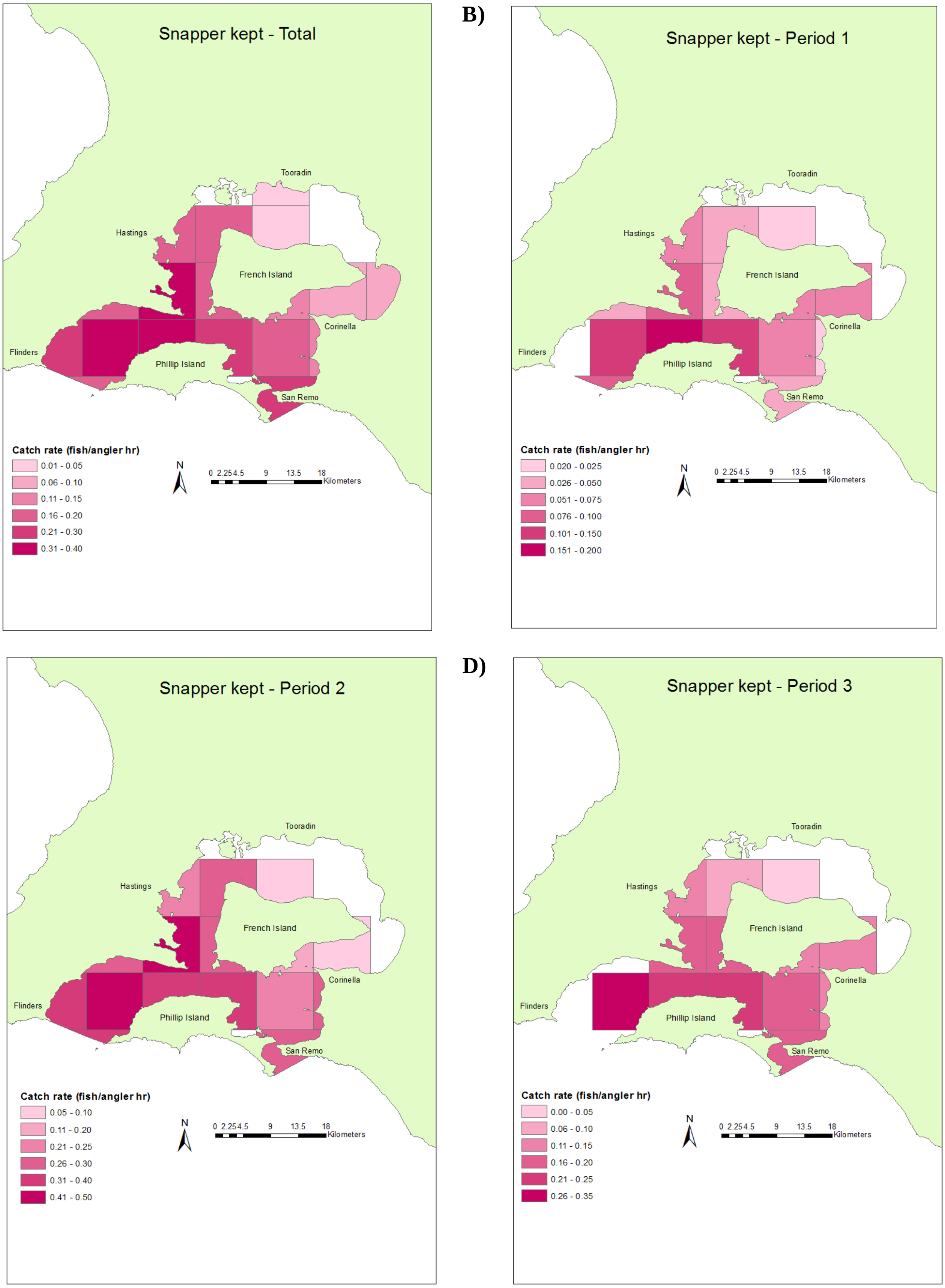


Figure 8. Catch rate of Snapper: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

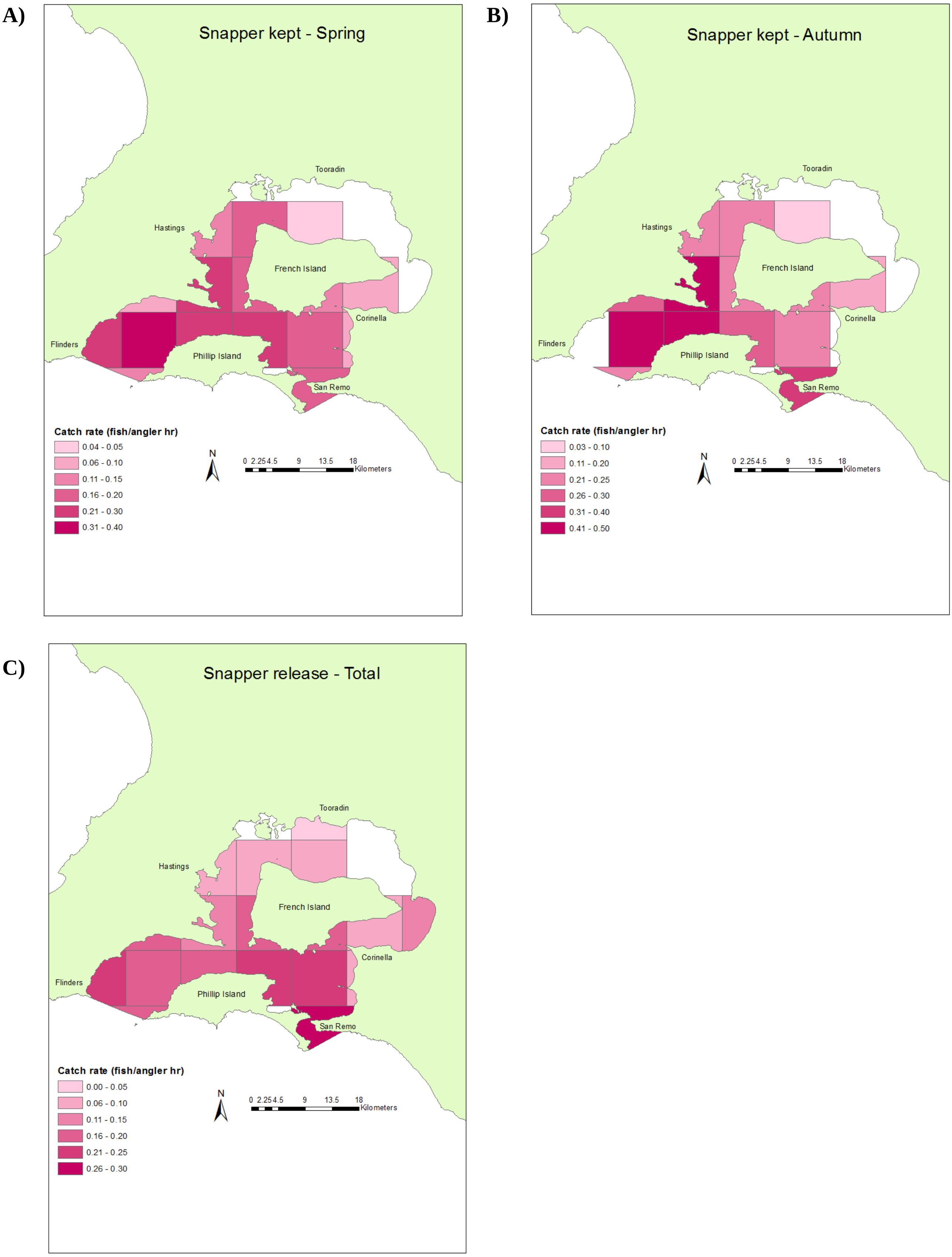


Figure 9. Catch rate of Snapper: (A) Spring, (B) Autumn, (C) Total released

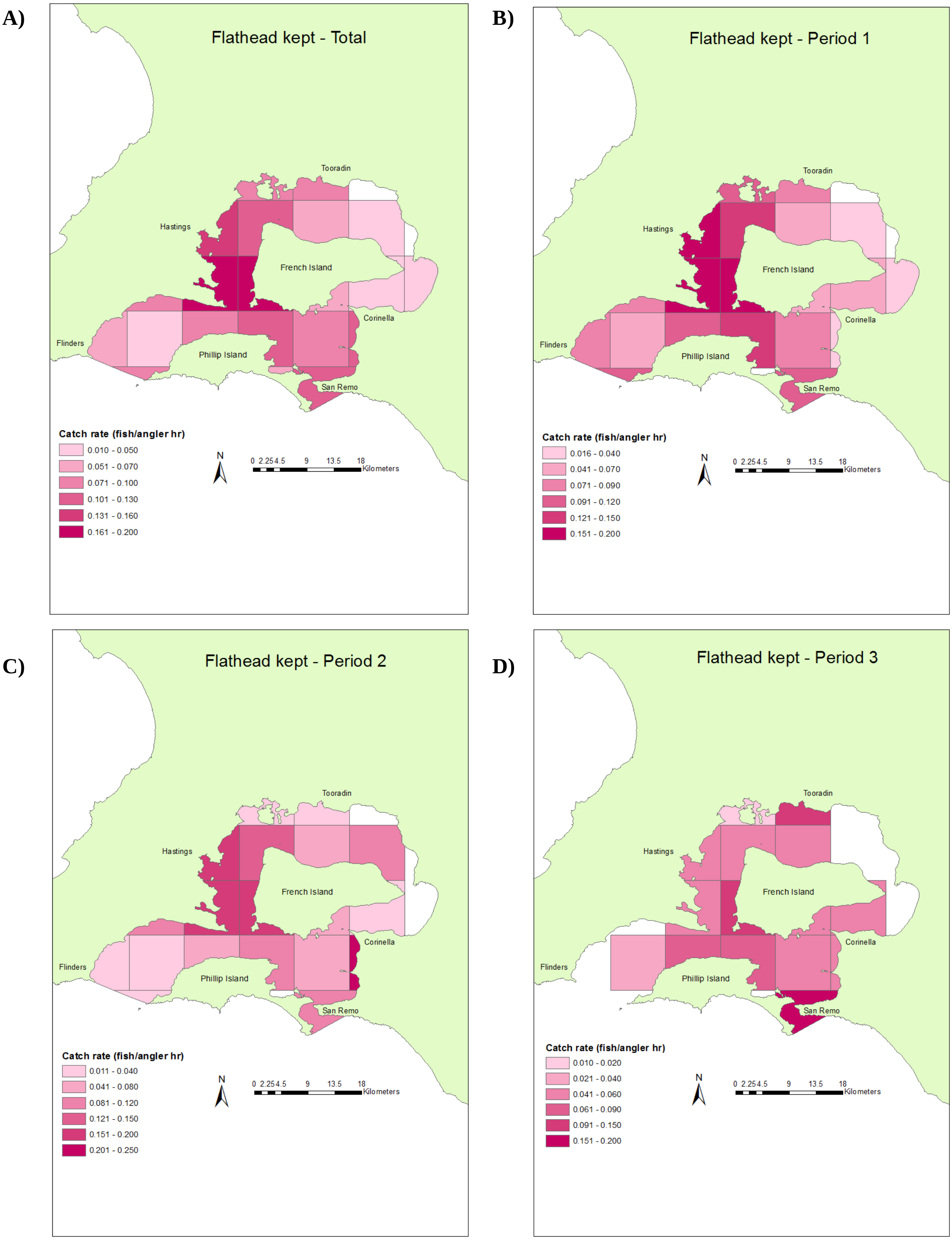
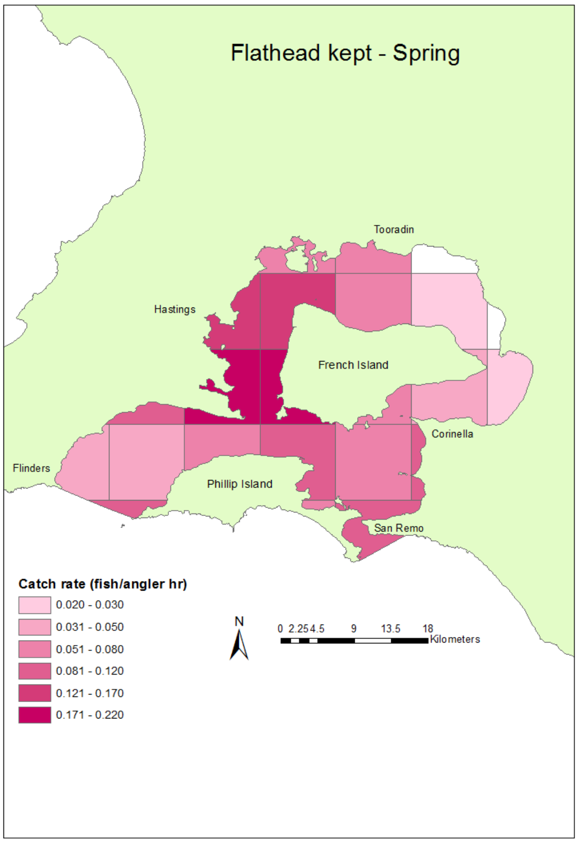
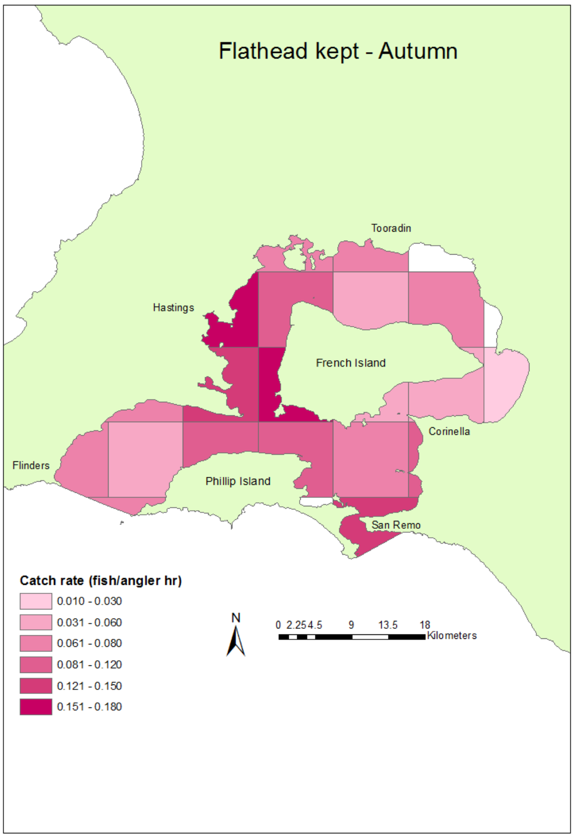


Figure 10. Catch rate of Flathead: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

A)



B)



C)

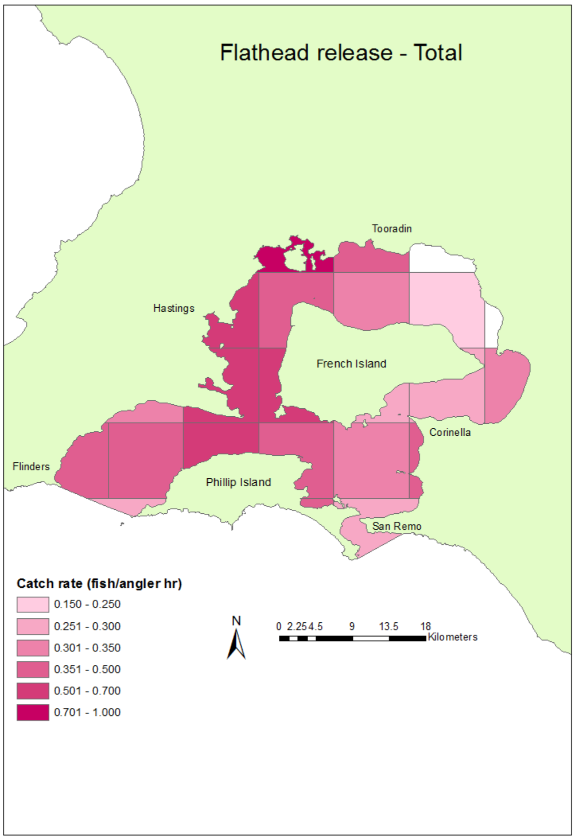


Figure 11. Catch rate of Flathead: (A) Spring, (B) Autumn, (C) Total released

Elephant Fish

The catch rate of kept Elephant Fish was highest in the Rhyll segment (Figure 12A). Areas of highest catch rates were similar for all three periods, with relatively high rates also recorded north-west of French Island in Period 1 (Figure 12B) north of Phillip Island in the Western Entrance Segment in Period 2 (Figure 12C), and restricted to the Rhyll Segment only in Period 3 (Figure 12D). Catch rates of released Elephant Fish (Figure 13A) were highest in the Rhyll Segment, reflecting the pattern for kept fish. Almost th e entire catch of Elephant Fish occurred in the autumn period. Areas of highest catch rates of released Elephant Fish for individual periods (Figure 13B-D) also reflected the patterns for kept fish.

Gummy Shark

Gummy Sharks were caught throughout Western Port with highest catch rates of kept fish in the Western Entrance Segment and also in the Upper North Arm near Tooradin (Figure 14A). There was some variation in areas with highest catch rates over time, with catch rates in Period 1 reflecting the pattern for all data (Figure 14B), but in Period 2 catch rates were also high in the Rhyll and Corinella Segments (Figure 14C), and in Period 3 the Corinella Segment continued to be an area of high catch rate (Figure 14D). High catch rates of kept Gummy Sharks occurred in the Western Entrance Segment in both seasons, with high rates also in the Upper North Arm near Tooradin in spring (Figure 15A) and relatively higher catch rates in the Rhyll Segment in autumn (Figure 15B). The areas of highest catch rates for released Gummy Shark were slightly different to those for kept sharks (Figure 15C), with highest catch rates in the Rhyll Segment and in the north-west of the bay in catch cell A4 (Figure 5).

Southern Calamari

Catch rates of kept Calamari were highest in the western entrance near Flinders, on the western side of the Lower North Arm, and on the south-east coast of the Rhyll Segment (Figure 16A). The areas of highest catch rates in Periods 1 and 2 largely reflected those for the total data (Figure 16B,C) but in Period 3 there was no catch rate recorded in the western entrance near Flinders due to a lack of fishing effort, while there was a relative increase in the catch rate in the Corinella Segment (Figure 16D). There was little variation in the areas of highest catch rate between spring (Figure 17A) and autumn (Figure 17B).

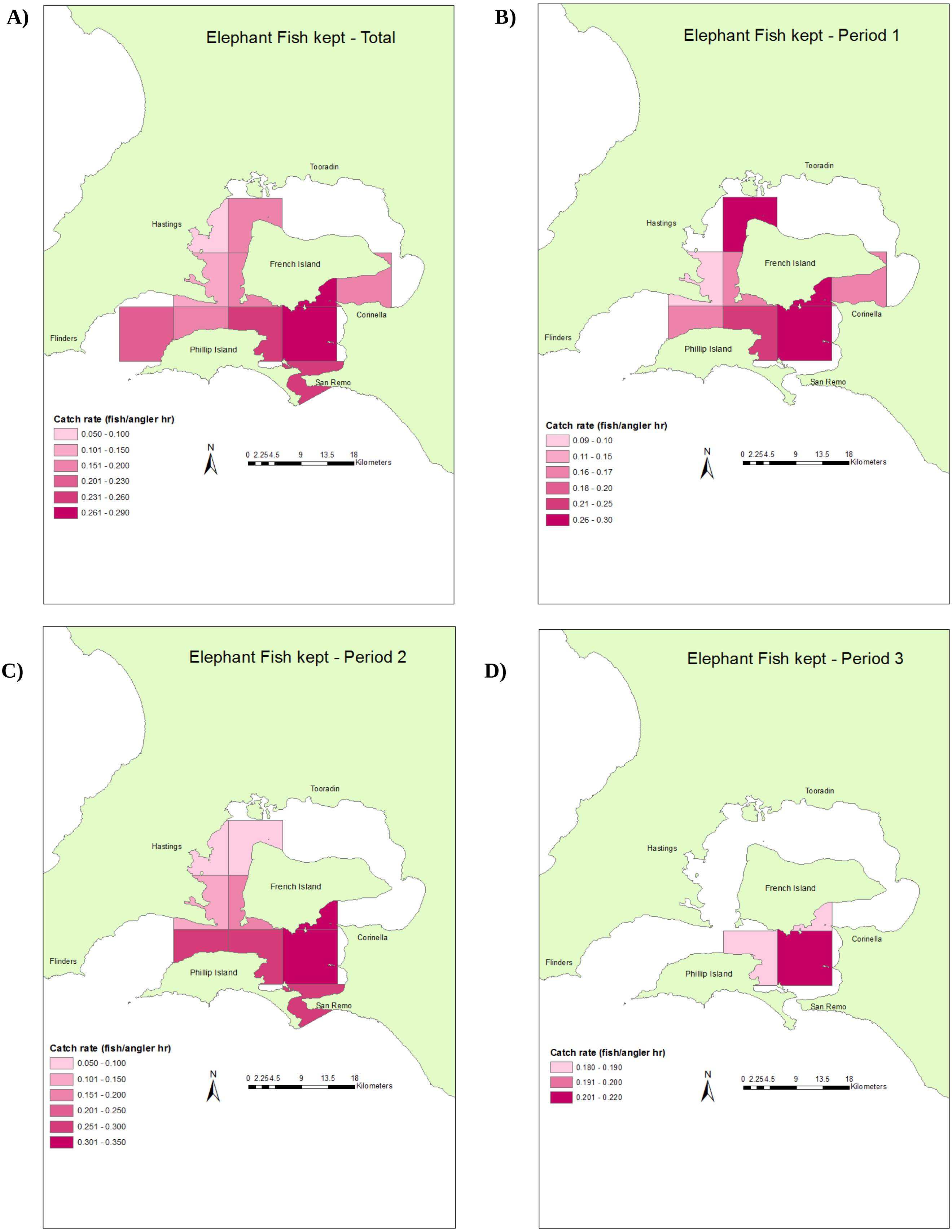


Figure 12. Catch rate of Elephant Fish: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

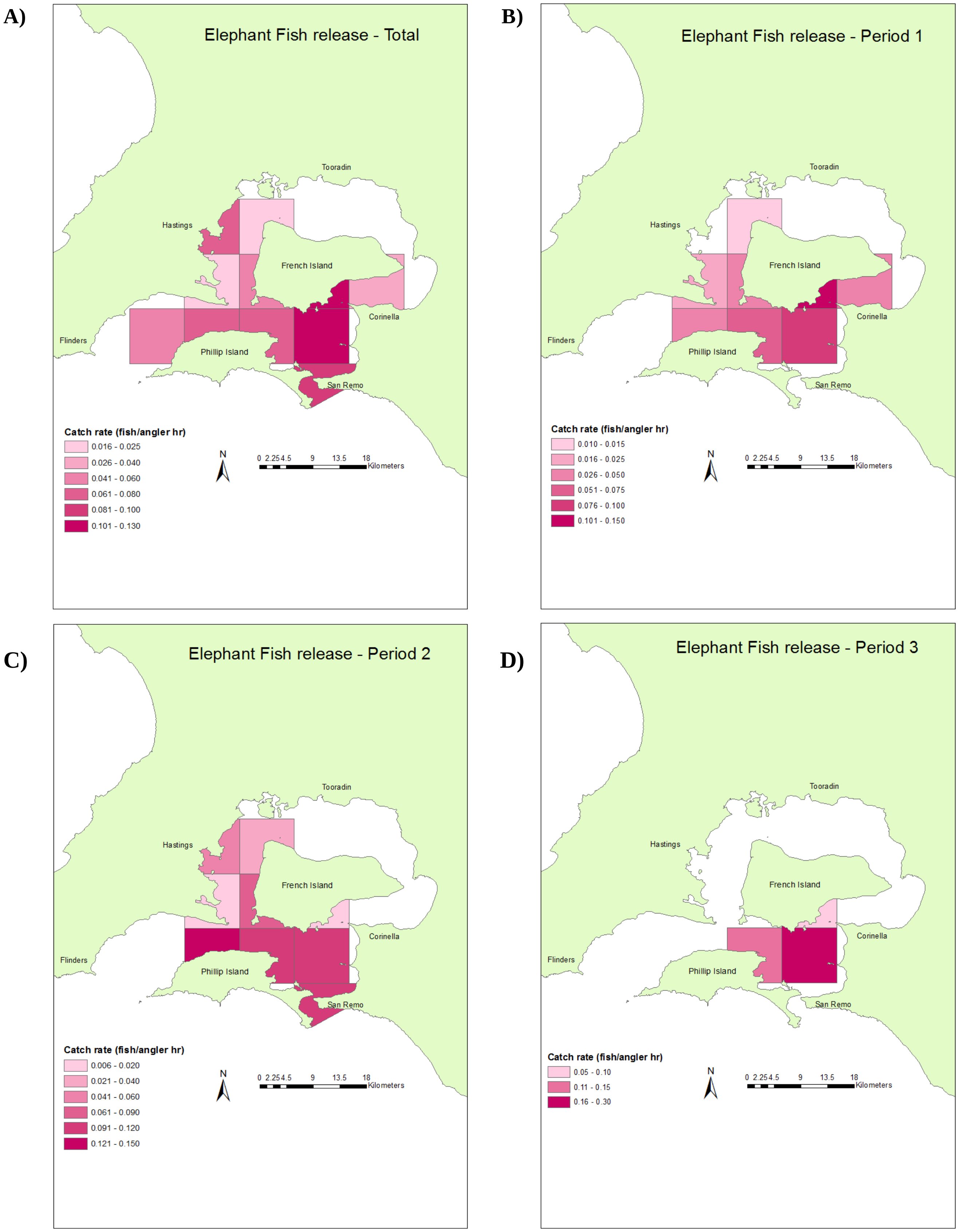


Figure 13. Catch rate of Elephant Fish released: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

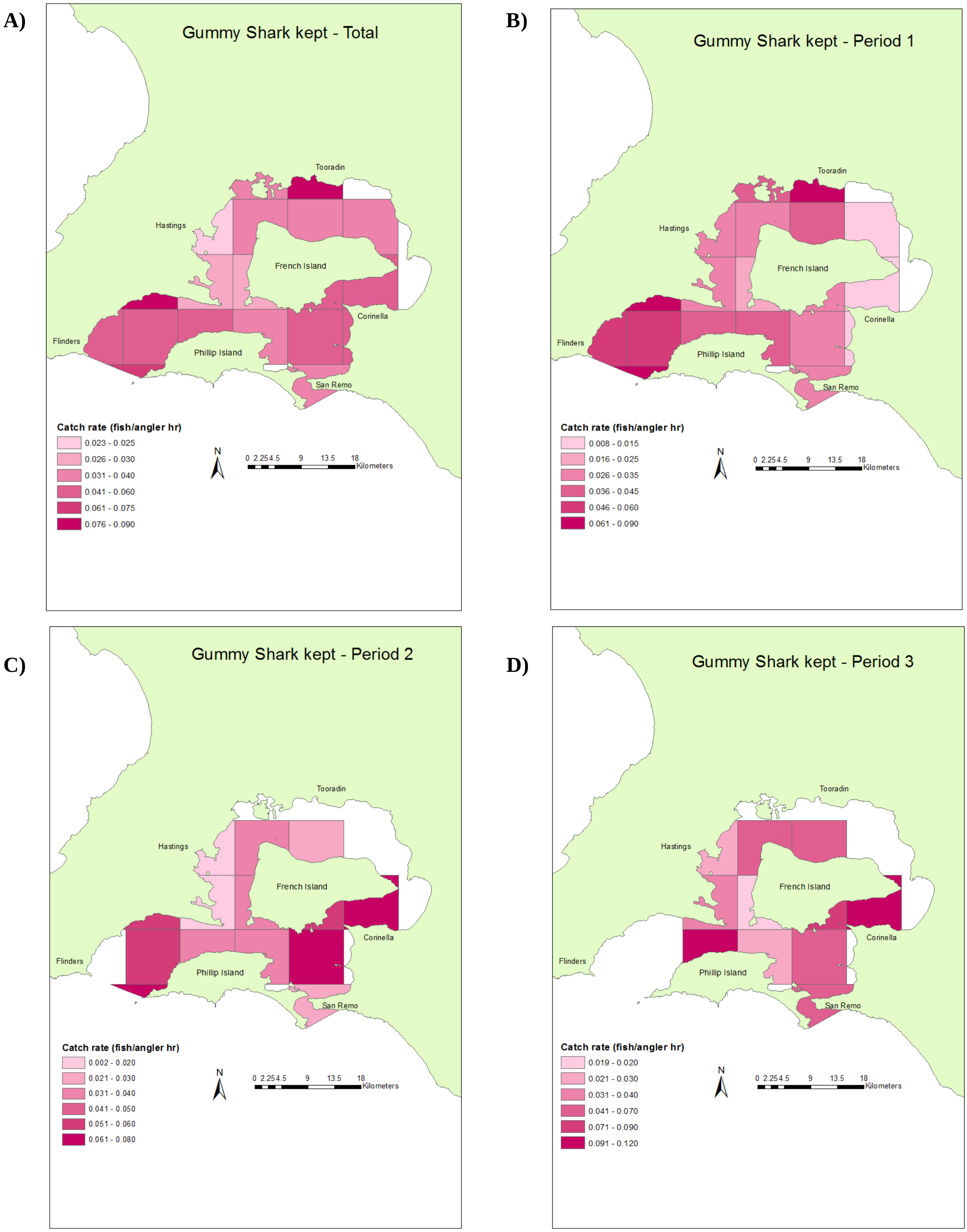


Figure 14. Catch rate of Gummy Shark: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

A)

B)

C)

