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Corrective Action Form	Recommendation ☐ to be checked during the following audit Minor NC ☐ proposal within three weeks Major Nc X implementation within 3/6 months	Form 08.01 Rev.01 18/01/2016

Ref. Check list :		Company name: **Ferguson Australia Proprietary Ltd** Site(s) audited: Adelaide, Kangaroo Island & Point Lincoln Contact person: Eliza Ferguson Sustainability manager: Contact details: eliza@fergusonaustralia.com Signature of the company representative: 
Audit date: 14/12/2016	CB: **RINA SERVICES S.P.A.**	
Ref. Requirement: Point 1.1.2 Checklist: **FOS - Wild – Non-Freezer Vessels Sustainable fishing Requirements**	Auditor : **Mr. Harry Owen**	

NC notification date 25/02/2017	Deadline	Date of implementation/proposal
Notified by Mr. **Harry Owen** 	Checked by _____	Accepted Yes ☐ No ☐

NC or recommendation description	Req. N. 1.1.2
1.1.2 Some of the species going for certification have stock levels that are considered outside F_{msy}. These include: Southern Garfish in the Northern Gulf St. Vincent, King George Whiting in the Spencer Gulf and Gulf St. Vincent/Kangaroo Island.	

AC proposal ☐ implementation ☐	Req. N.
Remark for the auditor: In case of implementation the auditor is kindly asked to provide evidences in attachment to this form	

Auditor comments (not mandatory)
Will be eligible for certification the fish caught Southern Garfish in the Northern Spencer Gulf, Southern Spencer Gulf, Southern Gulf St. Vincent, South East and West Coast King George Whiting fished in the West Coast

Fisheries

SOUTH AUSTRALIAN RESEARCH & DEVELOPMENT INSTITUTE
PIRSA

King George Whiting

(*Sillaginodes punctatus*) Fishery

AJ Fowler, R McGarvey, J Carroll and JE Feenstra

SARDI Publication No. F2007/000843-4
SARDI Research Report Series No. 801

SARDI Aquatic Sciences
PO Box 120 Henley Beach SA 5022

September 2014

Fishery Assessment Report to PIRSA Fisheries and Aquaculture

PREMIUM FOOD AND WINE FROM OUR CLEAN ENVIRONMENT

SOUTH AUSTRALIA

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ACKNOWLEDGEMENTS

We wish to extend our gratitude to the numerous fish processors and fishers who gave us access to samples of King George whiting for the collection of data and biological material. In particular we wish to thank Adelaide's SAFCOL fish market for their on-going support of the catch sampling program. In all cases the data on population structure make a significant contribution to our stock assessment work.

The data on catch and effort from the commercial sector of the Marine Scalefish Fishery were provided to us by Angelo Tsolos of the Information Systems and Database Support Program of SARDI (Aquatic Sciences). The market sampling was undertaken by Bruce Jackson, Matt Lloyd and Mike Steer. The report was reviewed by Drs Ben Stobart and Crystal Beckman from SARDI Aquatic Sciences, and Michelle Besley of PIRSA Fisheries and Aquaculture whose comments helped to improve an earlier draft of the report. The report was also externally reviewed by Dr Tony Smith from CSIRO, whose comments led to considerable improvement to the presentation of the report, particularly with respect to inputs and outputs from the stock assessment model WhitEst. The contributions of all are acknowledged and greatly appreciated.

1. EXECUTIVE SUMMARY

This is the 9th in a series of stock assessment reports on South Australia's King George whiting fishery since 1997, and updates the most recent report from 2011. This assessment comes nearly 10 years after important changes were made to the management arrangements in response to a significant, broad-scale down-turn in the fishery from 1999 to 2002.

Three types of fishery performance indicators were considered at the State-wide scale and for the three stocks; West Coast (WC), Spencer Gulf (SG) and Gulf St. Vincent/ Kangaroo Island (GSV/KI). The first indicators were from the commercial fishery statistics from 1984 to 2013. The second indicators were the recent estimates of population size and age structures for numerous regions across the State. Finally, there were estimates of biological performance indicators from the fishery assessment model WhitEst for 1984 to 2013, including annual estimates of fishable biomass, exploitation rate and recruitment.

Emphasis was on statistics from the commercial handline sector as net fishing effort on King George whiting has declined to relatively low levels. At the State-wide scale, total catches and handline effort decreased between 1992 and 2013, partly relating to declining numbers of commercial fishers. State-wide estimates of handline CPUE were variable but increased after the low period of 1999 to 2002. However, trends in handline CPUE differed amongst stocks. For the WC, handline CPUE increased to a record level in 2013, whilst for both the SG and GSV/KI stocks, estimates of handline CPUE declined after 2007.

Size and age structures determined from market sampling done during 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 showed no obvious differences from the estimates from the 1990s and early 2000s. Thus, there is no evidence for population truncation relatable to the fishery.

The State-wide estimates of performance indicators from the stock assessment model WhitEst show strong increases in recruitment and fishable biomass since 2002, and declining exploitation rate since 1992. These largely reflect the influence of the WC which now contributes about 56% of the State-wide biomass of King George whiting. In contrast, model estimates of fishable biomass have declined marginally or

remained relatively flat for SG and GSV since 2009. For SG, this reflects relatively low recruitment but for GSV/KI reflects an increase in exploitation rate.

The general fishery performance indicators for 2013 were assessed against limit reference points from the time series back to 1984, at both the State-wide and stock-wide scales. Breaches of limit reference points differed amongst stocks. For the WC stock, there was a record level of handline CPUE in 2013. For both the SG and GSV/KI stocks they related to record low catches and effort.

The biological fishery performance indicators from 2013 included fishable biomass, recruitment and exploitation rates estimated by the WhitEst model at both the State-wide and stock-wide spatial scales. For the WC, estimates of fishable biomass and recruitment were above average, resulting in breaches of trigger reference points. For GSV, the high exploitation rate of 34% in 2013 also activated the trigger reference point.

The fourth biological performance indicator was population age structure. There was no evidence that any regional population age structure had changed significantly either over the last five years or over the long-term.

King George whiting remains the premium species in the Marine Scalefish Fishery. Its stock status for the WC fishery was determined as **sustainable**, based on increasing trends in CPUE, and estimated fishable biomass and recruitment from WhitEst. Alternatively, the SG stock was assigned the status of **transitional depleting** based on concomitant declining trends in commercial catch, effort and CPUE and estimated biomass from WhitEst. The stock status for GSV/KI was also classified as **transitional depleting**, due to similar declining trends in fishery statistics.

There are several uncertainties with respect to our assessment of stock status. These include the influence of increasing effective effort due to technology creep on handline CPUE, and the consequence of this for estimated biomass. A further uncertainty relates to the lack of time-series data on catch and effort from the recreational sector. The final uncertainty relates to the extent to which egg production may have been disrupted by targeted fishing on spawning aggregations.

2. GENERAL INTRODUCTION

2.1. Overview

Stock assessments have been produced regularly for South Australia's King George whiting fishery since 1997 with this being the ninth report since that time. This report has two aims; to summarise information about the fishery and biology of the species, and to synthesise this information into an assessment of the status of the stocks. The last stock assessment report was completed in July 2011, and summarised data that were available up to the end of 2010 (Fowler et al. 2011). This report incorporates a further three years of commercial catch and effort data, presenting data collected up to the end of 2013.

This introductory chapter establishes the context for the subsequent empirical and modelling-based chapters. It provides: a description of the fishery; summarises the management regulations; and provides a summary of the population biology and life history of the species based on research that has been done over the past 30 years across southern Australia. Chapter 3 summarises the commercial fishery statistics, which primarily involves the presentation of time series of estimates of catch, effort and catch rate at the State-wide, stock-wide and regional spatial scales.

Chapter 4 provides an analysis of the population size and age structures based on samples collected across the State by market sampling in 2011/12 and 2012/13. For comparison, these new data are provided along with those from 2006/07, 2008/09 and 2009/10 that were previously presented in Fowler et al. (2011). Since the population characteristics of King George whiting differ so much between regions and depend on life history processes, it is important that such data be collected every few years to consider possible size and age truncation and to update the computer fishery assessment model WhitEst.

Chapter 5 presents the results from WhitEst, the model that integrates all input data from the fishery to estimate biological indicators of stock status (Fowler and McGarvey 2000). The input data include: the time series of commercial catch and effort data; logbook data from charter boats; data on recreational catch from both the National Recreational and Indigenous Fishing Survey (Henry and Lyle 2003) and the 2007/08 State survey (Jones 2009); and regional samples by month of age, sex, and length proportions in the commercial catch collected at various times between 1995 and

2013. Model outputs include time-series of estimates of recruitment, fishable biomass and exploitation rate at the State-wide and stock-wide scales, by month and year.

Chapter 6 addresses the second aim of the report of determining the status of the King George whiting fishery in South Australia. This is done by assessing the fishery performance indicators specified in the Management Plan for the commercial Marine Scalefish Fishery (PIRSA 2013), and by comparing the data available for King George whiting against prescribed limit reference points. A synthesis of the findings is presented in the General Discussion in Chapter 7, along with the conclusions about stock status.

2.2. Description of Fishery

In South Australia (SA), the fishery for King George whiting is geographically extensive, and includes all coastal waters from Gulf St. Vincent westwards to Denial Bay, throughout which it is intensively targeted by recreational and commercial Marine Scalefish fishers. SA's commercial fishery makes the highest contribution to the national catch of King George whiting, which is generally greater than twice the biomass harvested from Victoria and considerably more than the catch from Western Australia (ABARES 2010). In South Australia, King George whiting was historically the most valuable Marine Scalefish species, but since 2007/08 its total value has been below that of snapper (Knight and Tsolos 2012). Nevertheless, it remains the highest value species by unit weight.

Juvenile King George whiting move from shallow, protected nursery areas to adjacent deeper water. This is where they become vulnerable to fishing. The faster growing individuals in each annual cohort reach fishable size during the period of rapid growth in late summer and autumn when water temperatures are highest. Seasonal levels of exploitation in the commercial fishery for both handlines and hauling nets peak in late autumn and winter, when the new recruits are targeted. Monthly catches generally peak in July. In early summer, when fish reach about 3.5 years of age (based on a birth date of 1st May, Fowler and Short 1998), movement of young adult fish located in the two gulfs is directed southwards. In doing so, they encounter a gauntlet of fishing nets and lines that are used to target these young adults resulting in high levels of exploitation. The fish that reach the southern, deeper, offshore spawning areas at and near the mouths of the two gulfs replenish the populations of larger, older, mature fish (Fowler et al. 2000a, 2002; Fowler and Jones 2008).

The fisheries in Gulf St. Vincent, Northern Spencer Gulf and the West Coast bays predominantly take relatively small, young, immature fish of about 3 years of age that are quite close to the minimum legal size, while fish on the spawning grounds tend to be larger and older, with some up to 18 years of age (Fowler et al. 2000a). Analysis of the reproductive activity of adult fish during the time of spawning in different regions of the two gulfs indicated that King George whiting of comparable size and age showed no evidence of spawning activity in the northern regions, but nearly all those found in the southern aggregations, regardless of size, showed evidence of active spawning (Fowler et al. 1999, 2000a). This indicated that spawning in the gulfs is confined to southern areas, which means that the reproductive sustainability of such populations is determined by successful persistence and replenishment of resident populations in these spawning areas. These spawning sub-populations of larger, older fish are replenished annually by immigrants of 3-4 years of age that come from inshore fishing grounds and the upper gulfs (Fowler et al. 2000a, 2002). Historically, the exploitation of spawning aggregations was relatively low, which may have accounted for the stable recruitment of King George whiting over the years for which catch data were available (Fowler and McGarvey 2000, McGarvey et al. 2000). However, anecdotal reports suggest that now, with an established charter boat fishery and an expanded range offshore of the commercial and recreational sectors, it is likely that fishing pressure on the spawning aggregations has increased over the years.

For the commercial sector of the Marine Scalefish Fishery there are numerous endorsed gear types. Of these, the principal ones used to target King George whiting are handlines, hauling nets and gillnets. Recreational fishing for this species is by hook and line, principally from boats.

2.3. Management Regulations

Changes to the management regulations for the South Australian King George whiting fishery were implemented in October 2004. These included: (1) an increase in legal minimum length (LML) from 30 to 31 cm in all waters east of longitude 136°E; (2) the daily recreational bag limit was reduced from 20 to 12 legal-size fish per person, with the boat limit reduced from 60 to 36 fish per boat; (3) the existing licence amalgamation scheme was enhanced by reducing the number of points needed to acquire an amalgamated licence (from 26 to 24); and (4) if a non-licenced person was detected in possession of more than 75 King George whiting, which is considered a commercial quantity, then that person may be guilty of an offence. At that time,

consideration of appropriate management options was informed by management simulations that were undertaken using the simulation model WhitSim that tested a range of different strategies. The results of these were summarised in an earlier stock assessment report (McGarvey et al. 2003).

The principal means of effort control in the commercial sector is 'limited-entry'. Since 1994, a licence amalgamation scheme has operated to reduce effort in this sector and remove latent effort from the fishery. In association with other targeted licence buy-backs, the number of commercial Marine Scalefish licences has fallen from 701 in 1984 to 322 ('M'-class = 312; 'B'-class = 7) in June 2014. Also, the type of gear used by the commercial sector is strongly regulated by a complex suite of input and output controls. This includes hauling nets that must have a mesh size of 3.2 cm or greater, a maximum length of 600 m, a maximum drop of 5 m in the wings and 10 m in the bunt or pocket. Their use is restricted to coastal waters of less than 5 m depth, and is banned within half a nautical mile of any officially recognised artificial reef and within a radius of 100 m of any jetty, wharf or pier. Gillnets cannot be used in waters shallower than 5 m, the mesh size must be from 5 cm to 15 cm, with a maximum length of 600 m and a maximum drop of 5 m. Handlines are limited to 2 per person, with a limit of 3 hooks per line. There are limits on the number of agents who can fish from a licence, and the master of the licence must be an owner-operator. There are also many permanent and seasonal netting closures that have been introduced over the years for a variety of reasons including the protection of nursery areas and spawning grounds (Noell et al. 2006). A significant rationalisation of the net sector was undertaken in 2005 when a net licence buy-back scheme resulted in the reduction of 61 net licences and endorsements from 113 to 52 (24 full net licences were removed, and 37 net endorsements for hauling nets and gillnets were removed from licences). This resulted in the removal of approximately 45% of net fishing effort. At that time, further permanent spatial closures to the net fishery were implemented in large parts of the State's inshore waters.

Previous significant management changes include a reduction in the recreational bag limit from 30 to 20 fish.day^{-1} or from 90 to 60 fish.boatday^{-1} in September 1994. This was followed by an increase in the LML from 28 to 30 cm TL for both commercial and recreational sectors in September 1995 (Fowler and McGarvey 1997).

2.4. Population Biology and Life History

Although the general life cycle of King George whiting has been known for a number of years (Jones et al. 1990), understanding of it was enhanced through FRDC project 95/008 (Fowler and McGarvey 2000). That study provided: growth functions; estimates of population age structures; descriptions of adult movement patterns; understanding of annual reproductive cycles; spatial and temporal aspects of recruitment; as well as a study of genetic structure. The findings were used to develop a comprehensive understanding of the demography, life history and stock structure of the species in South Australia.

The nursery areas for recruitment of King George whiting are shallow, protected bays where the post-larvae arrive during each winter and spring. They occur in the northern gulfs and bays of the west coast of Eyre Peninsula and Kangaroo Island. Juveniles reside in such nursery areas for a year or two before they move out into gulf waters or deeper areas outside the bays, which are characterised by broken, low-profile reef and stands of seagrass (e.g. *Posidonia* spp.) (Jones et al. 1990).

When the fish reach 3-4 years of age they are capable of moving up to several hundred kilometres within a few months (Fowler and McGarvey 1997, Fowler and March 2000, Fowler and McGarvey 2000, McGarvey and Feenstra 2002, Fowler et al. 2002, Fowler and Jones 2008). They migrate from nursery areas to spawning grounds, whilst there are also less directed movements among coastal areas, mostly along the coast. Fish from Gulf St. Vincent and northern Spencer Gulf move the greatest distances, generally in a net southerly direction. Some fish tagged in Gulf St. Vincent were recaptured along the north coast of Kangaroo Island; some from northern Spencer Gulf were recaptured principally in Hardwicke Bay in the southeast, whilst some were found around the islands of the southwest of the gulf; those from West Coast bays have rarely been recaptured, but are thought to end up around offshore shoals and islands. In contrast, fish tagged near Kangaroo Island and southern Spencer Gulf did not move far and showed no systematic directional displacement (Fowler and McGarvey 1997, 1999; Fowler and March 2000; Fowler et al. 2002). These different movement patterns influence population structure. In those source areas from where fish move and where fishing is concentrated, population structure is generally truncated, involving small fish from a few young age classes. By contrast, at destination locations, older fish can be well represented with some up to 18 years of age (Fowler et al. 1999, 2000a).

