2 SPATIAL AND TEMPORAL TRENDS IN TARGETED FISHING EFFORT

2.1 Introduction

This section of the report characterises patterns of fishing activity in the Marine Scalefish fishery through a detailed decomposition of targeted fishing effort by season, location, target species and fishing gear.

The South Australian Marine Scalefish Fishery is divided into 58 Marine Fishing Areas (MFA) for the purpose of statistical recording and monitoring of commercial fishing activity (Fig 2.1). All licensed fishers are required to log their fishing activities, recording specific details such as the MFA fished, number of fishers on board, species targeted, species caught, weight of catch, and method of capture. This level of detail was initially recorded on a monthly basis, but since 2003 fishers have been required to provide a daily log of fishing activity. These records must be submitted monthly to SARDI Aquatic Sciences where they are entered into a database which is routinely reviewed and cross-checked to ensure that the data meet management and research needs. The current database is a compilation of catch and effort data collected from 1983/1984 to the present and provides the primary source of data used for stock assessments on the primary marine scalefish species. The data used in this project were finalised up to December 2007, thus providing a 24 calendar-year dataset.

Figure 2.1. The commercial Marine Fishing Areas (MFAs) of the South Australian Marine Scalefish Fishery.
2.2 Methods

2.2.1 Data considerations

There is a large amount of catch and effort data currently stored on SARDI Aquatic Sciences’ Marine Scalefish database, as a consequence of the diverse permutations of the multi-species, multi-gear and multi-sector nature of this fishery. As such, for this project, it was necessary to constrain the data into a smaller, more manageable dataset that would still identify the major trends in fisher behaviour and fleet dynamics. There were several approaches adopted to achieve this. The first involved aggregating the data into monthly categories. This level of temporal resolution was considered appropriate, as monthly data were provided by many fishers prior to 2003 and it aligned with some short-term management arrangements that currently exist in this fishery (e.g. November snapper closure). The dataset was further constrained to only include those fishers who caught any of the following species; King George whiting, southern garfish, snapper, southern calamary and yellowfin whiting. These five species collectively account for >70% of total targeted effort and are considered high priority species by fishery managers (Noell et al. 2006). Certain gear types were also amalgamated. Haul nets, floating garfish nets, sinking and floating garfish nets, sinking mesh nets, and sinking mixed mesh nets, were collectively categorised as ‘haul nets’, but were differentiated from large mesh nets (>15 cm) and set gill nets (5 cm) which were considered ‘set nets’. Similarly, hand lines, drop lines, troll lines and fishing rods/poles in the line sector were categorised as ‘hand lines’.

Targeted fishing effort was the main variable of interest in this report, as it is a better indicator of fisher behaviour than total fishing effort. Determining targeted effort in the haul net sector, however, is problematic as most fishers catch multiple commercial species in a single fishing event (Fowler et al. 2009) and are non-specific in their target species. Although one species may dominate their catch, these fishers typically nominate “any species” as their fishing target. As these non-specific fishers constitute a major component of the fishery it was considered necessary to understand their behaviour and relative contribution to the dynamics of the commercial fishing fleet. These fishers were subsequently categorised as ‘any target’ fishers and their estimates of fishing effort were included in the analysis. Estimates of targeted effort were also differentiated between marine scalefish licence holders and rock lobster licence holders.
2.2.2 Confidentiality

SARDI has a commitment to commercial fishers and fish processors that the information that they provide in logbooks is used for research and development purposes only. As such the data that are supplied to SARDI, under the Fisheries Act 2007, cannot be divulged in a format where individual fishers can be identified or which indicates where they have been fishing. The data are therefore aggregated so that each grouping contains at least five licence holders.

2.3 Results

2.3.1 Trends in licence holders

Overall, there has been a 41.4% reduction in the number of fishers licensed to harvest MSF species over the past 26 years, declining from 1,132 licence holders in 1982 to 663 in 2007 (Fig. 2.2). The greatest reduction occurred for the ‘Restricted Marine Scalefish’ and ‘Marine Scalefish’ licence holders that declined by 92.6% and 34.1%, respectively. The rate of decline was accelerated in 1994 due to the implementation of the licence amalgamation scheme and 2005 by the voluntary net-buy back scheme (Fig. 2.2). There was also a significant decline in the rock lobster fishery, where the number of licences declined by 28.7% from 356 in 1982 to 249 in 2000, and has remained steady since. The numbers of licence holders in the Lakes and Coorong, and Miscellaneous fisheries have remained relatively stable over the last 20 years at ~38 and 22, respectively.