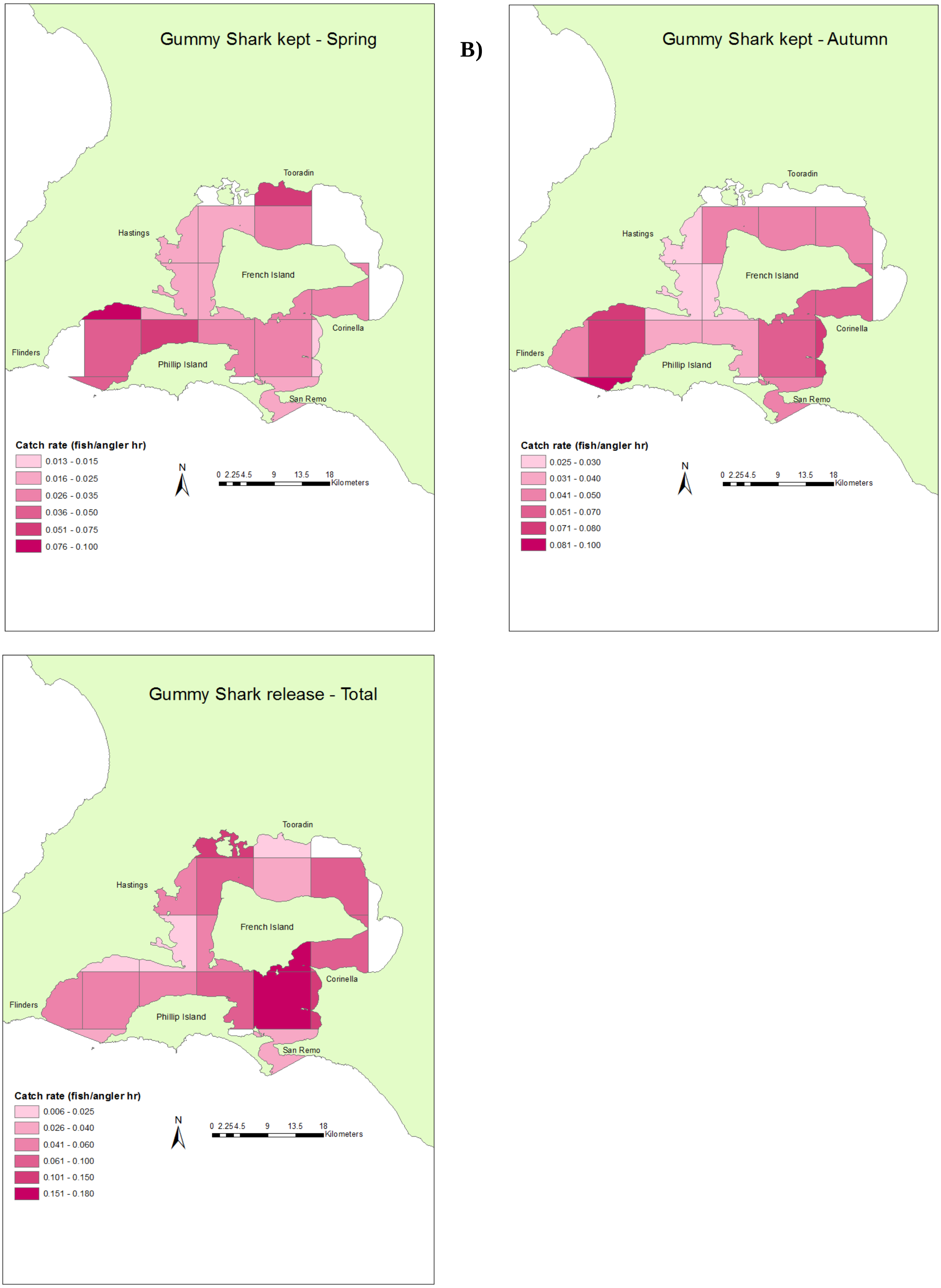


Figure 15. Catch rate of Gummy Shark: (A) Spring, (B) Autumn, (C) Total released

A) B) C) D)

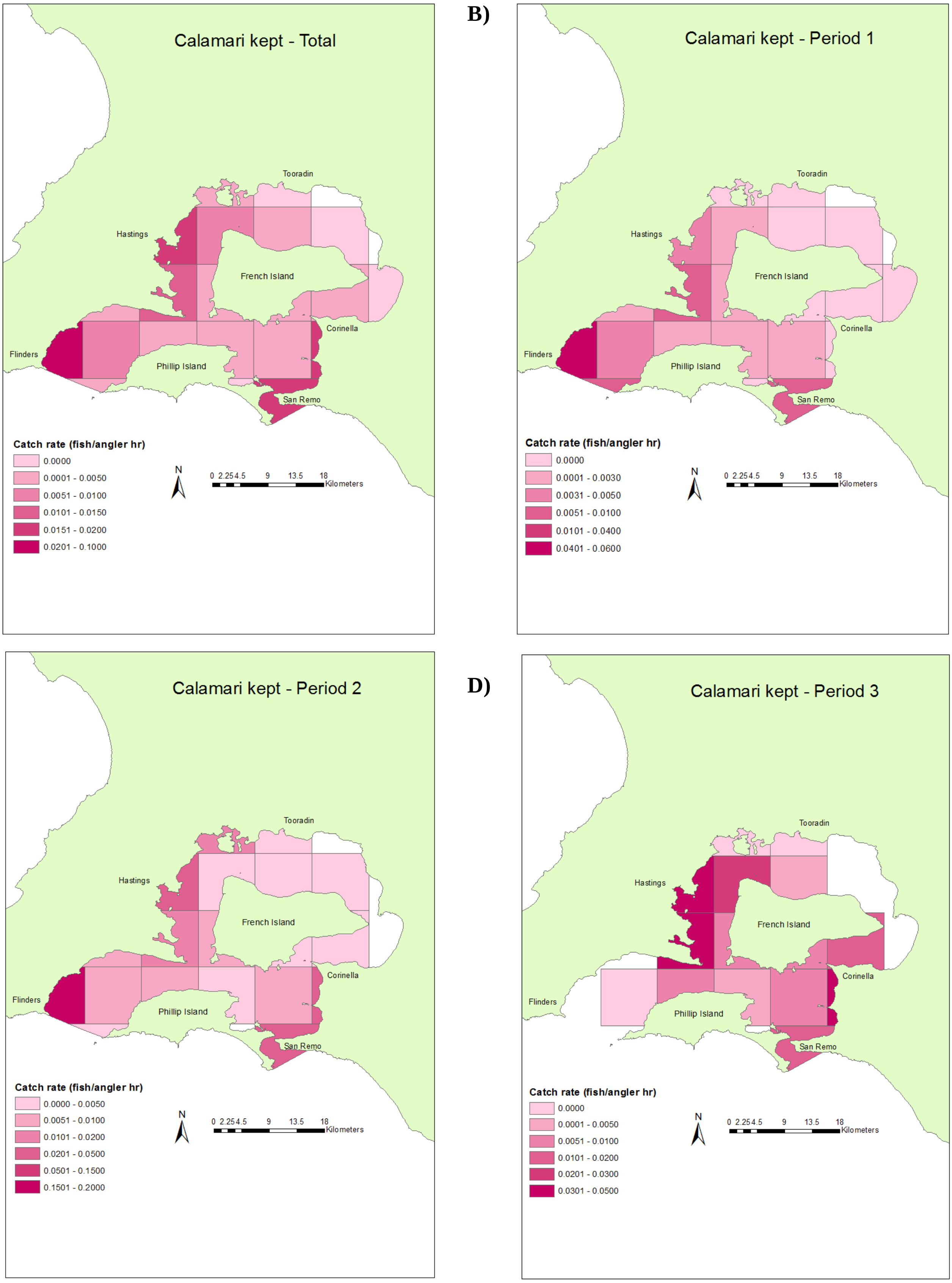


Figure 16. Catch rate of Calamari: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

A) B)

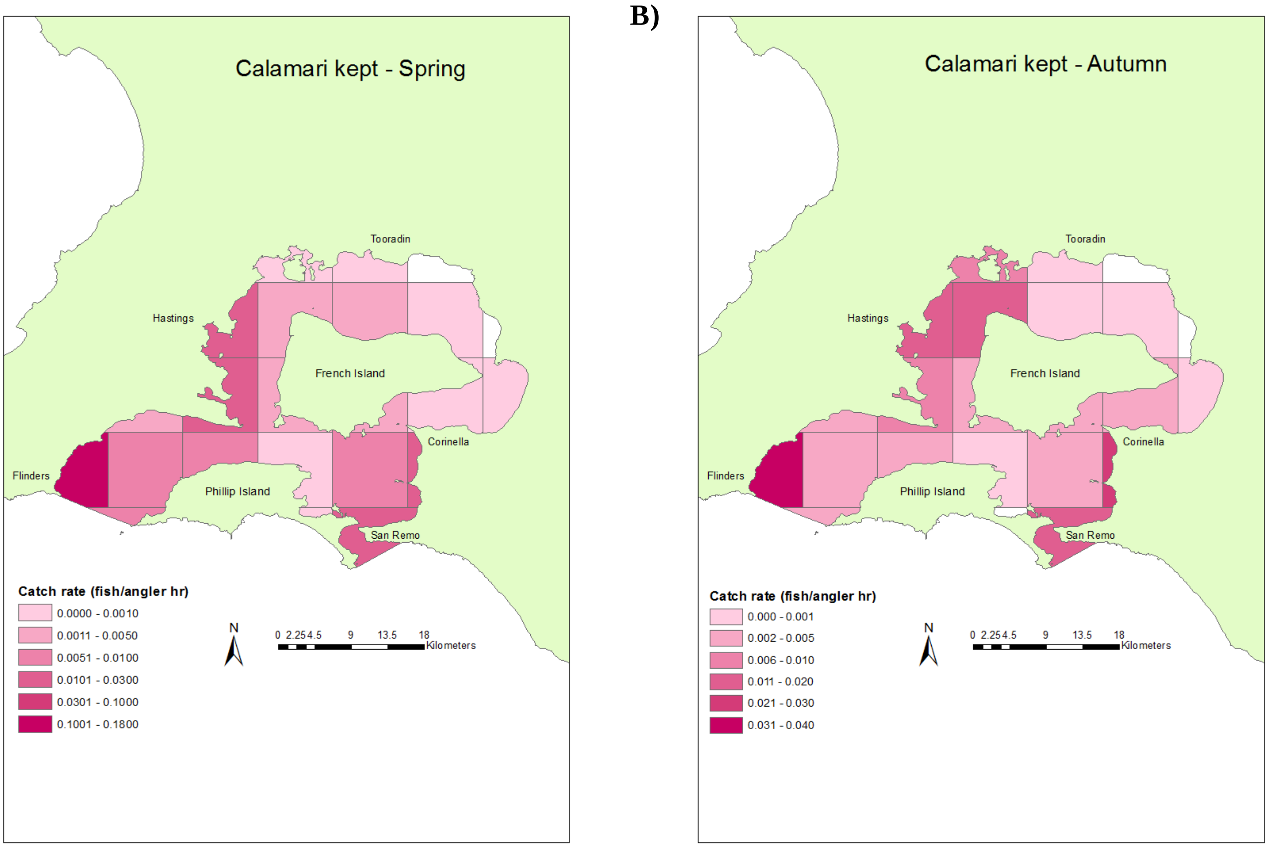


Figure 17. Catch rate of Calamari: (A) Spring, (B) Autumn

Australian Salmon

Salmon were caught throughout Western Port with highest catch rates of kept fish in the Rhyll Segment (Figure 18A). Areas of highest catch rates were broadly similar for all three periods, with relatively high rates in the Lower North Arm in Period 1 (Figure 18B), in the western entrance area near Phillip Island in Period 2 (Figure 18C), and in the Lower North Arm near Hastings in Period 3 (Figure 18D). Areas of highest catch rates varied seasonally with highest rates in spring in the Rhyll Segment and eastern entrance area (Figure 19A) but in autumn there were relatively high catch rates in the western entrance area near Phillip Island and also in the Upper North Arm north of French Island (Figure 19B). Areas with highest catch rate of released Australian Salmon were different to kept fish, with highest rates in the Corinella Segment and the eastern section of the Upper North Arm (Figure 19C), as well as in the north-west of the bay in catch cell A4 (Figure 5).

Southern Sea Garfish

Garfish were caught throughout Western Port with highest catch rates of kept fish in the Rhyll Segment, and relatively high rates in the western entrance near Flinders and the area to the north-west of French Island between Hastings and Tooradin (Figure 20A). Catch rates were high in the Rhyll segment in all periods, with relatively high catch rates also in the western entrance near Flinders in Period 1 (Figure 20B), in the Upper North Arm near Hastings and the north coast of the Western Entrance Segment in Period 2 (Figure 20C), and in the Upper North Arm near Tooradin in Period 3 (Figure 20D). The Rhyll Segment also had the highest catch rates in both seasons, with relatively high catch rates also in the Corinella Segment and the Upper North Arm near Tooradin in spring (Figure 21A), and in the western entrance near Flinders in autumn (Figure 21B).

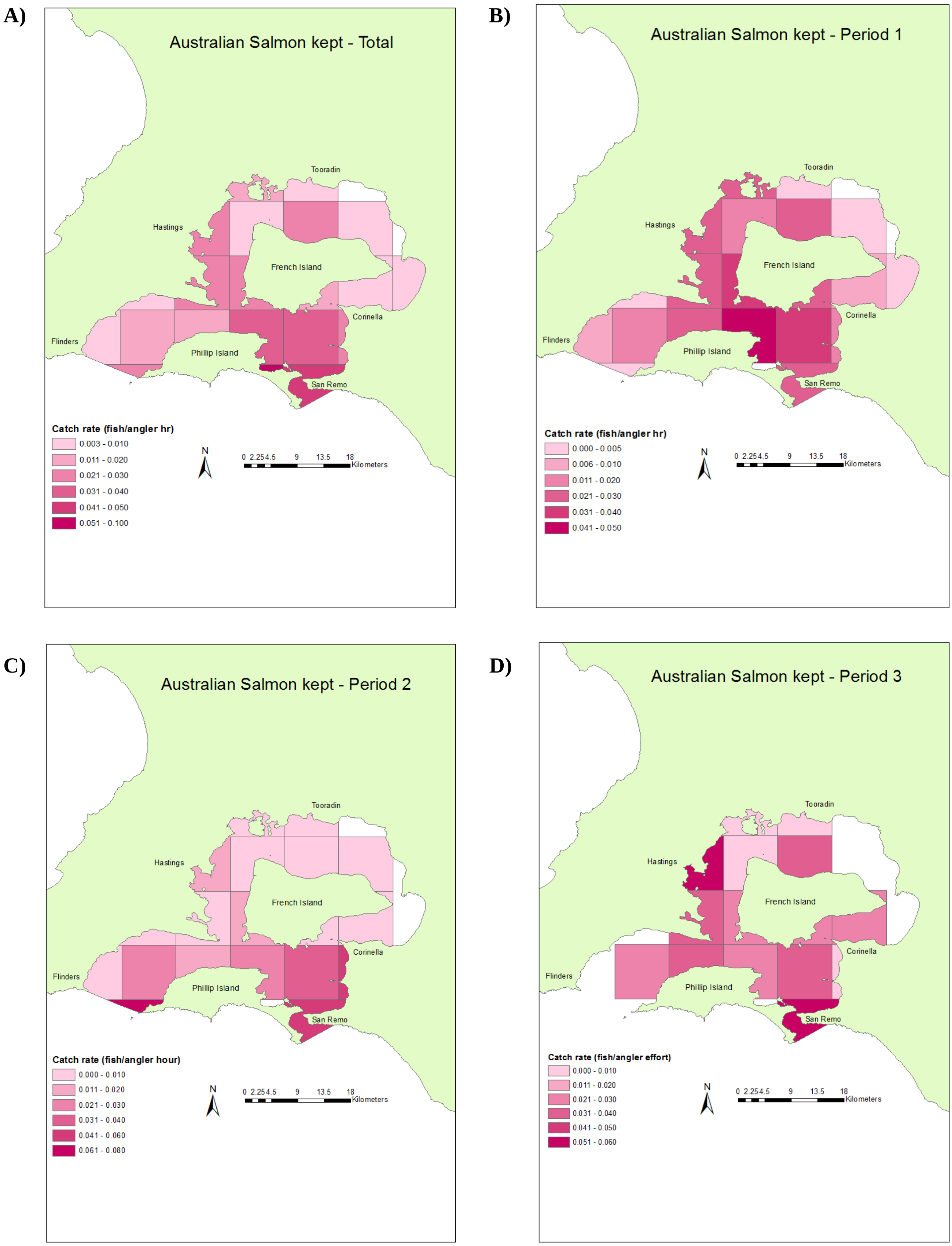
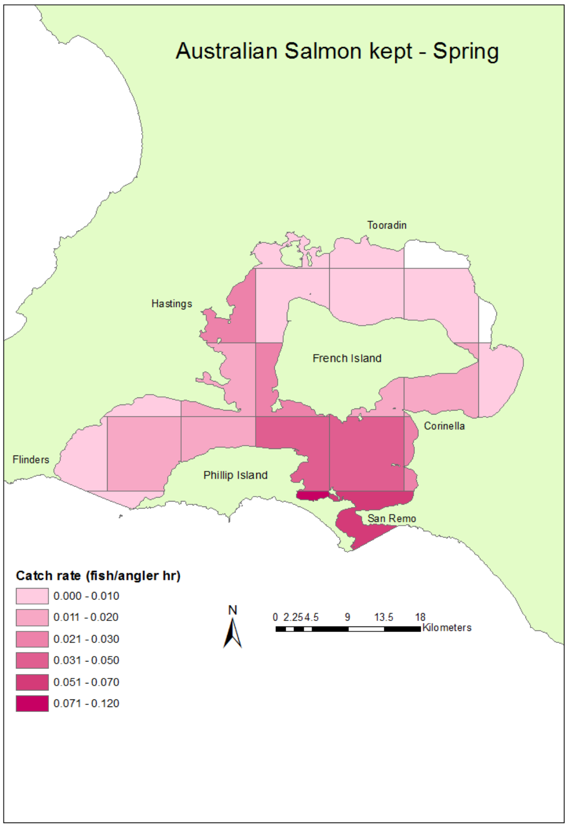
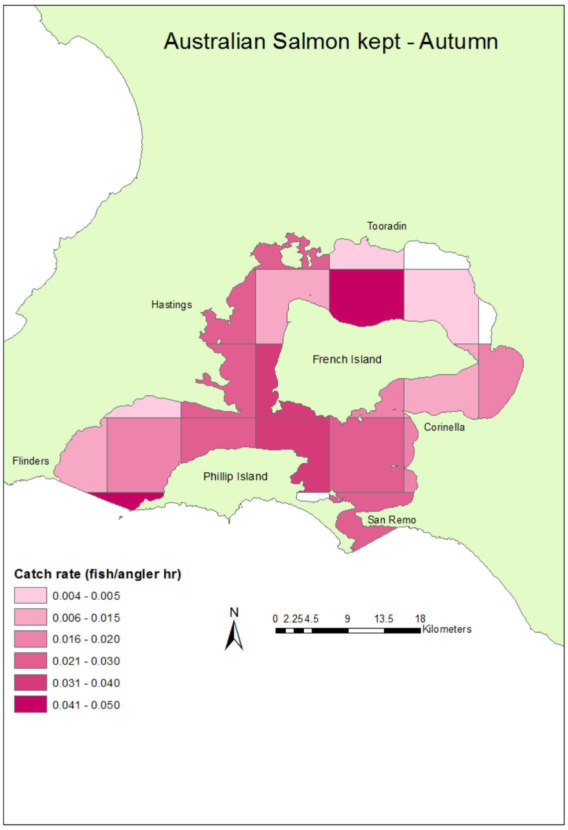


Figure 18. Catch rate of Australian Salmon: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

A)



B)



C)

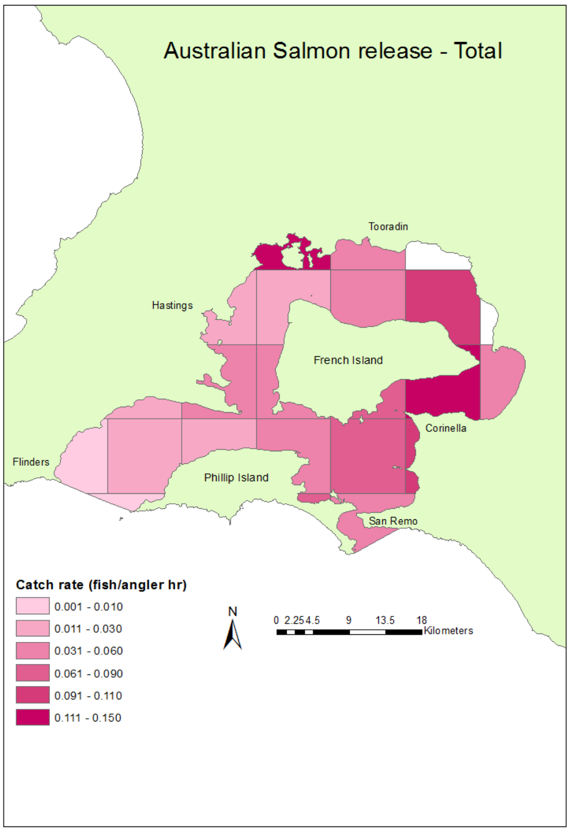


Figure 19. Catch rate of Australian Salmon: (A) Spring, (B) Autumn, (C) Total released

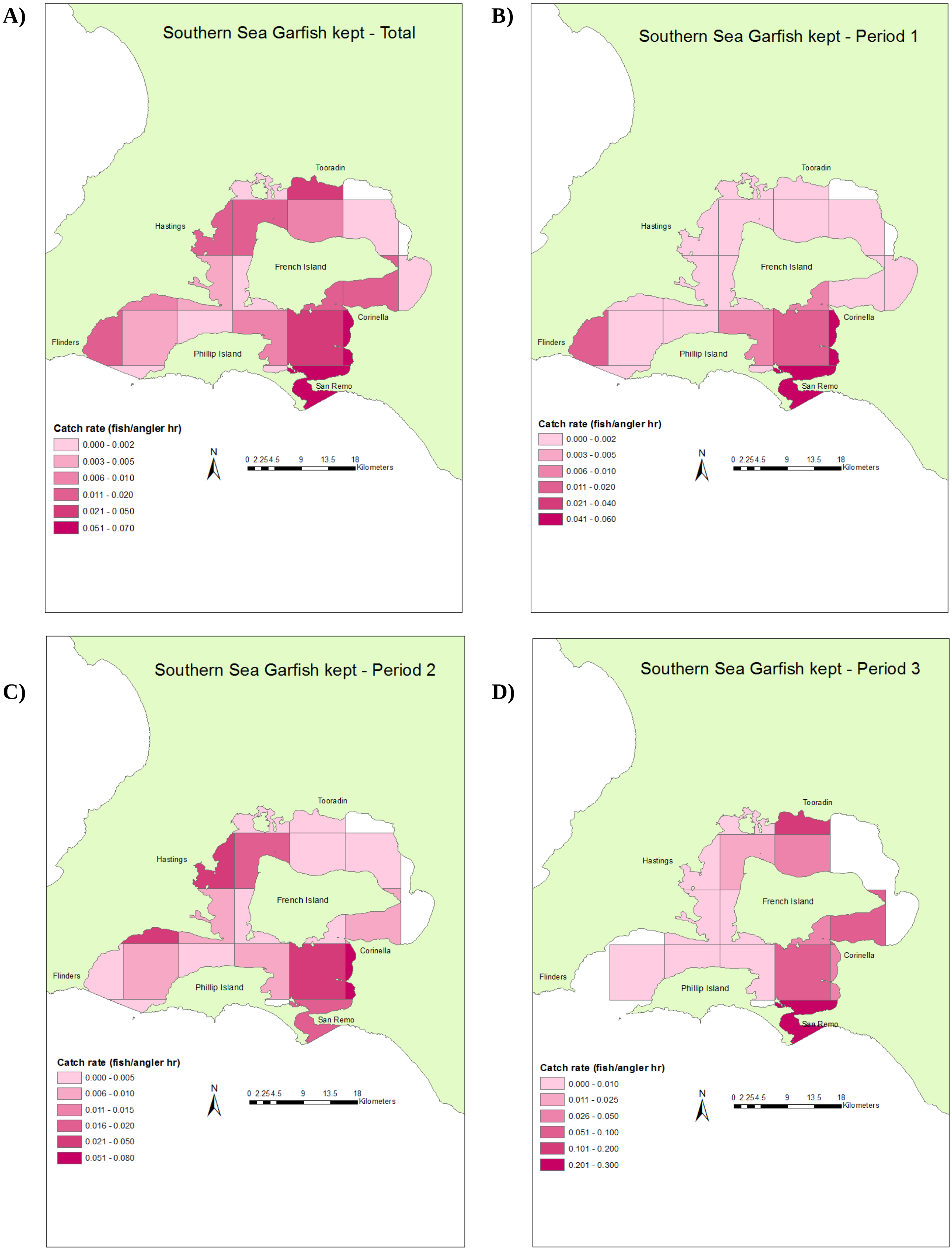


Figure 20. Catch rate of Southern Sea Garfish: (A) Total, (B) Period 1 (1998-2003), (C) Period 2 (2004-2008), (D) Period 3 (2009-2013)

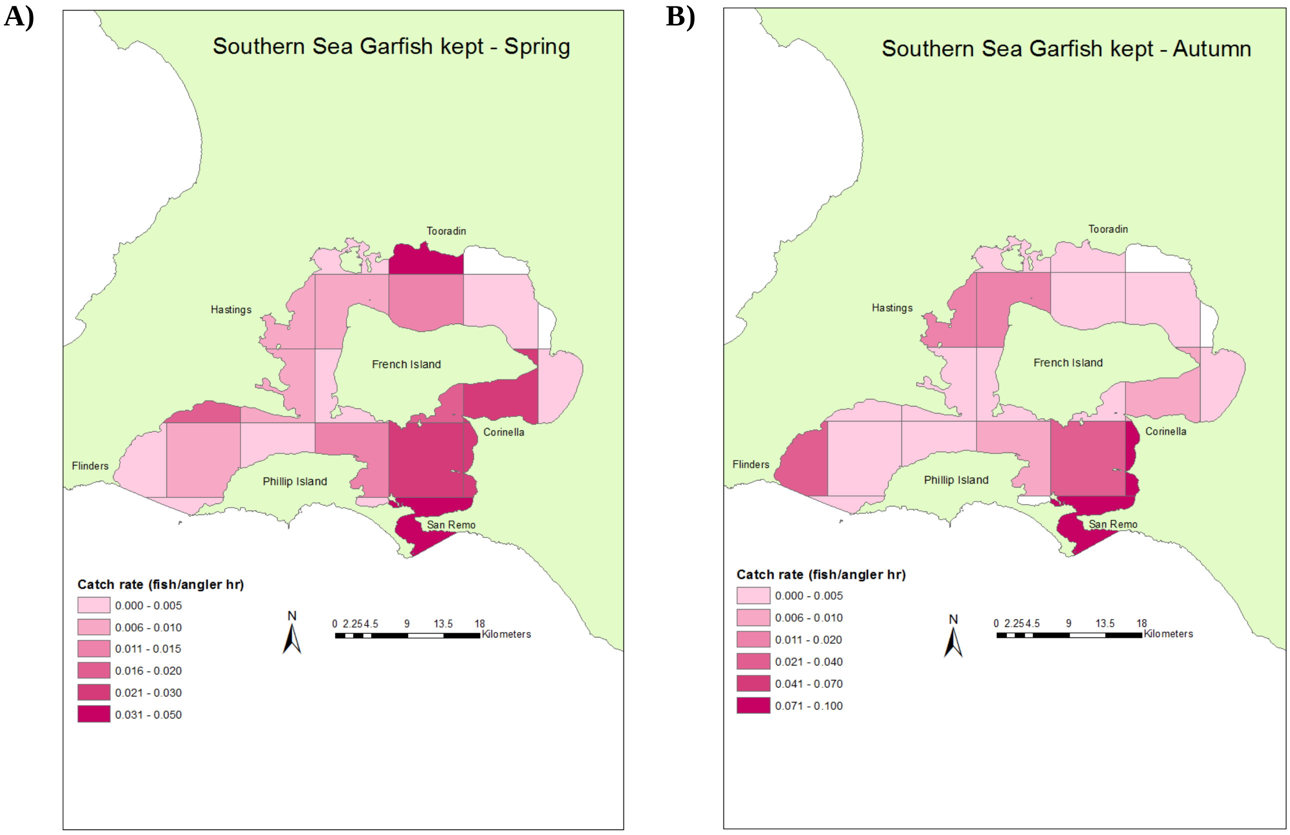


Figure 21. Catch rate of Southern Sea Garfish: (A) Spring, (B) Autumn

Annual Catch Rates from Recreational Creel Survey

King George Whiting

The catch rate of kept King George Whiting has been highly variable over the period of the survey with four distinct peaks in 1998/99, 2004/05, 2007/08 and 2011/12 (Figure 22). In the longer term there has been an increasing trend in catch rate since 2000/01 rising from approximately 0.2 to 0.8 fish/angler hr but across the whole survey the catch rate was relatively stable (Figure 22). The catch rate of released Whiting was also highly variable with four peaks (Figure 23); these aligned with the peaks in kept catch rates with the exception of the 2010/11 peak which preceded the fourth peak in the kept catch rate by one year. The long term trend in released Whiting catch rate was relatively stable (Figure 23). Like the pattern for kept Whiting in the creel survey, the commercial catch rate of King George Whiting in seine and mesh nets prior to the cessation of netting in 2008 also showed an increasing trend (after a stable period in the 1980's and early 1990's) with peaks in the late 1990's and in 2004/05 (Appendix A1).

Snapper

The catch rate of kept snapper has been variable over the period of the survey with an increase from the start of the survey to a peak of approximately 0.4 fish/angler hr in 2005/06 followed by a second peak in in 2007/08 (Figure 24). Since 2008/09 there has been a steadily rising trend in catch rate (Figure 24). The long-term trend for the survey period has been for increasing catch rate from approximately 0.05 to 0.25 fish/angler hr (Figure 24). The catch rate of released Snapper has also been highly variable with peaks in 2002/03, 2005/06 and 2010/11 (Figure 25). There has been a long term increase in catch rate of released snapper from essentially zero at the start of the survey to 0.2 – 0.4 fish/angler hr in the most recent years (Figure 25). Like the pattern for kept Snapper in the creel survey, the commercial catch rate of Snapper prior to the cessation of netting in 2008 also showed an increasing trend (after a declining period through the 1980's and 1990's) with a peak in the mid 2000's (Appendix A2).