Spawning occurs at the offshore grounds to which fish migrate, including: Investigator Strait along the north coast of Kangaroo Island; south-eastern tip of Yorke Peninsula in Gulf St. Vincent (Tapley Shoal); and south-eastern Spencer Gulf around Corny Point and Wardang Island. Spawning typically occurs between March and May (Fowler et al. 1999, 2000a). Patterns of larval distribution that were determined by plankton sampling during the 1980s (Bruce 1989), provided further evidence that spawning occurs in the southern locations and that larvae are advected northwards into and throughout the gulfs (B. Bruce unpublished data). To date, the spawning areas responsible for replenishing the bays of the west coast have not been determined. Commercially-harvested fish from these bays display minimal gonad maturation suggesting that spawning may occur offshore from these fishing grounds.

The long pre-settlement duration of 80 to >120 days of larval King George whiting (Fowler and Short 1996, Fowler and Jones 2008) provides ample opportunity for advection over long distances by hydrodynamic processes, as is the case for Victorian populations (Jenkins et al. 2000). In Port Phillip Bay, Victoria, the inter-annual variation in post-larval abundance is strongly correlated with the strength of the zonal westerly winds that influence the rate of transport of the larvae. This influences recruitment success and productivity to the fishery several years later (Jenkins 2005). Because of this, it is possible that spawning by King George whiting in South Australian waters replenish the fished populations in Port Phillip Bay, Western Port and Corner Inlet in Victoria. In contrast, however, hydrodynamic modelling for coastal areas around South Australia suggests that King George whiting larvae are advected over relatively short distances and that there exist relationships between particular spawning locations and nursery areas separated only by 100-200 km (Fowler et al. 2000b). This suggests that the South Australian populations are sustained by relatively local spawning. Furthermore, the combination of hydrodynamic modelling, sampled larval distributions, and adult movement patterns suggest that the two gulfs are largely-distinct, self-sustaining populations. Nevertheless, analysis of stock structure based on mitochondrial DNA and microsatellite primers found no significant phylogeographic structure across the distribution of King George whiting (Haigh and Donnellan 2000). This is consistent with the long pre-settlement duration, and does not counter the above-mentioned sub-population model since only a minimal but consistent exchange of two or three individuals per year between subpopulations is sufficient to maintain them as genetically homogeneous (Taylor and Dizon 1996).

South Australia's King George whiting population is genetically homogeneous (Haigh and Donnellan 2000). Nevertheless, several stocks are recognised based on our understanding of the spatial aspects of the life history that were described above. These include the interactions between: the adult movement patterns as determined by tag/recapture studies; reproductive biology with respect to the locations of spawning grounds and nursery areas; and advection of larvae, based on determination of early life history characteristics and hydrodynamic modelling (Fowler et al. 1999, 2000b, 2002). For management and stock assessment purposes the King George whiting population is divided into three adjacent stocks: west coast of Eyre Peninsula; Spencer Gulf; and Gulf St. Vincent / Kangaroo Island (Fowler and McGarvey 2000).

3. TRENDS IN COMMERCIAL CATCH, EFFORT AND CPUE

3.1. Introduction

Since 1984, commercial fishers in South Australia's Marine Scalefish Fishery have been required to submit, on a monthly basis, a catch return that relates their catch and effort data for the preceding month. This data time-series constitutes the most fundamental dataset for indicating the status of the fishery. These commercial statistics are considered here at several spatial scales, i.e. State-wide, stock and regional levels. The regional catch and effort data reported are also used in the fishery assessment model 'WhitEst', to calculate time-series of output parameters that relate to population processes and fishery status (Chapter 5). These output parameters are assessed against target reference points to indicate the status of the fishery. Also, in Chapter 6, the commercial statistics at the State-wide and stock levels are used to calculate general fishery performance indicators for comparison against trigger reference points.

3.2. Methods

The South Australian King George whiting fishery involves three stocks: West Coast of Eyre Peninsula (WC); Spencer Gulf (SG); and Gulf St. Vincent/Kangaroo Island (GSV/KI). Each stock involves at least two regional fisheries that consist of numerous adjacent Marine Fishing Areas (MFAs) (Fig. 3.1, Table 3.1). The WC stock includes the Far West Coast (FWC), Mid West Coast (MWC) and Coffin Bay (CB) (Fig. 3.1). The SG stock incorporates the regions of Northern Spencer Gulf (NSG) and Southern Spencer Gulf (SSG) (Fig. 3.1). The GSV/KI stock includes the waters inside Gulf St. Vincent (GSV), and those surrounding Kangaroo Island including Investigator Strait (Fig. 3.1). For this stock assessment, the fishery statistics for King George whiting were aggregated to provide annual totals at the regional, stock and State-wide levels. Annual totals of catch and effort by gear type were used to calculate annual estimates of catch per unit effort (CPUE) at the various spatial scales. The data for the three main gear types, i.e. handlines, hauling nets and gillnets were considered. Nevertheless, the focus in this report is on the handline sector as handline effort and CPUE are recognised as primary fishery performance indicators (PIRSA 2013). This is because the declining effort in the net sector has reduced the value of the data from this sector as fishery performance indicators. Furthermore, for some regions the presentation of data for this sector was limited by constraints of confidentiality, i.e. could not be presented if from <5 fishers. Consequently, detailed data for the net

sector are presented only at the regional level for the two northern gulfs, i.e. NSG and GSV, where most net fishing effort remains.

With respect to fishing effort, data are reported as fisherdays, which relate to the number of days fished and number of personnel involved, i.e. if there were two fishers on board a vessel for a day of fishing then this counted as two fisherdays. There are two components of fishing effort for each gear type, i.e. targeted and untargeted effort. The former relates to when the fishers intentionally try to catch King George whiting, whilst the latter refers to effort directed at other species that produces catches of King George whiting. For handlines and gillnets, total effort was estimated from targeted effort that was scaled upwards by the proportional additional catch that was taken by untargeted effort. Thus, for handlines and gillnets it was possible to provide annual estimates of total catch and effort and associated estimates of CPUE. However, for hauling nets the situation is more complex because fishers may catch substantial numbers of King George whiting whilst targeting other species, or when not targeting any species in particular. Under such circumstances it is not possible to determine the targeted effort directed specifically at King George whiting, making it impossible to provide a direct estimate of targeted CPUE. Consequently, for hauling nets, estimates of catch, effort and CPUE are reported for three different fishing effort categories: targeted effort; effort targeted at other species; and effort not directed at any particular species.

Table 3.1 Fishery stocks considered for the King George whiting fishery and the regions and the MFAs that comprise them (refer Fig. 3.1).

Stock	Region name	Marine Fishing Areas
West Coast	Far West Coast (FWC)	07, 08, 09, 10
	Mid West Coast (MWC)	15, 16, 17, 18
	Coffin Bay (CB)	27, 28
Spencer Gulf	Southern Spencer Gulf (SSG)	29, 30, 31, 32, 33
	Northern Spencer Gulf (NSG)	11, 19, 20, 21, 22, 23
Gulf St. Vincent /	Gulf St. Vincent (GSV)	34, 35, 36, 40, 43
Kangaroo island	Kangaroo Island (KI)	39, 41, 42, 44, 48, 49

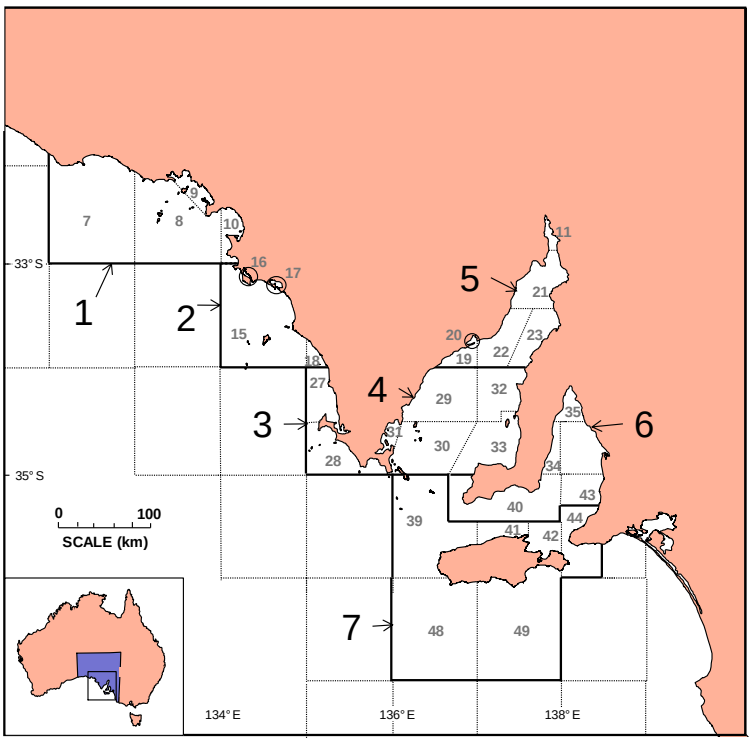

Fig. 3.1. Map of marine waters of South Australia identifying the seven fishery regions involved in the three stocks: WC (1 = Far West Coast, 2 = Mid West Coast, 3 = Coffin Bay); SG (4 = Southern Spencer Gulf, 5 = Northern Spencer Gulf); GSV/KI (6 = Gulf St. Vincent, 7 = Kangaroo Island).

3.3. Results

State-wide analysis of commercial fishery statistics

The time-series of State-wide estimates of commercial catch and effort for King George whiting extend from 1984 to 2013. The most notable feature of these long-term data is declining trends over time (Fig. 3.2a, b). The annual estimates of catch have decreased substantially since 1984, particularly since the record catch of 776 t was recorded in 1992. The most substantial annual decline in catch occurred in 2000, which involved a drop of 161 t. Since then, there has been further gradual decline to 2013 when the lowest annual catch of 293 t was recorded. The value of the annual commercial catch of King George whiting has varied considerably over time (Fig. 3.2a). It increased from its lowest value in 1984 to its highest in 1995 and has since varied between \$3.9 and \$5.2 million, with no long-term trend. Over the last four years to 2013, the estimated value has declined to \$4.4 million.

Since 1984, handlines have been the dominant gear type in the commercial fishery (Fig. 3.2a). Between 1984 and 1999, handline catch varied around 400 $t.yr^{-1}$.

Subsequently, handline catch has dropped by 41% from 428 t in 1999 to 253 t in 2013. The catch of King George whiting by hauling nets has also fallen considerably since the record net catch taken in 1992. The hauling net catch of 22 t in 2013 was the lowest for this gear type, representing a decline by 92% since 1992. Even though the total State-wide gillnet catch has always been less than 50 t.year^{-1}, it has declined over the years and fell to only 9 t in 2013 (Fig. 3.2a).

Handline effort on King George whiting has declined from 30,709 fisherdays in 1992 to 12,078 fisherdays in 2013, i.e. a reduction of 60.7% over this 21 year period (Fig. 3.2b). Gillnet effort has declined by 88.6% from 2,256 to only 257 fisherdays over the same period. Such falling fishing effort relates at least partly to the decrease in number of licence holders in the commercial fishery (Fig. 3.2d). This decline accelerated after 1994 when the licence amalgamation scheme was introduced and again in 2005 through the net buyback. Consequently, over the years, there has been a considerable decline in number of commercial fishers who targeted and/or caught King George whiting (Fig. 3.2d).

The estimates of State-wide CPUE for handlines and gillnets have been variable, but have trended upward over time (Fig. 3.2c). The trend for handlines is divisible into two time periods. It increased relatively consistently from 1984 to 1999, but then dropped noticeably in 2000 and then again in 2002. Since then, CPUE has gradually increased although with declines in both 2008 and 2010. This increase has culminated in the highest average handline CPUE of 20.9 kg. fisherday^{-1} being recorded in 2013. Since the early 2000s, CPUE has increased substantially in the gillnet fishery, but these estimates are based on very low levels of catch and effort and so are unlikely to provide a good indication of fishable biomass.

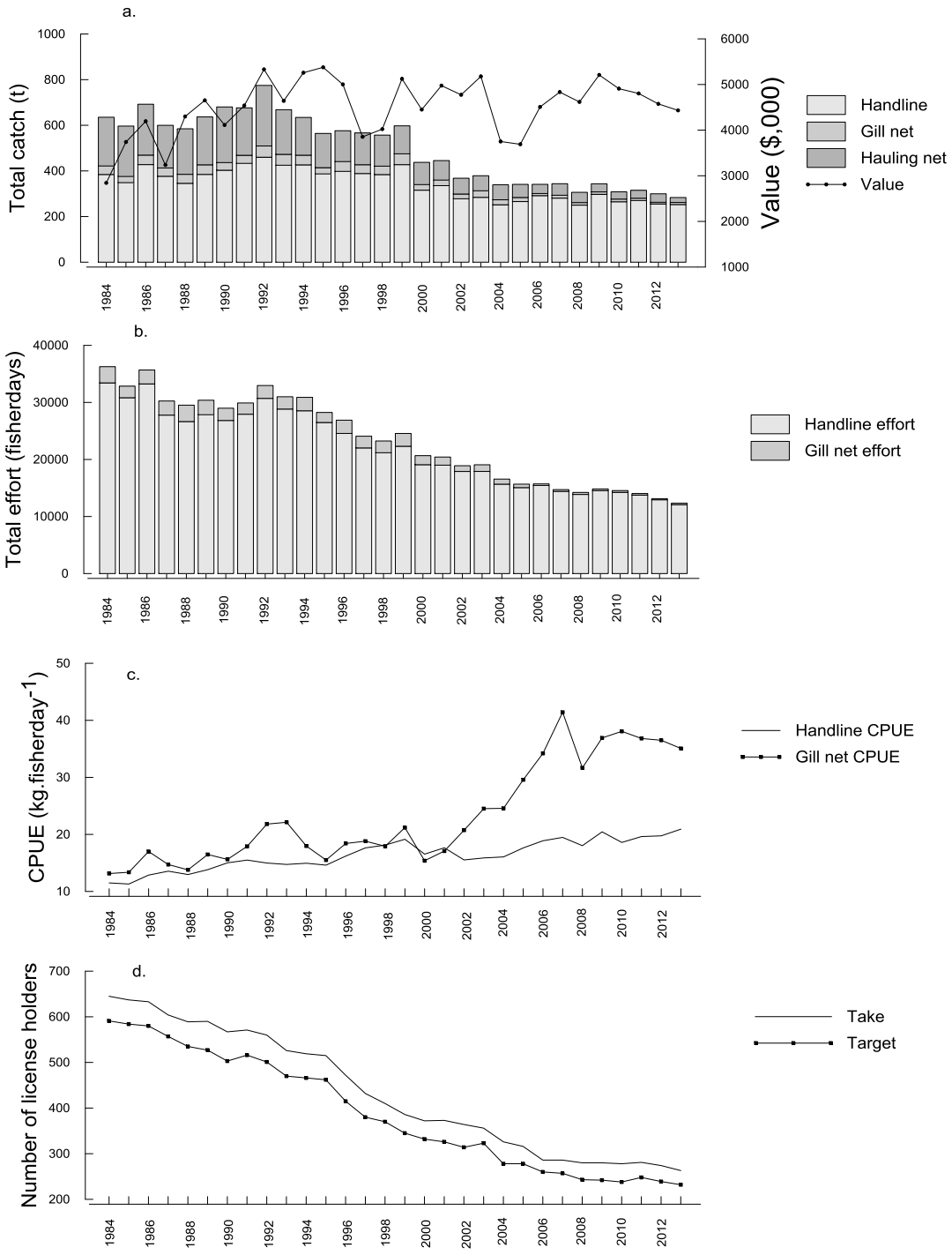

Fig. 3.2. State-wide fishery statistics. a. total annual catches by gear type and annual commercial value. b. total effort for handline and gill net sectors. c. annual State-wide estimates of CPUE for handline and gill net sectors. d. Annual estimates of number of commercial licence holders who reported taking and targeting King George whiting.

Stock-wide analysis of commercial fishery statistics

West Coast stock

The estimates of total catch for this stock have varied through several time periods. There was a general increase from 1984 to a maximum of 283 t in 1992 (Fig. 3.3a). From then, the catch gradually declined by 53% to the lowest level of 134 t in 2002. Subsequently there has been a gradual increase in catch to 170 t in 2013. In all years, handlines dominated the catches from this stock, ranging from a low of 129 t in 2008 to the record high level of 218 t in 1999. The drop in hauling net and gill net catches account for a significant proportion of the decline in total catch.

There was a step-wise decline in commercial handline effort between the maximum of 15,737 fisherdays in 1984 to 7,192 fisherdays in 2007 (Fig. 3.3b). Subsequently, the rate of decline slowed and was at 6,729 fisherdays in 2013. Handline CPUE has increased considerably in three multi-year steps since 1984 (Fig. 3.3b). It increased from 1987 to 1992 then declined considerably to 1995. It increased again to 1999 after which it fell from 20.8 to 15.6 kg.fisherday^{-1} in 2002. Subsequently, CPUE has increased by 61.8%, attaining the highest ever recorded value of 25.2 kg.fisherday^{-1} in 2013.

The number of fishers taking and targeting King George whiting for this stock have both declined considerably between 1984 and 2013 (Fig. 3.3c). The steepest rates of decline occurred between 1984 and 1997. Subsequently the declines have slowed, and in fact since 2007 there have been marginal increases in the numbers of fishers. From 1984 to 2013, the declines were from 211 to 97 in fishers who reported taking catches and 203 to 95 in numbers who targeted King George whiting.