Figure 2.2. Long-term trend in the number of licence holders from various commercial sectors that have access to the Marine Scalefish Fishery.
2.3.2 Commercial marine scalefish fishers

Prior to 1994, annual estimates of total fishing effort in South Australia's Marine Scalefish Fishery were relatively stable at approximately 98,000 fisherdays.year\(^{-1}\) (Fig. 2.3). Over the past 14 years, effort levels have declined by 51.9% to 47,527 fisher days in 2007. This decline has occurred at a consistent rate of approximately 3,769 fisherdays.year\(^{-1}\) and is clearly related to the licence amalgamation scheme implemented in 1994 and the voluntary net buy-back scheme implemented in 2005 (Fig. 2.3).

Most (~87%) of the fishing effort was targeted. Collectively, the four primary species attracted the greatest proportion (~72%) of targeted effort of which King George whiting has historically dominated (40%), followed by calamary (13%), snapper (11%) and southern garfish (8%) (Fig. 2.3). The secondary species attracted approximately 22% of the total targeted effort. The distribution of targeted effort amongst these species has changed over the past 24 years, with shark effort dominating during the 1990s, mud cockle effort attracting the most over the past three years, and a few periods of expansion for some ‘niche’ species such as ocean jackets and mulloway (Fig. 2.3). Approximately 3% of the targeted effort was directed at the tertiary species, mostly to yellow-eye mullet and annelid worms (Fig. 2.3). The remaining 3% of total targeted effort was distributed amongst approximately 40 species (see Table 1.1).

A variety of gear types were used to target at least one of the five priority species (Fig. 2.4). Haul nets and hand lines were the main gear types, and with the exception of the last five years, have contributed to >80% of targeted fishing effort for these species. The proportionate use of haul nets has gradually declined from 48.5% in 1984 to 29.9% in 2007, whereas hand line usage has increased from 38.6% to 43.7% over the same period. The use of squid jigs has appreciably increased by 12% and minor increases of 4.2% and 1.2% were observed for the long line and dab net sectors, respectively (Fig. 2.4). Set net usage declined by 3.6%.

Trends in gear usage by non-specific fishers who caught at least one of the five priority species has remained relatively consistent over the past 24 years. Haul net usage has consistently contributed >80% of the annual estimates of non-specific effort (Fig. 2.4). The proportional contribution of hand lines and long lines has
increased by 15.0% and 1.8%, respectively, whereas set net usage has declined 2.8% (Fig. 2.4).

Figure 2.3. Long-term trend in total effort in the commercial Marine Scalefish Fishery partitioned into targeted effort and non-targeted "any target" effort (top) and into species-specific targeted effort, presented in order of priority status.
Figure 2.4. Long-term trend in gear usage (%) for targeted effort and non-specific "any target" effort for the five priority species.

Historically the spatial distribution of fishing effort has been widespread with most of the State’s MFAs registering some level of fishing activity (Fig. 2.5). Fishing effort was most intense in the northern gulf and near major regional fishing ports such as Ceduna (MFAs 8, 9, 10), Coffin Bay (MFAs 27, 28), Port Lincoln (MFAs 30, 31) and Beachport (MFAs 55, 56, 57) (Fig. 2.5). Since 1999 there has been an overwhelming contraction of fishing effort to within the gulf, as fishing intensity around the regional centres has diminished to relatively low levels (<5,000 fisher days per year) (Fig. 2.5). Of the regional centres, Port Lincoln and Ceduna are the only two that have maintained some consistent fishing activity. The northern gulf has continued to account for most of the fishing effort, but this has also become substantially diluted over the past 24-years, declining from >20,000 fisher days per year during the 1980s and early 1990’s to <10,000 fisher days per year since 2002 (Fig. 2.5).
Figure 2.5. Spatial and temporal distribution of total fishing effort in the Marine Scalefish Fishery.
2.3.3 Species-specific trends

2.3.3.1 King George Whiting

Historically, commercial fishers have targeted King George whiting in May and June, with effort estimates often exceeding 5,000 fisherdays in each of these months (Fig. 2.6). This temporal trend has dissipated over time and in recent years levels of targeted effort have remained relatively stable throughout most of autumn and winter, rarely exceeding 2,000 fisherdays per month. This spreading of effort over a longer fishing season has been accentuated by the decrease in haul net effort, which unlike handline effort, is highly seasonal (Fig. 2.7). Handlines have always been the dominant gear type in this fishery, accounting for >80% of targeted effort. Although total targeted handline effort declined by 59.7% over the past 24 years, levels have remained relatively consistent throughout the seasons (Fig. 2.7). Conversely, haul nets were predominantly used to target King George whiting throughout late autumn and winter. Overall, targeted haul net effort has declined by 90.4% from a peak of 14,718 fisherdays in 1986 to 1,408 fisherdays in 2007, as a result of numerous management arrangements specific to the net sector (Table 1.1). Despite this considerable reduction, haul nets remain the second most significant gear type used to target King George whiting, constituting ~ 8% of total targeted effort over the last three years.