Flathead

The catch rate of kept Flathead has been highly variable over the period of the survey with peaks in 1998/99, 2001/02, 2006/07 and 2010/11 (Figure 26). In the long term there has been a slightly decreasing trend in catch rate of kept flathead over the survey period (Figure 26). The catch rate of released Flathead has also been variable over the survey period with peaks in 1998/99, 2001/02 and 2005/06 (with a minor peak in 2009/10 and a recent upward trend) (Figure 27). The long-term trend in catch rate of released Flathead has been relatively stable (Figure 27). The main commercial fishing species of Flathead prior to the cessation of netting in 2008 was Rock Flathead. Like the pattern for kept Flathead in the creel survey, the commercial catch rate of Rock Flathead prior to the cessation of netting in 2008 showed a peak in the early to mid-2000's (after a decline in the early 1980's followed by a stable to increasing trend) (Appendix A3).

Elephant Fish

The catch rate of kept Elephant Fish has been variable, with low catch rates occurring in 2000/01, 2005/06 and 2010/11 (Figure 28). The result for 2005/06 should be treated with caution because it does not include information from the south-eastern boat ramps (see Methods). The long term trend is increasing to 2005/06 but then a decreasing trend in recent years, with an overall decreasing trend (Figure 28). The decreasing catch rate of kept Elephant Fish since 2007/08 may be partially attributable to the reduction in the daily bag limit from three to one in 2008. The catch rate of released Elephant Fish has shown variation mainly attributable to a sharp increase in catch rate in 2008/09 when the bag limit was reduced; however, the catch rate of released fish then quickly dropped off in the following years; albeit with an overall increasing trend for the whole survey (Figure 29). The long-term trend for combined kept and released fish was relatively stable over the survey period (Figure 30). Like the pattern for kept Elephant Fish in the creel survey, the commercial catch rate of Elephant Fish prior to the cessation of netting in 2008 also showed peaks in the late 1990's and the early to mid-2000's (after an increasing period through the 1980's and 1990's) (Appendix A4). In the commercial case, however, the peak in the late 1990's was higher than for the early to mid-2000's (Appendix A4).

Gummy Shark

The catch rate of kept Gummy Shark has been relatively stable over the survey period with the exception of an increase in 2009/10 and 2010/11 when rates more than doubled the previous level before returning to a similar level to earlier years in 2011/12 (Figure 31). The long-term trend in catch rates of kept Gummy Shark for the entire survey period can be considered stable (Figure 31). With the exception of 2005/06 where the data did not include south-eastern boat ramps, the catch rate of released Gummy Shark showed a relatively steady increase before plateauing between 2006/07 and 2010/11, and then showed a decline at the end of the survey to levels similar to early in the survey (Figure 32). This pattern was also apparent for the catch rate of combined kept and released sharks with an increasing trend over the survey period until a decline in 2011/12 to levels similar to the start of the survey (Figure 33). Like the pattern for kept Gummy Shark in the creel survey, the commercial catch rate of Gummy Shark prior to the cessation of netting in 2008 showed a marked increase from the mid 2000's (after an increasing period through the 1980's and stable period in the 1990's and early 2000's based on mesh net which was the main capture method) (Appendix A5).

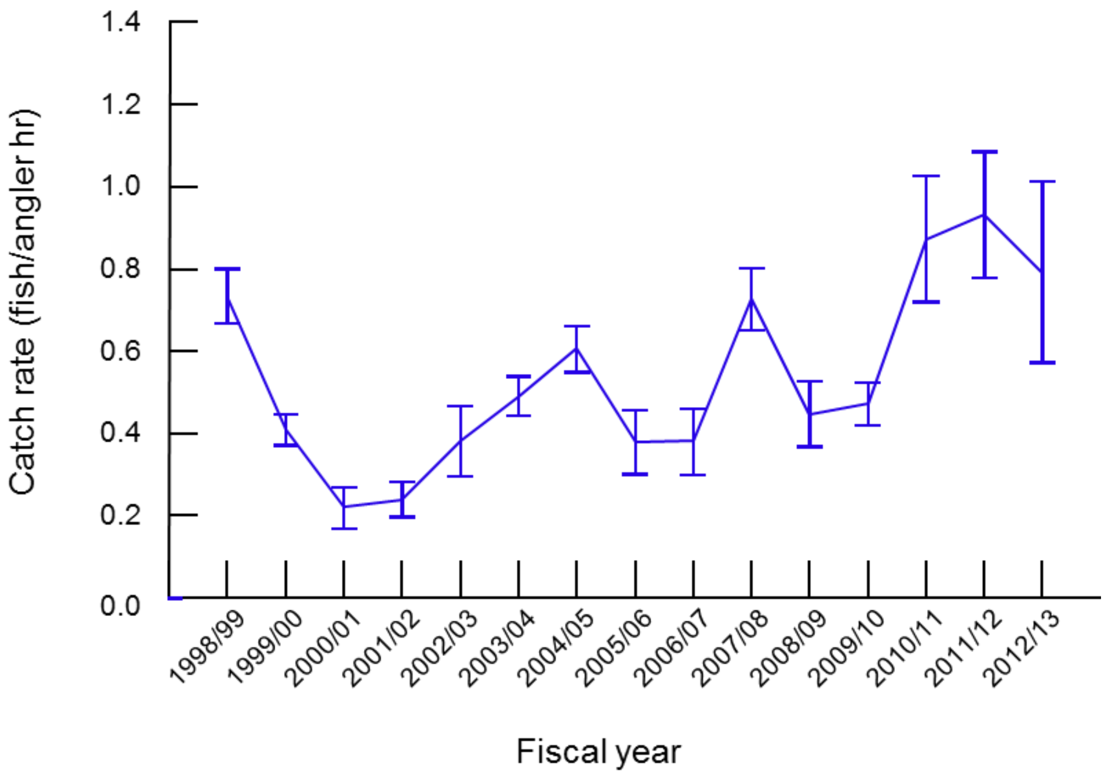


Figure 22. Catch rate of kept King George Whiting (targeted)

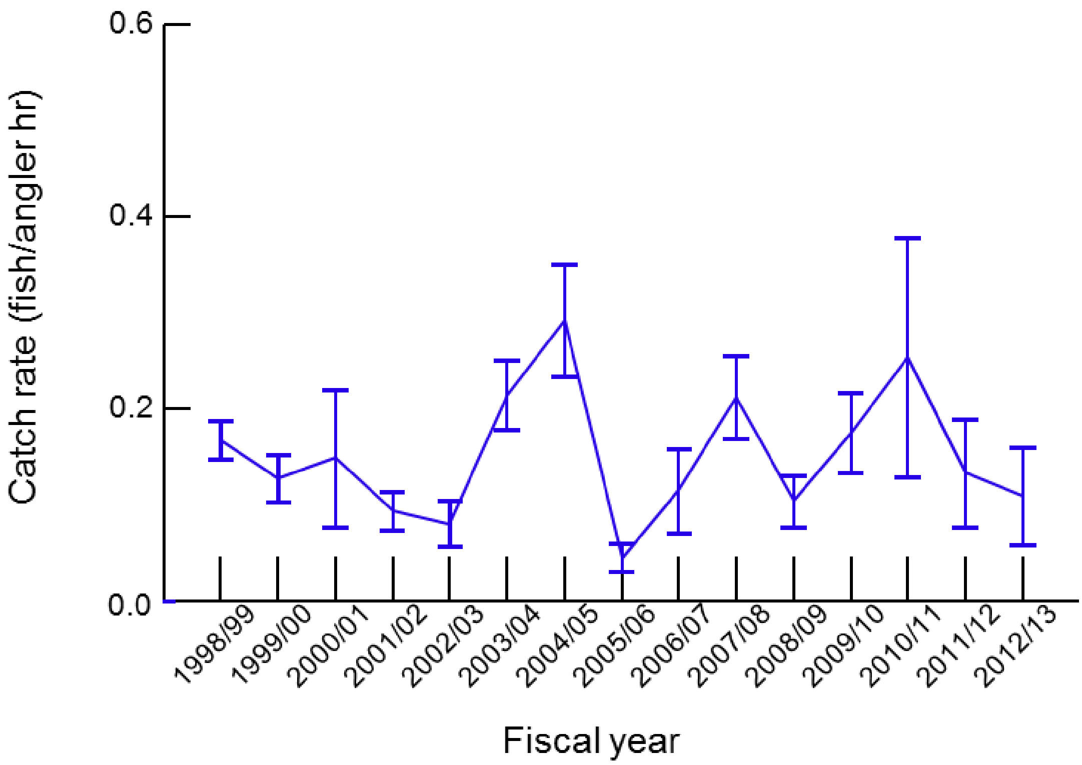


Figure 23. Catch rate of released King George Whiting (targeted)

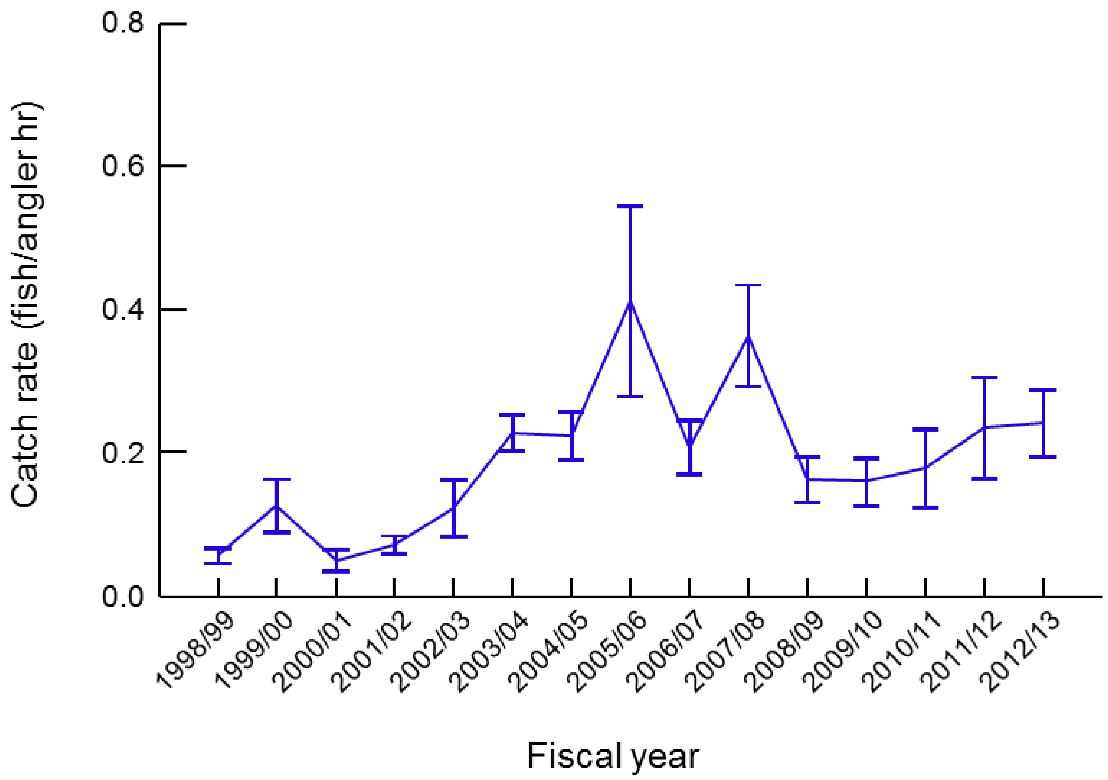


Figure 24. Catch rate of kept Snapper (targeted)

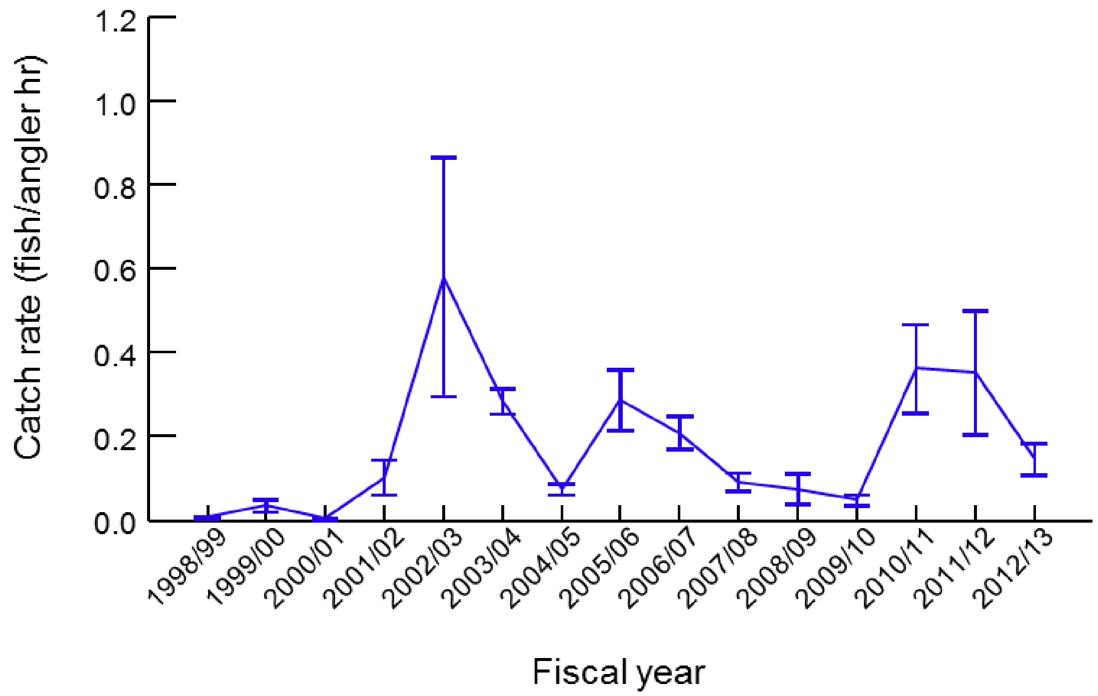


Figure 25. Catch rate of released Snapper (targeted)

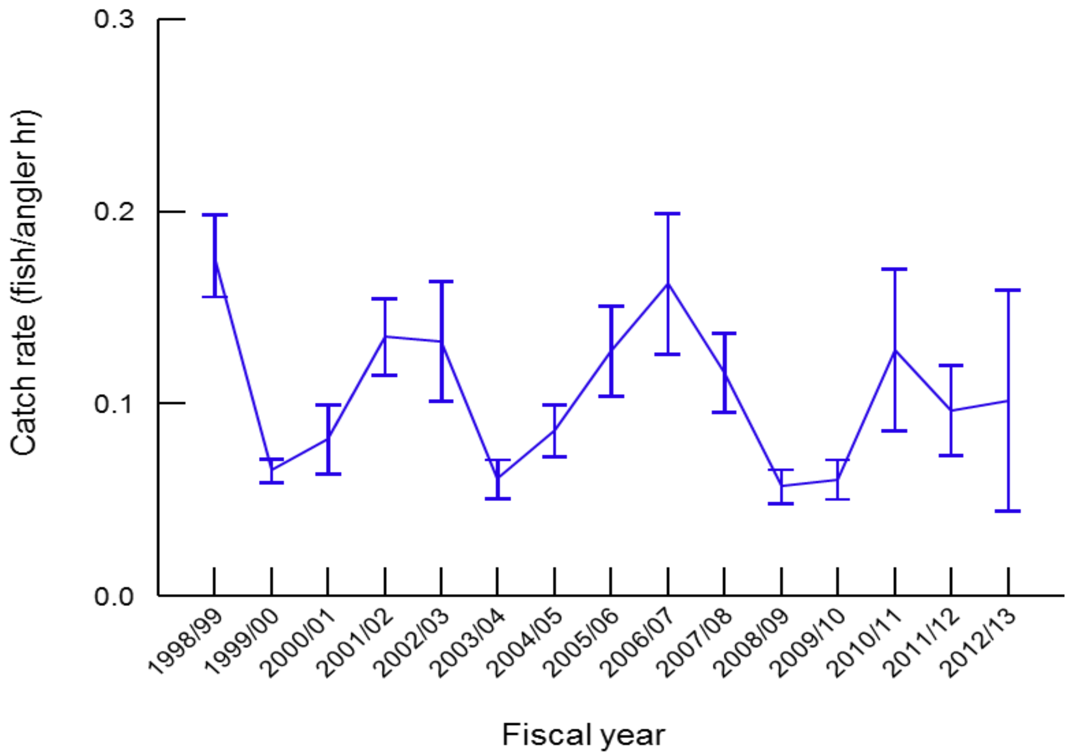


Figure 26. Catch rate of kept Flathead (non-targeted)

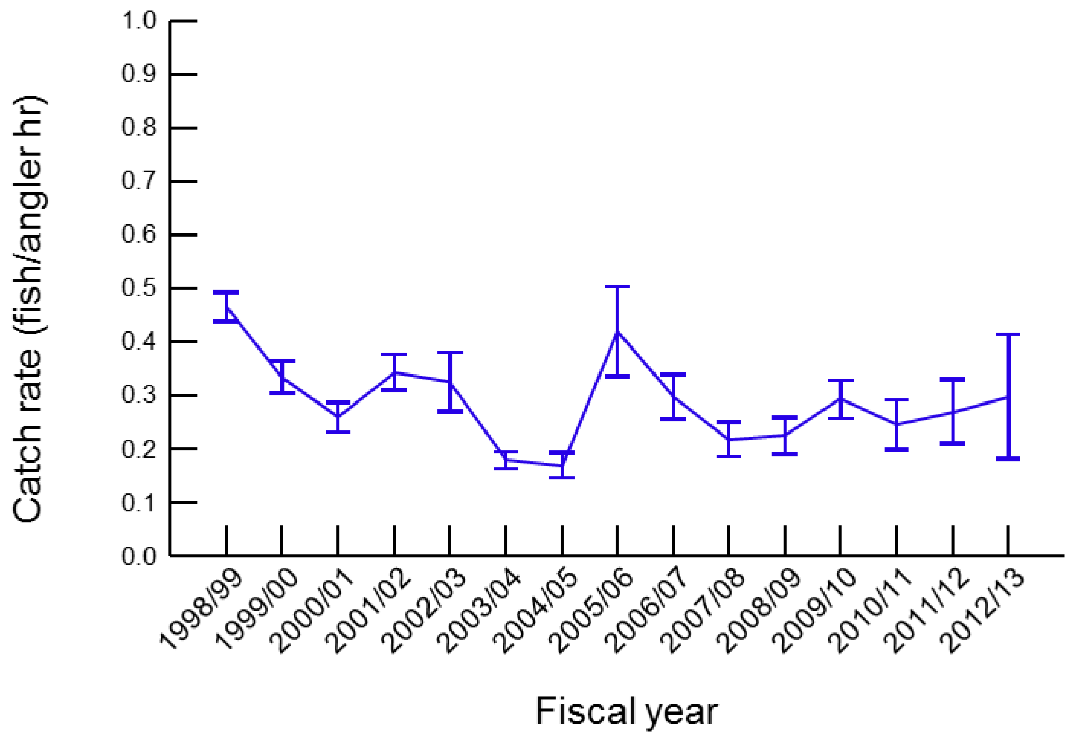


Figure 27. Catch rate of released Flathead (non-targeted)

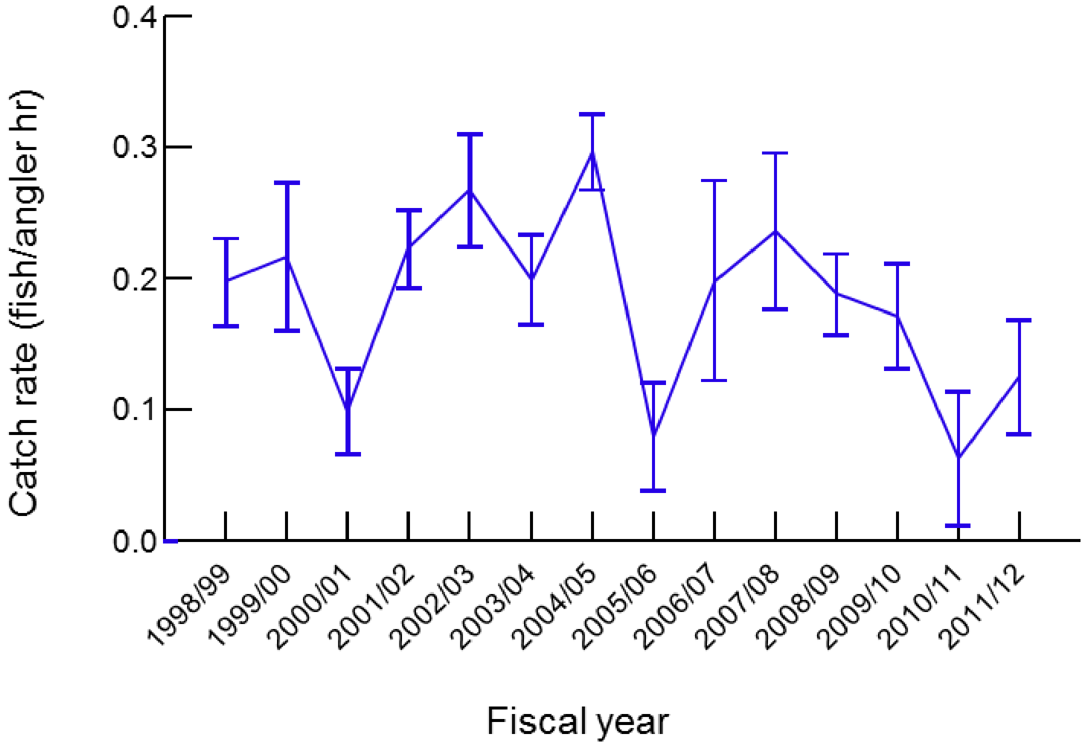


Figure 28. Catch rate of kept Elephant Fish (targeted)

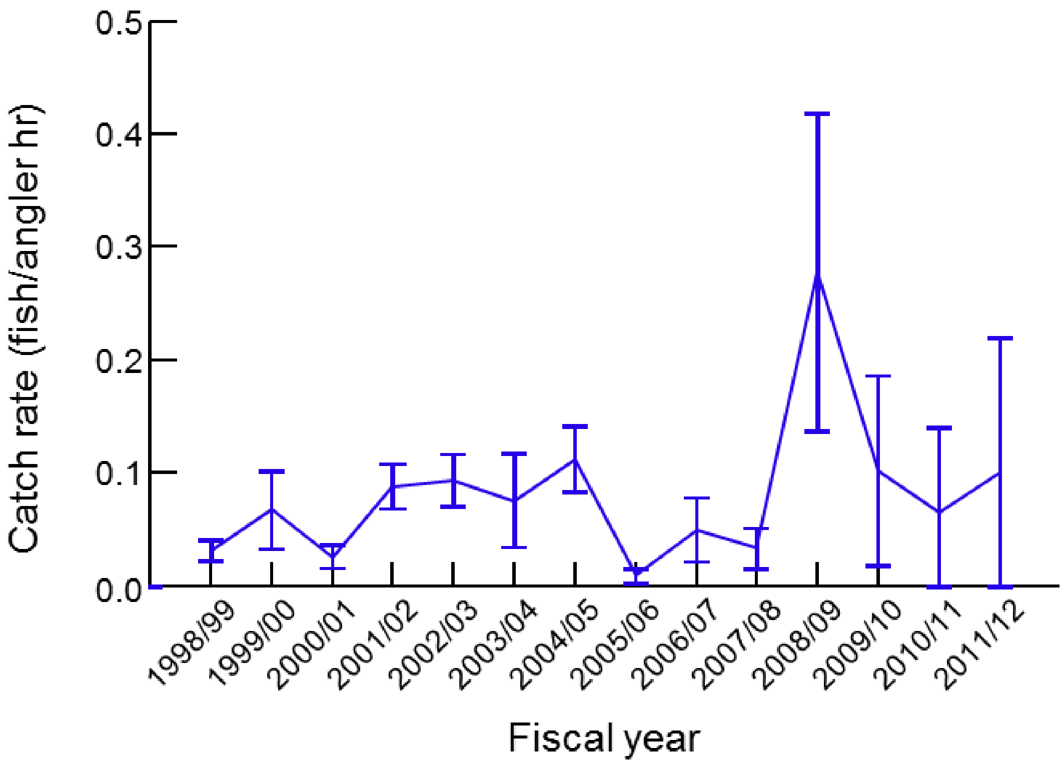


Figure 29. Catch rate of released Elephant Fish (targeted)

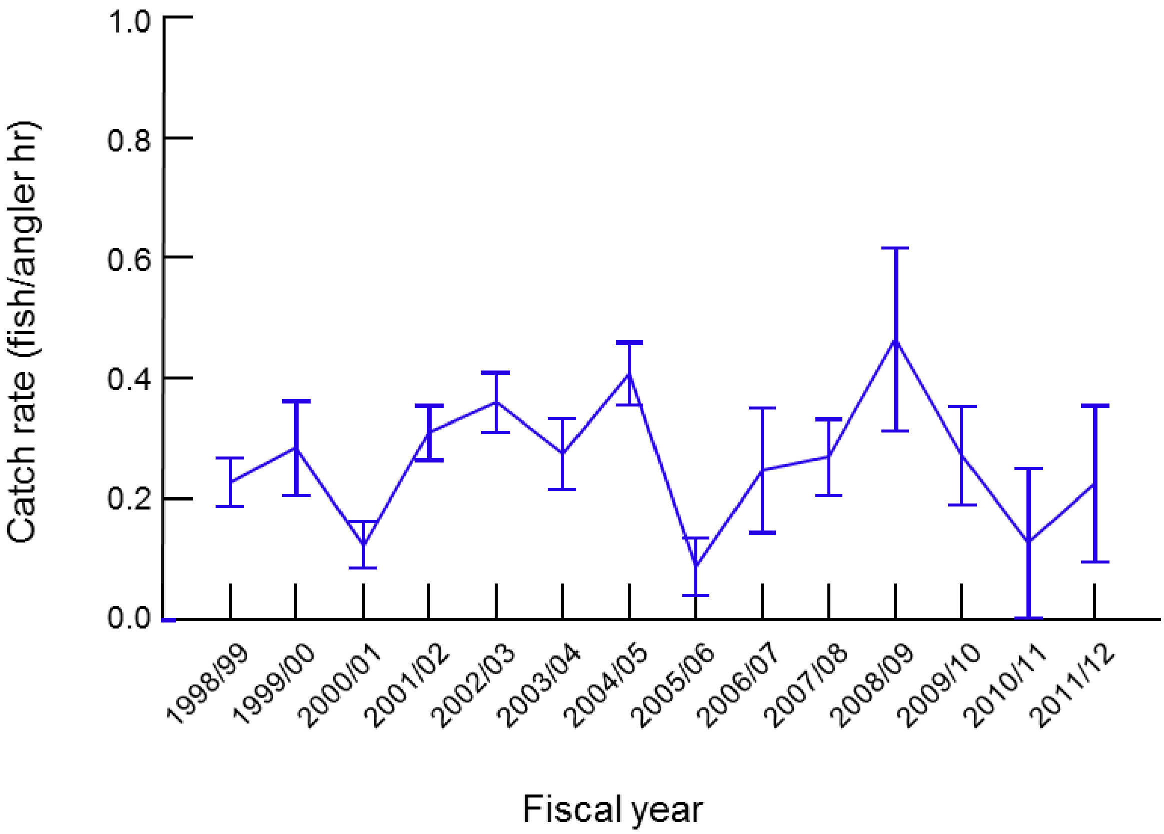


Figure 30. Catch rate of combined Elephant Fish (targeted)

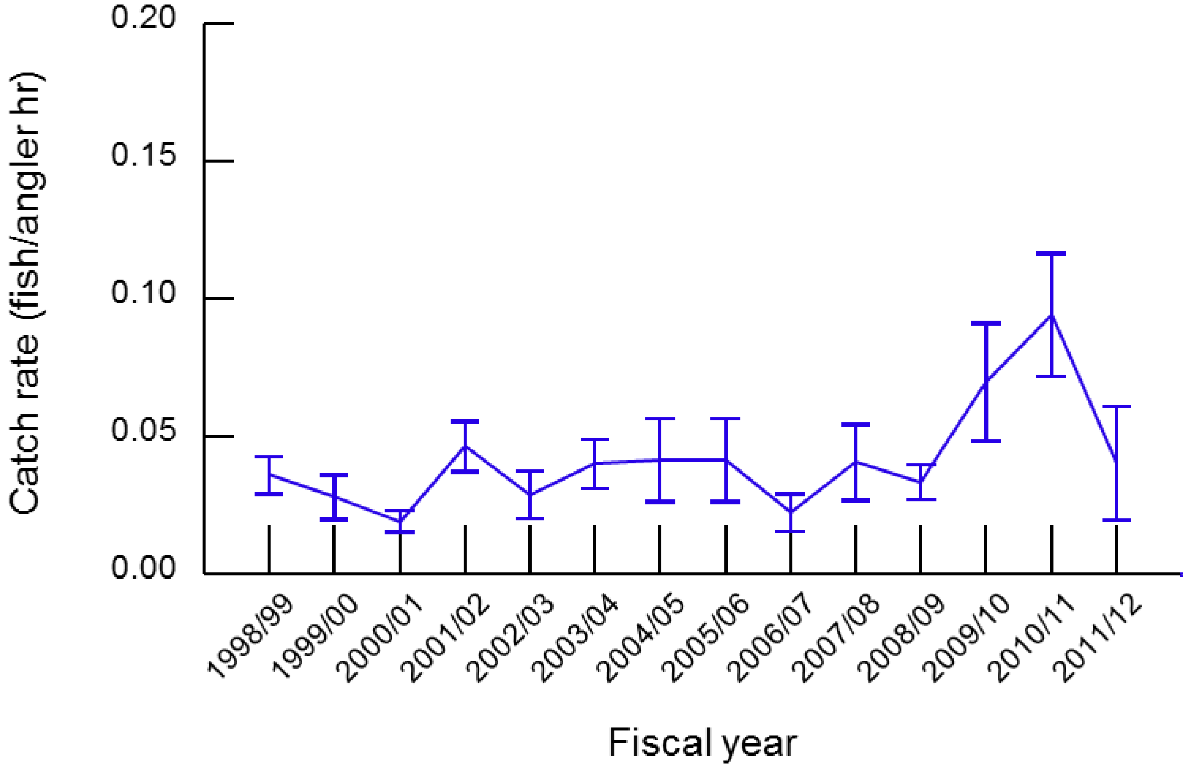


Figure 31. Catch rate of kept Gummy Shark (targeted)