Spencer Gulf stock

Total catch from this stock was variable from 1984 to 1997, but showed no long-term trend (Fig. 3.4a). It then declined by 57.1% between 1997 and 2004. Then from 2007 to 2013, total catch declined by a further 44.8% to the lowest ever recorded value of 68.6 t. This reflects declining catch by each of the major gear types but is particularly evident for the hauling net sector.

Handline fishing effort was variable between 1984 and 1992 (Fig. 3.4b). However, it then declined almost from year-to-year until 2004, giving a total decline of 60%.

Handline effort was then relatively stable for a number of years, but by 2013 had decreased by a further 28.3% to the lowest ever recorded level of 3,270 fisherdays. Handline CPUE increased considerably from 11.7 kg.fisherday^{-1} in 1984 to a high level of 19.6 kg.fisherday^{-1} in 1997 (Fig. 3.4b). It then declined by 20.7% to only 15.6 kg.fisherday^{-1} in 2003. After this, there was a considerable rise to 20.6 kg.fisherday^{-1} in 2007. However, from 2007 to 2013, handline CPUE declined almost annually by 17.4%. Apart from the low values recorded between 2002 and 2004, this is the lowest recorded level since 1996.

The number of licence holders taking and targeting this stock of King George whiting has declined considerably over the years. Those taking this species declined from 325 in 1984 to 136 in 2013. The decline in fishers targeting this species was from 295 to 119.

Gulf St. Vincent/Kangaroo Island stock

The total catch from this stock has generally been consistently lower than for the other two stocks and has varied through a number of different periods (Fig. 3.5a). First, it declined between 1984 and 1988 before increasing to the record level of 146.4 t in 1992. Subsequently, it has declined to the lowest annual catch of 45 t in 2013. Each of the three major gear types contributed to these catches over time, with the catch from each having declined. Handline catches were relatively stable from 2000 to 2006, but subsequently declined by a further 43.3% to 27.3 t.

Handline fishing effort on this stock reached its highest level of 7,649 fisherdays in 1992 (Fig. 3.5b). It subsequently declined by 54.9% to 3,449 fisherdays in 2000. It then remained relatively flat to 2009, after which there was further decline to 2,092 fisherdays in 2013. Although variable amongst years, handline CPUE increased by 57.7% between 1984 and 2000 (Fig. 3.5b). It then declined for a few years before increasing between 2003 and 2007. Subsequently, CPUE has declined by 19.3% from 16.2 to 13.1 kg.fisherday^{-1} in 2013.

The number of licence holders who captured or targeted King George whiting showed no consistent trend between 1984 and 1992 (Fig. 3.5c). However, subsequently the numbers have declined considerably. In 1984, a total of 187 fishers took King George whiting, which fell to 69 in 2013. Furthermore, the number of fishers who targeted this species declined from 160 to 51 over the same time period.

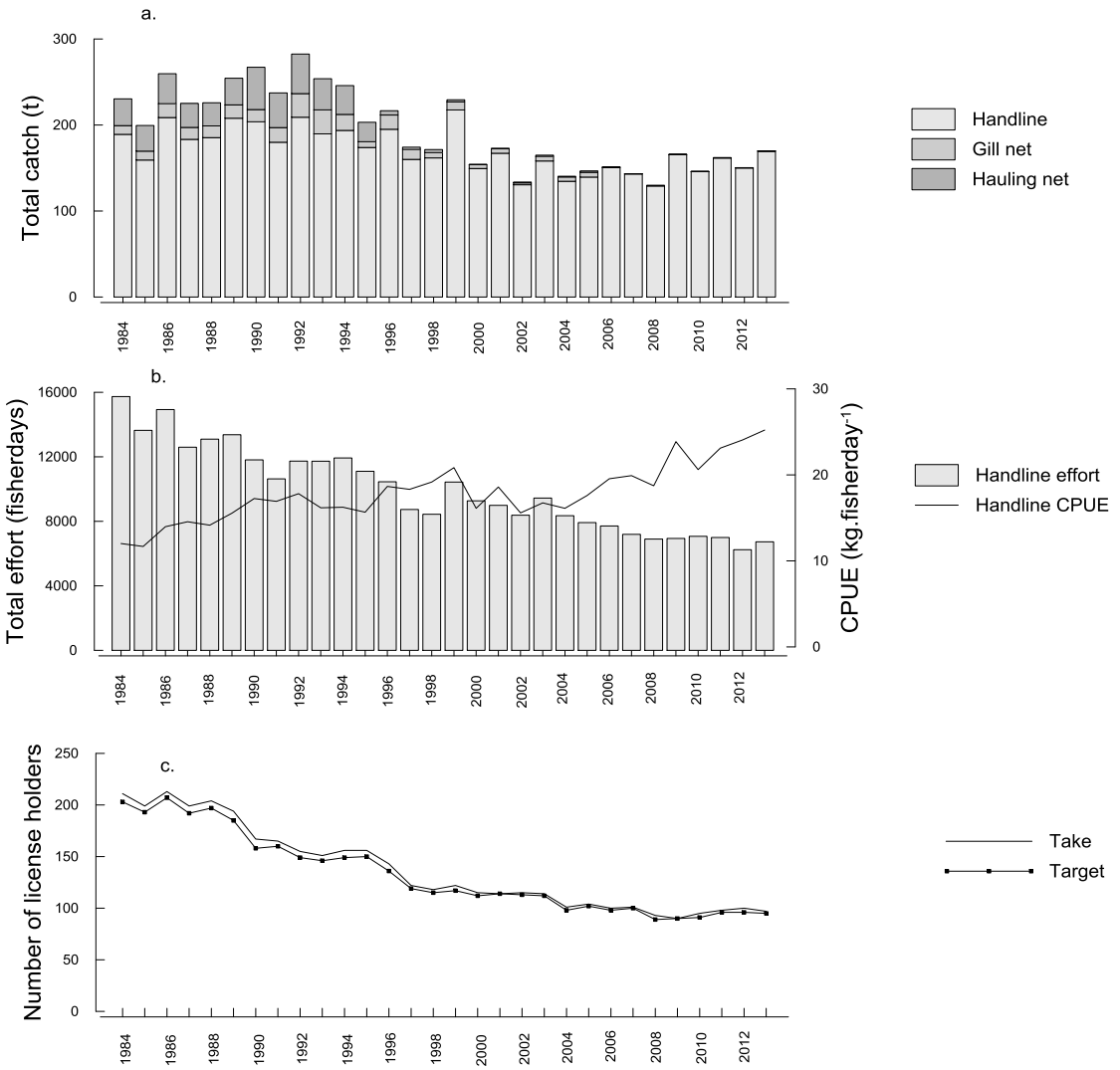

Fig. 3.3. Fishery statistics for West Coast stock. a. total annual catches by gear type. b. total effort and CPUE for handlines. c. annual estimates of numbers of commercial licence holders who reported taking and targeting King George whiting.

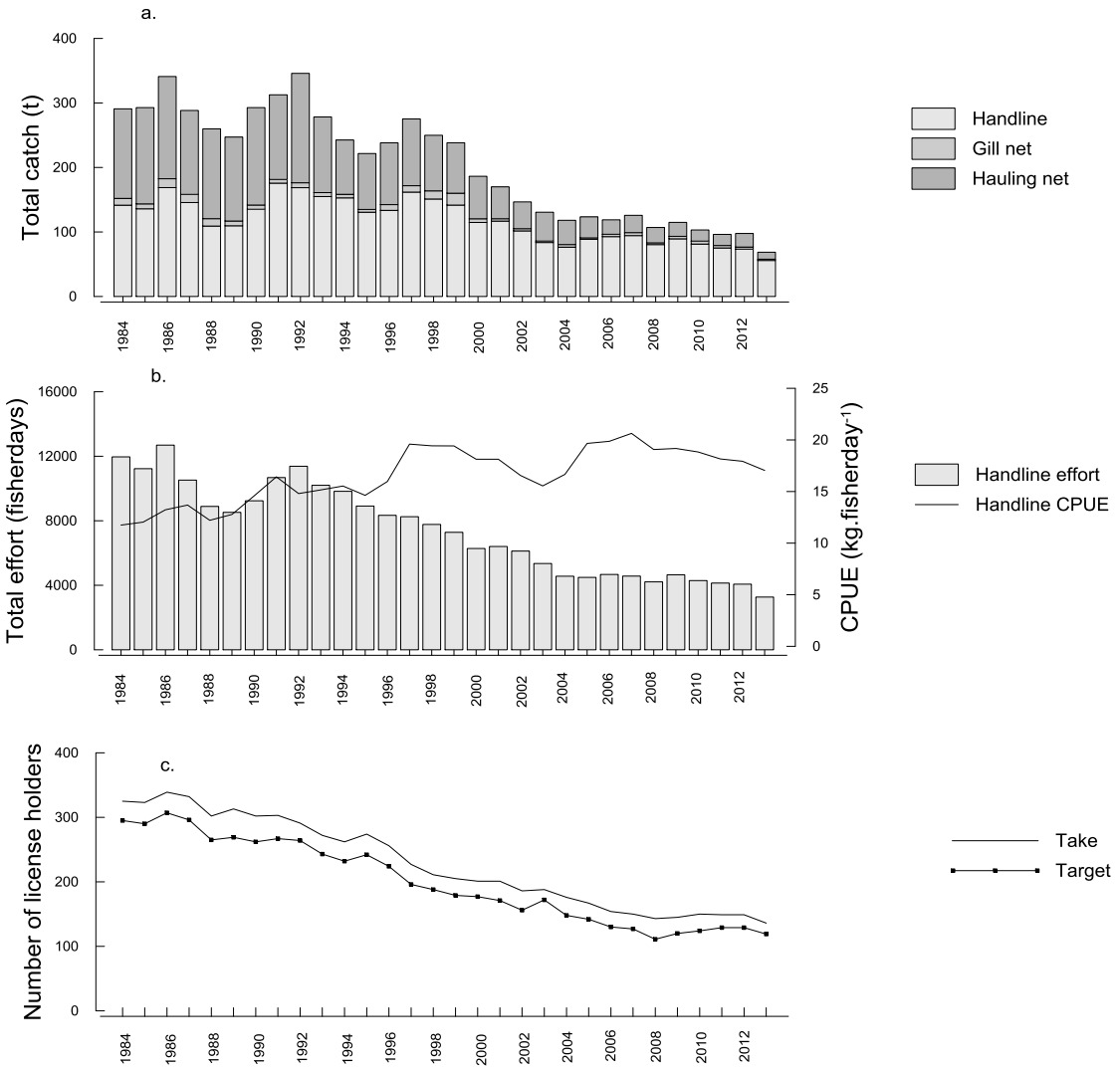

Fig. 3.4. Fishery statistics for Spencer Gulf stock. a. total annual catches by gear type. b. total effort and CPUE for handlines. c. annual estimates of numbers of commercial licence holders who reported taking and targeting King George whiting.

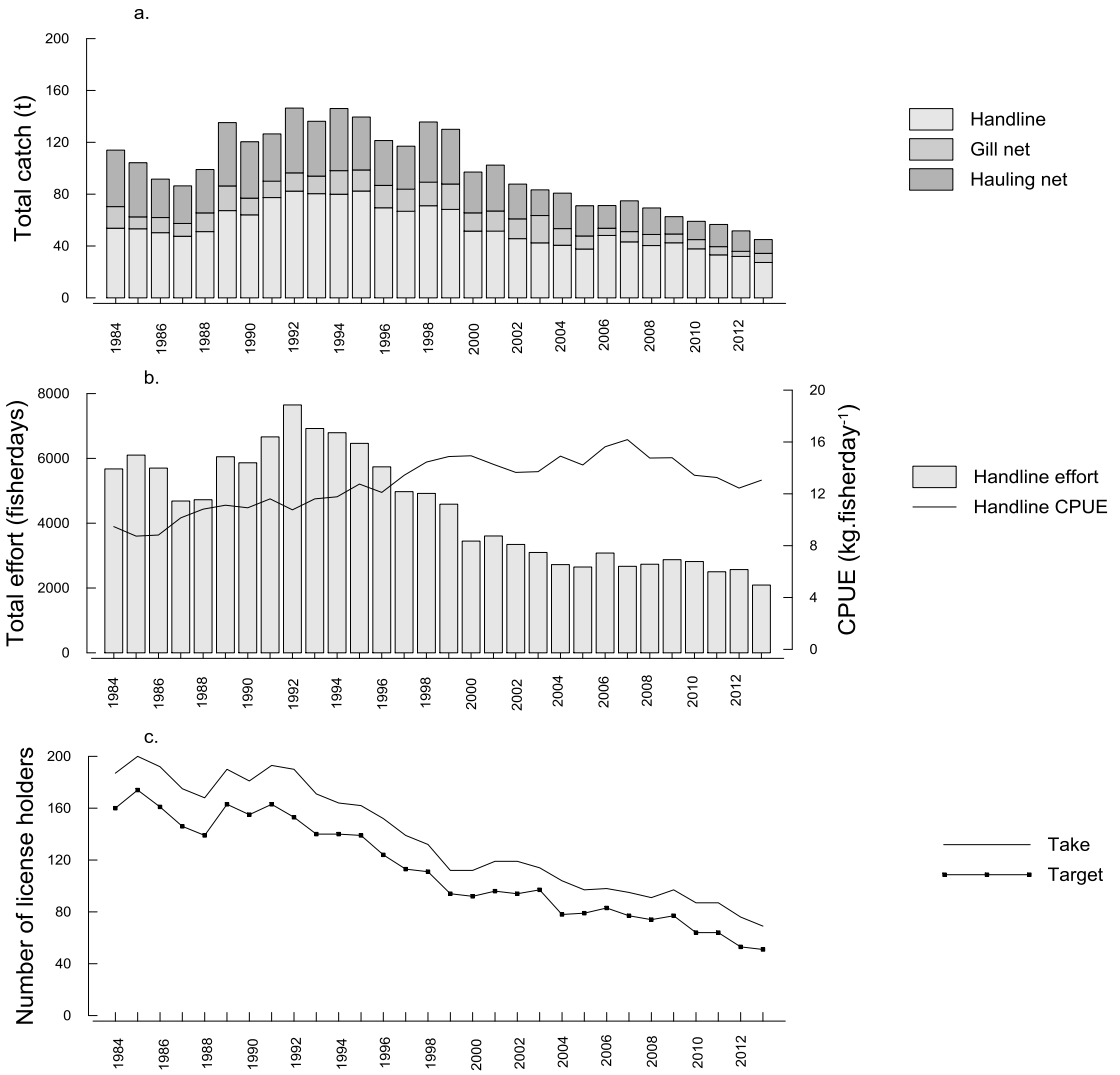

Fig. 3.5. Fishery statistics for Gulf St. Vincent / Kangaroo Island stock. a. total annual catches by gear type. b. total effort and CPUE for handlines. c. annual estimates of numbers of commercial licence holders who reported taking and targeting King George whiting.

Regional analysis of commercial fishery statistics

The fishery statistics were considered in further detail to assess for consistency in trends amongst the different regions of the three stocks. The time series of total annual catches across all gear types for the seven regions demonstrated some consistent changes over time. The FWC has generally been the most consistent contributor amongst all regions (Fig. 3.6). The catches from the MWC and CB have generally been lower and more variable than those of the FWC. The catches from SSG were generally higher and more consistent than those of NSG, which demonstrated the most consistent decline amongst all regions. The total catches from GSV and KI have been relatively low, whilst those from GSV declined from the early 1990s and those from KI declined considerably over the past five years.

When considered at the spatial scale of MFA, there has been a gradual contraction in fishery catches over time towards several MFAs (Fig. 3.7). MFA 9, located on the WC, has been the most productive block throughout the entire time period, whilst MFAs 10 and 27 have also been consistently significant for the WC stock. For the SG stock, catches were historically widespread but have eventually contracted back to those from MFA 23 in NSG and MFAs 30 and 33 in SSG. For the GSV/KI stock, catches have been most consistent from MFA 35 in NGSV and MFA 42 for KI.

The remainder of this chapter examines the trends in annual catch, effort and CPUE for the seven different regions. For each region, annual estimates of handline catch, effort and CPUE are presented. Furthermore, for both NSG and GSV, where hauling nets remain a significant gear type, a separate figure is also presented that relates the region-specific estimates of hauling net catch, effort and CPUE with effort divided into the categories of ‘targeted’, ‘no specific species targeted’ and ‘other species targeted’.