Trends in targeted catch have reflected trends in effort, i.e. they typically peaked above 60,000 kgs during the winter months in the 1980s and sequentially declined to below 40,000 kgs in the 2000s (Fig. 2.7). Catch rates were consistently higher in the haul net sector, with net fishers catching up to three times that of handline fishers during the peak of the season. Since 2002, haul net catch rates appeared to dramatically increase over the summer months, but these estimates have been exaggerated by only considering a small group (<12) of specialist net fishers operating during this time (Fig. 2.7). Catch rates in the handline sector have steadily increased from approximately 11 kgs.fisherday$^{-1}$ in the mid 1980s to the current estimate of 17 kgs.fisherday$^{-1}$ (Fig. 2.7.)

The bays of the Far West Coast (MFA 9), northern Spencer Gulf (MFA 21) and south eastern Spencer Gulf (MFA 33) have historically been heavily targeted for King George whiting (Fig. 2.8). Annual estimates of targeted effort in MFA 9 are usually the highest of any area across the State, regularly exceeding 4,000 fisherdays.year$^{-1}$. 
This concentration of effort is dominated by the handline sector as the majority of the area has been closed to netting since 1958 (Fig. 2.9). The spatial distribution of fishing effort within the remaining gulf waters is separated by gear. Line fishers have typically fished the deeper water in the southern regions of Spencer Gulf (MFAs 29, 30, 32, & 33) and Investigator Strait (MFA 40), whereas netters have concentrated their effort in the shallow northern reaches of both gulfs (MFA 21, 22, 34, 35 & 36) (Figs. 2.9 & 2.10). Over time there has been a relatively even dilution of fishing effort in the handline sector and, with exception of some low level fishing around Kangaroo Island (MFA 42) and southern Spencer Gulf (MFAs 30 & 33), haul net effort has contracted northward (Figs. 2.9 & 2.10).

![Figure 2.6. Long-term trend in the seasonal targeted effort for King George whiting.](image-url)
Figure 2.7. Long-term seasonal trends in State-wide total targeted effort, catch and CPUE for King George whiting for the main gear types used by commercial Marine Scalefish fishers.
Figure 2.8. Spatial and temporal distribution of targeted effort on King George whiting.
Figure 2.9. Spatial and temporal distribution of targeted handline effort on King George whiting.
Figure 2.10. Spatial and temporal distribution of targeted haulnet effort on King George whiting.
The snapper fishery is seasonal, extending from late spring through autumn with commercial fishers historically concentrating most of their fishing effort in November, December and January (Fig. 2.11). Estimates of targeted effort over these three months have generally exceeded 3,000 fisherdays, but since 2003 have declined below 2,000 fisherdays (Fig. 2.11). This is principally due to a State-wide management arrangement that prohibited snapper fishing for most of November (midday 1st - midday 30th). Although there were substantial increases in catch in December, following the closure, there were no real appreciable increases in targeted effort when compared to previous years, with estimates remaining around 1,200 fisherdays.month\(^{-1}\) (Fig. 2.11). Despite this, there has been a general reduction in targeted fishing effort over the last 22 years, declining from a peak of 11,136 fisherdays in 1986 to 6,556 fisherdays in 2007, representing a decrease of 41.1%.

Initially, handlines, longlines and haul nets were the three main gear types in this fishery, contributing 75%, 21% and 4% of the total targeted effort, respectively (Fig. 2.12). However, the use of haul nets to catch snapper was banned in 1993. Although haul nets only harvested a small proportion (<4%) of the total targeted catch, their catch rates were often 1 – 2 orders of magnitude higher than those of the other two gear types (Fig. 2.12). Trends in targeted effort between the hand line and long line sectors are asynchronous. Longline fishers frequently contribute a greater proportion of the total effort during autumn and winter whereas hand line fishers dominate during the spring and summer (Fig. 2.12). Catch rates have generally increased in both sectors, particularly accelerating over the past nine years. With the exception of the record increases in CPUE (>130 kgs.fisherday\(^{-1}\)) that followed the November fishing closures, handline catch rates have, on average, increased by ~63%, from approximately 35 kgs.fisherday\(^{-1}\) in 1984 – 1988 to 57 kgs.fisherday\(^{-1}\) in 2005 – 2007 (Fig. 2.12). Similarly, longline catch rates have increased by ~140% over the same period, from approximately 29 to 69 kgs.fisherday\(^{-1}\). The most recent longline catch rates have been the highest on record, with June estimates exceeding 110 kgs.fisherday\(^{-1}\).