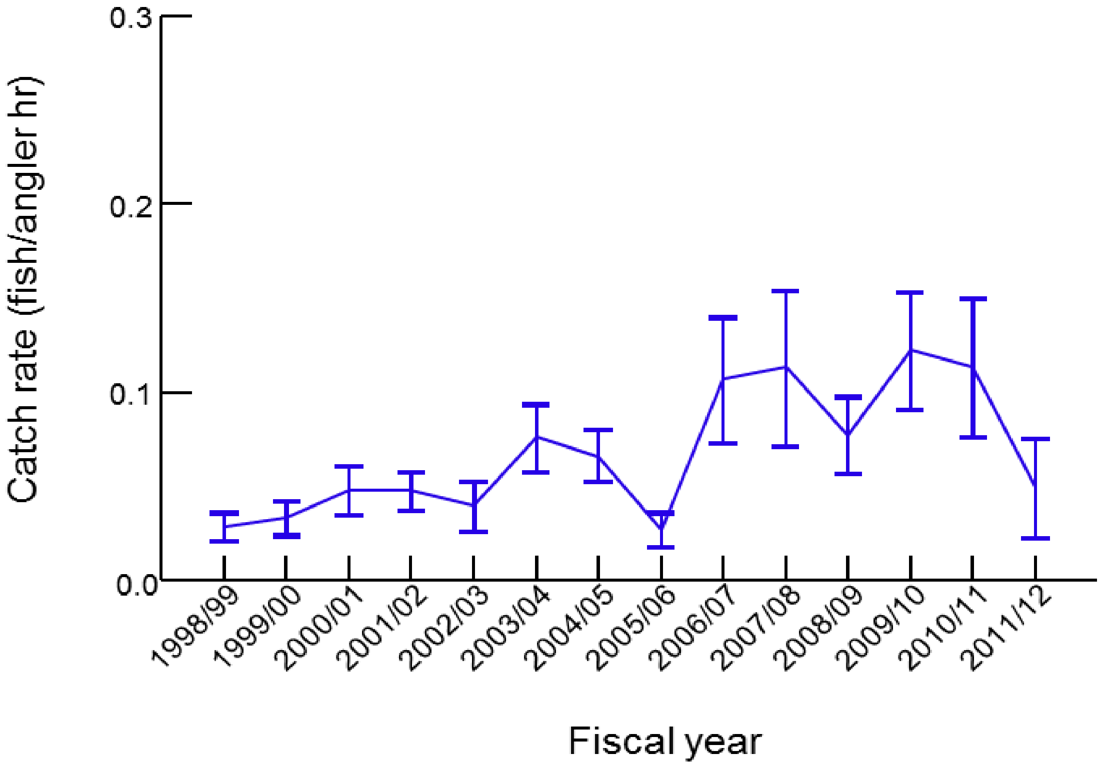


Figure 32. Catch rate of released Gummy Shark (targeted)

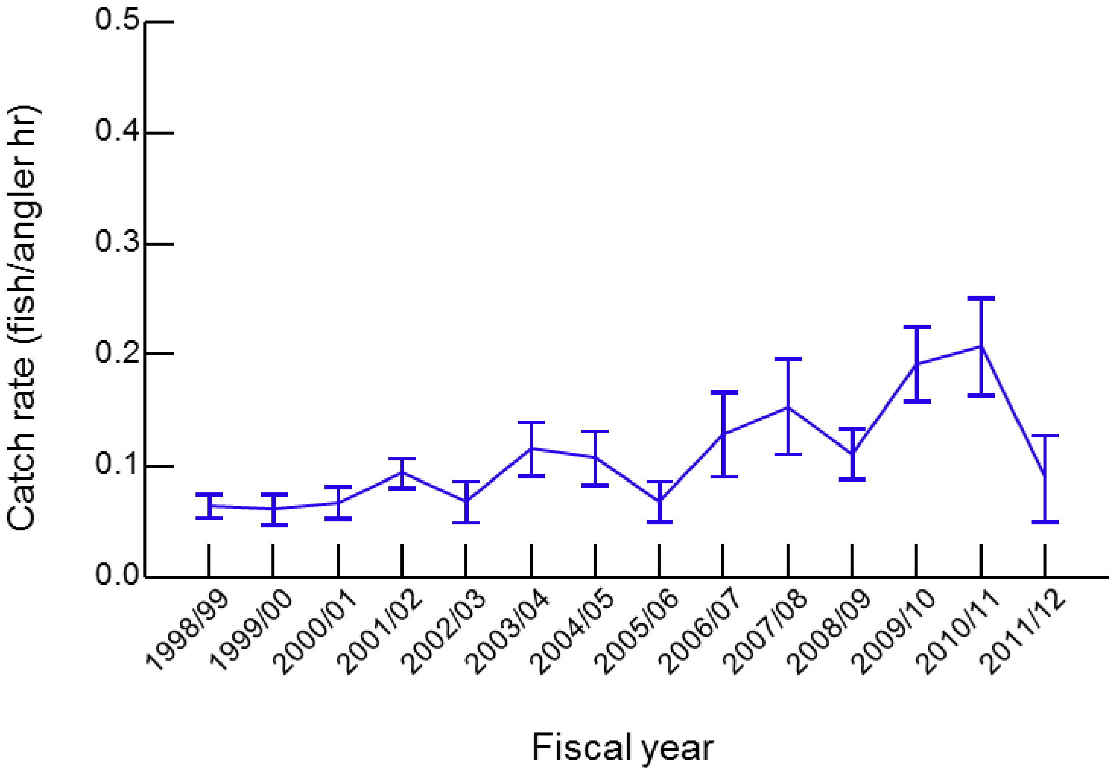


Figure 33. Catch rate of combined Gummy Shark (targeted)

Southern Calamari

The catch rate of kept Calamari showed an increase from the start of the survey until 2006/07 and then dropped sharply in 2007/08 followed by a slow increase to the end of the series (Figure 34). The long-term trend in catch rate was relatively stable (Figure 34). Large error bars occurred in some years due to low levels of targeting resulting in small sample sizes and/or occasional large catches (Figure 34). Like the pattern for kept Calamari in the creel survey, the commercial catch rate of Calamari prior to the cessation of netting in 2008 showed an increasing trend in the early to mid-2000's (after a stable period through the 1980's and an increasing trend from the mid 1990's) (Appendix A6).

Australian Salmon

The catch rate of Australian salmon showed variability across the survey with an initial increase to 2000/01 followed by a decline to 2006/07 and then increasing again to 2010/11 (Figure 35). The long-term trend in the catch rate for the entire survey period was relatively stable (Figure 35). Catch rate of released Australian Salmon showed a general decline from the start of the survey to 2006/07 (superimposed on significant interannual variability) and then increase to a peak in 2008/09 before dropping to an intermediate level at the end of the survey (Figure 36). Over the long-term there was a decreasing trend in catch rate for released Australian Salmon (Figure 36). Unlike the decline in Australian Salmon catch rate in the early to mid-2000's in the creel survey, the commercial catch rate of Australian Salmon prior to the cessation of netting in 2008 was stable but highly variable (after a declining period through the 1980's and stable period in the 1990's) (Appendix A7).

Southern Sea Garfish

The catch rate of Southern Sea Garfish was low and variable in the early part of the survey period before increasing to a peak in 2008/09 and then remaining relatively higher for the remainder of the survey period (Figure 37). The long term trend for the entire survey period was for increasing catch rate (Figure 37). The commercial catch rate of Garfish prior to the cessation of netting in 2008 was quite different to the catch rate in the creel survey, showing high catch rates in the late 1990's / early 2000's, and a secondary peak in 2006/07 (after a declining period through the 1980's and an increasing trend in the 1990's) (Appendix A8). The time series was affected by very low effort in the early to mid-2000's (zero effort in 2004/05) (Appendix A8).

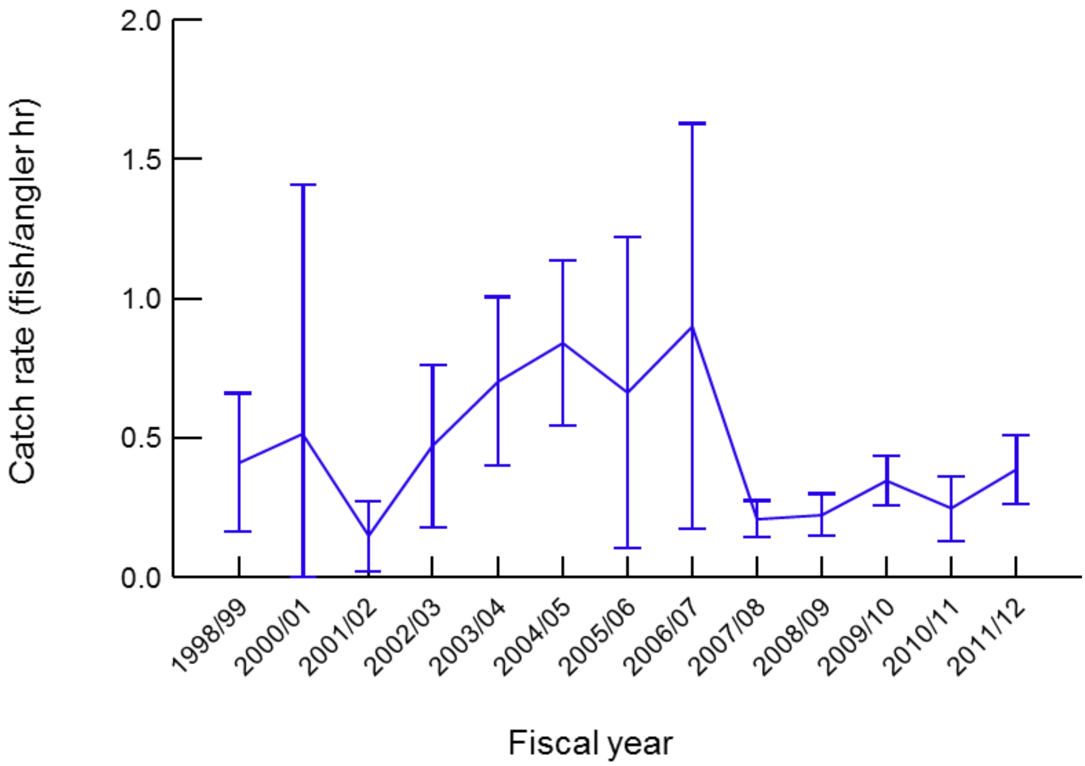


Figure 34. Catch rate of kept Southern Calamari (targeted)

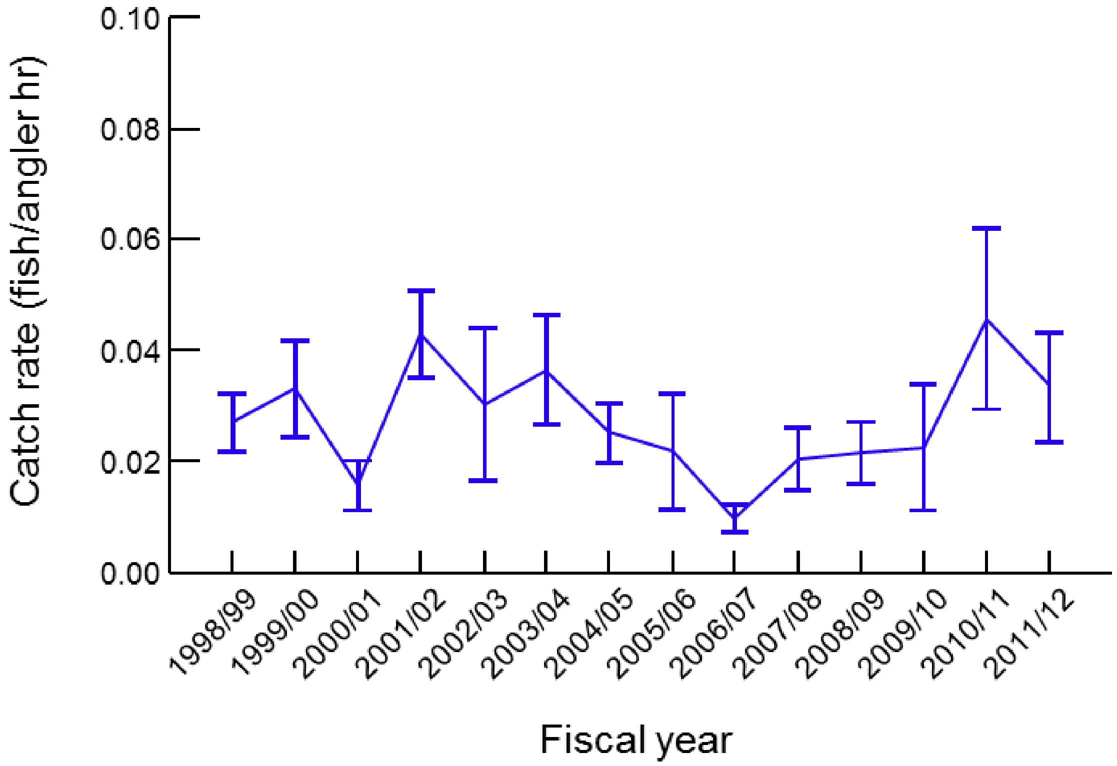


Figure 35. Catch rate of kept Australian Salmon (non-target)

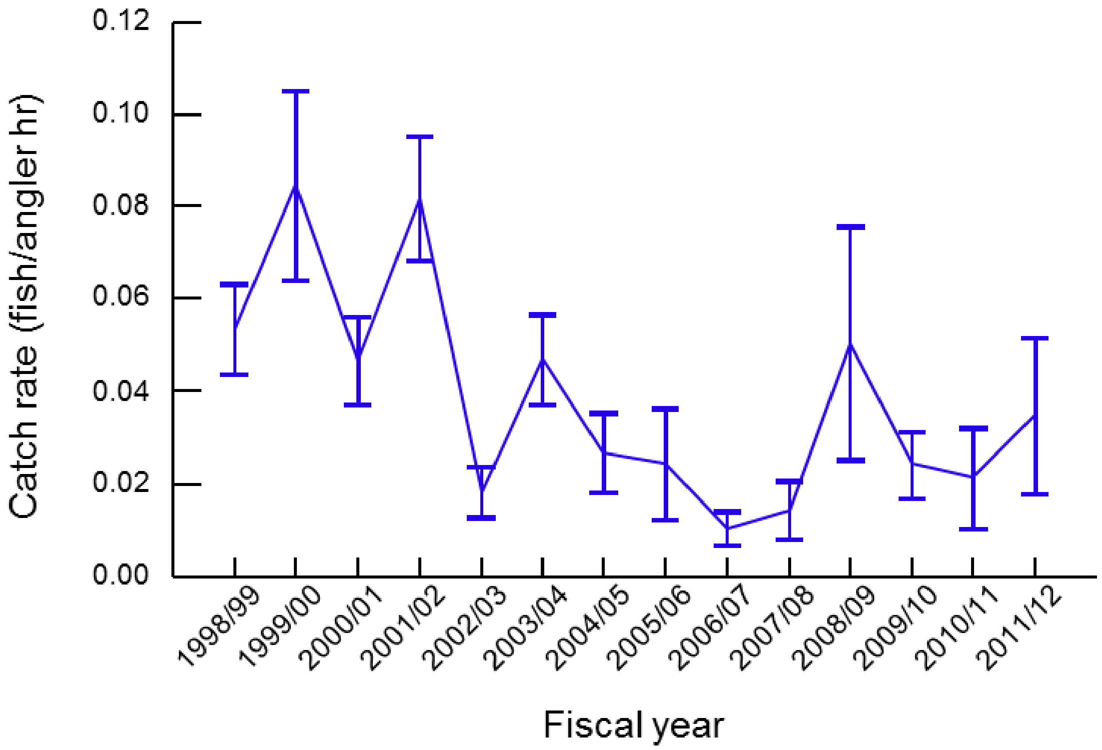


Figure 36. Catch rate of released Australian Salmon (non-target)

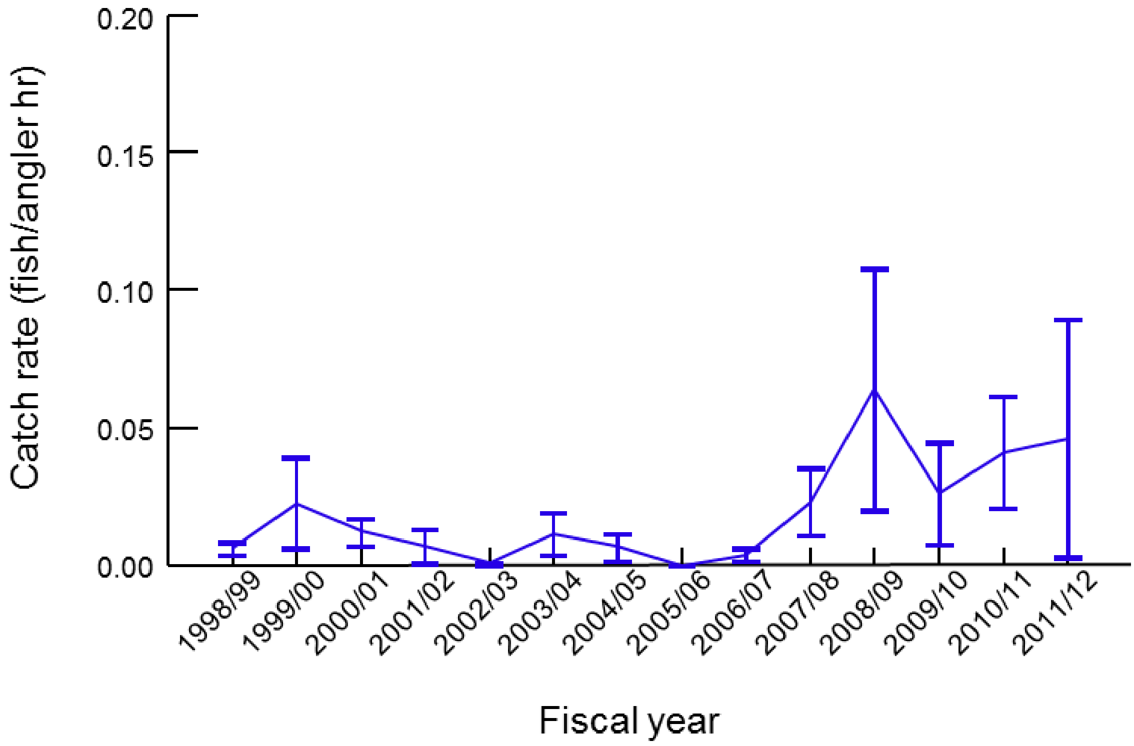


Figure 37. Catch rate of kept Southern Sea Garfish (non-target)

Annual Catch Rates from the Angler Diary Program

The catch rate of King George Whiting from the Angler Diary Program was highly variable over the survey period with peaks in 1999, 2004, 2006-2007 and 2011 (Figure 38). The pattern of variability was very similar to that recorded for released King George Whiting in the Recreational Creel Survey (Figure 23). The long term trend for the entire survey period for the Angler Diary Program was stable to increasing (Figure 38).

The catch rate of Snapper from the Angler Diary Program was highly variable over the survey period with peaks in 2002, 2005-2007 and 2011 (Figure 38).The pattern of variability was very similar to that recorded for released King George Whiting in the Recreational Creel Survey (Figure 25). The long term trend for the entire survey period for the Angler Diary Program was increasing (Figure 38).

The catch rate of Flathead from the Angler Diary Program was highly variable over the survey period with peaks in 1998, 2001-2002 and 2006 (Figure 38).The pattern of variability was very similar to that recorded for released Flathead in the Recreational Creel Survey (Figure 27). The long term trend for the entire survey period for the Angler Diary Program was decreasing (Figure 38).

Long-term trends in the Creel Survey and Angler Diary Programs are summarised in Table 1.

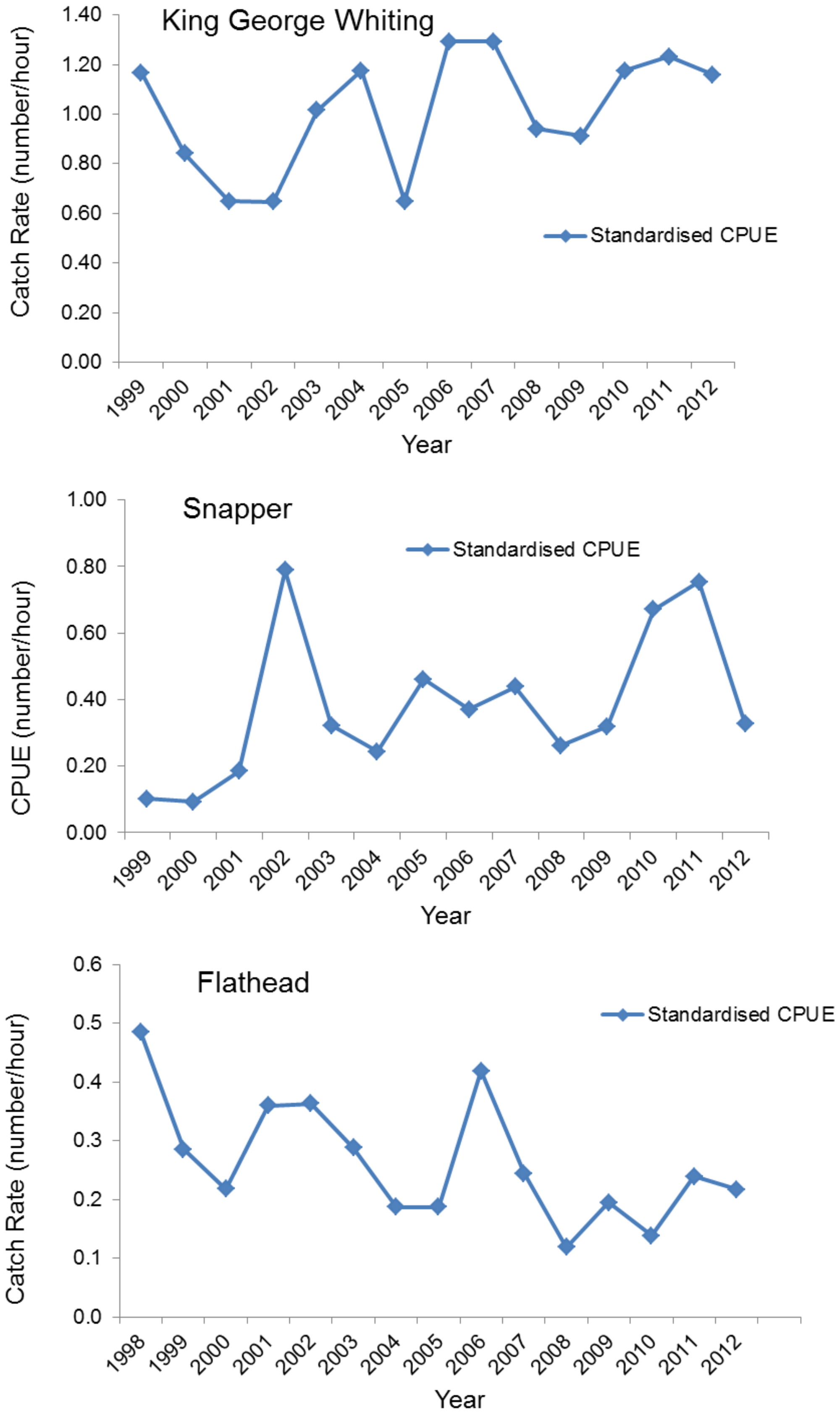


Figure 38. Catch rates of King George Whiting, Snapper and Flathead in Western Port based on Angler Diary Records

Table 1. Summary of Catch Rate trends for the Recreational Creel Survey and Angler Diary Programs

Species	Creel Survey kept	Creel survey released	Creel survey combined	Angler Diary
King George Whiting	↔ ↑	↔		↔ ↑
Snapper	↑	↑		↑
Flathead	↓	↔		↓
Elephant Fish	↓	↑	↔	
Gummy Shark	↔	↔	↔	
Southern Calamari	↔			
Australian Salmon	↔	↓		
Southern Sea Garfish	↑			

Increasing ↑, decreasing ↓, stable ↔

Annual Length Distributions from the Recreational Creel Survey

King George Whiting

The length-frequency distributions for King George Whiting typically ranged from approximately 25 to 45 cm Fork Length (FL) and had a mode of approximately 30-32 cm FL (Figure 39, Figure 40). In 2004/05 a few larger (>50 cm FL) individuals were also recorded (Figure 39). The size frequency distribution was slightly different in 2005/06 with the mode shifted upwards to approximately 35 cm FL (although this may have been influenced by not including surveys from south-eastern boat ramps in this year) (Figure 39). The size-frequency distribution in 2009/10 was notable in that a high proportion of the measured fish were under 33 cm FL (Figure 40). The size frequency distribution in 2012/13 had a significant proportion of fish around 35 cm FL and a low proportion of fish near the legal minimum length (LML) (Figure 40).

Snapper

The length-frequency distribution of Snapper in 1998/99 had a mode between 25 and 35 cm FL with a peak around 30 FL cm, and a second smaller mode around 60 to 75 cm FL (Figure 41). From 1999/00 to 2001/02 the mode of smaller fish was broader, ranging from approximately 25 to 45 cm FL and there were fewer large fish (Figure 41). In 2002/03 the length-frequency distribution was dominated by smaller fish around 25 cm FL, and this distinct mode increased in modal length each year to 2004/05 (Figure 41). By 2005/06 the mode of small fish had increased to 30 to 35 cm FL but in 2006/07 and 2007/08, small fish of 25 to 30 cm FL again dominated the distribution (Figure 42). From 2008/09 to 2012/13 the length-frequency distribution showed a higher proportion of larger fish (40 to 70 cm FL) (Figure 42). A higher proportion of small (20-25 cm FL) fish were evident in 2011/12 (Figure 42).

Flathead

The flathead category includes a number of species, most commonly the Sand Flathead that tend to be a smaller species, but also including Southern Bluespotted Flathead and Rock Flathead where larger individuals are caught. From 1998/99 to 2002/03 the length-frequency distribution was dominated by fish 25 to 40 cm FL with a mode of approximately 26 to 29 cm FL (Figure 43). In 2003/4 the length-frequency distribution shifted smaller with fish ranging from 20 to 35 cm FL and a mode of approximately 26 cm FL (Figure 43). In 2004/05 the length-frequency distribution was also dominated by smaller 25 – 30 cm FL fish but also included a small proportion of larger fish up to 70 cm FL (Figure 43). From 2006/07 to 2009/10 the length-frequency distribution was reasonably stable, ranging from approximately 25 to 50 cm FL with a mode around 28 to 30 cm FL (Figure 44). From 2010/11 to 2012/13 there were less small (25 to 27 cm FL) and a greater proportion of larger (35 to 50 cm FL) fish (Figure 44).