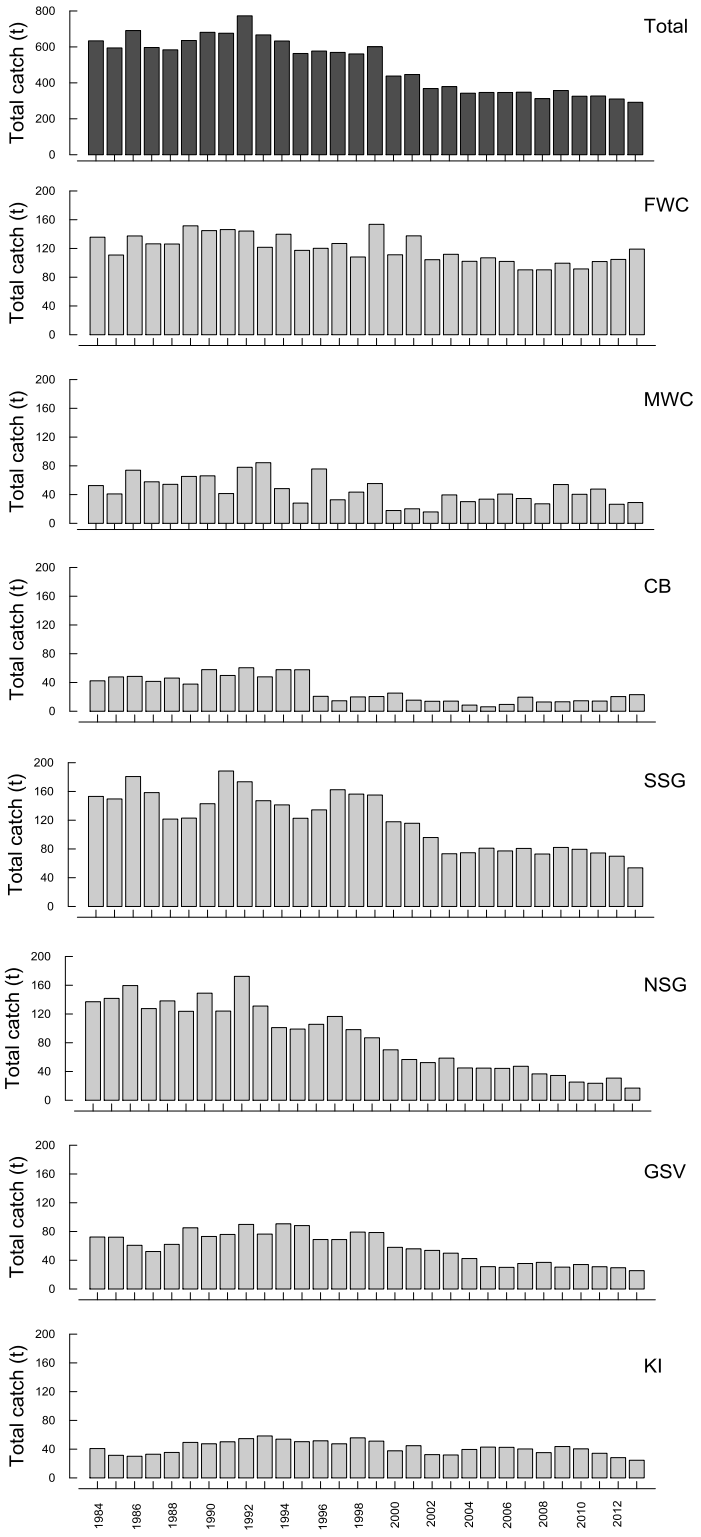

Fig. 3.6. Summary of annual commercial catches of King George whiting at the State-wide and regional scales from 1984 to 2013.

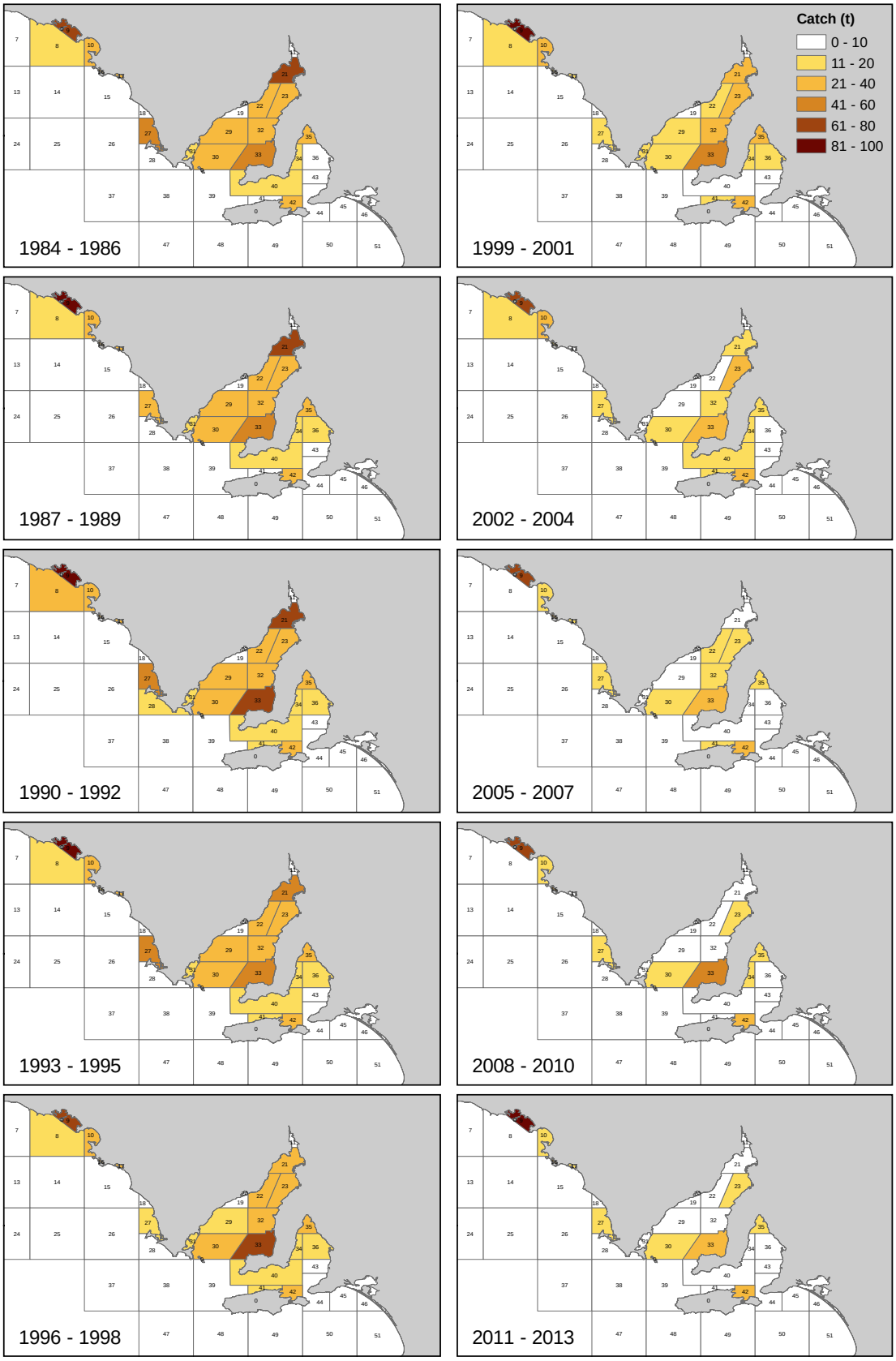

Fig. 3.7. Maps of South Australian coastal waters showing the average annual catch in each Marine Fishing Area for the three-year periods indicated.

Far West Coast (Denial and Streaky Bays)

The annual catches from the bays of the Far West Coast have been relatively high and consistent over time and dominated by the handline sector since the implementation of a netting ban in 1958 (Fig. 3.8a). Up to 2001, the handline catches varied around an average of 130 t.yr^{-1}. From 2002, the catches have been generally lower although the catch of 118.7 t recorded in 2013 was the highest recorded for 12 years. Between 1984 and 1998, handline effort declined by 40% to approximately 6,000 fisherdays.year^{-1} (Fig. 3.8b). It then increased through the period of 1999 to 2005 before gradually declining again. It declined by 24.4% from 6,384 fisherdays in 2004 to 4,824 fisherdays in 2013.

Handline CPUE showed a long-term increasing trend from 1984 to 1999 (Fig. 3.8b). Through this time there were several periods of higher catch rates, one from 1989 to 1992 and the second from 1996 to 1999. It then declined considerably through the period of 1999 to 2002. However, from 2004, handline CPUE has gradually recovered and in 2013 attained the highest level ever recorded of 24.6 kg.fisherday^{-1}.

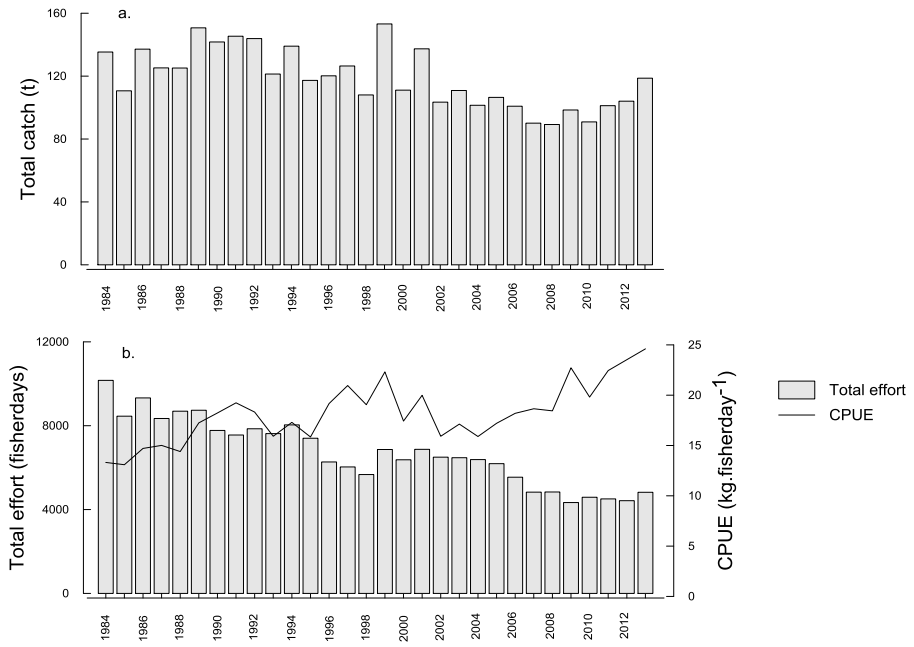

Fig. 3.8. Far West Coast. Historical trends in commercial fishery statistics for King George whiting. a. total catch by handlines. b. total effort and CPUE for handlines.

Mid West Coast (Baird and Venus Bays)

Between 1958 and 2005, the bays of the Mid West Coast were closed to net fishing through a number of management measures. As such, only handline fishery statistics are considered below for this region.

The annual handline catches from the bays of the Mid West Coast have been highly variable from year-to-year (Fig. 3.9a). From 1984 to 1999, annual catches showed no long term trend. In 2000, the catch dropped to the lowest recorded level of 13.1 t and remained low in both 2001 and 2002. From 2003 to 2011, it increased before declining again to 26.5 and 28.9 t in 2012 and 2013, respectively. These recent catches were higher than the low catches at the start of the decade. Handline effort has also been highly variable from year-to-year but has demonstrated a long-term decline, particularly from 1999 to 2002, culminating in the lowest recorded fishing effort in 2002 of 1,065 fisherdays (Fig. 3.9b). Subsequently, handline fishing effort was also relatively low in 2012 and 2013. Between 1984 and 2000, handline CPUE was variable but showed no long-term trend (Fig. 3.9b). However, since 2000, it has risen from a low level of 7.8 kg.fisherday^{-1} to a maximum of 26.1 kg.fisherday^{-1} in 2009, before falling back to 24.5 kg.fisheryday^{-1} in 2013.

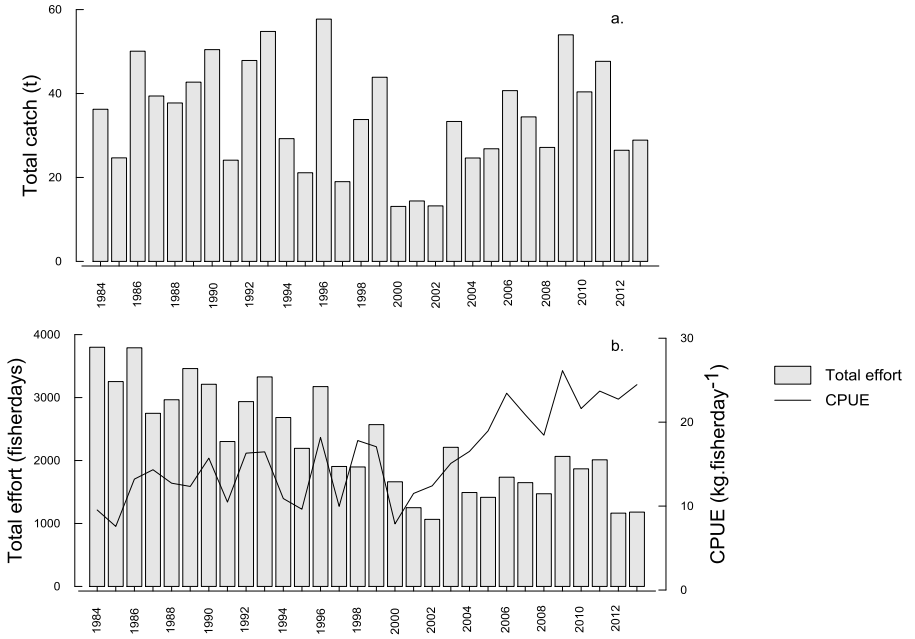

Fig. 3.9. Mid West Coast. Historical trends in commercial fishery statistics for King George whiting. a. total catch by handlines. b. total effort and CPUE for handlines.

Coffin Bay

As a consequence of a review of the net fishery in 1995 and 1996, Coffin Bay was closed to net fishing in 1996. Since then, the region has supported only a line fishery. As such, only line-based statistics are presented here.

From 1984 to 2000, the handline catch of King George whiting was highly variable but showed no long-term trend (Fig. 3.10a). From 2000 to 2005, it declined to 6 t, but has since recovered to 22 t in 2013. The temporal variation in fishery catches is also reflected in the trends in effort (Fig. 3.10b). There was a considerable decline to 316 fisherdays in 2005, after which it increased to 723 fisherdays in 2013. Handline CPUE has been variable but nevertheless generally increased over time (Fig. 3.10b). However, handline CPUE declined by 25.8% between 1998 and 2002 from 22.9 to 17.0 kg.fisherday^{-1}. It has subsequently increased to >20.0 kg.fisherday^{-1} in 2006, and to >30.0 kg.fisherday^{-1} in 2012 and 2013.

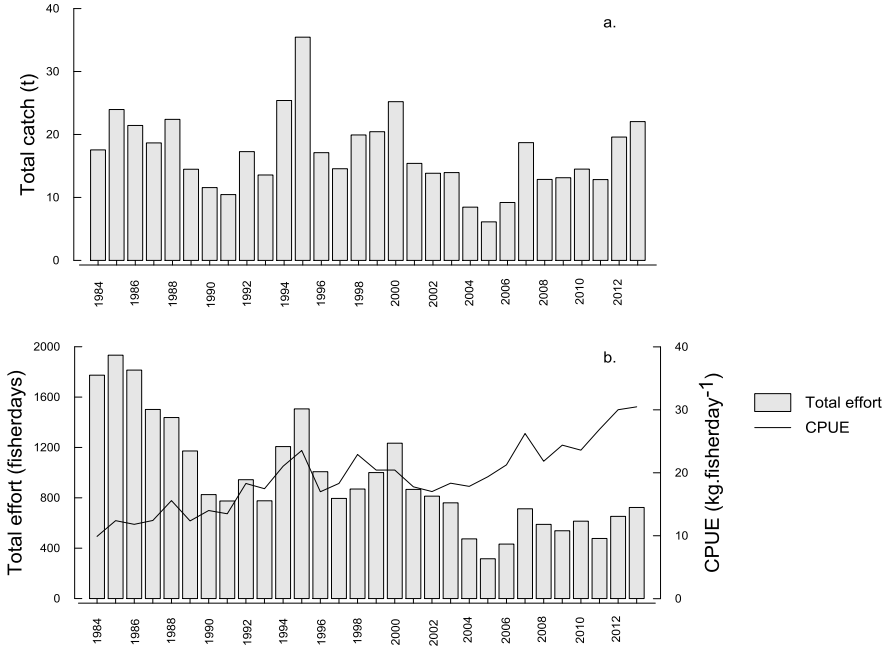

Fig. 3.10. Coffin Bay. Historical trends in commercial fishery statistics for King George whiting. a. total catch by handlines. b. total effort and CPUE for handlines.

Southern Spencer Gulf

Handlines have always been the dominant gear type in this region followed by hauling nets and gillnets. The gillnet catches fell considerably in 2000 and have remained low, contributing only a few tonnes per year. The hauling net catch was always higher than the gillnet catch before dropping to only a few hundred kg per year as a consequence of the netting closures that were implemented in 2005. Consequently, now only the statistics associated with the handline fishery provide a reasonable indication of the stock status.

Handline catch has been variable over the years with three obvious peaks, one in 1986, the next in 1991 and the third in 1997 (Fig. 3.11a). After that, catches have declined regularly from 131 t to only 57.4 t in 2004, followed by an increase to 76.6 t in 2009. Since then, catch has declined to 48.5 t in 2013. Handline effort was particularly variable in this region between 1984 and 1993 (Fig. 3.11b). From then until 2004, handline effort fell systematically by approximately one half from 7,716 to 3,583 fisherdays. It was then relatively stable from 2004 to 2012, before falling by 20% to 2,761 fisherdays in 2013.