The majority of targeted fishing effort for snapper has historically occurred within the northern and eastern parts of Spencer Gulf, particularly MFAs 21 to 23, 32 and 33
Fishers have also regularly targeted snapper in Investigator Strait (MFA 40) and Backstairs Passage (MFA 44). Although there has been a steady reduction in targeted effort in this fishery over the years, this spatial fishing pattern has remained relatively consistent from 1984 until 2005. From 2005 to 2007, targeted effort extended southwards with fishing intensity increasing in southern Spencer Gulf (MFAs 29, 30 & 33), south of Kangaroo Island (MFA 49) and the Fleurieu Peninsula (MFA 45) (Fig. 2.13). This shift was evident in both sectors, but predominantly driven by changes in the long line sector (Figs. 2.14 & 2.15).

**Figure 2.11.** Long-term trend in the seasonal targeted effort for snapper.
Figure 2.12. Long-term seasonal trends in State-wide total targeted effort, catch and CPUE for snapper for the main gear types used by commercial Marine Scalefish fishers.
Figure 2.13. Spatial and temporal distribution of targeted effort on snapper.
Figure 2.14. Spatial and temporal distribution of targeted handline effort on snapper.
Figure 2.15. Spatial and temporal distribution of targeted longline effort on snapper effort.
2.3.3.3 Southern Calamary

South Australia’s southern calamary fishery has undergone considerable development over the last 24 years expanding from a relatively minor fishery during the 1980’s to become the third most valuable species in the Marine Scalefish Fishery. During the early developmental years, commercial fishers expended <7,000 fisherdays year\(^{-1}\) targeting calamary, with the majority of this effort concentrated in late winter and spring (Fig. 2.16). In 1991, total targeted effort increased to 9,068 fisherdays, representing an annual increase of 44%. Since then, annual estimates of targeted effort have frequently exceeded 10,000 fisherdays, peaking at 11,880 fisherdays in 2004. The seasonality of the fishery has also expanded to encompass the entire year, with commercial fishers consistently expending >600 fisherdays per month targeting calamary (Fig. 2.16).

Squid jigs have always been the dominant gear type in this fishery, accounting for >80% of the total annual targeted effort. Since 1992, intra-annual trends in average targeted jig effort have been relatively consistent; remaining around 650 fisherdays.month\(^{-1}\) for most of the year and escalating to >800 fisherdays.month\(^{-1}\) in late spring and summer (Fig. 2.17). Targeted effort in the haul net sector, however, which has rarely exceeded 20% of the annual estimate, has generally occurred from March to September each year, with virtually no haul netters targeting calamary through summer (Fig. 2.17). Catches and catch rates in each of these two sectors have, therefore, peaked at different times. Catch rates in the haul net sector have typically peaked in either June or July and have generally exceeded 40 kgs.fisherday\(^{-1}\). Conversely, catch rates in the jig sector rarely exceeded 30 kgs.fisherday\(^{-1}\) and usually peaked in October and November (Fig. 2.17).

The southern tip of Fleurieu Peninsula (MFA 44), northern Gulf St. Vincent (MFA 35) and north-east Spencer Gulf (MFA 23) have been consistently targeted by calamary fishers over the past 24 years (Fig. 2.18). As the fishery developed throughout the 1990’s targeted fishing effort intensified in southern Spencer Gulf (MFAs 30, 32 & 33), along the Adelaide metropolitan coast (MFAs 36 & 43) and extended into Investigator Strait and northern Kangaroo Island (MFAs 40 to 43) (Fig. 2.18). This expansion was predominantly driven by the jig sector as, despite a short-lived period of expansion along eastern Spencer Gulf in 1990-1992, the greatest concentration of haul net effort has historically been restricted to northern Gulf St. Vincent and north-
east Spencer Gulf (cf. Figs. 2.19 & 2.20). Over the last three years, targeted effort in the haul net sector has significantly declined to a point where none of the State’s MFAs have recorded effort levels >50 fisherdays per year (Fig. 2.20).

Figure 2.16. Long-term trend in the seasonal targeted effort for southern calamary.
Figure 2.17. Long-term seasonal trends in State-wide total targeted effort, catch and CPUE for calamary for the main gear types used by commercial Marine Scalefish fishers.
Figure 2.18. Spatial and temporal distribution of targeted effort on southern calamary.