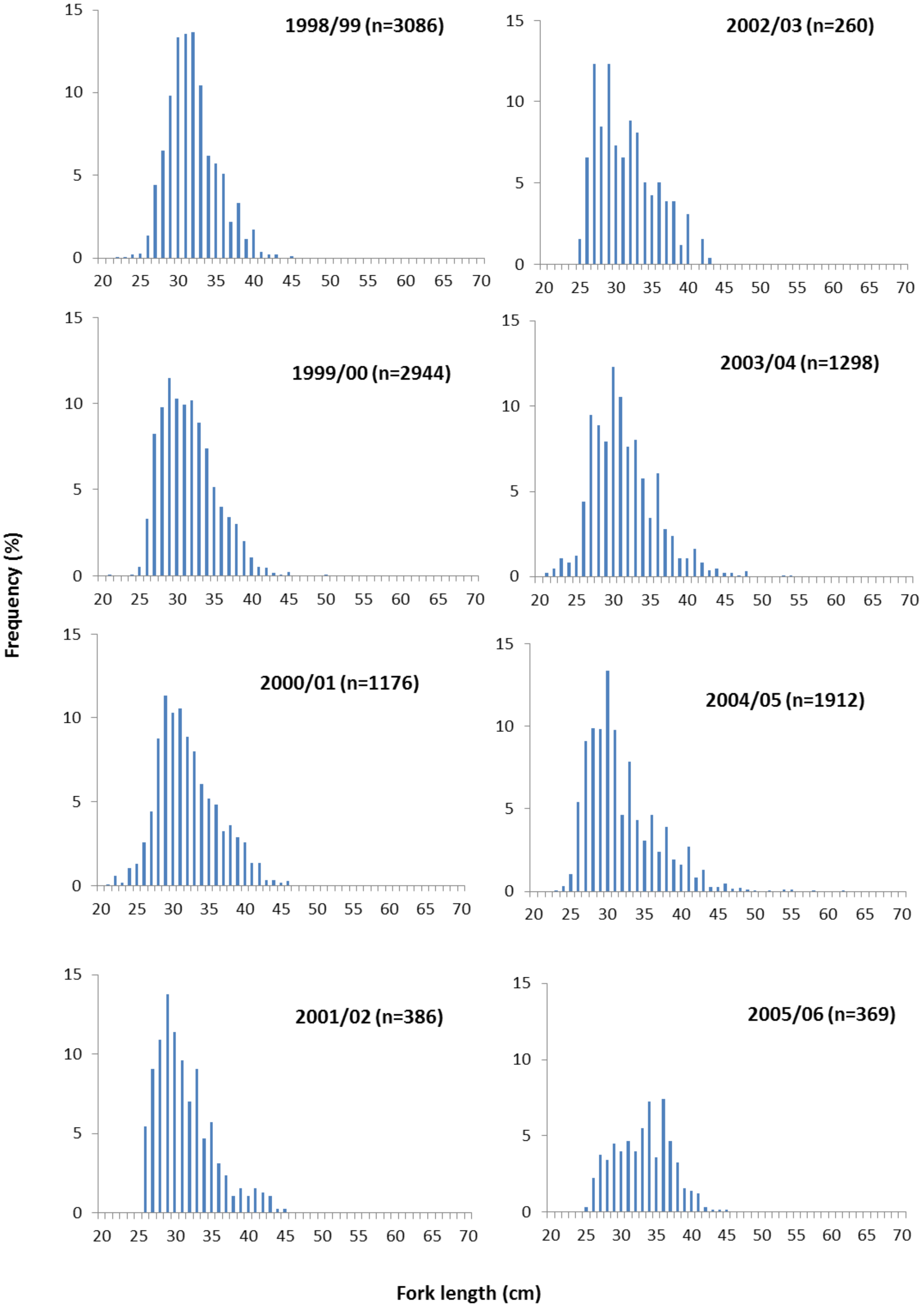


Figure 39. Length frequency distribution of King George Whiting: 1988/89 – 2005/06

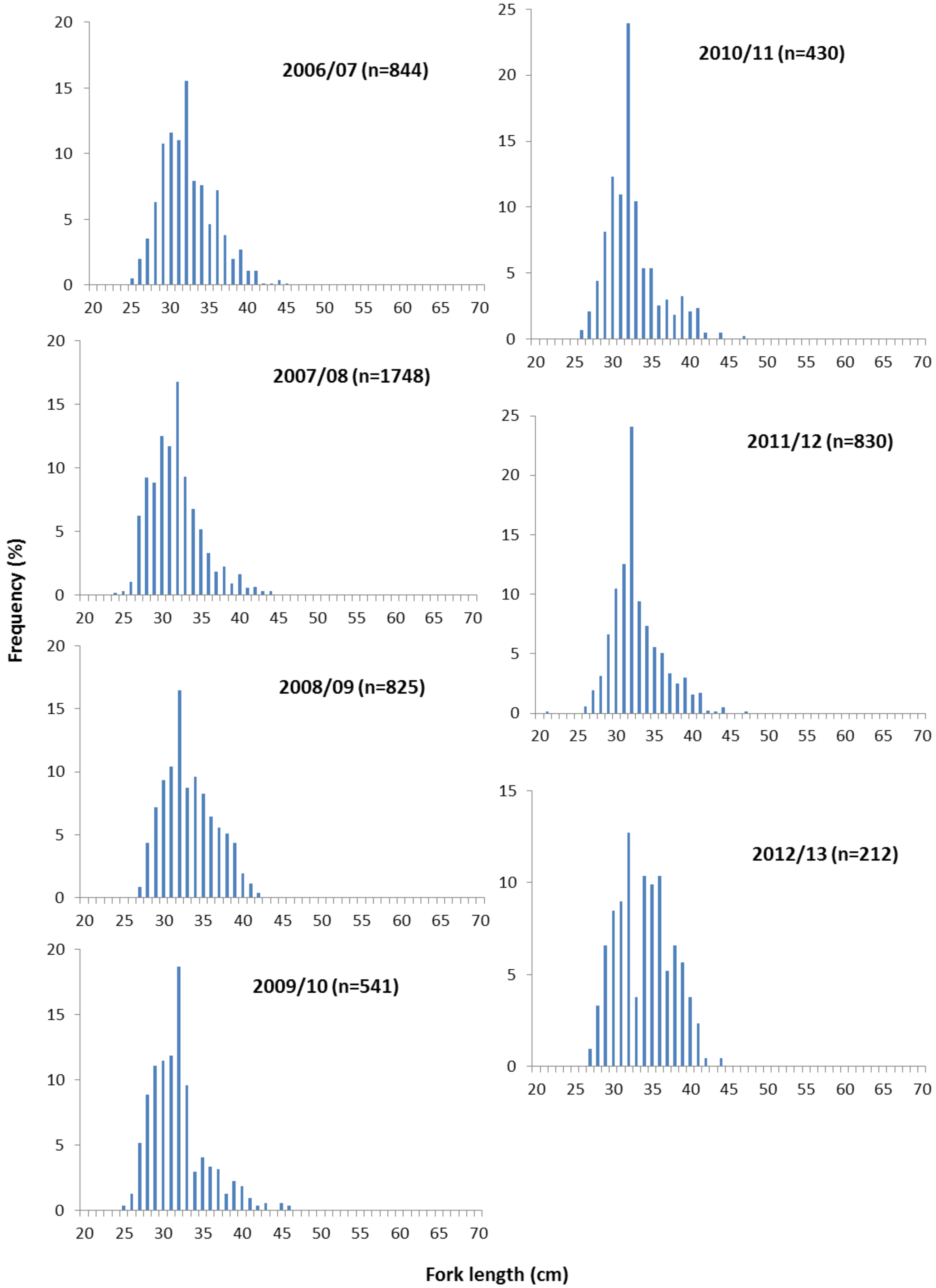


Figure 40. Length frequency distribution of King George Whiting: 2006/07 – 2012/13

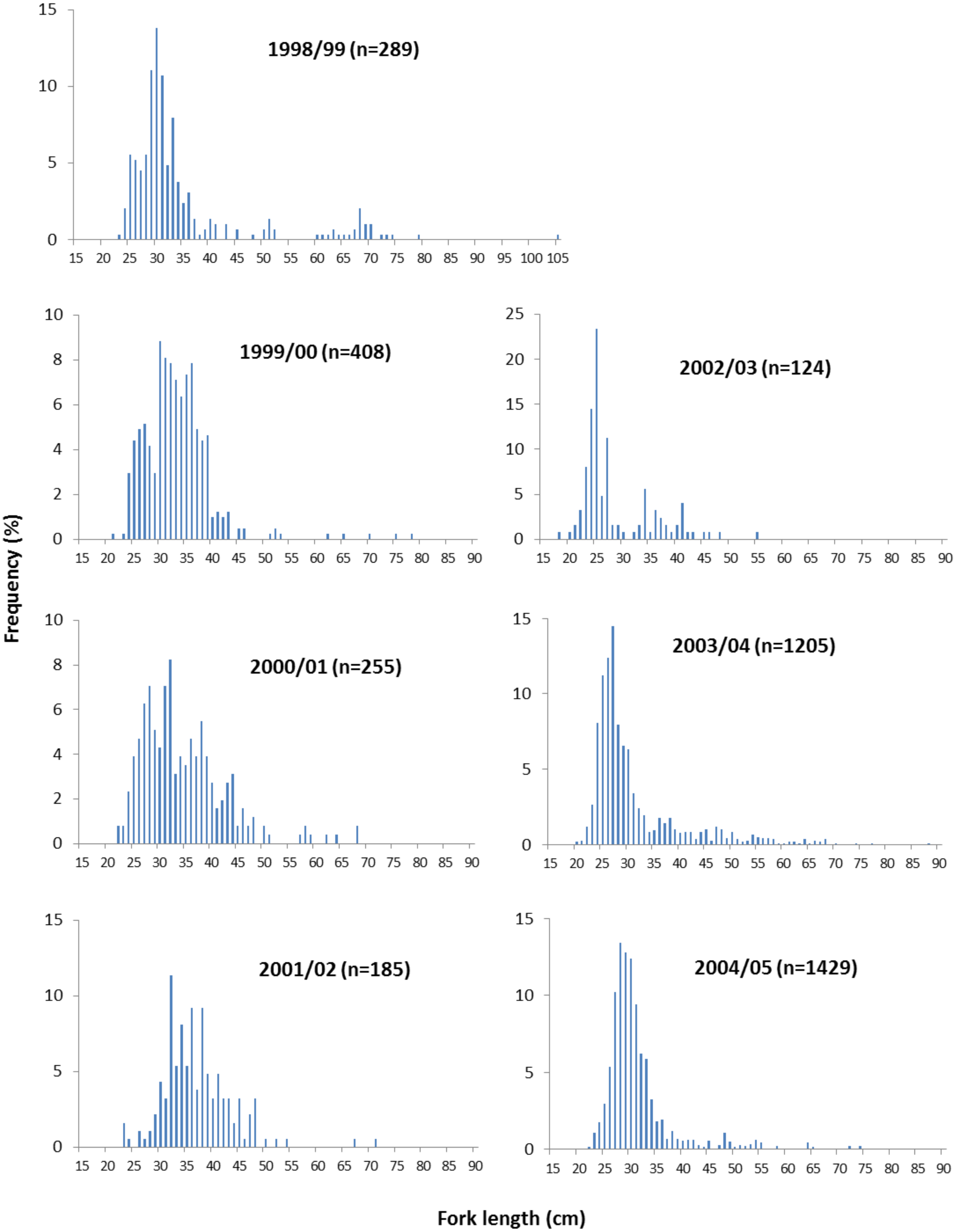


Figure 41. Length frequency distribution of Snapper: 1988/89 – 2005/06

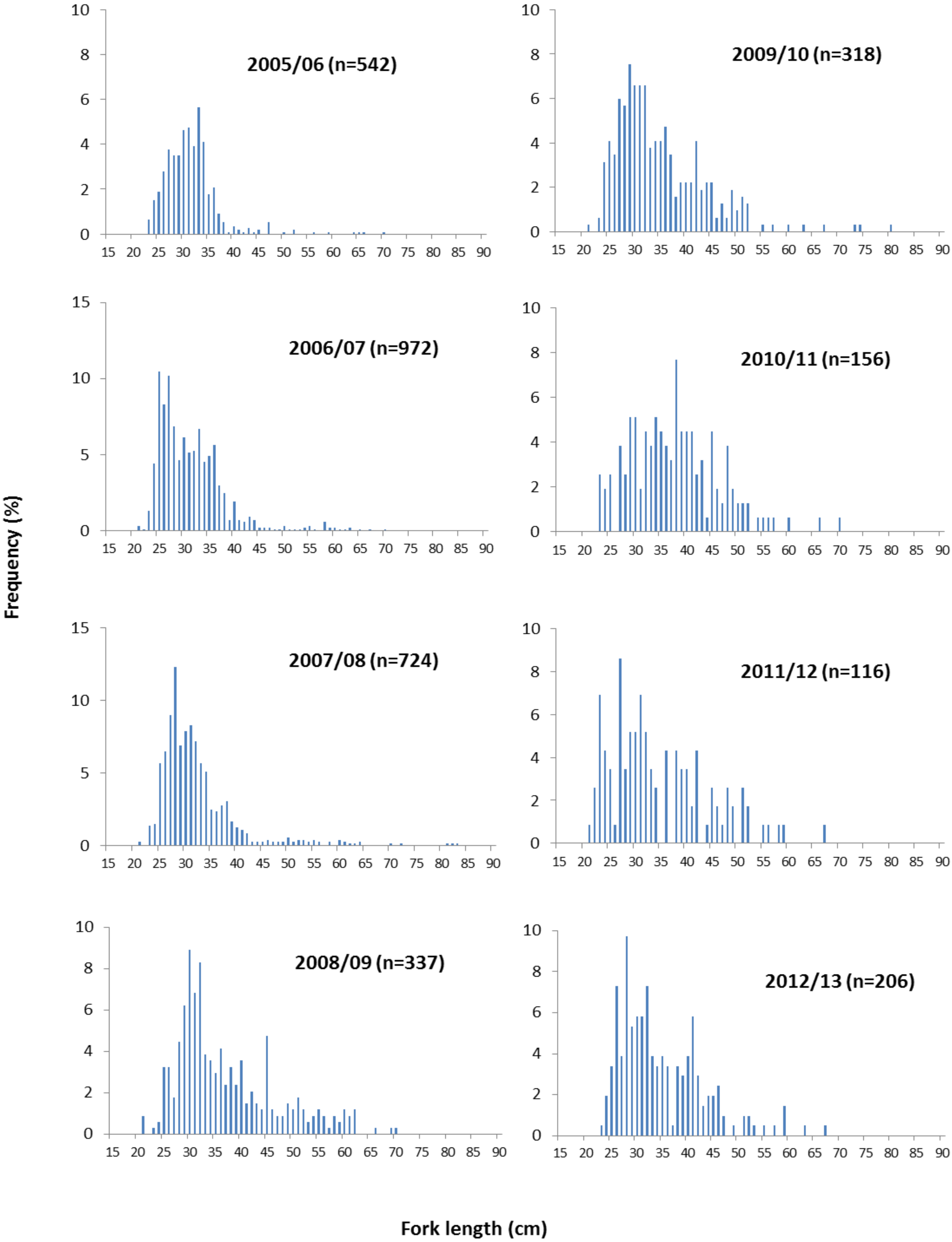


Figure 42. Length frequency distribution of Snapper: 2006/07 – 2012/13

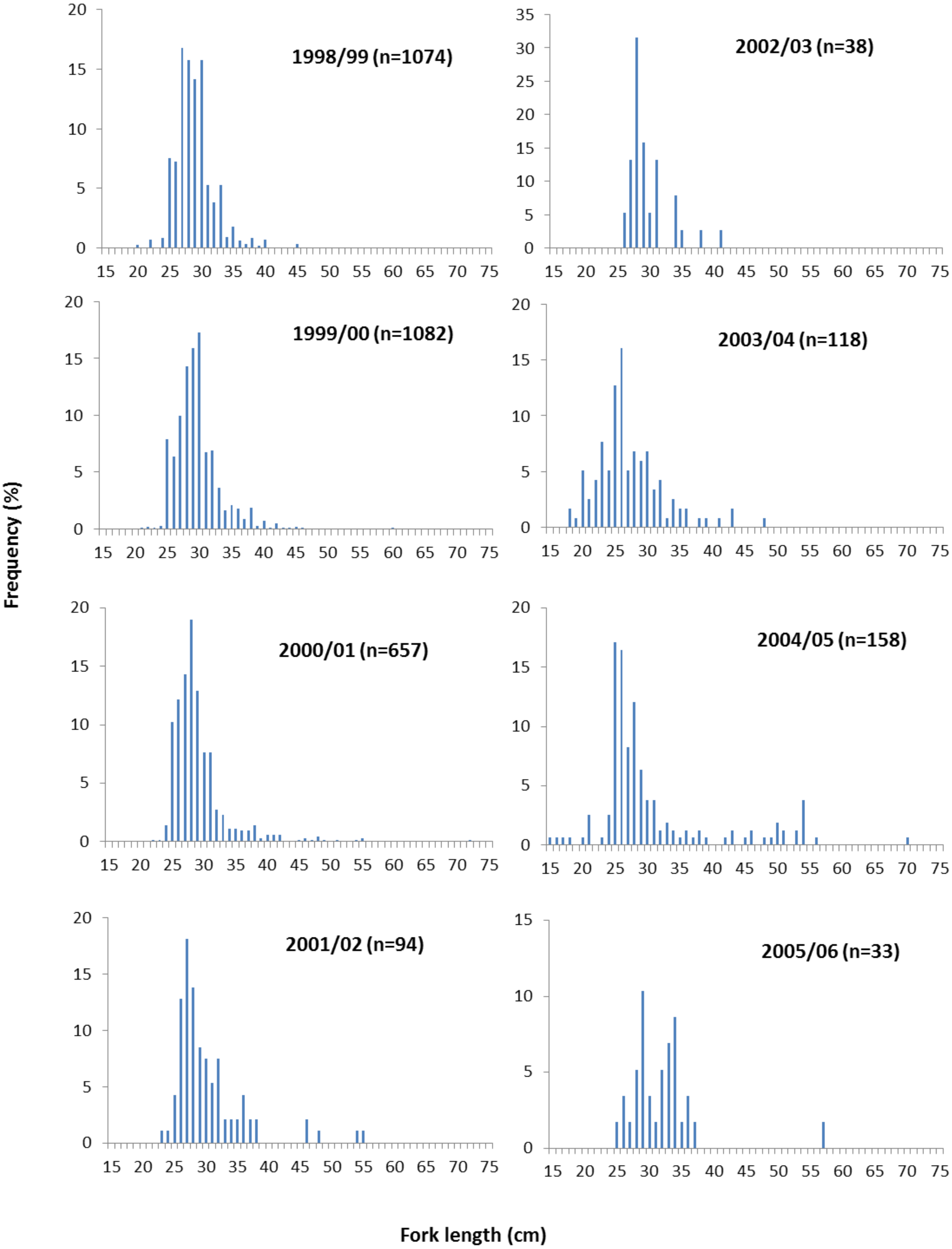


Figure 43. Length frequency distribution of Flathead: 1988/89 – 2005/06

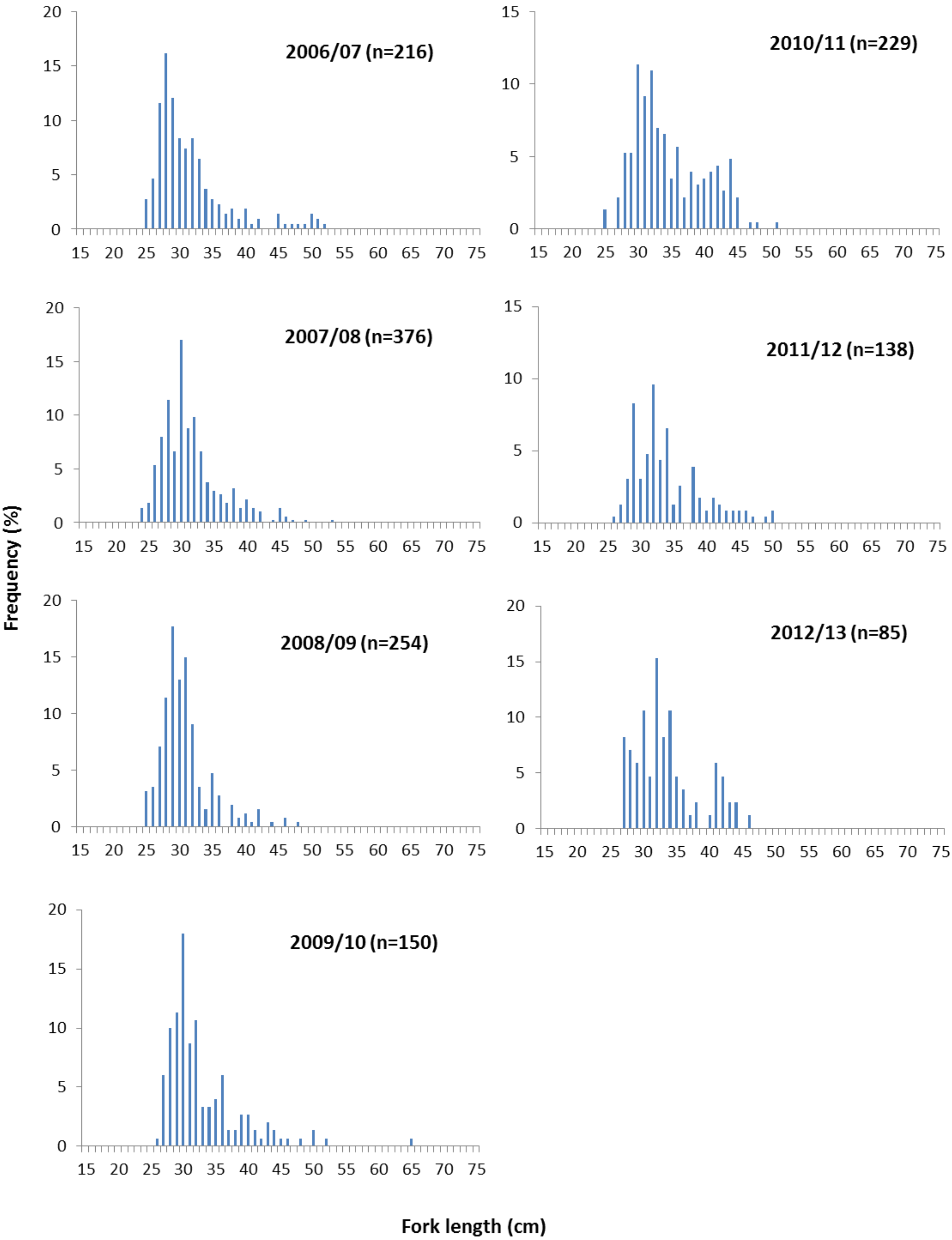


Figure 44. Length frequency distribution of Flathead: 2006/07 – 2012/13

Fish Captures in Relation to Depth from the Annual Creel Survey

King George Whiting

Fishing trips where Whiting were caught were mainly in shallow depths of 2 to 10 m with a small proportion of catches in depths of 10 to 30 m (Figure 45A). The distribution of depths of capture was slightly shallower for released Whiting with a high proportion of released fish captured in depths of 3 to 7 m and a very low proportion caught in depths greater than 10 m (Figure 45B).

Snapper

Fishing trips where Snapper were caught were in a broad range of depths with the highest proportion between 7 and 18 m (Figure 46A). A small proportion of fish were caught at greater depths ranging down to 35 m (Figure 46A). Released Snapper were caught over a similar depth range but the highest proportion of catches was slightly shallower in the range of 5 to 15 m (Figure 46B).

Flathead

The highest proportion of Flathead were caught in shallow (3 – 5 m) depth and then there was an approximately linear decline in the trips where Flathead were captured with increasing depth to approximately 25 m (Figure 47A). The distribution of trips where Flathead were released showed a similar pattern with depth to that for kept Flathead (Figure 47B).

Gummy Shark

Fishing trips where Gummy Sharks were caught were mainly in depths of 5 to 20 m with a high proportion in a depth around 10 m (Figure 48A). In a small proportion of trips, Gummy sharks were caught in depths 20 to 30 m (Figure 48A). The distribution of trips where Gummy Sharks were released showed a similar pattern with depth to that for kept Gummy Shark (Figure 48B).

Elephant Fish

Fishing trips where Elephant Fish were caught were mainly in depths of 4 to 12 m with a high proportion in depths around 6 to10 m (Figure 49A). In a small proportion of trips, Elephant Fish were caught in depths of 13 to 20 m and on one trip in 27 m depth (Figure 49A). The distribution of trips where Elephant Fish were released showed a similar pattern with depth to that for kept fish with the exception of a slightly higher proportion of trips where fishing occurred in 2-3 m depth (Figure 49B).

Australian Salmon

Fishing trips where Australian Salmon were caught were mainly in depths of 4 to 20 m with a high proportion in depths around 5 to 7 m (Figure 50A). In a small proportion of trips, Australian Salmon were caught in depths around 25 m (Figure 50A). The distribution of trips where Australian Salmon were released showed a similar pattern with depth to that for kept fish (Figure 50B).

Southern Calamari

Fishing trips where Calamari were caught were mainly in depths of 2 to 10 m with a high proportion in depths of 2 to 5 m (Figure 51A). In a small proportion of trips, Calamari were caught in greater depths between 10 and 30 m (Figure 51A).

Southern Sea Garfish

Fishing trips where Garfish were caught were mainly in depths of 1 to 6 m with a high proportion in depths of 2 to 4 m (Figure 51B). In a small proportion of trips, Garfish were caught in greater depths between 6 and 10 m (Figure 51A).

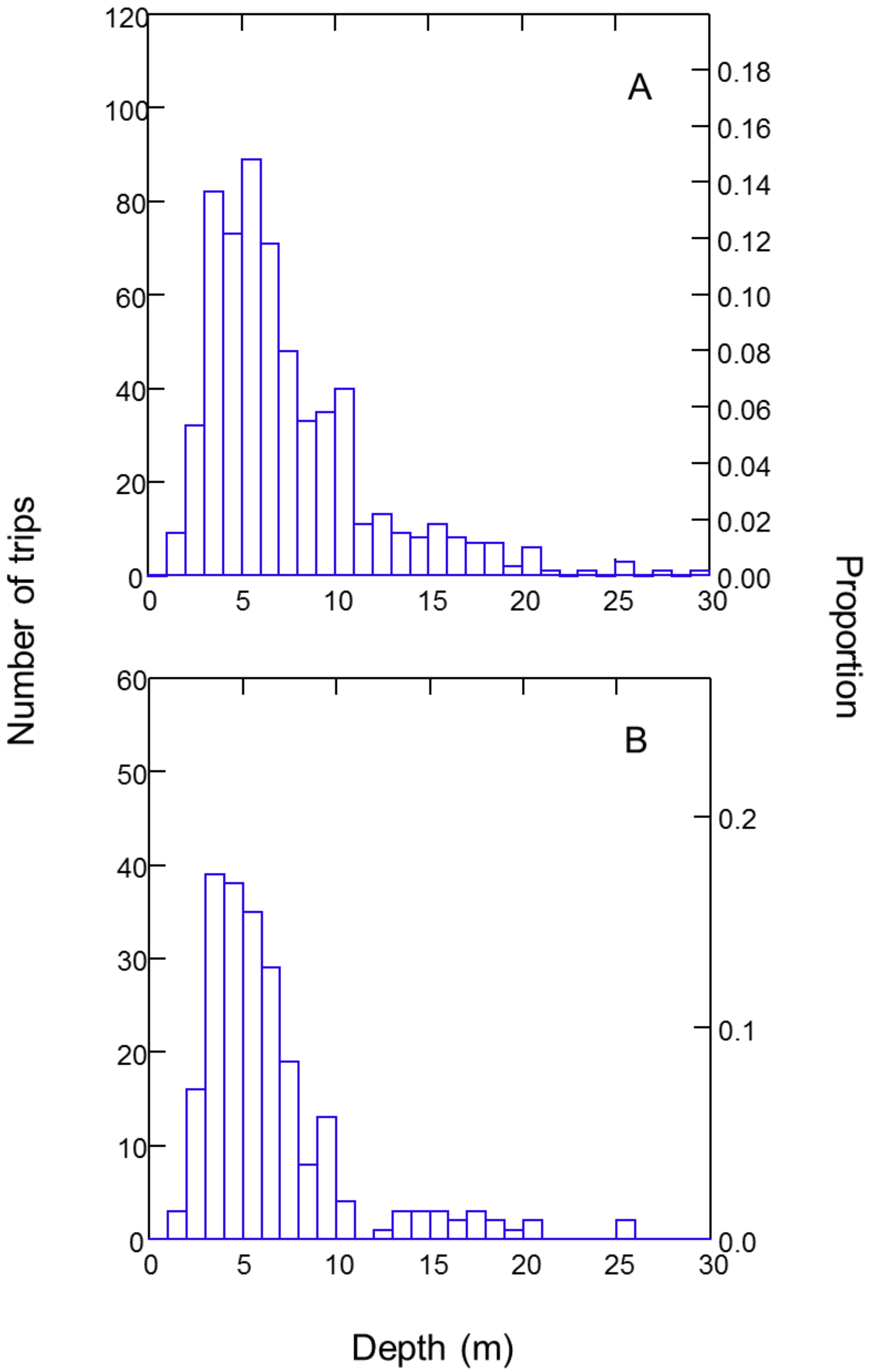


Figure 45. Number of trips where King George Whiting were caught in relation to depth at the fishing location. A) Kept fish, B) Released fish

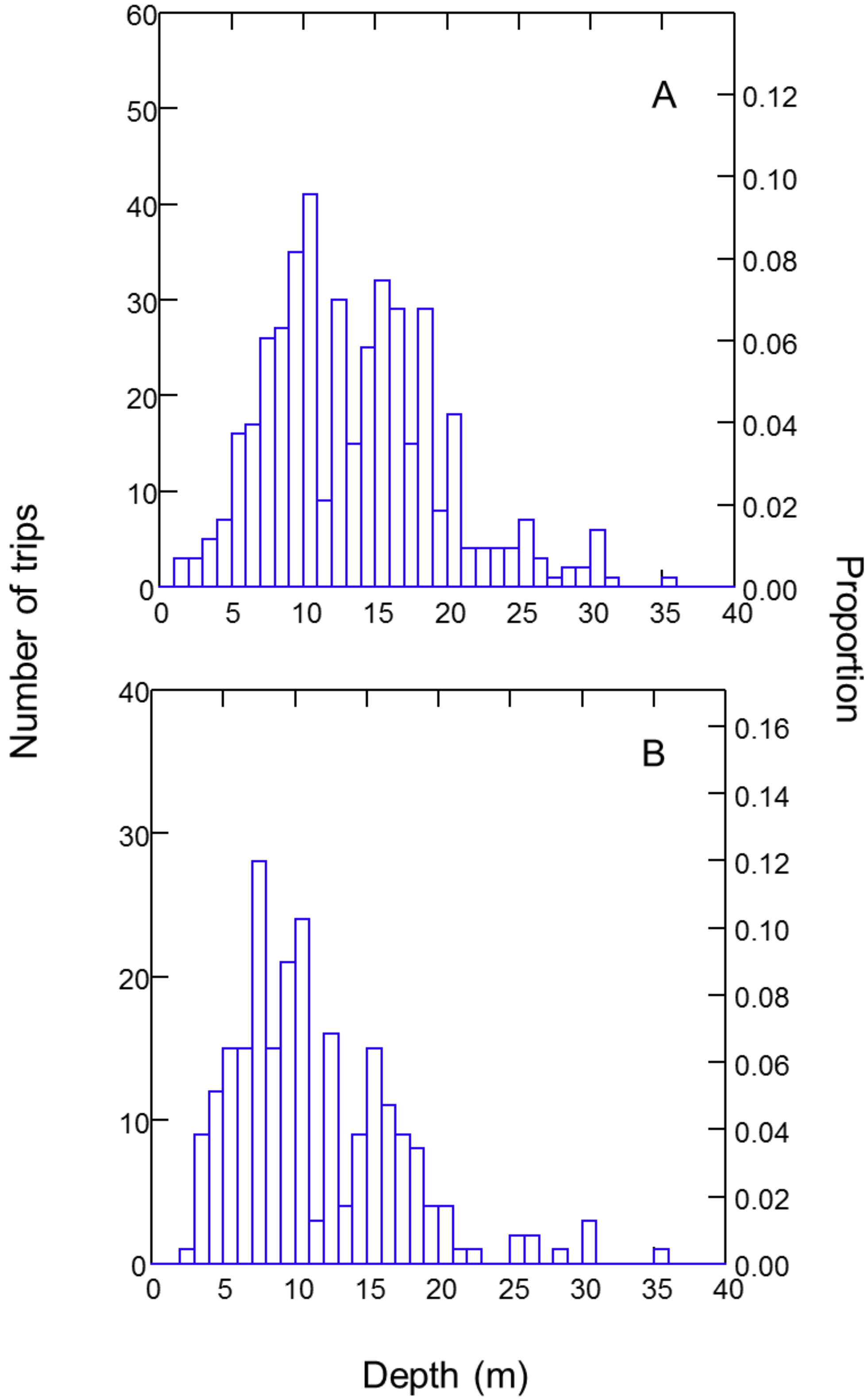


Figure 46. Number of trips where Snapper were caught in relation to depth at the fishing location. A) Kept fish, B) Released fish