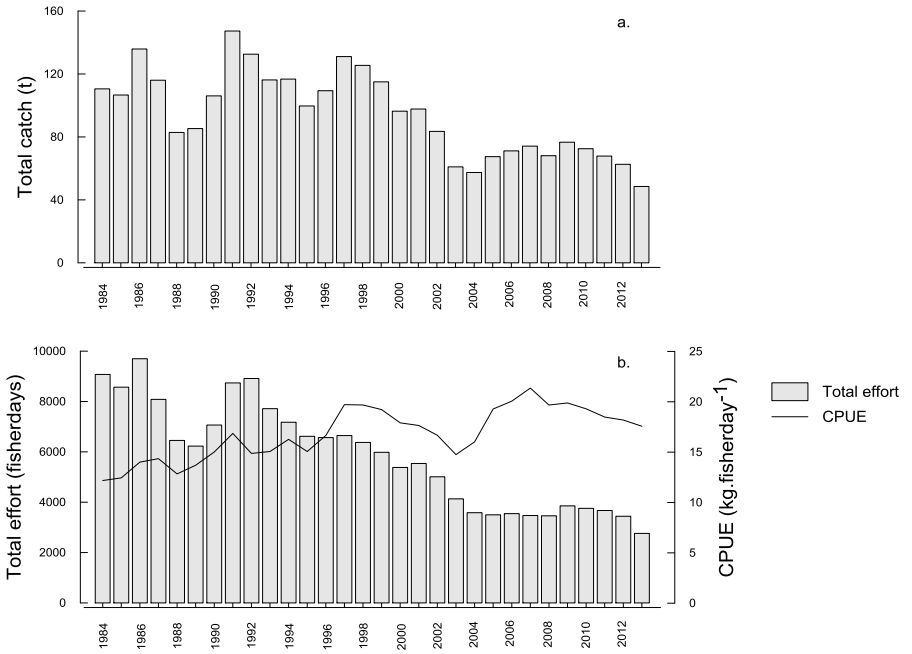

Fig. 3.11. Southern Spencer Gulf. Historical trends in commercial fishery statistics for King George whiting. a. total catch by handlines. b. total effort and CPUE for handlines.

The estimates of CPUE for handlines between 1984 and 2010 have been highly variable (Fig. 3.11b). Through the period from 1984 to 1997 they increased from 12.2 to 19.7 kg.fisherday^{-1}, but over the following six years declined to 14.8 kg.fisherday^{-1}. Handline CPUE rose again to 21.4 kg.fisherday^{-1} in 2007, but has subsequently declined by 17.8% to 17.6 kg.fisherday^{-1} in 2013.

Northern Spencer Gulf

Hauling nets have consistently been the dominant gear type for catching King George whiting in this region (Fig. 3.12a). Hauling net catch was relatively high and variable until 1997 after which there was a downward trend to 2013, when the catch fell to 9.7 t. Handline catch has also declined considerably since the relatively high catches of the early 1990s, producing the lowest catches from 2010 onwards with the lowest catch on record of 7.2 t in 2013. The decline in handline catch from 1993 onwards is consistent with declining fishing effort, particularly between 1994 and 2001, but also from 2007 to 2011 (Fig. 3.12b). Gillnet catches have declined to minimal levels since 2000 and involved less than five fishers (not presented on Fig. 3.12a).

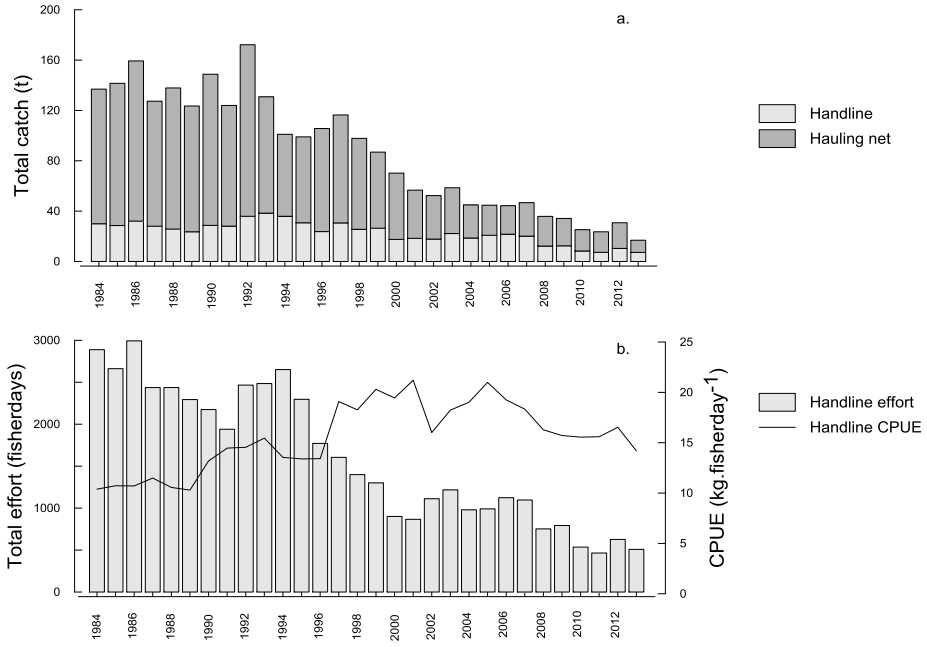

Fig. 3.12. Northern Spencer Gulf. Historical trends in commercial fishery statistics for King George whiting. a. total catch by handlines and gill nets. b. total effort and CPUE for handlines.

Between 1984 and 2005, CPUE in the handline sector varied in several phases, but nevertheless demonstrated a long-term increasing trend (Fig. 3.12b). CPUE in 1984 was 10.4 kg.fisherday^{-1} and gradually increased to 21.0 kg.fisherday^{-1} in 2005. Since then it has fallen by 32.4% to 14.2 kg.fisherday^{-1} in 2013, the lowest value recorded since 1996.

Both targeted and non-targeted hauling net catches have declined since 1992 (Fig. 3.13a). There have also been continual declines in both targeted and non-targeted effort since 1988 (Fig. 3.13b). Whilst CPUE of targeted effort has slowly declined since 1990, the estimates from the non-targeted categories have been variable but show no long-term trends (Fig. 3.13c).

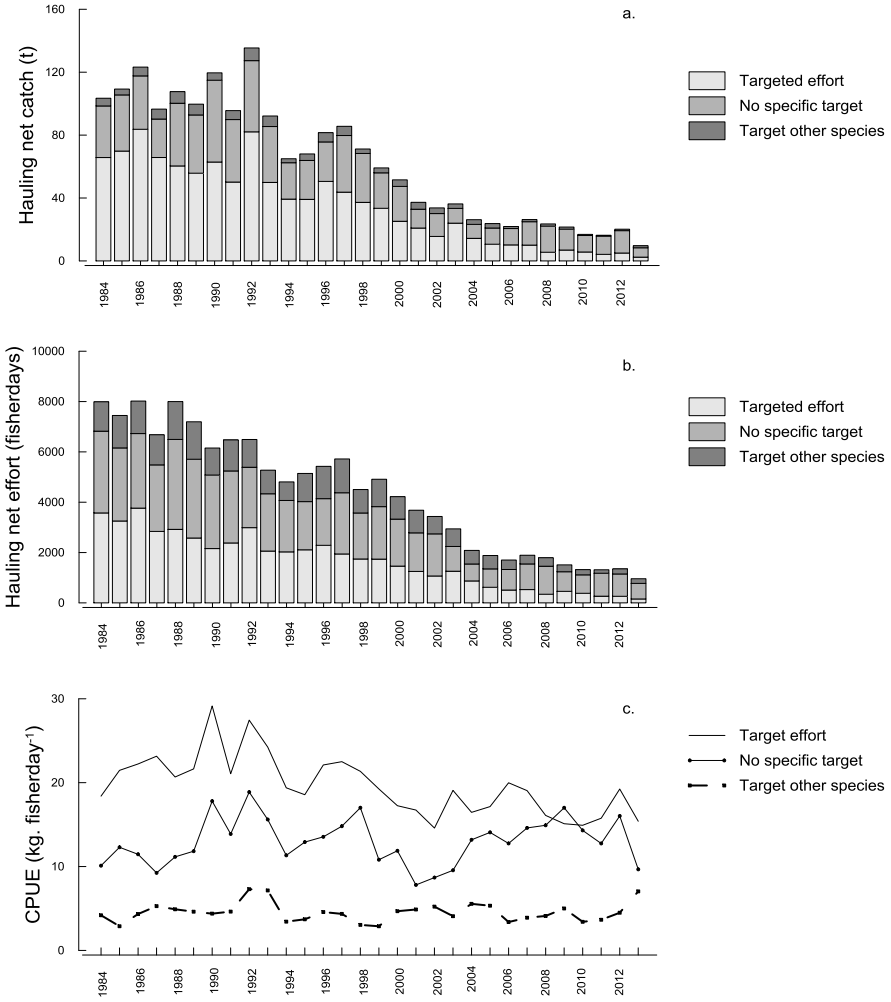

Fig. 3.13. Northern Spencer Gulf. Historical trends in commercial hauling net fishery statistics for King George whiting. a. hauling net catch by effort category. b. hauling net effort by effort category. c.CPUE by effort category.

Gulf St. Vincent

Hauling nets, handlines and gillnets have each contributed substantially to the fishery for King George whiting in Gulf St. Vincent over the years (Fig. 3.14a). Hauling net catch was quite variable from 1984, reached a peak of 37.8 t in 1998. Since then it has declined to only 7.0 t in 2013. Handline catches were highest through the early and mid 1990's but since then demonstrated a long-term systematic decline from 39.2 t to only 9.4 t in 2005. Since then they have recovered marginally to 13 t in 2013. The gillnet catches were also relatively low through 2000-2002, increased in 2003, but then decreased to a minimum level of 2.0 t in 2006. Since then, gillnet catches have remained less than 6 t.yr^{-1}.

Handline effort was quite variable from 1984 until it peaked in 1992, after which it declined to 2005 (Fig. 3.14b). It has remained relatively stable up to 2013. The peak in effort in 1992 was 3,789 fisherdays, decreasing to the minimum of 789 fisherdays in 2005. Gillnet effort has also declined over the same period, particularly between 2001 and 2006, and has remained less than 200 fisherdays.yr^{-1}.

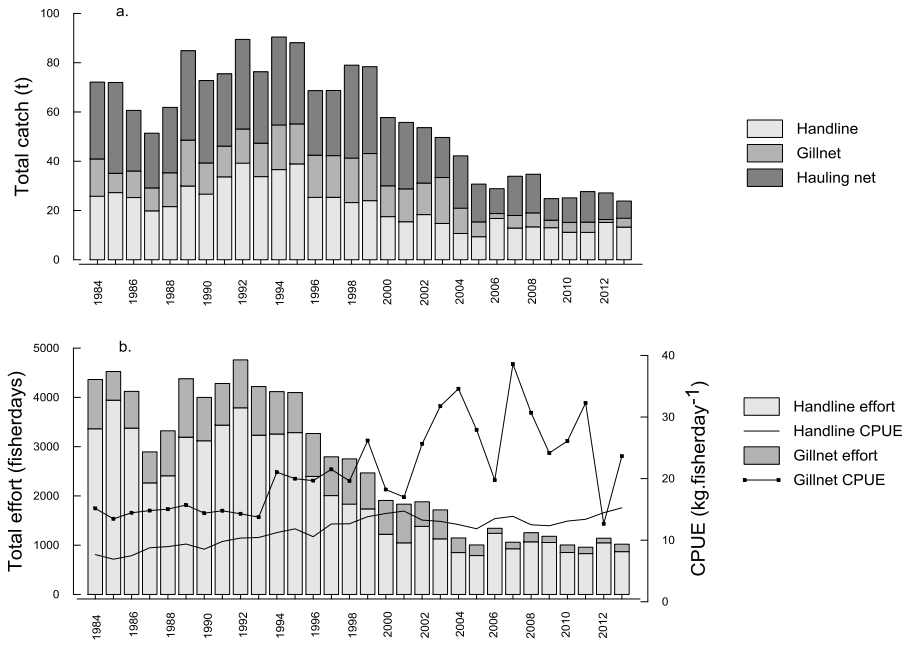

Fig. 3.14. Gulf St. Vincent. Historical trends in commercial fishery statistics for King George whiting. a. total catch by gear type. b. total effort and CPUE for handlines and gill nets.

CPUE in the handline fishery increased consistently from 1984, attained a maximum of 14.7 kg.fisherday^{-1} in 2001 before decreasing annually between 2001 and 2005 (Fig. 3.14b). It has subsequently varied between 12 and 14 kg.fisherday^{-1}. From

2009 onwards, handline CPUE has increased annually to 15.3 kg.fisherday^{-1} in 2013. CPUE for gillnets increased to 26.2 kg.fisherday^{-1} in 1999, but then became highly variable due to the low levels of catch and effort.

Hauling net catch has decreased considerably since 1998 (Figs. 3.14a, 3.15a), primarily reflecting a significant decline in effort directed at 'no specific targeted species' (Fig. 3.15b). The different categories of CPUE in the hauling net sector have generally increased over time, particularly from 2003 to 2007 (Fig. 3.15c). However, estimates of CPUE for the three effort categories have declined over the recent three years.

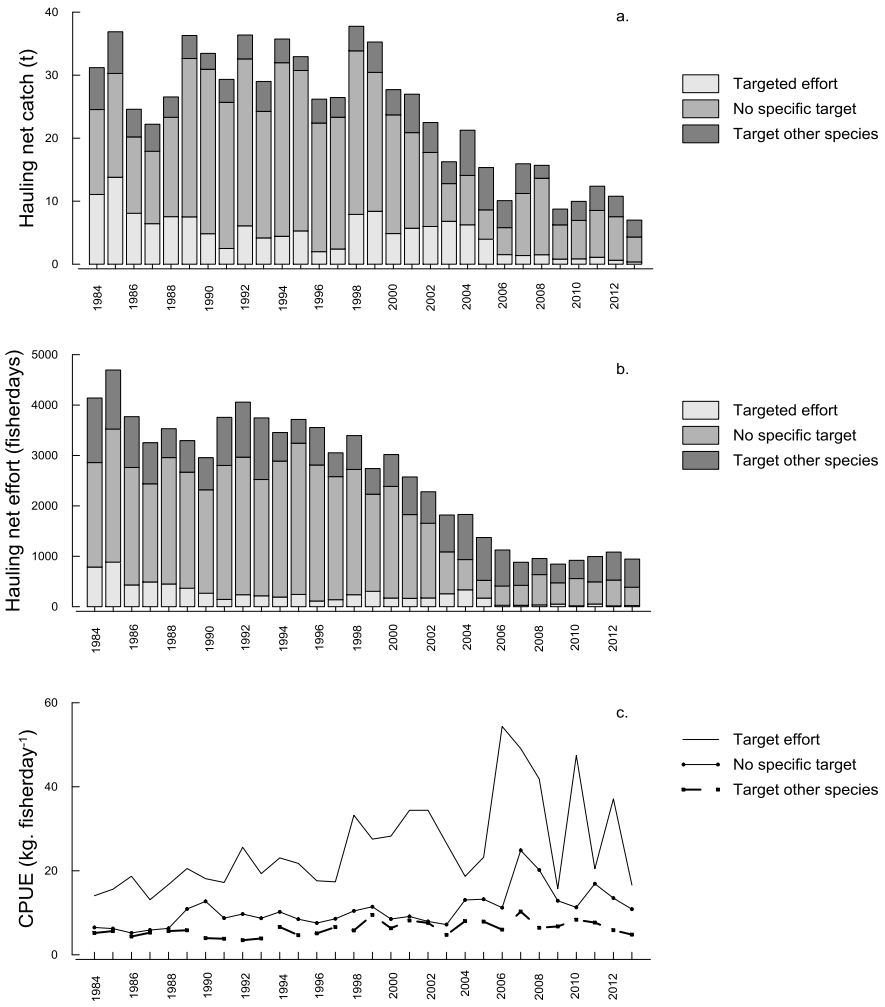

Fig. 3.15. Gulf St. Vincent. Historical trends in commercial hauling net fishery statistics for King George whiting. a. hauling net catch by effort category. b. hauling net effort by effort category. c.CPUE by effort category.

Kangaroo Island

Handlines have been the main gear type in this region since 1984. Handline catches increased from 25.0 t in 1986 to a peak of 47.9 t in 1998, before declining substantially to 27.3 t in 2002 (Fig. 3.16a). After that, the annual catches were relatively consistent until 2010. Through 2011, 2012 and 2013, they have declined annually to the lowest recorded level of 14.1 t in 2013.

Handline effort increased substantially between 1988 and 1992 (Fig. 3.16b). From 1992 to 2002, handline effort fell from 3,861 fisherdays to 1,963 fisherdays. It then remained relatively consistent to 2010, after which it has declined systematically to 1,223 fisherdays in 2013.

CPUE in the handline sector increased moderately through the years to a maximum of 15.5 kg.fisherday^{-1} in 1998 (Fig. 3.16b). After that, it slowly declined to 13.9 kg.fisherday^{-1} in 2002, but subsequently increased to 17.4 kg.fisherday^{-1} in 2007, the highest ever recorded. From then, CPUE decreased by 36.2% to the low level of 11.1 kg.fisherday^{-1} in 2012 before recovering marginally to 11.5 kg.fisherday^{-1} in 2013.

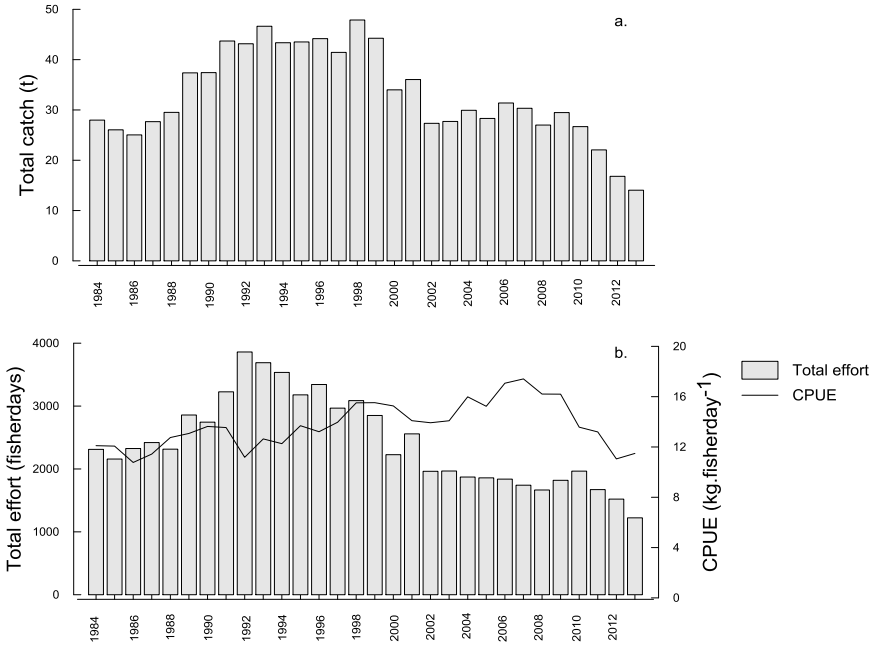

Fig. 3.16 Kangaroo Island. Historical trends in commercial fishery statistics for King George whiting. a. total catch by handlines. b. total effort and CPUE for handlines.

3.4. Discussion

The commercial fishery statistics for King George whiting were considered here at three spatial scales, i.e. State-wide, stock and regional scales. At the former scale, the statistics demonstrated some strong temporal trends that largely reflected significant changes in the structure of the fishery. Since 1984, the State-wide catch of King George whiting has dropped considerably. This reflects a gradual decline from 1992 to 1999, a significant drop in 2000, followed by further gradual decline to 2013. These reflected substantial reductions in handline and gillnet catches since 1999 and a gradual decline in hauling net catch since 1992. Such reductions reflect substantial declines in commercial fishing effort. Both targeted handline and gillnet fishing effort have fallen considerably since 1992. It is more problematic to determine levels of targeted hauling net effort, nevertheless since 1984 there has been a substantial reduction in the number of net endorsements that has culminated in a decline in the total number of hauling net fishing days (Fowler 2005), suggesting the likelihood that targeted hauling net fishing effort on King George whiting has also declined. The State-wide estimates of CPUE for handlines and gillnets have generally increased since 1984 but nevertheless demonstrated considerable declines during the early 2000s. Since 2002, the State-wide estimates of handline and gillnet CPUE have increased. The recovery for handline CPUE was quite slow but increased to the highest on record in 2013.

The analysis of commercial fishery statistics at the scale of the three stocks identified some consistencies and some differences amongst them. The dominant consistency was the decline in handline fishing effort over time. There was some variation amongst stocks in the timing and extent of these declines. For the two gulfs the declines were most dramatic between 1992 and the early 2000s, whilst for the West Coast the decline was from 1984 onwards. In each case, they reflect declining trends in the numbers of fishers taking and targeting King George whiting. For each stock, there were also associated declining catches over time, although the reductions were proportionally greater for the gulf stocks than for the WC stock. The trends in CPUE were also similar amongst stocks, at least until relatively recently. Each stock shows a long-term increasing trend that is interrupted, to some extent, by reductions in the rates of increase through the early to mid 1990s and again from around 1999 to 2002. However, these stock-wide trends in CPUE then diverged from 2007 onwards. Whilst that for the WC stock continued to increase attaining a record level by 2013, those

from SG and GSV/KI declined from 2007 onwards. These different trends imply different trajectories for the fishable biomass of the different stocks.

The analysis of trends in fishery statistics at the regional scale provided opportunity to assess for spatial consistency within each of the three stocks. Of the three regions of the WC, the MWC and CB experienced proportionally more variable fishing effort than did the FWC that resulted in more variable catches. Nevertheless, the three regions displayed similar trends in CPUE, particularly with respect to the record high levels attained in recent years. Such results are consistent with relatively high levels of fishable biomass in these recent years. For the SG stock, both SSG and NSG have experienced declining handline catches and catch rates since at least 2007. These consistent recent trends between NSG and SSG suggest declining levels of biomass in the two regions. There was less similarity in the recent trends between GSV and KI. For KI, handline catch and CPUE declined significantly between 2007 and 2013, providing a strong indicator of fishery status. For GSV, handline catch has been relatively stable since 2009, whilst handline CPUE has increased marginally over the same time period. In contrast, both the hauling net catch and CPUE for GSV have declined over the same period. The latter trends provide ambiguous temporal trends in fishable biomass for the GSV regional population.

4. POPULATION STRUCTURE

4.1. Introduction

Populations of fish that are subjected to fishing pressure normally experience some degree of truncation of their age and size distributions as a consequence of the removal of the larger, older individuals by the fishery. This can have considerable population-level effects by influencing egg production, and ultimately recruitment success (Longhurst 1998, Francis 2003, Berkeley et al. 2004). As such, population structure can be an important indicator of the status of a fishery. Nevertheless, its assessment as an indicator depends on having a good understanding of how the population structure naturally varies amongst different places, as a consequence of the life history of the species.

The characteristics of the populations of King George whiting throughout South Australia's coastal waters have been determined at different times, revealing a complex interaction between population structure and life history. King George whiting are not distributed evenly with respect to size and age (Fowler 1998, Fowler et al. 2000a, Fowler and McGarvey 2000). Catches from throughout Gulf St. Vincent, northern Spencer Gulf and bays of the west coast of Eyre Peninsula generally involve relatively small fish from the 3+ age class. Alternatively, fish sampled from Investigator Strait along the northern coast of Kangaroo Island and from south eastern Spencer Gulf involve much broader size and age ranges that consist of multiple year classes of fish that are up to 20 years of age. These latter populations occur in deeper waters in more exposed places.

Tag/recapture studies have revealed that the populations on the spawning grounds that involve the larger, older King George whiting are replenished by migration from the northern gulfs (Fowler et al. 2002, Fowler and Jones 2008). Thus, fish movement constitutes an important obligative process that closes the life history cycle between the nursery areas and spawning grounds. The older, larger fish found in the deeper, offshore places constitute the spawning populations (Fowler et al. 1999). As such, spawning by this species does not occur generally throughout all of South Australia's coastal waters, but rather is restricted to particular locations or spawning grounds. Given that there is an obvious geographic separation between the spawning grounds and nursery areas, the eggs and larvae must be advected to the nursery areas. As such, it is likely that the larger, older fish in the spawning populations make substantial

contributions to egg production. Therefore, the age structures of these populations may be important indicators of egg production.

The studies on population structure of King George whiting that were done between 1995 and 1998 identified both the spatial dispersion patterns with respect to size and age, as well as the locations of the spawning grounds (Fowler et al. 1999, Fowler and McGarvey 2000, Fowler et al. 2002). Sampling done between 2001 and 2004 focussed on the age structures of the populations on the spawning grounds, which may have been important indicators of egg production. In each case, these two historic sampling programs depended on samples that were accessed from both the commercial and recreational fishing sectors. In 2006, a new sampling protocol for King George whiting was initiated, which was based on sampling the commercial catches. So far this focussed market-sampling has been done for King George whiting throughout five financial years, i.e. 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13. The aim of this chapter is to present the results from this sampling and provide a qualitative comparison with data collected from similar regions in the past that have been published elsewhere (Fowler and McGarvey 2000, Fowler et al. 2000a).

4.2. Methods

The market sampling was primarily done at the SAFCOL fish market in Adelaide, which receives commercial catches of King George whiting from the regional areas. Generally once per week a team of three researchers processed samples of King George whiting prior to the morning auction at this wholesale market. Catches were selected from those available on the market floor to ensure as broad a geographic coverage as possible. This regular sampling was augmented by occasional sampling trips to Kangaroo Island and the west coast of Eyre Peninsula to access local catches. A two-stage sampling protocol was used in processing the individual catches. First, a relatively large number of fish were measured to obtain size information for the catch, from which a random sub-sample of fish was taken for further biological analysis. Back in the laboratory, the latter fish were measured for total length (TL) and weighed individually, sexed and stage of reproductive development determined. They were then dissected for the removal of the sagittae, i.e. the largest pair of otoliths, for ageing. For this, one otolith from each fish was embedded in resin and sectioned using a diamond saw to produce a thin transverse section. This was mounted on a glass microscope slide and its structure was interpreted using low power microscopy by counting the opaque zones. Each count was then interpreted to provide an

estimate of fish age (Fowler and Short 1998). For each region, an age/length key was developed to convert the sample proportions by length into proportions by age. In this way, population size and age structures were produced for each region. For this work, the State's coastal waters were divided into a number of regions for which the data on population structure were presented. In general, these regions corresponded to those that were considered for the analysis of both the commercial and recreational fishery statistics (Figs. 3.1), with the primary difference being the division of the waters of Gulf St. Vincent, Investigator Strait and Kangaroo Island. Throughout this broad region, the data were grouped and presented for three areas: Northern Gulf St. Vincent (MPAs 34, 35, 36); Kangaroo Island bays (MFA 42); and the remaining waters of Investigator Strait and Kangaroo Island (MFAs 39, 40, 41, 44, 48, 49).

4.3. Results

Far West Coast (MFAs 7, 8, 9, 10)

Across the five years, >10,000 fish captured from the bays of the Far West Coast (FWC) were measured (Fig. 4.1). The resulting size distributions were characterised by medium-sized fish that were generally <40 cm TL, although with a few large fish between 40 and 52 cm TL. The modal sizes were 32 – 34 cm TL. The age structures consisted of the 2+ to 5+ age classes. They were dominated by the 3+ age class in 2006/07, 2009/10 and 2012/13, whilst the 2+ age class was most apparent in 2008/09 and 2011/12. The sampling trips in these latter years were done largely in March and April, prior to the nominated birthday of 1st May. As such, it is unlikely that the nominal differences in age structures between years reflected population truncation.

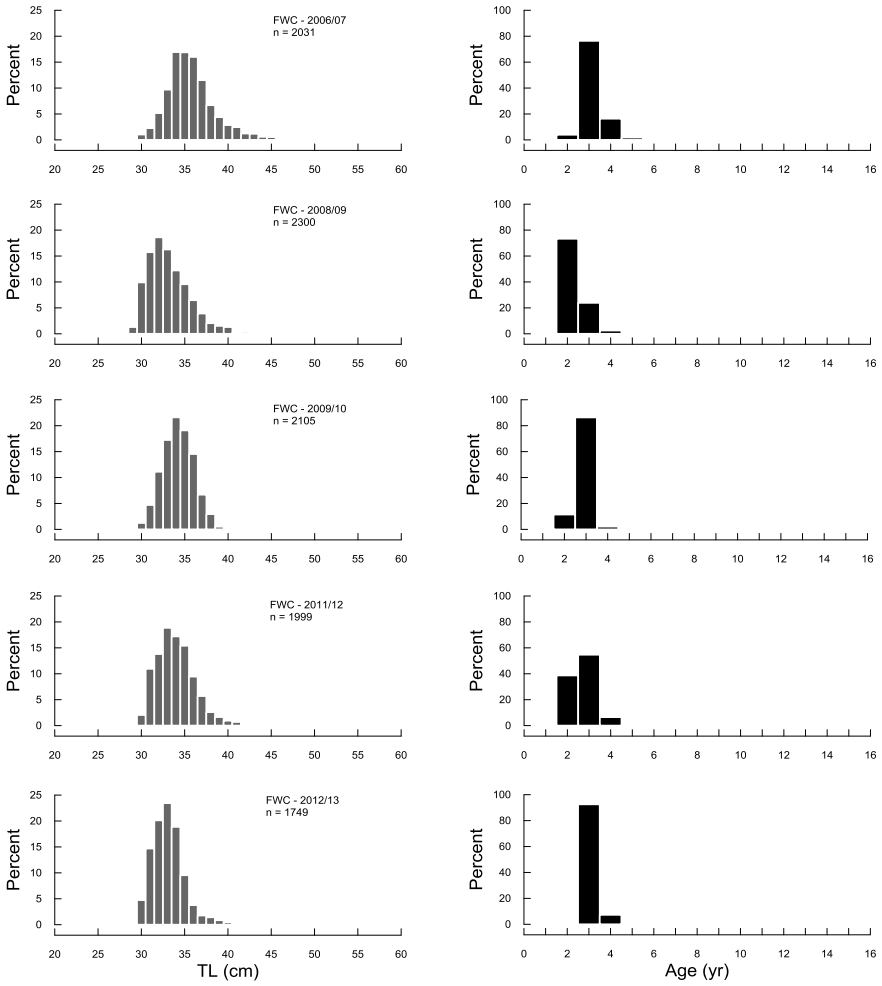

Fig. 4.1 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 from Far West Coast of Eyre Peninsula.

Mid West Coast (MFAs 15, 16, 17, 18)

The sizes of King George whiting captured from the bays of the Mid West Coast (MWC) have always generally been relatively small, i.e. <34 cm TL (Fowler and McGarvey 2000). This was the case for the five years sampled between 2006/07 to 2012/13 during which the modal sizes were from 30 to 32 cm TL (Fig. 4.2). There were also occasional incidental catches of big fish of up to 58 cm TL taken from these bays in some years. The age structures generally involved the 2+ to 4+ age classes and were dominated by the 3+ age class that accounted for 90% or more of the catches. The exceptions were in 2008/09 and 2011/12 when the 2+ age class dominated, which reflected the timing of the sampling trips to this region.

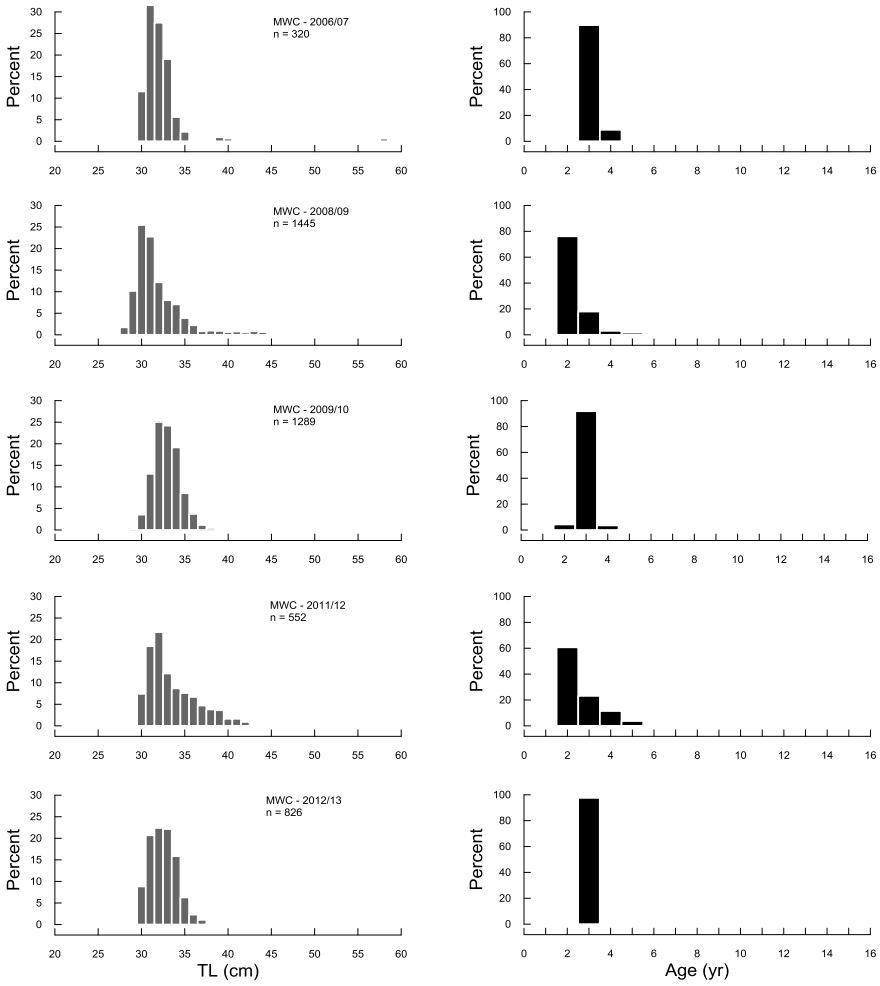

Fig. 4.2 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 from the Mid West Coast of Eyre Peninsula.