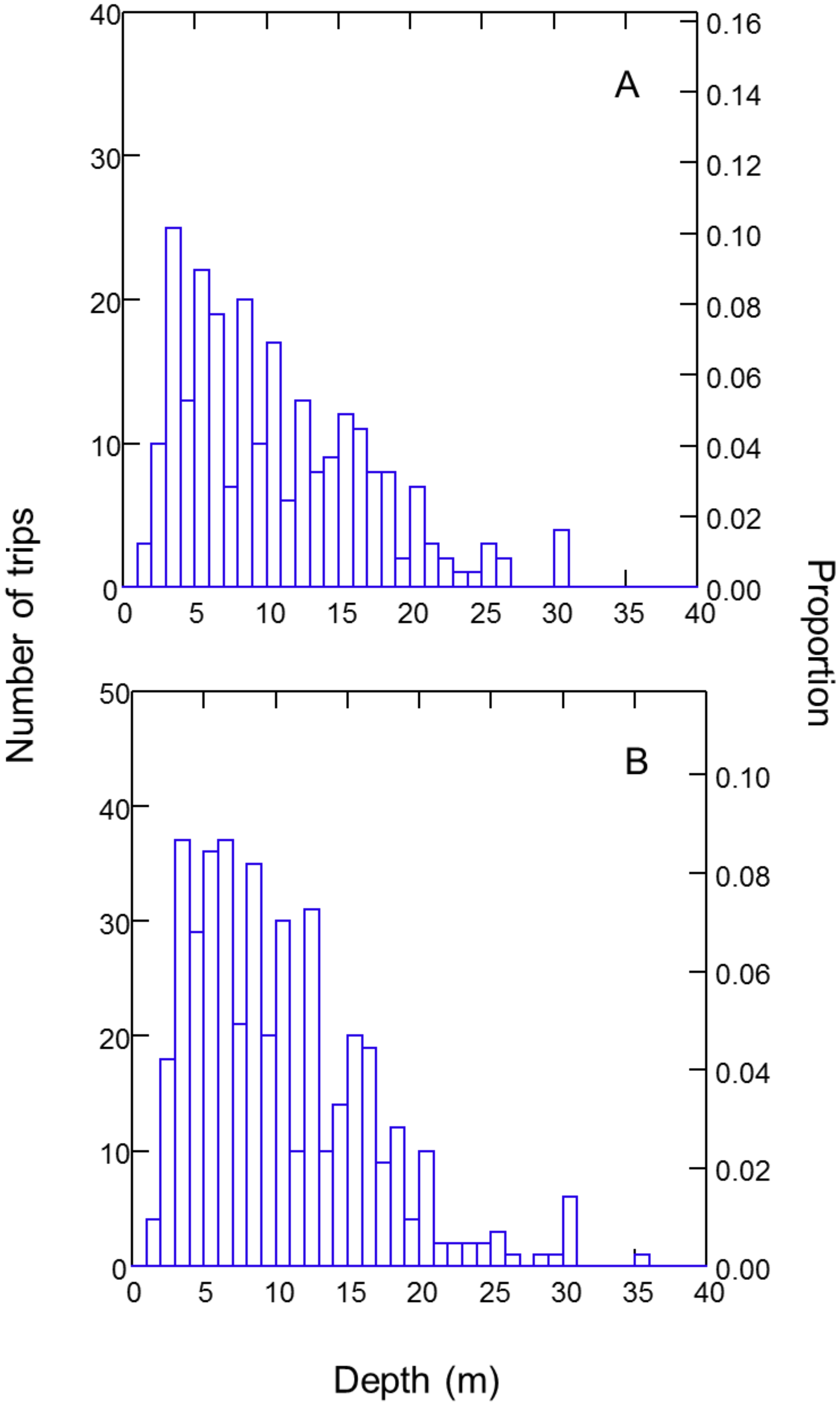


Figure 47. Number of trips where Flathead were caught in relation to depth at the fishing location. A) Kept fish, B) Released fish

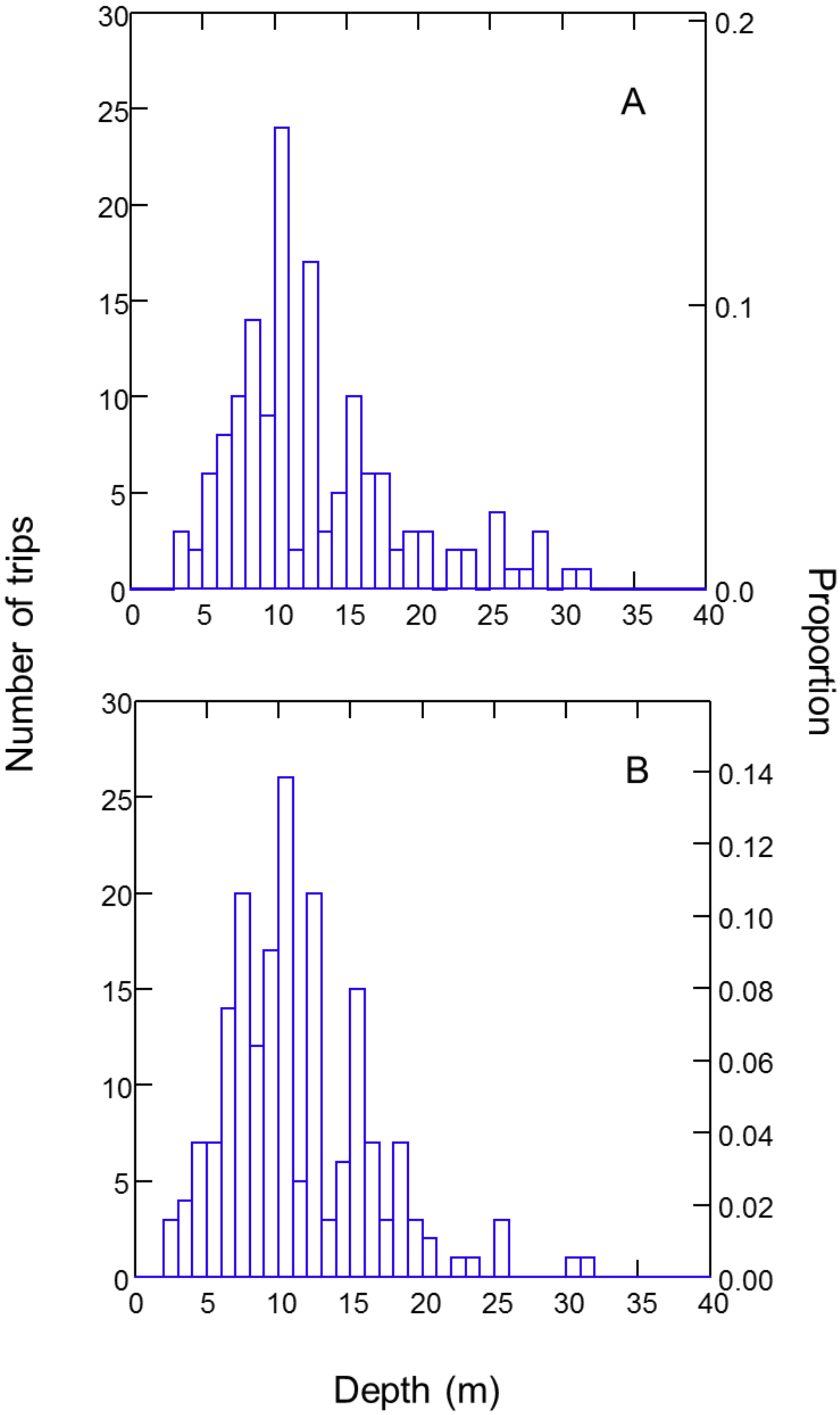


Figure 48. Number of trips where Gummy Shark were caught in relation to depth at the fishing location. A) Kept fish, B) Released fish

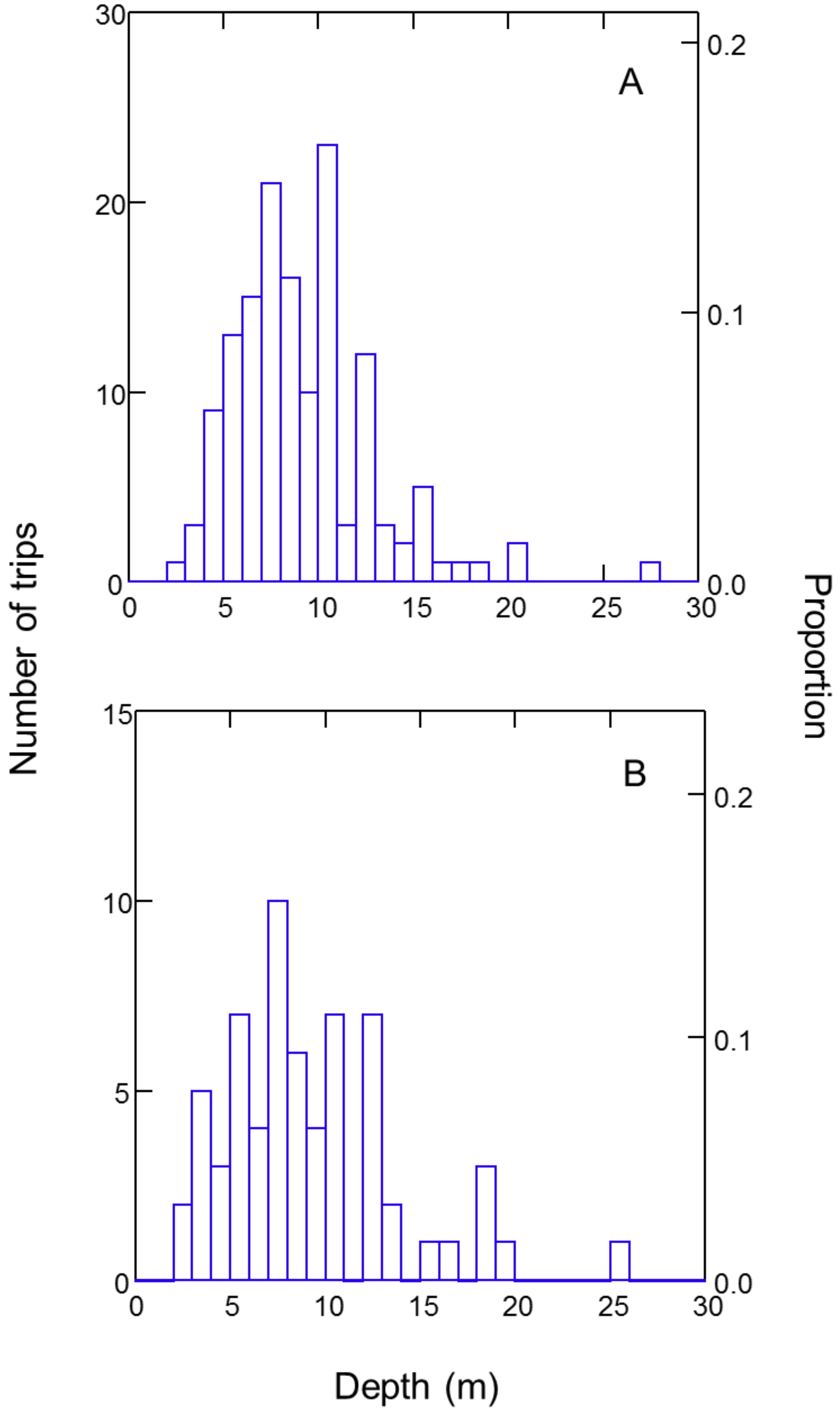


Figure 49. Number of trips where Elephant Fish were caught in relation to depth at the fishing location. A) Kept fish, B) Released fish

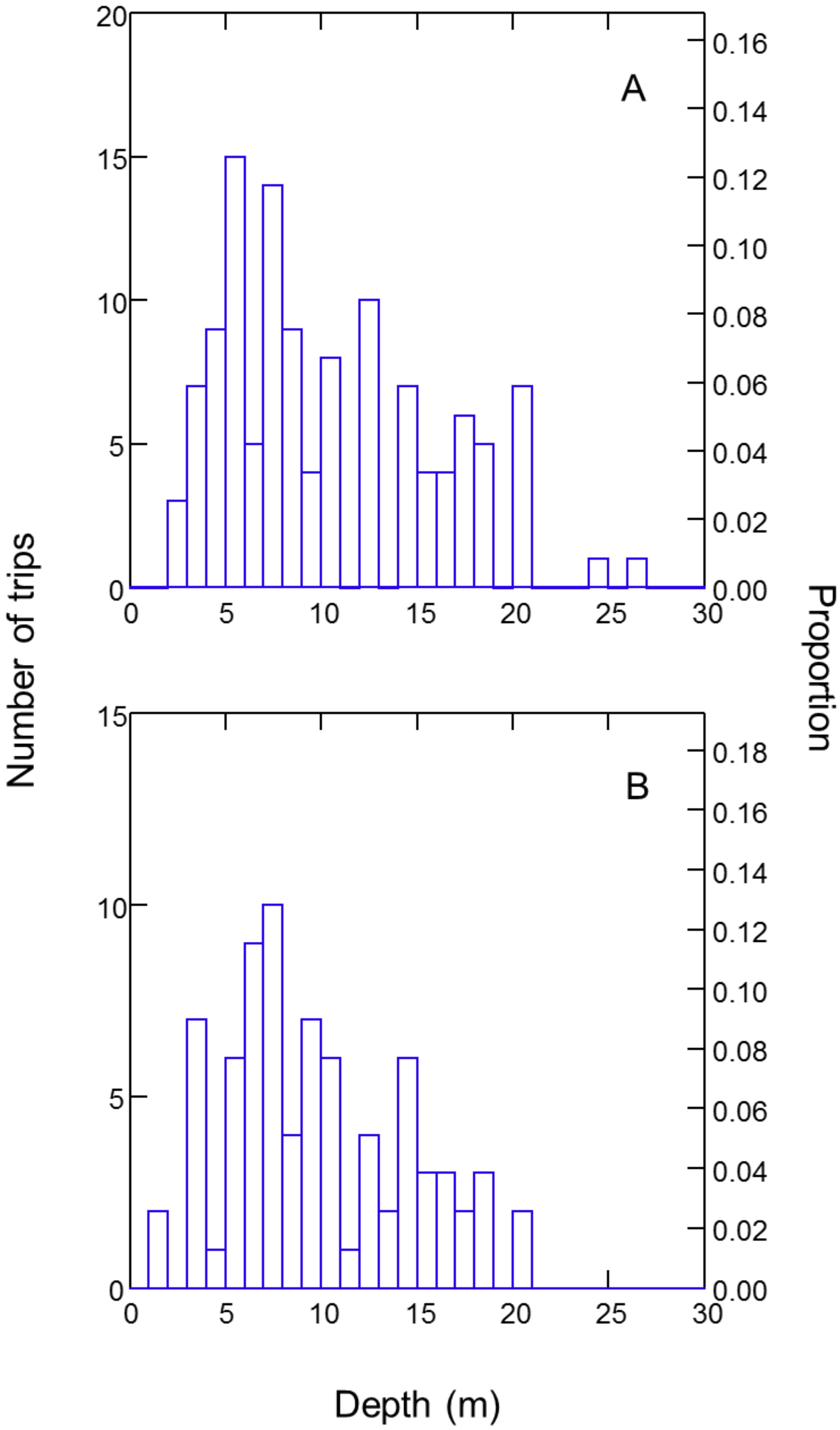


Figure 50. Number of trips where Australian Salmon were caught in relation to depth at the fishing location. A) Kept fish, B) Released fish

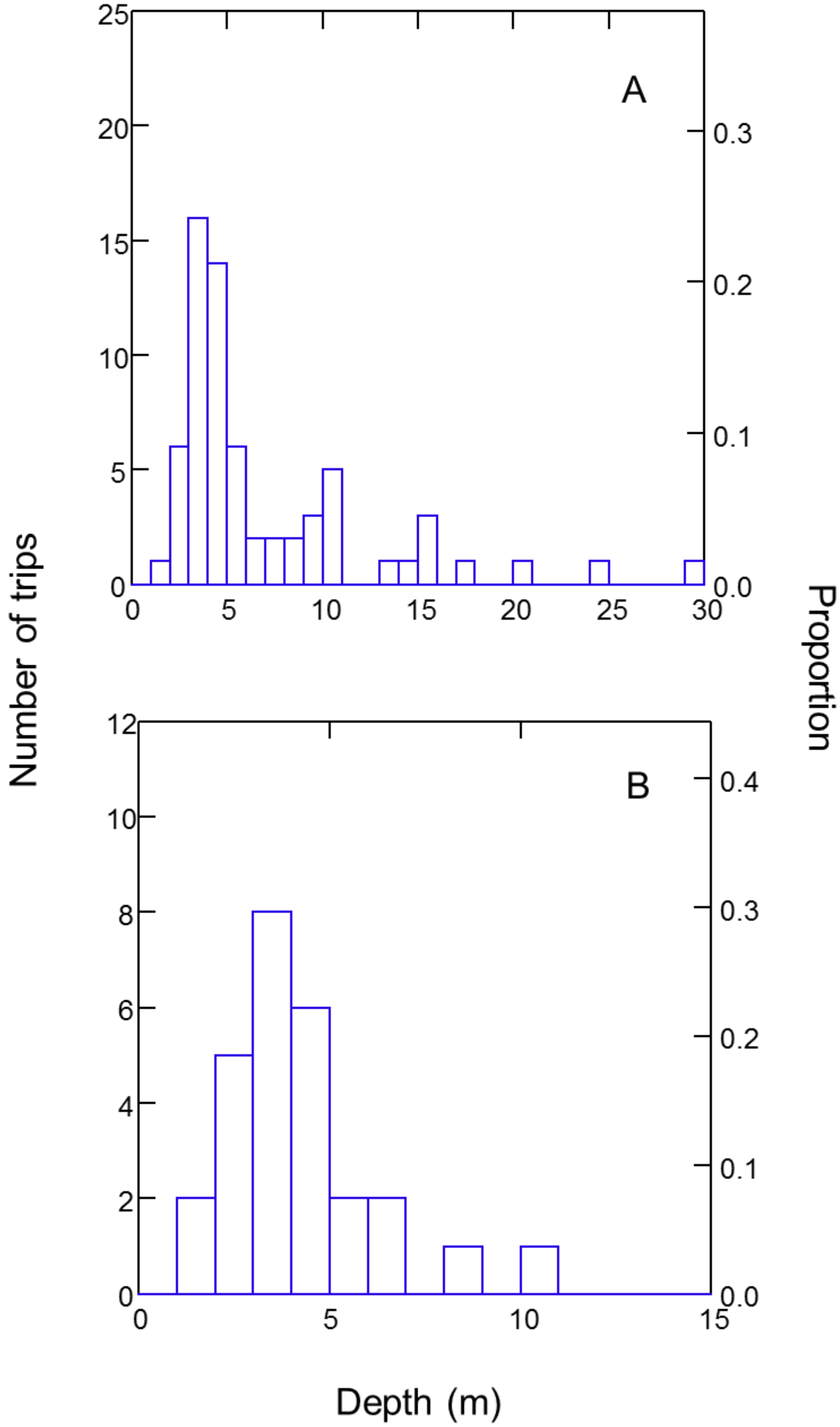


Figure 51. Number of trips where kept A) Southern Calamari and B) Garfish were caught in relation to depth at the fishing location

Fish Captures in Relation to Habitat from the Annual Creel Survey

King George Whiting

Most fishing trips where Whiting were caught were on mixed sand and seagrass habitat, with trips fishing on sand and seagrass habitat also commonly producing Whiting (Figure 52A). Fishing trips on reef associated habitats did not result in many Whiting captures (Figure 52A). The pattern was similar for released Whiting with mixed sand and seagrass the most important habitat while reef associated habitats were of low importance (Figure 52B).

Snapper

Most fishing trips where Snapper were caught were on reef habitat, with trips fishing on mixed sand and seagrass habit also producing some Snapper (Figure 53A). Very few fishing trips resulted in Snapper captures where fishing was on seagrass habitat (Figure 53A). The pattern was similar for released Snapper although mixed reef and sand habitat, sand habitat, and mixed sand and seagrass habitat were relatively more important than for kept Snapper (Figure 53B).

Flathead

Most fishing trips where Flathead were caught were on sand habitat, with trips fishing on mixed sand and seagrass and mixed sand and reef habitat also producing some Flathead (Figure 54A). In some cases fishing trips on reef habitat also produced Flathead (Figure 54A). The pattern was similar for released Flathead although mixed sand and reef habitat, mixed sand and seagrass habitat, and reef habitat were relatively more important than for kept Flathead (Figure 54B).

Gummy Shark

Most fishing trips where Gummy Shark were caught were on reef habitat, sand habitat, or mixed sand and reef habitat (Figure 55A). Fishing trips on seagrass associated habitats were less successful in producing Gummy Shark (Figure 55A).

Southern Calamari

Most fishing trips where Calamari were caught were on seagrass, mixed sand and seagrass, and sand (Figure 55B). Fishing trips on reef associated habitats were relatively less successful in producing Calamari (Figure 55B).

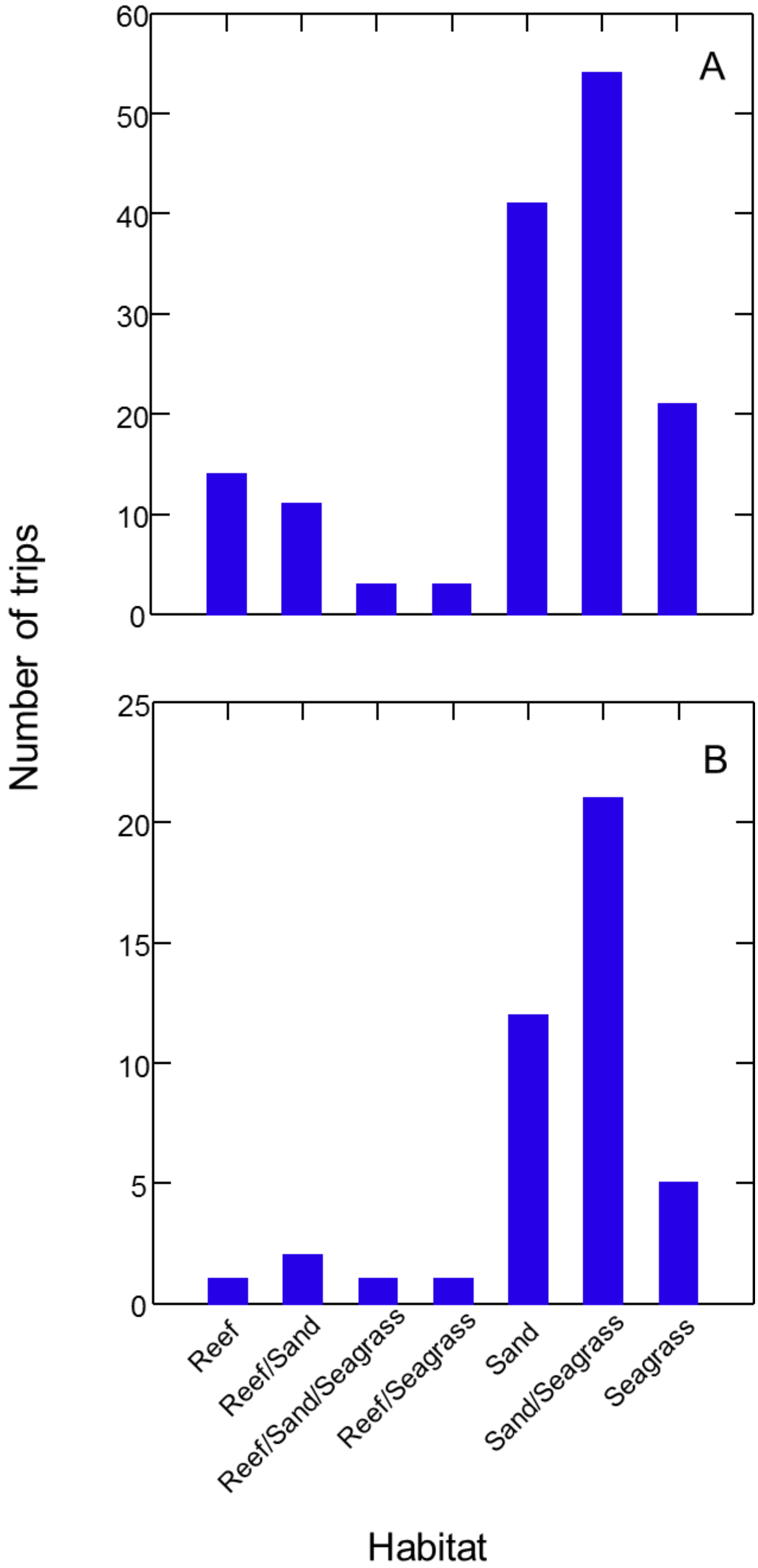


Figure 52. Number of trips where King George Whiting were caught in relation to habitat at the fishing location. A) Kept fish, B) Released fish

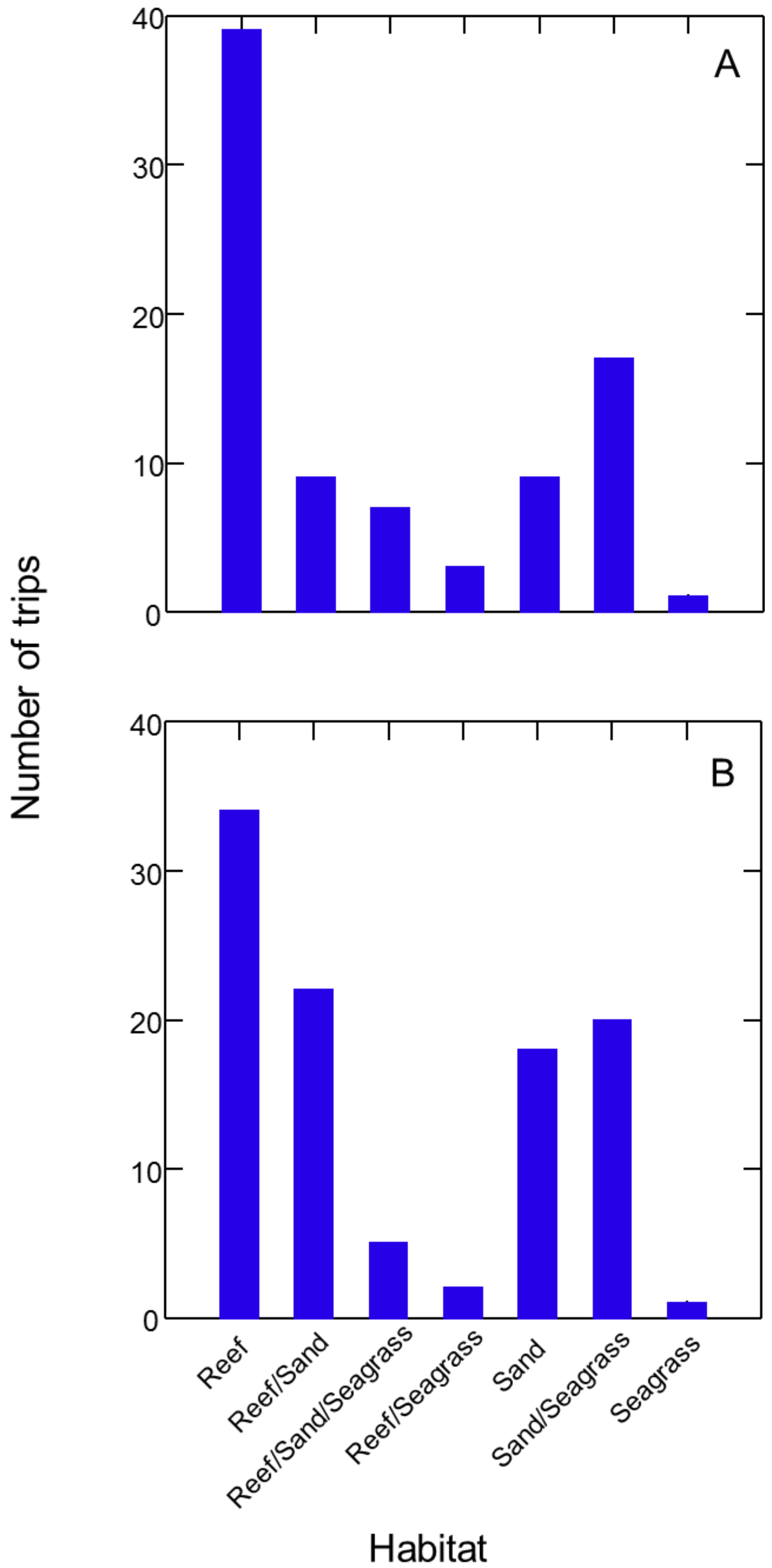


Figure 53. Number of trips where Snapper were caught in relation to habitat at the fishing location. A) Kept fish, B) Released fish