Coffin Bay (MFA 27, 28)

More than 5,000 fish captured in Coffin Bay (CB) between 2006/07 and 2012/13 were measured for development of size structures. The size structures were relatively consistent between years, being skewed to the right as they were dominated by small fish with relatively low numbers of larger fish (Fig. 4.3). Only a few fish >40 cm TL were measured from this region in each year. The age distributions also were consistent from year to year being dominated by the 3+ age class that generally accounted for >60% of the fish aged in each year. The 4+ age class accounted for the majority of the remaining fish with occasional fish captured from the 2+ and 5+ age classes.

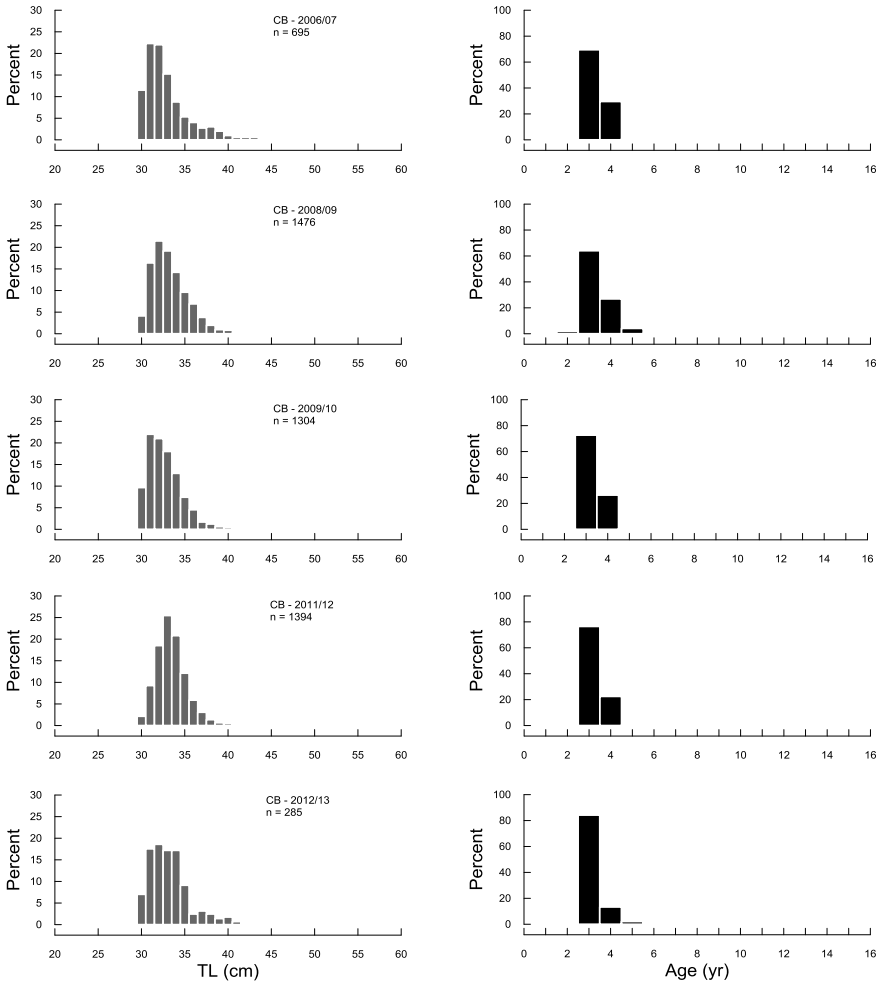

Fig. 4.3 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 from Coffin Bay, southern Eyre Peninsula.

Northern Spencer Gulf (MFAs 11, 19, 20, 21, 22, 23)

Approximately 20,000 fish captured from Northern Spencer Gulf (NSG) between 2006/07 and 2012/13 were measured for development of size structures. The resulting size structures were consistent between years, being skewed to the right as they were dominated by small fish with decreasing numbers of larger fish (Fig. 4.4). Relatively few fish >40 cm TL were captured from this region. The modal size classes were generally 33 or 34 cm TL. The age distributions also were consistent from year to year being dominated by the 3+ age class that generally accounted for >70% of the fish aged in each year. The 2+ and 4+ age classes accounted for the majority of the remainder with a few fish from the 5+ and 6+ age classes also captured.

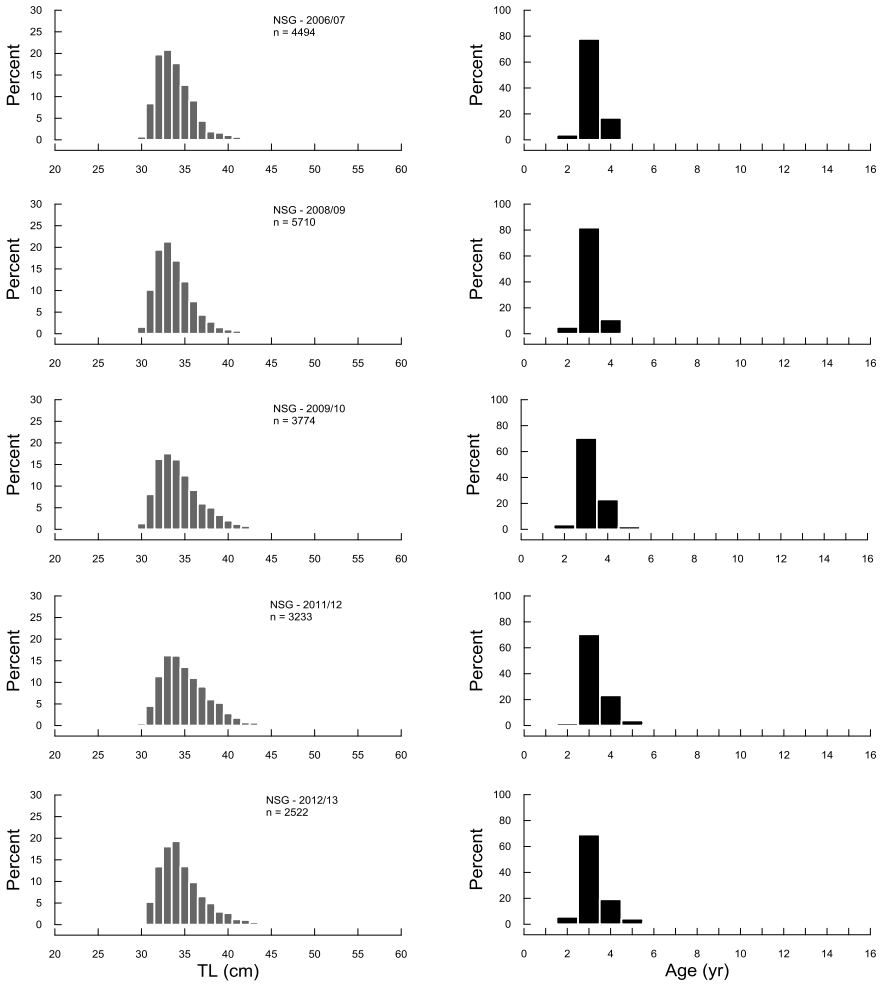

Fig. 4.4 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 from Northern Spencer Gulf.

Southern Spencer Gulf (29, 30, 31, 32, 33)

Greater than 14,000 fish captured from Southern Spencer Gulf were measured. Although the size distributions were skewed to the right, due to the small and decreasing numbers in the larger size classes of up to 52 cm TL, the fish were generally larger than those captured in NSG (Fig. 4.5). The modal sizes were between 35 and 37 cm TL in the five sample years. Up to 20% of the fish measured in every year were 40 cm or larger. The age distributions were consistent between years and dominated by the 3+ and 4+ age classes, whilst the older age classes of 5+ to 15+ age classes were more numerous than in the other regions. The oldest fish aged in each year was 10+ years or more, with the oldest of 15+ years in 2011/12.

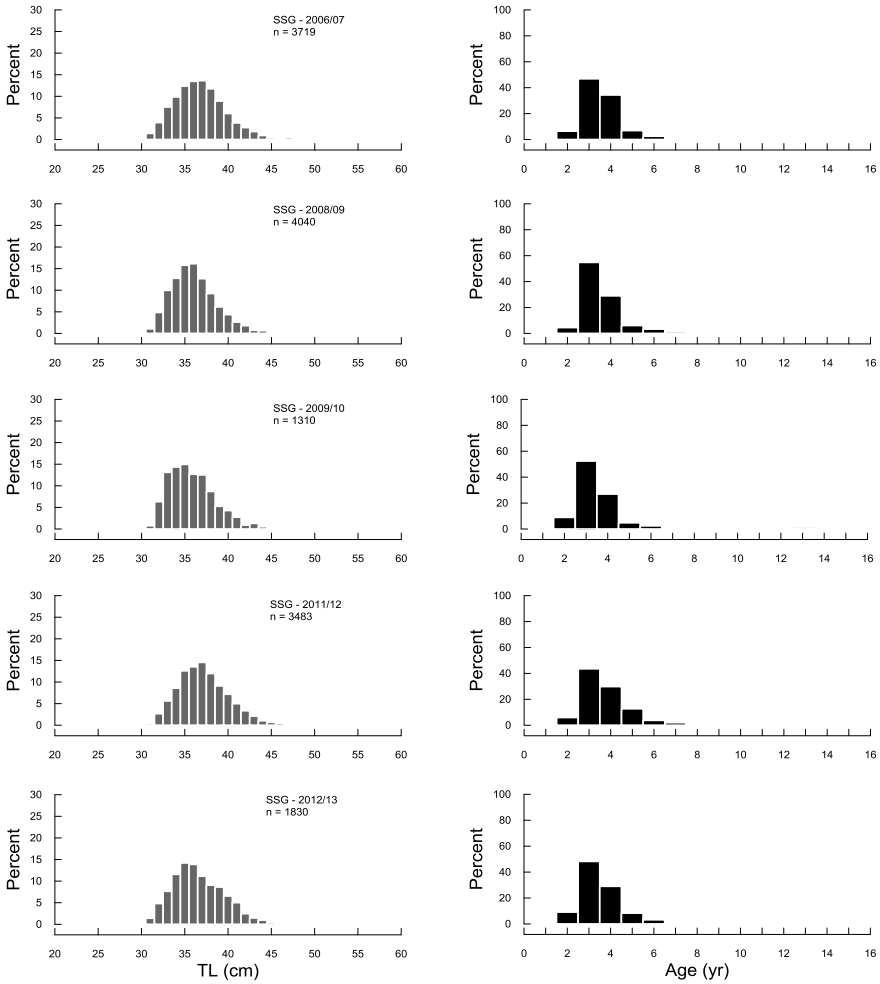

Fig. 4.5 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 from Southern Spencer Gulf.

Gulf St Vincent (MFAs 34, 35, 36)

Nearly 10,000 fish were sampled from northern Gulf St. Vincent, primarily from MFAs 34 and 35. The resulting annual size distributions were dominated by small-medium fish, i.e. <40 cm TL, with a small number of fish up to 52 cm TL also captured (Fig. 4.6). The modal sizes varied between 32 and 35 cm TL across the three years. The age structures were consistently dominated by the 3+ age class whilst the remaining fish were largely from the 2+ and 4+ age classes, although with occasional representation from the 5+ to 10+ age classes.

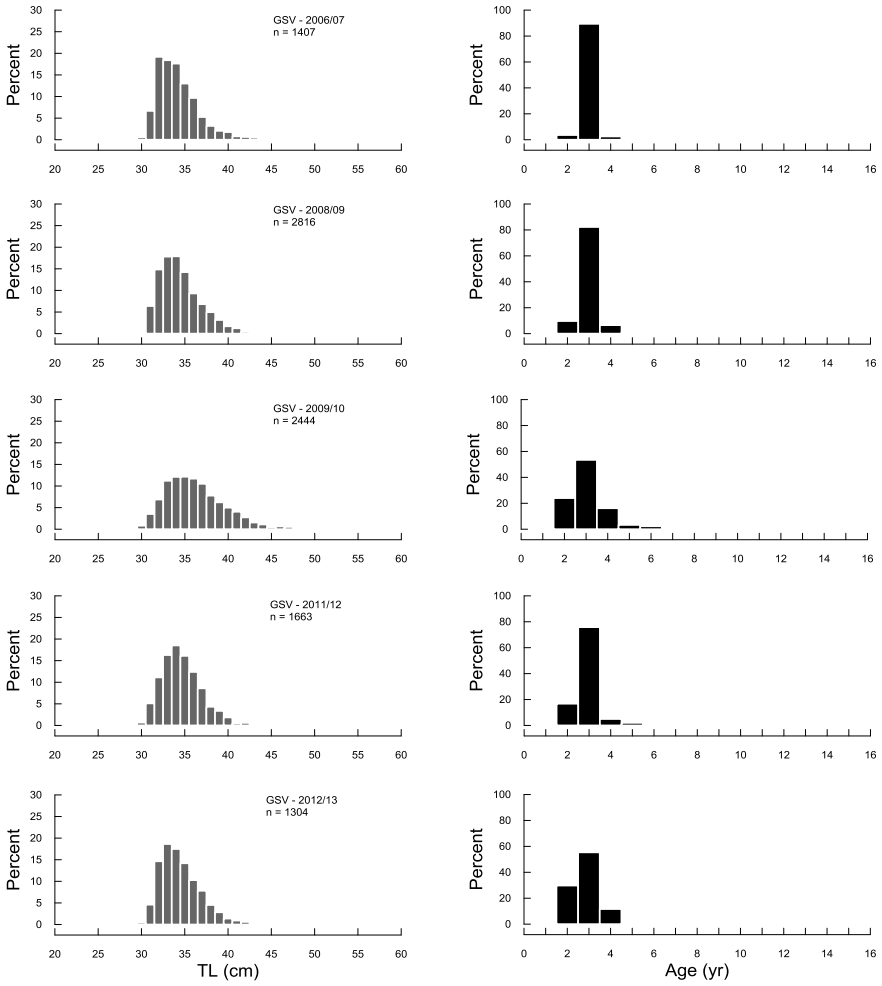

Fig. 4.6 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09 and 2009/10 from Gulf St. Vincent.

Kangaroo Island (MFA 42)

MFA 42 (refer Fig. 3.1) was considered independently from the other MFAs in this region because it includes the inshore, shallow bays of Kangaroo Island, which have traditionally provided large numbers of relatively small King George whiting to the local fishery, probably reflecting that its coastal margins constitute an important nursery area. Nevertheless, the fish sampled from this MFA between 2006/07 and 2009/10 reflected relatively complex size structures (Fig. 4.7). Those for 2006/07 and 2008/09 reflected the influence of several modes of small and relatively large fish. This probably relates to the small fish being captured in the bays in relatively shallow water whilst the larger ones were captured further offshore. Each size distribution is skewed to the right and includes relatively high contributions from fish in the high 30s and 40s cm TL. The age structures were also relatively complex. Although dominated by the 3+ age class they also involved considerable numbers of 4+ and 5+ fish, and small contributions from the 6+ to 14+ age classes.

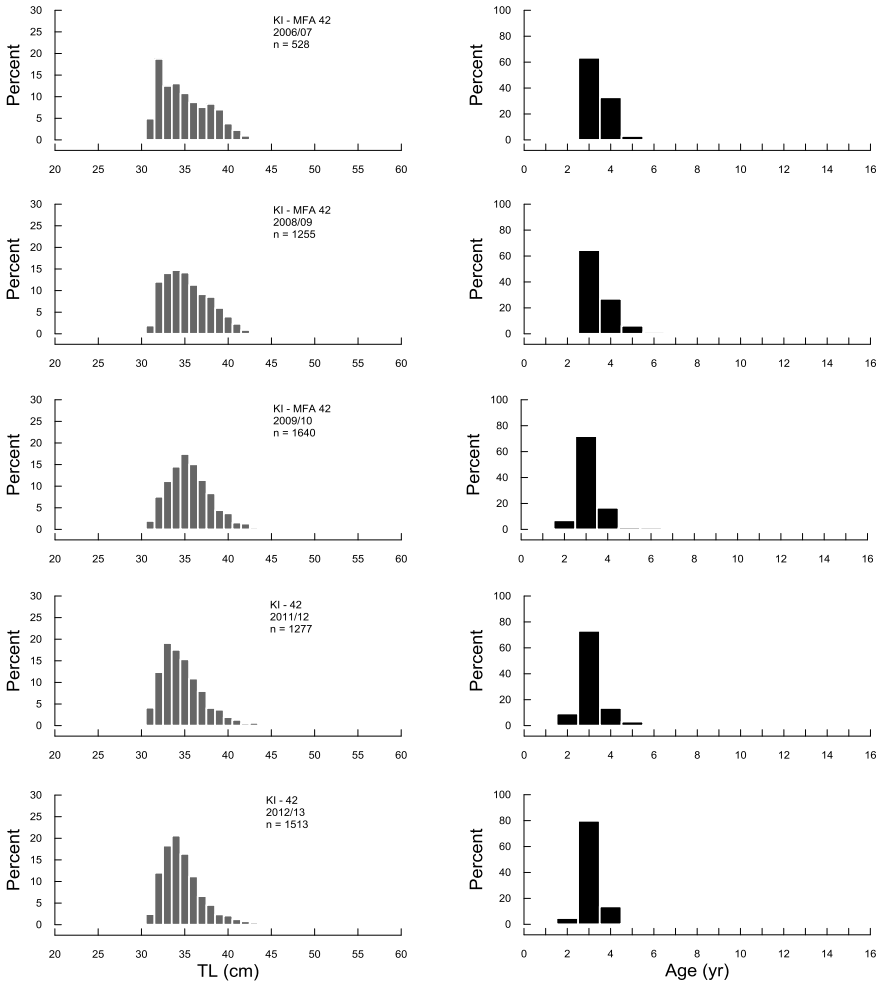

Fig. 4.7 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 from MFA 42 in Investigator Strait.