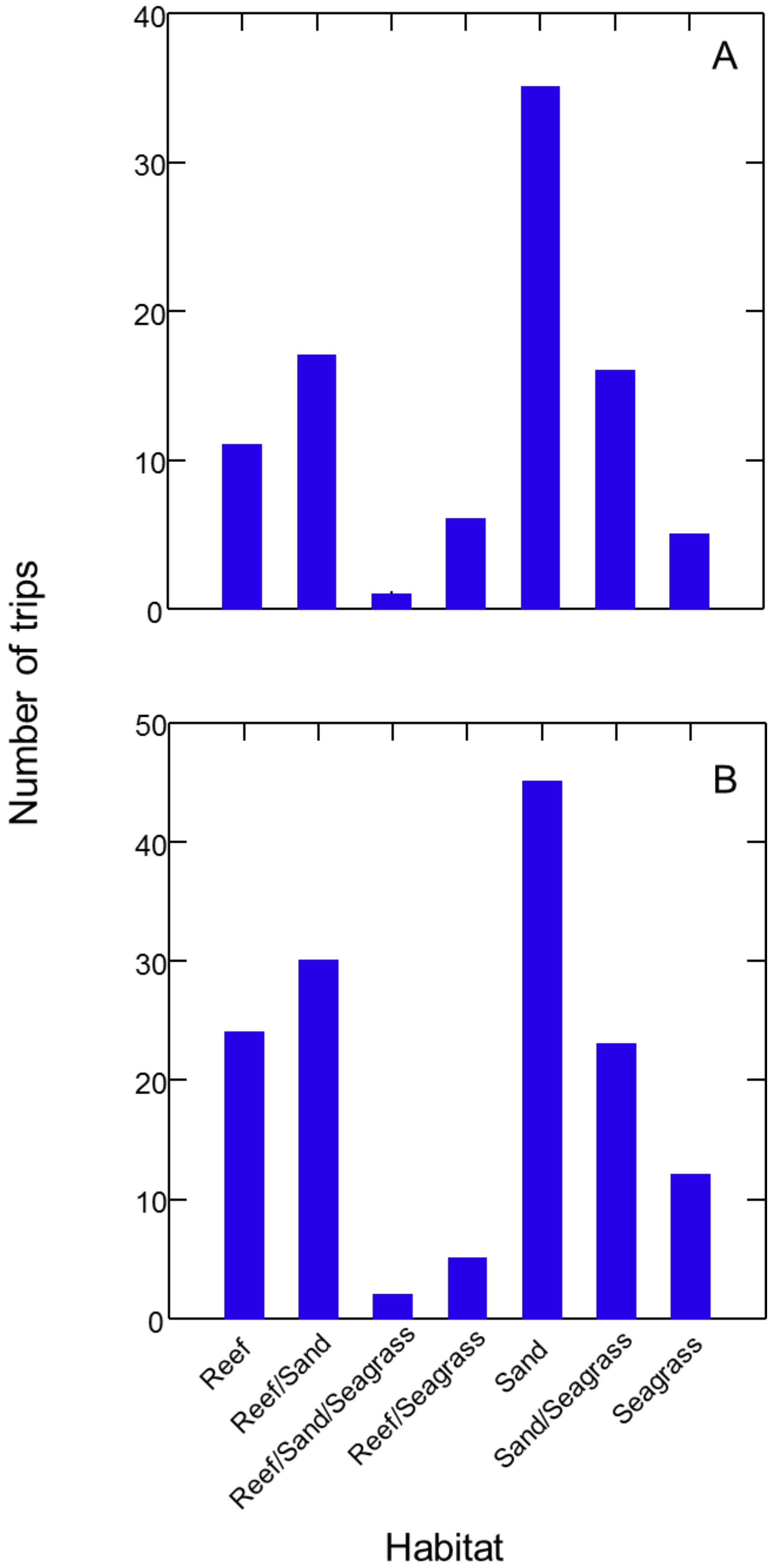


Figure 54. Number of trips where Flathead were caught in relation to habitat at the fishing location. A) Kept fish, B) Released fish

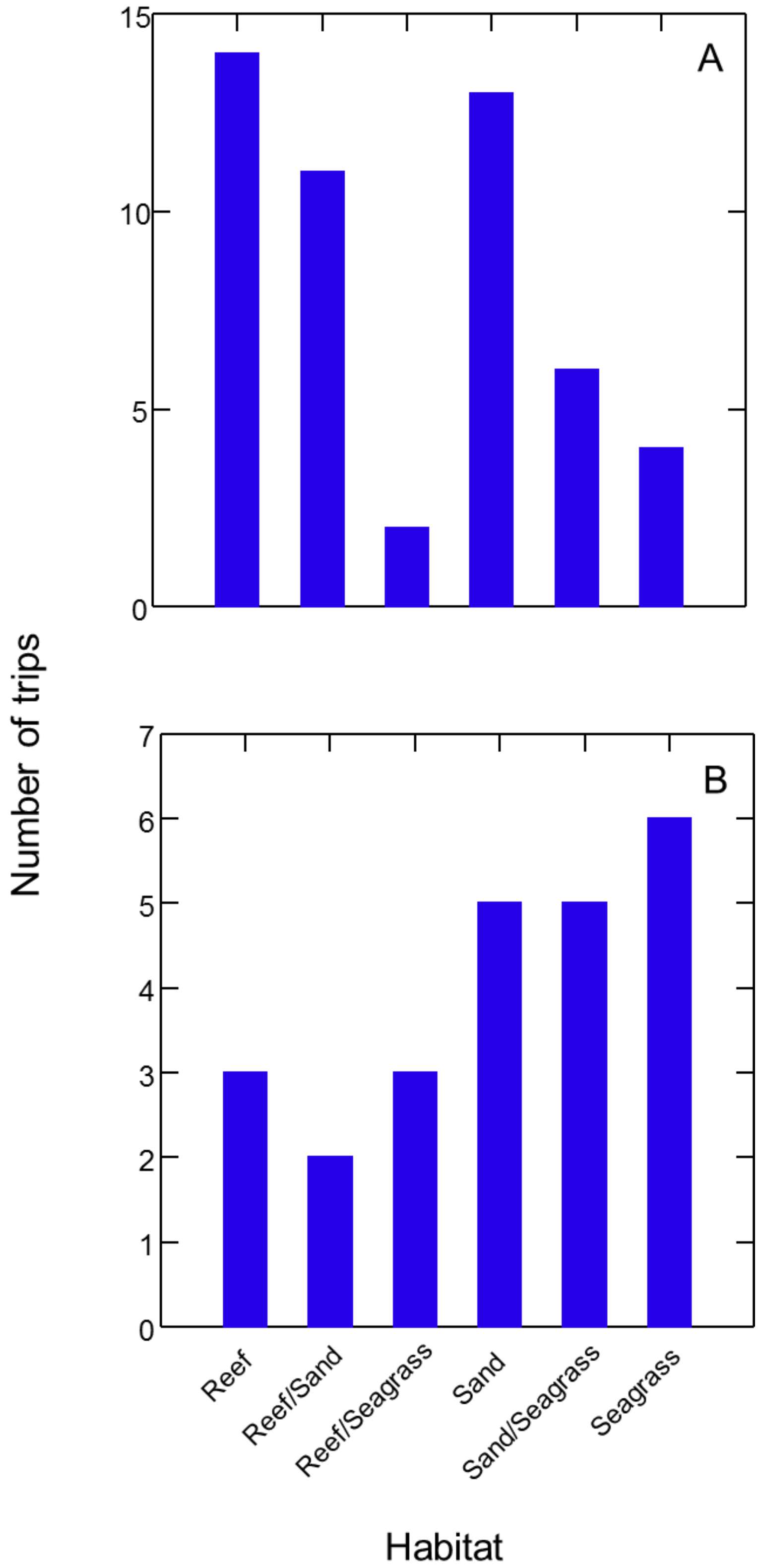


Figure 55. Number of trips where kept A) Gummy Shark and B) Southern Calamari were caught in relation to habitat at the fishing location.

Discussion

King George Whiting

The GIS analysis showed that Whiting are most abundant to the north-west of French Island and also in the Upper North Arm near Tooradin. This is an important area as there are two Marine Parks located nearby as well as the Port of Hastings. It is also an area of significant seagrass cover that is consistent with observations that Whiting were mainly taken in areas of seagrass and sand, and in particular mixed (patchy) seagrass/sand habitat. Research in Port Phillip Bay has shown that Whiting initially settle in shallow seagrass habitat (Jenkins and Wheatley 1998; Smith *et al.* 2011), but as they grow they tend to occur in mud/sand habitat near the edge of seagrass beds (Jenkins and Wheatley 1998; Smith *et al.* 2011; Jenkins *et al.* 2012). This habitat shift, based on previous research in Western Port, may relate to a shift from a diet dominated by seagrass epifauna to one dominated by infaunal polychaetes (Robertson 1977). The productivity of the sand/mud habitat near the edge of seagrass is likely to be increased by enrichment from seagrass detritus (Jenkins *et al.* 2012). Whiting were primarily taken in shallow sub-tidal depths down to 10 m and mostly in depths down to 6 m. This depth range is consistent with the depth distribution of seagrass in the bay (Blake *et al.* 2012).

The dependence of Whiting on seagrass, combined with their high abundances in the Upper North Arm and Rhyll Segments of Western Port where water quality is strongly influenced by catchment inputs in the north-east of the bay (Lee 2011), means that this species is vulnerable to changes in catchment activities that may alter pollutant loads, particularly sediments. Seagrass loss in the early 1970’s was mainly in the Upper North Arm, and the Corinella and Rhyll Segments, and was thought to be related to sediments from the catchment settling on seagrass leaves and blocking light (Shepherd *et al.* 1989).

‘Released’ whiting (i.e. those smaller than the legal minimum length) would have been mostly 2 year olds in the 20 – 27 cm range, and their abundance patterns based on GIS analysis were similar to that of ‘kept’ Whiting (i.e. those greater than the legal minimum length); however, they were taken from a slightly shallower depth range. This is consistent with research in Port Phillip Bay showing that juvenile whiting gradually move into deeper water as they grow (Jenkins *et al.* 2012).

King George Whiting catch rates showed variability over the 15 year period that can be explained by variability in the settlement of post-larvae. Catches and catch rates in Western Port and Port Phillip are known to show similar variability over time (Jenkins 2005). Monitoring of post-larval settlement in seagrass beds in Port Phillip Bay has recorded peaks in settlement in 1996, 2001, 2005 and 2008 (Jenkins 2010). These peaks in settlement would be expected to translate into increased Whiting entering the fishery about 2-3 years later. This corresponds well to the peaks in the recreational catch rate of kept Whiting recorded in Western Port in 1998/99, 2004/05, 2007/08 and 2011/12, indicating that similar variation in post-larval settlement is driving the catch rate variation in Western Port. The pattern was also consistent with the peaks in catch rate of released Whiting. The major factors that influence the settlement patterns are thought to occur when larvae are drifting in offshore waters (Jenkins *et al.* 2000), primarily the strength of westerly winds and the sea temperature in Bass Strait (Jenkins and King 2006). The reasons for increasing longer-term trend in the survey since the start of the 2000’s is unclear but may relate to the gradual increase in seagrass cover in the bay.

The size distribution of Whiting was also consistent with the recruitment variation, for example the high settlement of post-larvae in 2008 was evident in the size structure in 2009/10 with a high proportion of small fish and by 2012/13 the mode of the distribution had shifted to larger fish with few small fish, indicating the passage of the strong year-class through the population structure. The size distribution also indicated that the Whiting population in Western Port is dominated by juvenile and sub-adult fish (< 40 cm), although in a few years some larger individuals were recorded that may have reached reproductive maturity (Fowler *et al.* 1999).

Snapper

The spatial distribution of kept Snapper catch rates was highest in the Western Entrance segment and the southern part of the Lower North Arm, corresponding with the deepest areas of Western Port. These areas are relatively isolated from the effects of catchment inputs and are more influenced by exchange with coastal waters of Bass Strait (Lee 2011). The distribution is also well away from the Marine National Parks in the north of the bay, but significant catch rates do occur near the Port of Hastings. There was no strong association with seagrass distribution which is also the case in Port Phillip where Snapper above Legal Minimum Length (LML) mostly occur on deeper soft sediments and reefs (Coutin *et al.* 2003; Kemp *et al.* 2012). Catch rates of released Snapper were relatively higher in the Rhyll Segment compared to kept Snapper, making these younger juvenile fish more vulnerable to water quality impacts from the catchment.

The contention that the distribution of snapper is linked to the deeper areas of Western Port is supported by data showing fishing was most successful in depths of 7 to 18 m (and down to 35 m), indicating that fishing is often occurring in deeper channels. In particular, successful snapper fishing trips occurred when fishing deeper reef habitat, although trips fishing on mixed sand/seagrass also resulted in some snapper catches. Released (mainly undersized) Snapper tended to be caught in shallower water and a greater variety of habitats, probably reflecting their higher abundance in the relatively shallow Rhyll Segment.

Catch rates of kept snapper over time showed variation that was consistent with the recruitment patterns of young juvenile snapper in Port Phillip Bay where strong year classes were recorded in 2000/01, 2003/04, 2004/05 and low to moderate year classes from 2008 – 2011 (Jenkins 2010). These strong year classes in the early to mid-2000s were reflected in increasing catch rates of kept snapper in the mid-2000s in Western Port. This correspondence with recruitment in Port Phillip Bay reflects the fact that the majority of spawning of the western snapper stock (from Wilsons Promontory to the SA border) occurs in Port Phillip (Hamer *et al.* 2011) and there is only limited evidence of recruitment of small juveniles in Western Port (Hamer and Jenkins 2004). After recruitment in Port Phillip Bay, Snapper as young as one year old can apparently migrate out to the coast and enter other bays and inlets such as Western Port (Hamer *et al.* 2005). The migration of these young Snapper into Western Port can be seen in the pattern of catch rate of released snapper from the recreational survey.

The size distribution of snapper in Western Port is also consistent with the recruitment variation in Port Phillip Bay with, for example, a dominance of small fish in the 2002/03 and 2003/04 year classes following recruitment of the strong year class in 2000/01 in Port Phillip (Jenkins 2010). The Catch in Western Port was dominated by pre-adults and young adults up to 60 – 70 cm FL but there were few large, older fish in the order of 100 cm length, possibly related to Western Port apparently not being an important spawning area for this species (Hamer and Jenkins 2004). Further sampling, using plankton nets to sample eggs and larvae, needs to be conducted before firm conclusions can be drawn about the importance or otherwise of Western Port as a spawning area for snapper (Hamer *et al*. 2011; Jenkins 2011).

Flathead

The catch of flathead in many cases were not identified to species, but based on those that were identified, were mainly Sand Flathead, *Platycephalus bassensis*, with lesser numbers of Rock Flathead, *Platycephalus laevigatus* and Bluespotted Flathead, *Platycephalus speculator*. The highest catch rates of Flathead were in the Lower North Arm and were relatively close to the Port of Hastings. These species have divergent habitat preferences with Sand Flathead mainly found on unvegetated sand (Gomon *et al.* 2008; Hirst *et al.* 2011) while Rock Flathead tend to occur in seagrass beds (Jenkins *et al.* 1997; Gomon *et al.* 2008). Flathead were mainly caught on sand habitat, which is consistent with most of the catch consisting of Sand Flathead, while trips fishing on seagrass or reef would have been more likely to result in the capture of Rock Flathead. It is possible that the sediment grain-size profile in the Lower North Arm makes the area more suitable for Sand Flathead than other areas of the bay. Although Flathead were mainly caught in shallow water, there were a significant number of trips where Flathead were caught at depths greater than 15 m (for both kept and released fish). In Port Phillip Bay, Sand Flathead are most abundant in depths greater than 15 m, and this may also contribute to higher catch rates in the Lower North Arm where the water depth is greater than other areas of Western Port (with the exception of the Western Entrance) (Hirst *et al.* 2011; Hirst *et al.* 2014) . The distribution of released (below legal minimum length) Flathead was broader than for kept Flathead, but the profile of habitats they were caught in was very similar to kept flathead, indicating no distinct shift in habitat preference with size. In the case of Rock Flathead, previous research has shown that small juveniles are found mainly on unvegetated sediments, but with growth they move into seagrass habitats (Jenkins *et al.* 1997).

Flathead showed variable catch rates over the survey period with the timing of peaks in catch rate (and appearance of smaller fish in the length frequency distributions) consistently in the years following high catch rates of 1-year old Sand Flathead in the Pre-recruit survey in Port Phillip Bay, where peaks occurred in 2001/02, 2004 and 2008/09 (Jenkins 2010; Hirst *et al.* 2014). It is not known whether, like Snapper, most spawning of Sand Flathead occurs in Port Phillip and then juveniles move to Western Port, or whether significant spawning occurs in Western Port and broad-scale climatic variables (e.g. rainfall (Hirst *et al.* 2014)) drive recruitment variability in both bays. Like snapper, further sampling, using plankton nets to sample eggs and larvae, would allow us to determine whether Western Port is an important spawning area for Sand Flathead.

The long-term catch rate for Flathead in Western Port was slightly downward, and this trend was more pronounced for standardized catch rates from the Angler Diary Survey. In Port Phillip Bay there has been a major decline in the Sand Flathead population over the past 25 years (Hirst *et al.* 2014). This decline has been attributed to a decline in recruitment strength, possibly related to a decline in nutrients entering the bay during the drought, affecting the pelagic food chain for larvae (Hirst *et al.* 2014). The decline in catch rate in Western Port, although much less pronounced than in Port Phillip, may have occurred as a consequence of the effects of the drought on planktonic productivity.

Elephant Fish

The area of significant catch rates of both kept and released Elephant Fish was relatively broad at the start of the survey, although highest in the Rhyll Segment, but over the survey period became more restricted to the Rhyll Segment. This may have been partly a reflection of the smaller numbers of interviews conducted towards the end of the survey period, but may also have been related to increasingly concentrated targeting of this area. The majority of Elephant Fish caught in Western Port are adults (8 to 20 years of age) that enter the bay in the autumn to breed (Braccini *et al.* 2008). Based on observations of deposited eggs, Braccini *et al.* (2008) suggested that breeding occurs in subtidal, unvegetated silt/mud areas that are characteristic of the Rhyll Segment. The fine sediments are derived from catchment inputs in the north-east of the bay (Lee 2011) and as such the breeding of this species is dependent on the water quality of the water entering from the catchment. Most successful trips targeting Elephant Fish were fishing in less than 10 m depth, indicating that breeding occurs in relatively shallow water.

The trend in catch rate over the survey period is difficult to interpret because of the reduction in bag limit to one fish in 2008; which may explain the decreasing trend in catch rate of kept fish and increasing trend in catch rate of released fish since that time. The trend for catch rate of combined kept and released fish over the survey period was relatively stable. Braccini *et al.* (2008) found in the mid 2000's that while catch rates from the creel survey were relatively stable, a charter boat survey indicated a decline in Elephant Fish catch rates in Western Port. The apparent stability in the catch needs to be treated with caution because the aggregating behavior of the species may lead to 'hyperstability' where the catch rate is maintained because fish aggregate into a smaller area over time as the stock is reduced (Braccini *et al.* 2008). There was evidence that this phenomenon may be occurring in the spatial distribution of catch rates that became more restricted to the Rhyll Segment over the period of the survey. An estimated 45 Tonnes of Elephant Fish were caught in Western Port by recreational fishers in 2008, compared to a 10 year average of 69 Tonnes from the commercial fishery in Bass Strait (Braccini *et al.* 2008). A decline in catch rate of Elephant Fish in Western Port may be masked to some extent by continual migration of fish from Bass Strait into the bay up to the carrying capacity of the habitat (Braccini *et al.* 2008). In this case, stocks in Bass Strait may be declining due to fishing in Western Port (Braccini *et al.* 2008).

Gummy Shark

Gummy shark were caught throughout Western Port with highest catch rates of kept Gummy Shark in the Western Entrance and in the Upper North Arm, with moderate catch rates in the Corinella and Rhyll Segments. This distribution overlaps with the influence of catchment inputs in the north-east (Lee 2011), and also with the Marine National Parks in the north. The spatial distribution overlaps areas of major seagrass cover as well as deeper areas in the Western Entrance. Trips where Gummy Shark were caught were primarily fishing on reef and/or sand habitat, most likely reflecting the fishing activity in the Western Entrance Segment, and also that many fishers targeting Gummy Shark were also targeting Snapper. Previous sampling of Gummy Shark in Western Port indicated that they were evenly distributed across seagrass, unvegetated and channel habitats (Edgar and Shaw 1995a). Most trips where Gummy Shark were caught were fishing on depths of less than 20 m indicating that they were less abundant in the deeper channels. Released Gummy Shark would have been a mixture of under-size and catch in excess of the bag limit of two sharks. The catch rate of released Gummy Shark was relatively higher in the Rhyll Segment compared with kept Gummy Shark. This is consistent with previous research showing that juvenile Gummy Sharks were common in the Rhyll Segment, indicating that this is an important pupping area (Stevens and West 1997).

Catch rates of Gummy Shark showed an increasing trend through the survey period (consistent with commercial catch rate up till the cessation of netting) before declining in the final year to the initial level, suggesting an overall stable catch rate. Gummy Shark in Western Port form a small part of the southern stock in Bass Strait that is considered to be sustainable at the present rate of commercial exploitation (Marton *et al.* 2014).

Southern Calamari

Southern Calamari were caught throughout Western Port with high catch rates in the Western Entrance Segment near Flinders, the Lower North Arm and the Rhyll Segment which are areas of significant seagrass cover. An association with seagrass is supported by the finding that trips resulting in capture of Calamari were mainly fishing in shallow depths with seagrass and/or sand habitat. Calamari in the Western Entrance Segment have previously been found to be associated with *Amphibolis* seagrass beds near the western coast (Jenkins *et al.* 2013) and have also been collected from *Zostera* seagrass beds within Western Port (Hindell *et al.* 2004). Seagrass beds, particularly *Amphibolis* beds in the Western Entrance Segment, are likely to be an important spawning habitat for Calamari (Green 2015). The *Amphibolis* beds in the Western Entrance Segment have been identified as an important Marine Asset for Victoria (Jenkins *et al.* 2013).

Calamari catch rates appeared to increase to the mid 2000’s and then dropped off substantially in 2007/08 before slowly increasing. This trend is difficult to interpret though given the large error bars on the mean for years up to 2006/07 due to low fishing effort and occasional large catches, although it was consistent with an increase to the mid 2000’s in the commercial catch rate. Across the whole survey period the catch rate was relatively stable. The life history of Calamari, characterised by high growth rates and longevity of less than one year, increases the likelihood that the fishery will be sustainable compared to long-lived fish and shark species (Green 2015).

Australian Salmon

Salmon were caught throughout Western Port with highest catch rates in the Rhyll Segment. The Rhyll Segment is affected by catchment inputs in north-east of the bay (Lee 2011) which may make this species vulnerable the water quality changes, although as a pelagic species they may better placed to avoid poor water quality than site-attached species. Relatively high catch rates were also recorded in the Upper North Arm near the French Island and Yaringa Marine National Parks. Released (undersize) Salmon had a different spatial distribution to kept fish, with high catch rates in the Upper North Arm and Corinella Segments, in areas of extensive intertidal mudflats that are directly influenced by catchment inputs. Juveniles of both Eastern and Western Australian salmon *(Arripis trutta* and *A. truttaceus*) have been sampled over intertidal mudflats with patchy seagrass in Western Port (Robertson 1982), moving into deeper water at about 1 year of age.

The catch rate of kept Australian Salmon was relatively stable over the survey period but the catch rate for released Salmon declined in the first half of the survey before stabilising. It is possible that the catch rate of kept Salmon may be more dependent on migration of sub-adult and adult fish to and from the bay (Hoedt and Dimmlich 1994), while the catch rate of released fish may be more related to recruitment of small juveniles to the bay (Robertson 1982).

Southern Sea Garfish

The catch rates for Garfish were highest in the Rhyll and Corinella Segments, as well as the north-west section of the bay, and the western coast of the Western Entrance Segment. The distribution was generally in areas of high seagrass cover, and association with seagrass is consistent with capture in shallow depths (<5 m). Even though Garfish inhabit the water column they have been shown to feed on seagrass (likely to have been drifting) during the day-time and on invertebrates that emerge from the seagrass at night (Robertson and Klumpp 1983; Edgar and Shaw 1995b). High catch rates in the Rhyll and Corinella Segments suggest that the species may be vulnerable to changes in water quality coming from the catchment that would affect these areas (Lee 2011).

Catch rates of Garfish showed an increase from 2007/08 that meant there was an overall increasing trend across the survey period. Reasons for this increase could relate to factors such as changes to cover of seagrass habitat, increased targeting of Garfish by fishers, and the cessation of netting in 2008.

Conclusions

The recreational fishing survey data proved a valuable tool for understanding biodiversity values in Western Port. Some species, such as King George Whiting, Southern Calamari and Southern Sea Garfish had higher catch rates (indicating greater abundance) in areas of higher seagrass cover. In contrast, species such as Snapper and Gummy Shark had higher catch rates in the deeper reef habitats of the Western Entrance Segment and the Lower North Arm. An area of high catch rates for most species was the Rhyll Segment, a broad subtidal sedimentary plain with habitats such as seagrass, macroalgae and sedentary invertebrate isolates (Blake *et al.* 2012; Jenkins *et al.* 2013). The Rhyll Segment is also strongly influenced by water quality and sedimentation entering the north-east of the bay from the catchment (Lee 2011), so catchment management to maintain water quality entering the bay is likely to be critical to maintaining fish biodiversity and sustaining recreational fishing in the bay. Overall, the study provided new information on the spatial distribution and habitat use of important fish populations in Western Port that will inform management of the marine environment in relation to catchment inputs, coastal development, recreational fishing and marine protected areas.

In terms of changes to catch rates over the survey period, there was a common pattern for a number of species of strong fluctuations at the scale of a few years. For species such as King George Whiting and Snapper, research has shown that these fluctuations are related to variability in recruitment that is driven by environmental fluctuations e.g. wind patterns and catchment flows. Long term trends were also evident for some species across the survey period. Snapper showed an increasing trend that was most likely related to a series of successful recruitment years in Port Phillip Bay in the 2000's following poor recruitment in the 1990's (Jenkins 2010). Flathead showed a slightly decreasing trend in catch rate that may be related to the much more significant decrease in Sand Flathead catch rates in Port Phillip Bay over the same period (Hirst *et al.* 2014). This decline is also thought to be mainly driven by a period of poor recruitment related to environmental conditions (Hirst *et al.* 2014). Although catch rates of Elephant Fish were relatively stable across the survey period, the contraction of the spatial distribution in the catch rates to the Rhyll Segment may be a cause for concern through hyperstability in catch rates where decline in the population is masked by increased aggregation (Braccini *et al.* 2008).

It was difficult to discern any effects of the 2008 ban on commercial netting in the recreational data; catch rates of many species did not change markedly at this time, and while Garfish showed an increase in catch rate at this point, Calamari catch rate showed a decrease. For most species, the results suggested that variation in catches by recreational fishers was primarily influenced by the environmental drivers of recruitment of young fish to the Western Port ecosystem.

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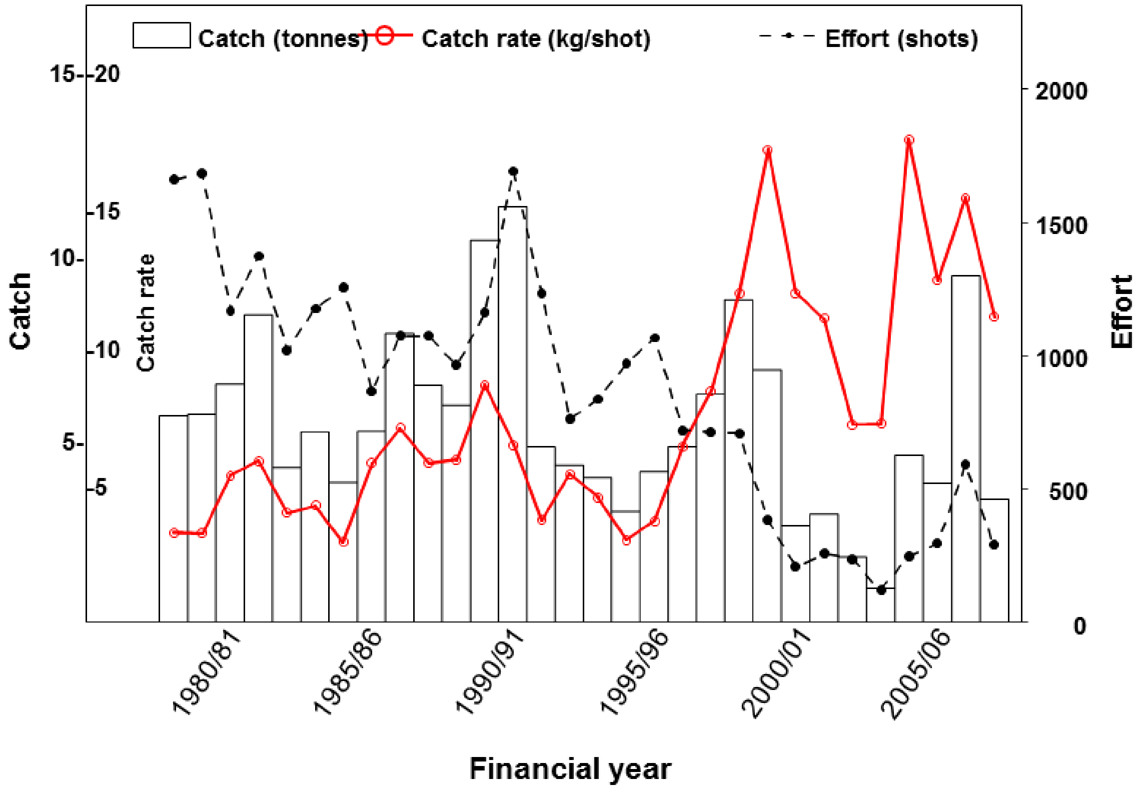
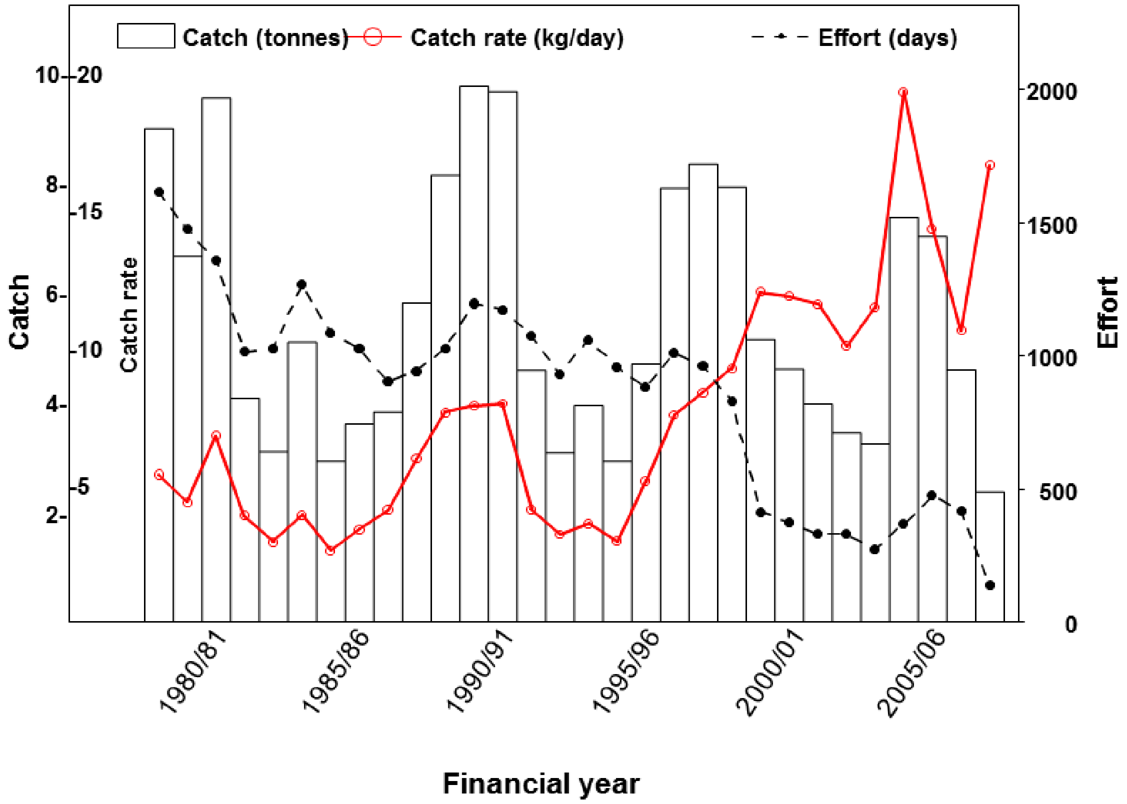
Appendix A

Commercial Catch, Effort and Catch Rate for Fiscal Years 1978/79 to 2007/08

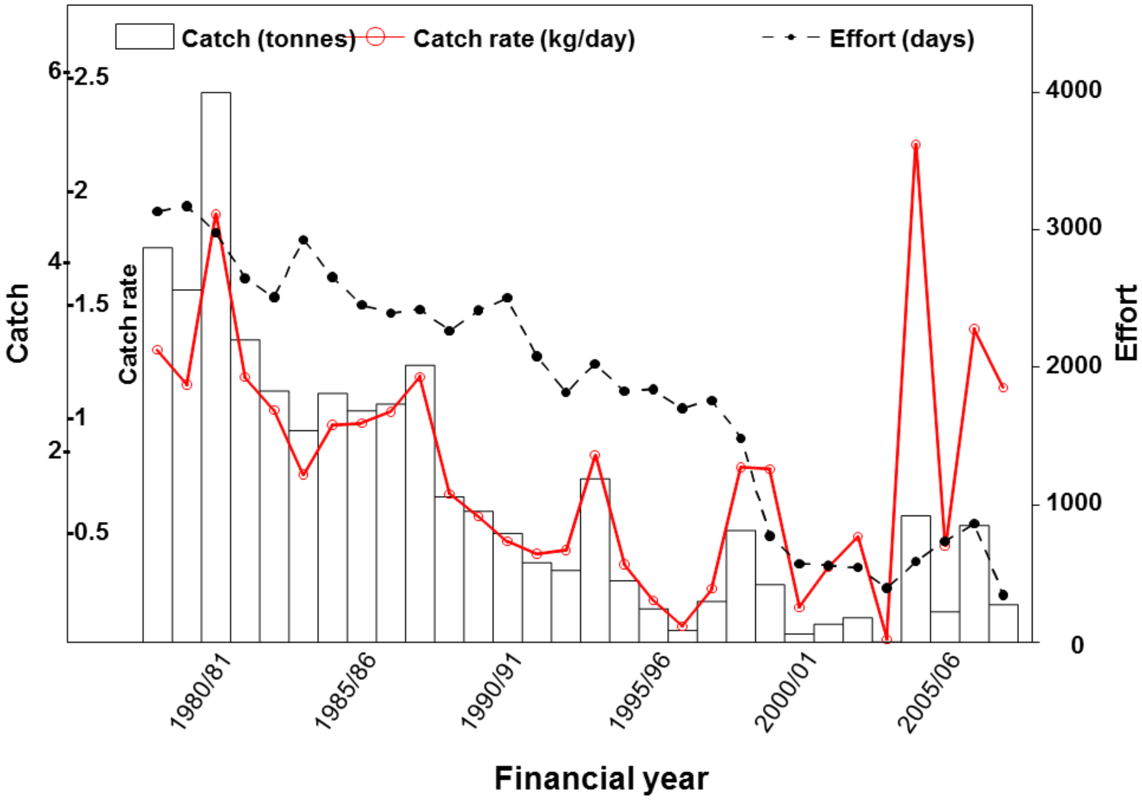
A.



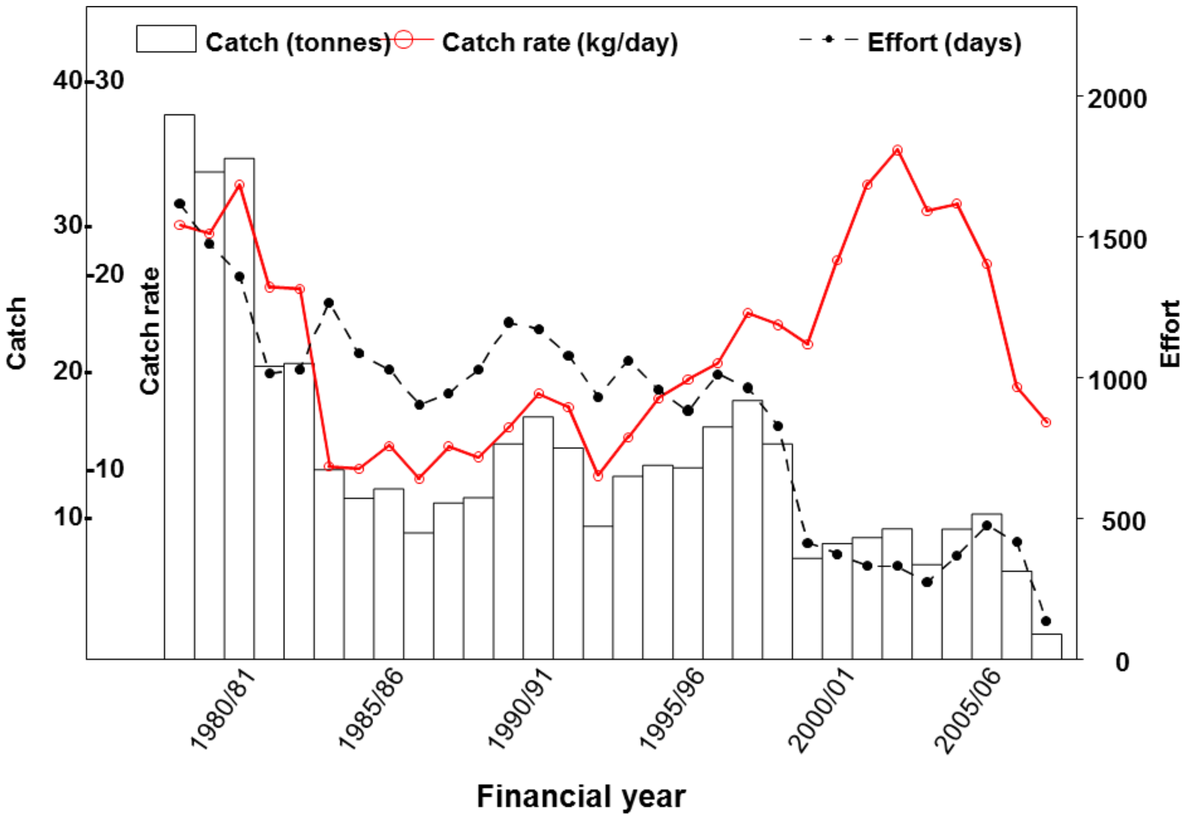
B.



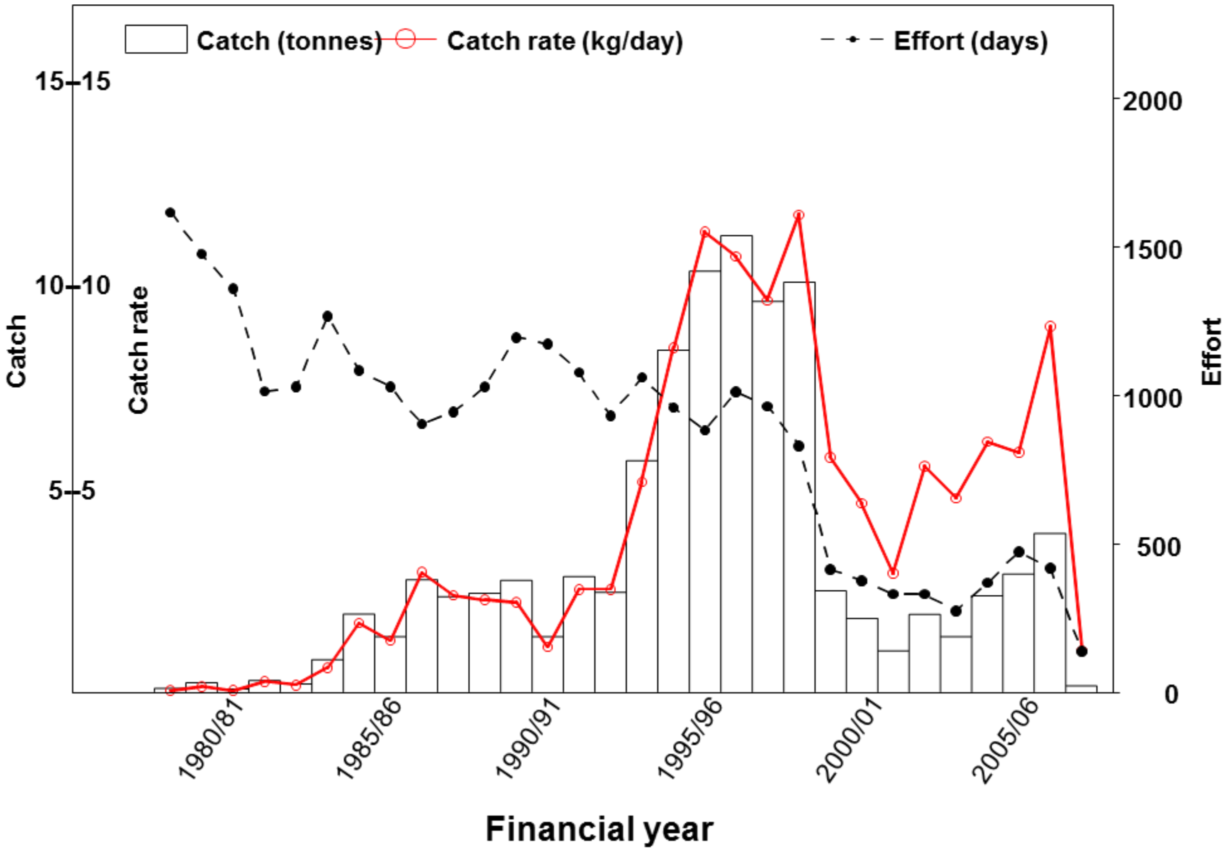
Appendix A1. Catch, Effort and Catch Rate for King George Whiting caught using A) Seine net, B) Mesh net



Appendix A2. Catch, Effort and Catch Rate for Snapper caught using all methods

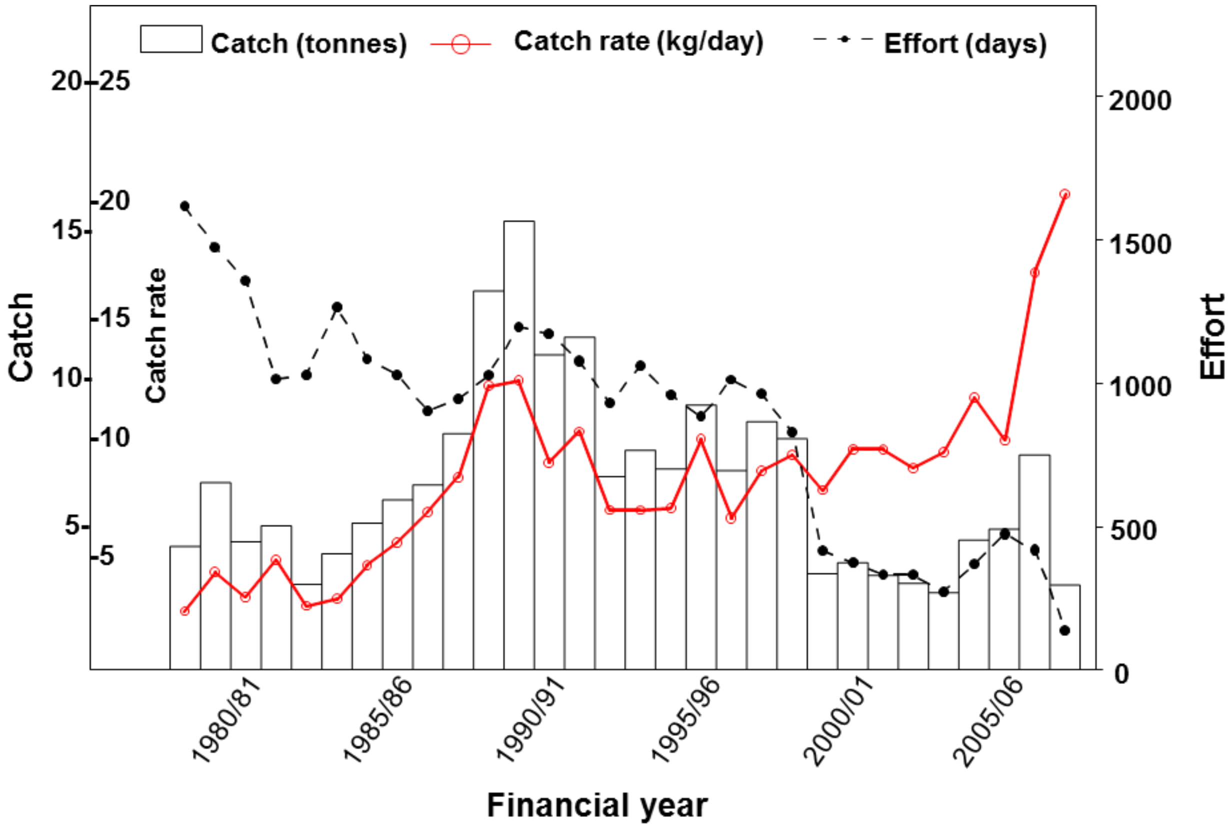


Appendix A3. Catch, Effort and Catch Rate for Rock Flathead caught using all methods

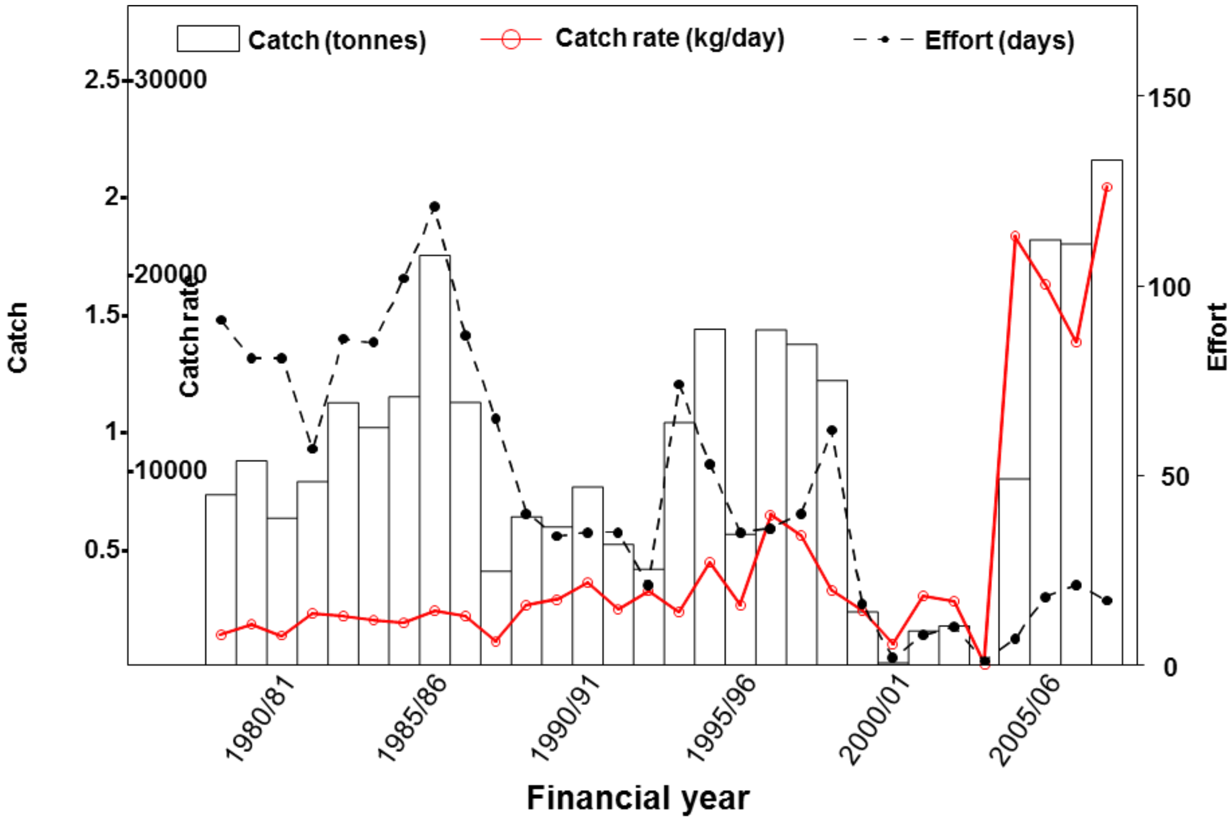


Appendix A4. Catch, Effort and Catch Rate for Elephant Fish caught using mesh nets

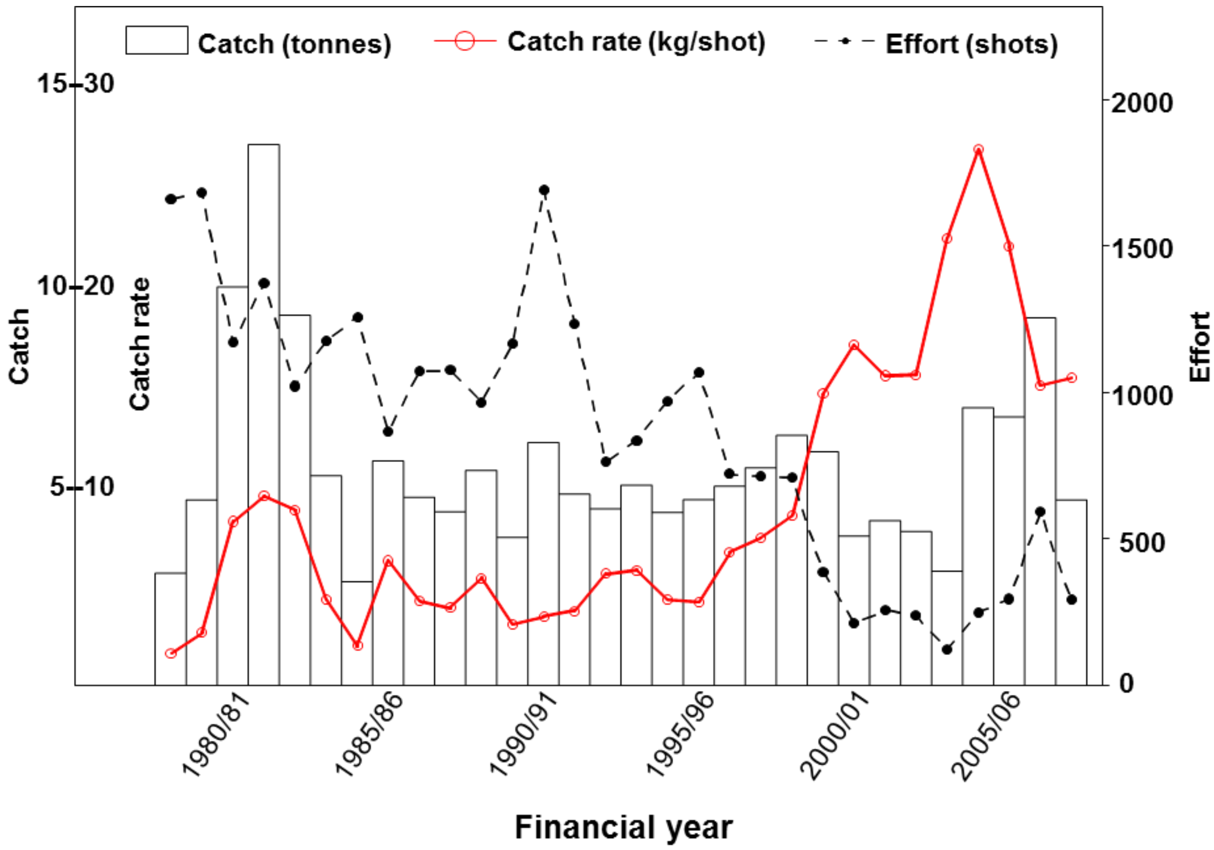
A.



B.

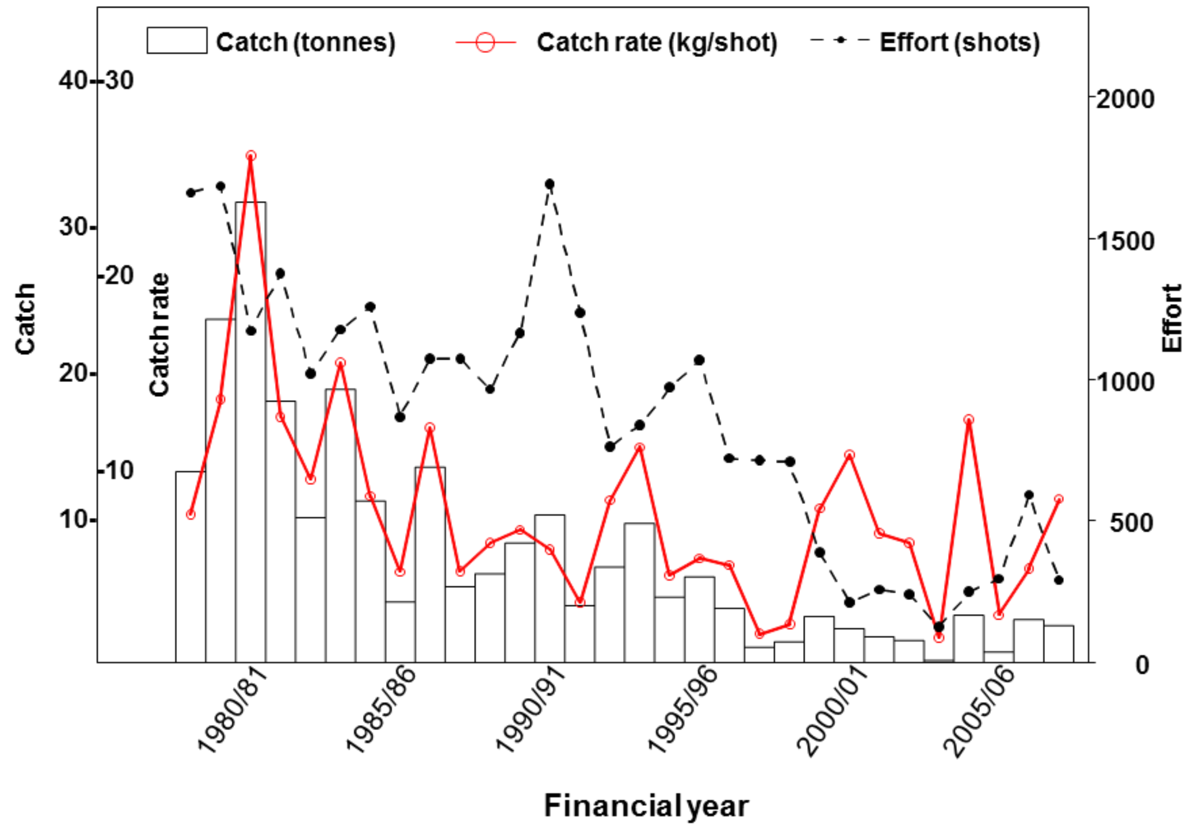


Appendix A5. Catch, Effort and Catch Rate for Gummy Shark caught using A) Mesh net, B) Long-line

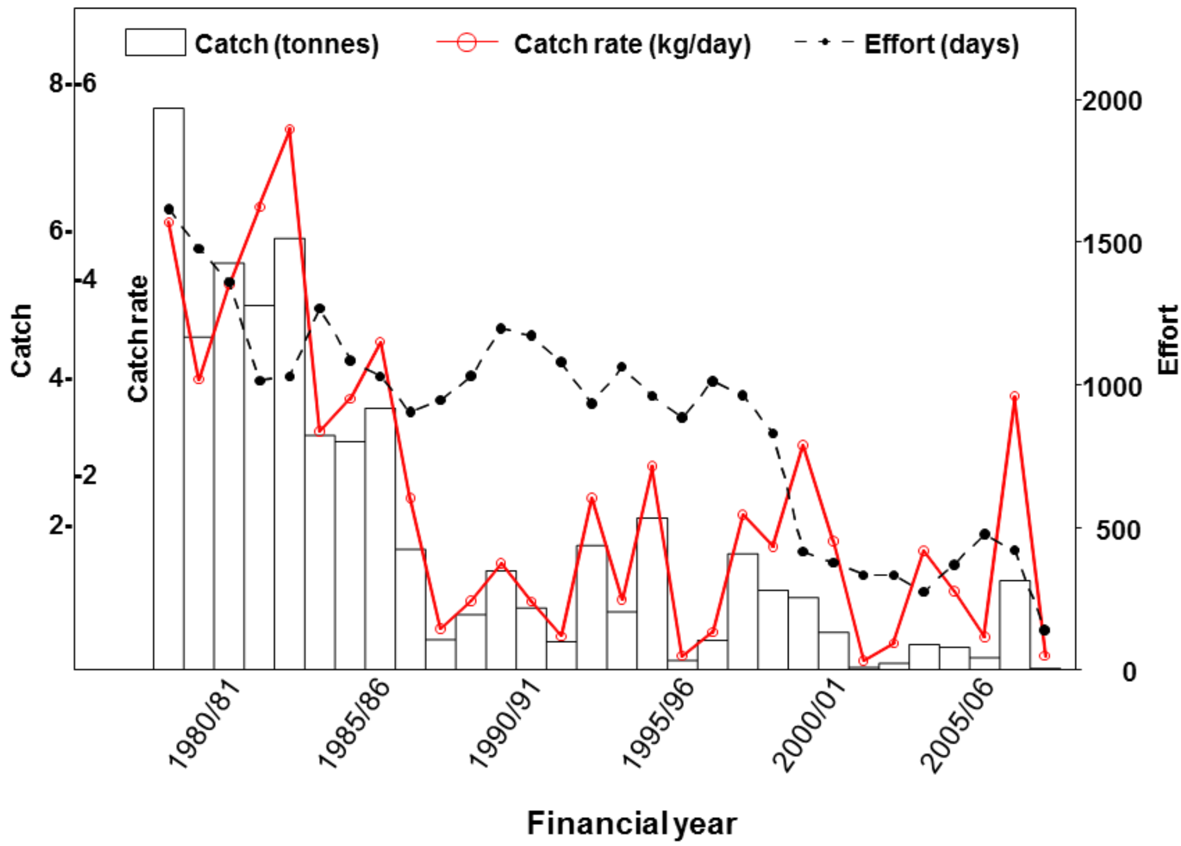


Appendix A6. Catch, Effort and Catch Rate for Southern Calamari caught using seine nets

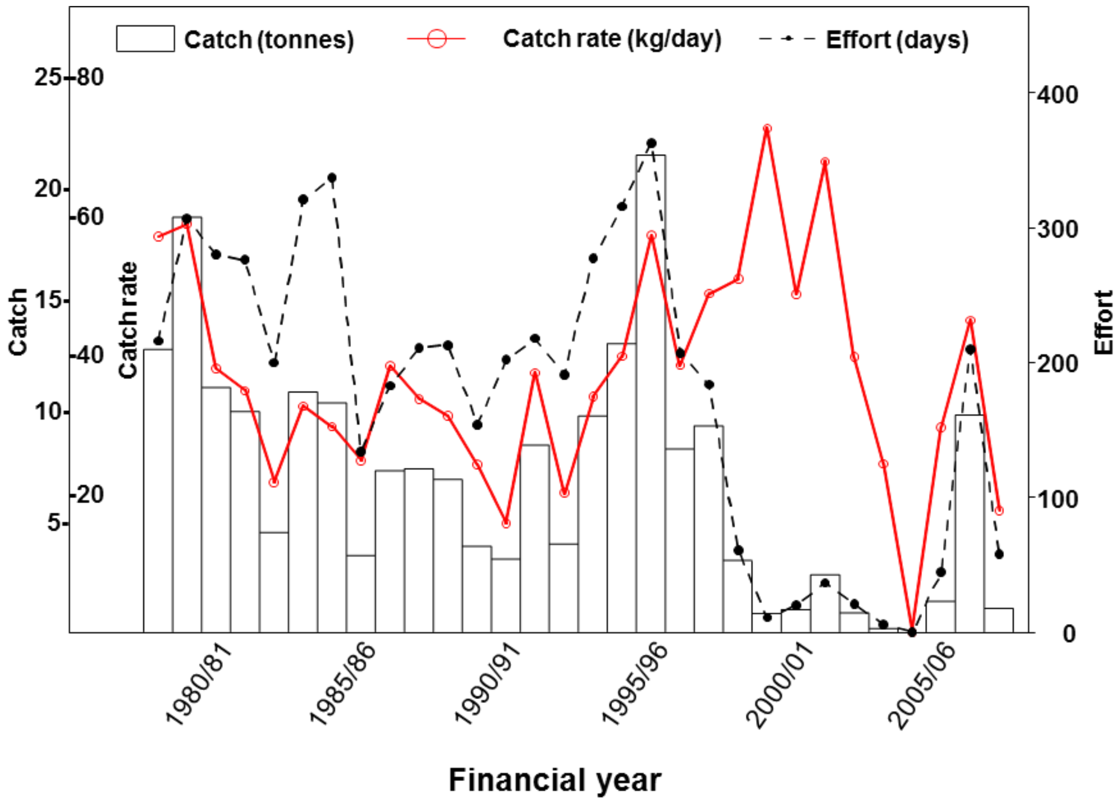
A.



B.



Appendix A7. Catch, Effort and Catch Rate for Australian Salmon caught using A) Seine net, B) Mesh net



Appendix A8. Catch, Effort and Catch Rate for Southern Sea Garfish caught using Garfish Seine