Kangaroo Island / Investigator Strait (MFAs 39, 40, 41, 43, 44, 48, 49)

Although the remaining area of southern Gulf St. Vincent, Investigator Strait and Kangaroo Island included numerous MFAs, the samples considered for this region primarily came from MFAs 40 and 41 (Fig. 3.1). Approximately 2,000 fish were measured from across the five years, from which size structures were developed. The annual size distributions were broader than for the other regions as 19 to 29% of fish measured were in the 40 – 50 cm TL size classes (Fig. 4.8), with the modal sizes of 35 to 37 cm TL in each year. Whilst the 3+ and 4+ age classes dominated numerically, the age structures were complicated and skewed to the right. The oldest fish aged in each year was at least 10+ years, with a 17+ age class fish captured in 2011/12.

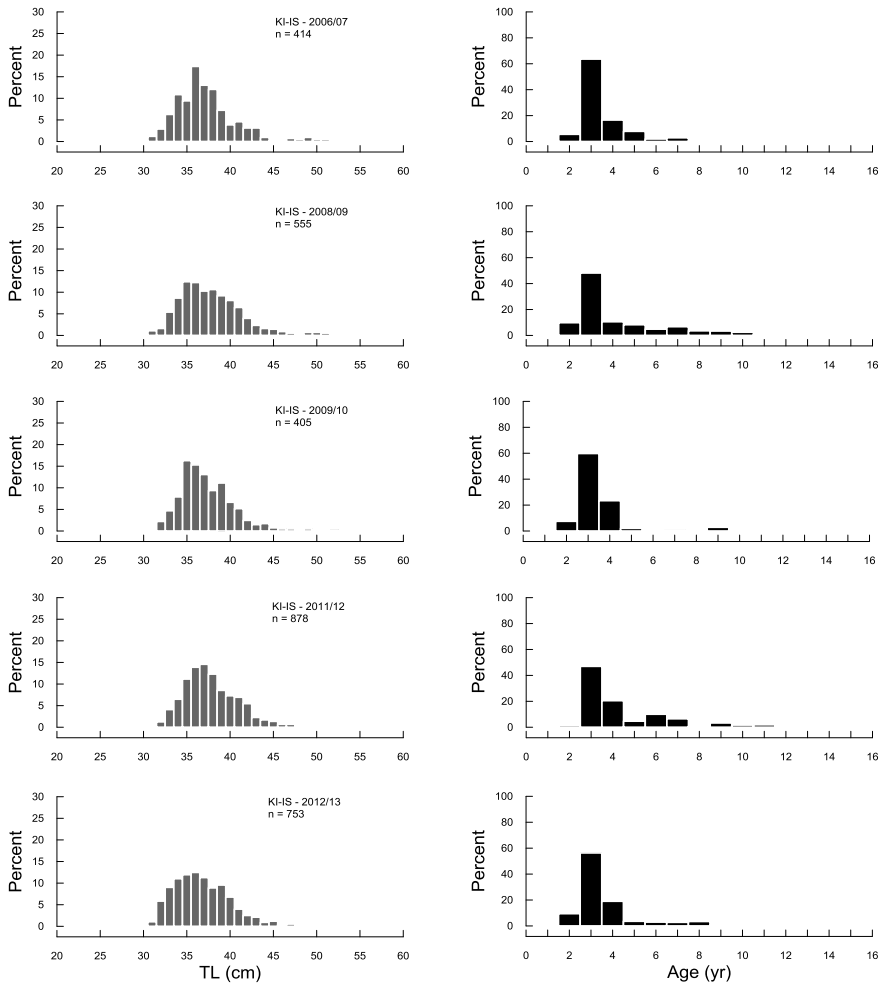

Fig. 4.8 Age and size structures of samples of King George whiting collected in 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 from Kangaroo Island / Investigator Strait.

4.4. Discussion

Earlier sampling-based studies have documented the size and age structures of populations of King George whiting captured from throughout South Australia's coastal waters and have consistently demonstrated that there are considerable differences in population structure at different locations (Fowler and McGarvey 2000, Fowler et al. 2000a). Furthermore, these differences relate to the reproductive biology of the species that result in a complex relationship between habitat, population structure and reproductive maturity and activity (Fowler et al. 2000a). Fish located in shallow, inshore areas adjacent to nursery areas tend to be relatively small, young and immature. Alternatively, fish located in deeper water associated with off-shore reefs, shoals or large mounds in exposed locations that experience medium to high wave energy tend to support populations with broader size and age structures. Furthermore, these are the places where reproductive maturation takes place, and thereby represent the spawning grounds. Such populations can involve fish up to approximately 20 years of age, which means that in any year there are numerous age classes in the populations.

One intention of considering population age structures in a fishery context is to determine whether there is evidence of a reduction in the number of age or size classes in the population as a consequence of the fishing activity. This occurs because fishing tends to remove the largest, oldest individuals from fish populations and thereby reduces the number of age classes in such populations (Berkeley et al. 2004).

Since age-based sampling commenced in the 1990s in a number of the regions considered here (FWC, MWC, NSG and GSV), the populations have been characterised by relatively small, young fish that have been primarily dominated by the 3+ year class (Fowler and McGarvey 2000, Fowler et al. 2000a, 2005). Such fish recruit to the fishery as fast-growing 2+ or later as 3+ fish. They are fished relatively heavily in this gauntlet fishery, whilst their numbers are also depleted as the fish emigrate southwards in the gulfs or leave the bays of the west coast (Fowler et al. 2002). Since these populations primarily consist of a single year class, it would be difficult to detect truncation of their age structures. In fact, in contrast, there are some indications that older fish in the 5+ and 6+ age classes are now more evident in these northern regions.

The fish that emigrate as 3+ individuals from the northern gulfs move to the spawning populations that are located in the deeper waters of SGSV, SSG or Investigator Strait that support multiple age classes of up to 20 years of age (Fowler et al. 2002). So far, the size and age structures of these populations have been monitored through several research programs from 1996 to 1998, from 2001 to 2004 and most recently from 2006/07 to 2012/13. By comparing the results between sampling regimes during these periods for the different regions, it is apparent that the age structures still support relatively old fish. The 6+ to 10+ age classes have been relatively abundant in SSG and Investigator Strait over time, whilst in 2011/12, SSG still had some fish that were in the 15+ age class whilst Investigator Strait supported fish that were in the 17+ age class. Overall, these results provide no evidence that any obvious truncation of population size and age structures has occurred either between 2006/07 and 2012/13 or over the longer term between the 1990s and 2000s, as a consequence of fishing activity.

5. MODEL ESTIMATION OF BIOLOGICAL PERFORMANCE INDICATORS

5.1. Introduction

For King George whiting in South Australia the primary management objective remains to ensure sustainability of the fishery. To facilitate this, a fishery stock assessment model, WhitEst, was developed in an FRDC-funded project (Fowler and McGarvey 2000). This is a dynamic, spatial, age- and length-structured model that integrates data from 1984 to the most recent complete calendar year of 2013 to provide estimates of biological performance indicators of the status of the fishery.

A spatial breakdown with a monthly time step allows the model to account for seasonal movement and exploitation levels that vary seasonally and in space. The model divides the fishery into six spatial cells, five of which contribute most of the catch, i.e. the West Coast, and northern and southern regions of the two gulfs. Negligible King George whiting catch is reported from the sixth cell which is located offshore (Fig. 5.1). The model takes into account annual summer migration rates from inshore nursery areas in the northern gulfs to the spawning regions in the southern gulfs and to offshore WC grounds. Exploitation rates are higher in the upper gulfs and inshore waters where King George whiting typically mature and reach legal size prior to migration.

5.2. Methods

The data sources that inform the maximum likelihood estimation of model parameters in WhitEst are: (1) monthly totals for catch (kg) and effort (fisherdays); (2) market samples of the commercial catch giving proportions by age and sex in different spatial cells for most months through the four sampling periods of September 1994 to June 1997, July 2004 to June 2007, July 2008 to December 2010, and October 2011 to September 2013; (3) information on movement by King George whiting in the two South Australian gulfs, based on results from tag-recapture studies undertaken in the 1960s, 1970s, and 1980s (Jones et al. 1990, Fowler et al. 2002). Migration rates from the northern to southern gulf regions are estimated with other parameters in the overall model likelihood (McGarvey and Feenstra 2002). WhitEst uses a partition of model fish numbers by length within each age group, dividing the gaussian length distribution of each yearly cohort into length bins called ‘slices’. A new slice of fish is

created in each monthly time step, a slice being defined as the fish that grow across the legal minimum length into legal size each month. The growth of each cohort, as mean and standard deviation of length-at-age at each monthly age, estimated from the age-length samples while accounting for the sharp cut-off in samples below legal minimum length (McGarvey and Fowler 2002), is used as input to the slice-partition sub-model. This slice-partition framework (McGarvey et al. 2007) quantifies the on-going monthly arrival of each cohort into the legally harvestable size range, with faster growth observed during the months of late summer and autumn of each year. This annual arrival via growth of each cohort to legal size is an important aspect of the fishery dynamics of this stock, as it attracts a large shift of fishing effort to these newly legal-size fish each winter, with commercial effort often peaking in July. The slice-partition method separates these heavily-exploited, legal-sized fish from sub-legal fish, and keeps account of the changing numbers of legal fish by both age and length. The fits of the assessment model to age and sex proportions from catch sampling are plotted in Figs. 9.4 and 9.5.

The model is fitted to monthly catches, conditional upon the effort in fisher days required to take each catch (Fig. 9.1). Commercial catch and effort data are analysed and modelled separately for the four gear types (handline, hauling net, gillnet, and all other gears combined) and three target types (targeting King George whiting, targeting any other species, and not targeting any species in particular), as reported in monthly commercial catch returns.

Recreational catch and effort estimates by month and spatial cell used in WhitEst are taken from the two recent telephone-diary surveys done in 2000/01 and 2007/08 (Fowler et al. 2011). Each survey covered one full year, providing estimates of monthly recreational catches, both charter and non-charter. To fit the assessment model to recreational catch data, the procedure was modified this year to reduce the importance of assumptions about how the recreational sector's catch and effort varied outside the two 12-month survey time periods. Monthly recreational efforts prior to the 2000/01 survey were interpolated backward in time in yearly proportion to South Australian population size (Fig. 5.2). No interpolation was undertaken for years after the second survey, the monthly catches from the second 12-month survey (2007/08), by spatial cell, assigned to equal those for all subsequent model years (Fig. 5.2). Between the two surveys, catch and effort numbers were interpolated assuming they vary linearly between the levels estimated by the two surveys, by spatial cell (Fig. 5.2). This year, to improve the fits of survey and charter boat logbook reported catches, a

large number of additional recreational catchability parameters were added by month and spatial cell. This had the effect of permitting very close fits to recreational catch (Fig. 9.2) while also down-weighting the relative influence of recreational catch rates on estimated stock size, allowing the model estimates of biomass to more strongly respond to the principal biomass trend information from commercial catch rates, notably from handlines (Fig. 9.3).

Catch logbook data from the charter boat sector are now included in the model. In July 2007, charter operators began reporting their catches, in numbers of fish landed, and their effort, as numbers of anglers aboard each trip and hours of fishing. This provides high-quality information about this component of the recreational harvest. A new effort type was created in the WhitEst model to fit to these monthly catch and effort charter data, beginning in November 2007, the first month of the most recent recreational survey. Because catch from charter boats was included in the two recreational surveys of 2000/01 and 2007/08, for model years prior to 2007, charter catches were fitted as part of overall recreational survey data. However, the recreational surveys are not precise. For the year 2007/08 when two estimates of charter catch are available, a direct measure of the reliability of the survey estimate is obtainable by comparing it with the more reliable reported totals, by spatial cell, from charter logbooks. In Fig. 5.2, the survey-estimated charter catches are given as the difference of the red cross-hatched bars from the top of the green bars, the latter showing the estimated survey catches with charter excluded (Fig. 5.2, years 2008-2010). The charter logbook catches are given as the height of the light blue bars. The much larger size of the blue bars imply that the survey greatly underestimated charter catches in 2007/08 in SGSV and SSG. Charter catches in WhitEst from November 2007 onward are now fitted separately and modelled using the census (total) logbook data of reported monthly charter catch (in numbers of fish landed) and effort (in angler hours).

The model estimates three principal biological performance indicators; recruitment, legal-size population biomass, and exploitation rate. Biomass and exploitation rate are given as monthly model estimates, and also as yearly averages. Yearly biomass is computed as the mean of monthly model biomass estimates in each calendar year. Exploitation rate (also known as harvest fraction) is the fraction of biomass harvested yearly. For King George whiting, the yearly exploitation rate is calculated as the sum across all gear and target types of monthly model catches in each calendar year divided by the (year average) legal biomass. Recruitment for each yearly cohort is

estimated in the model as numbers of approximately 2 year olds. In the recruitment time series graphs, the year shown on the X-axis is the year each cohort has fully entered the fishable stock and is principally targeted in the fishery as 3 year olds.

Because of the increasing importance of the recreational sector in this fishery, the catches by sector, by year, for the three main regions are presented in Fig. 5.3. These are model-estimated catches for both sectors. One clear trend is the declining levels of commercial catches in the two gulfs (see also Chapter 3). The large increase in recreational take estimated for Gulf St. Vincent in 2008 reflects higher recreational estimates from the 2007/08 survey, and the inclusion of charter logbooks as an additional data source (Fig. 5.2).

Further details of WhitEst are included in the FRDC final report (Fowler and McGarvey 2000). The model was externally reviewed by Dr André Punt (University of Washington, Seattle, USA).

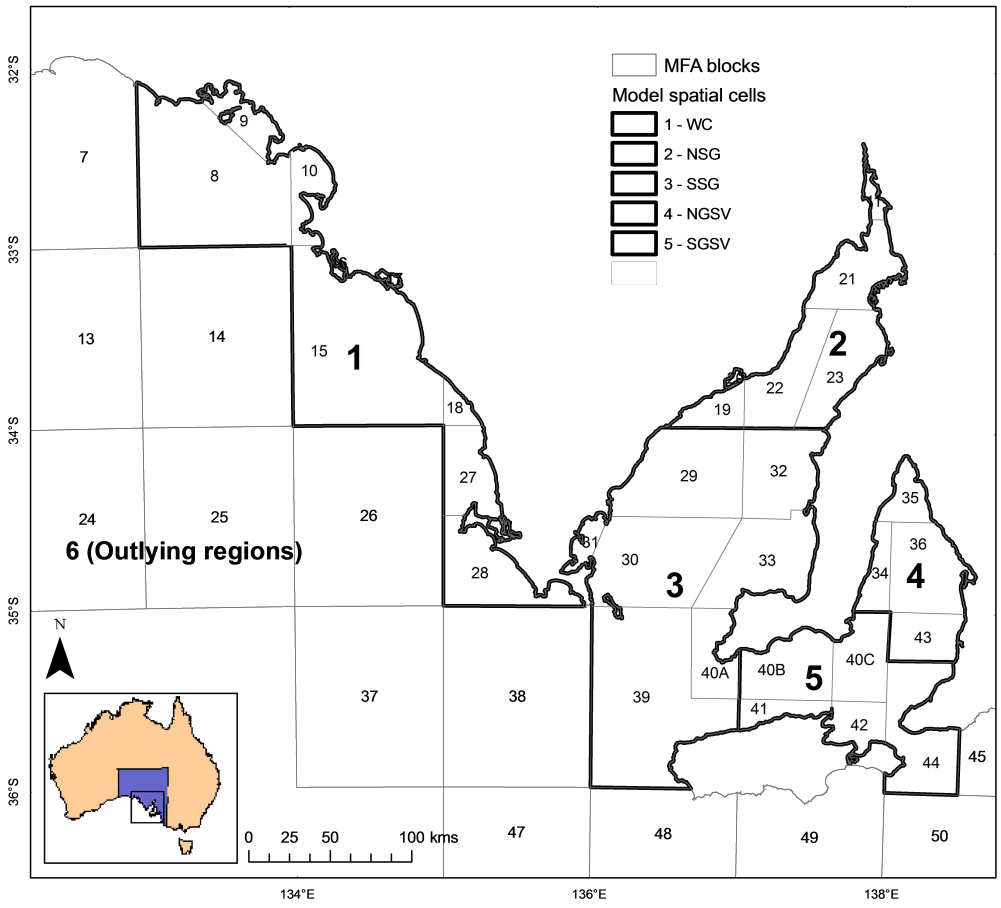

Fig. 5.1 Map of South Australia showing the six spatial cells used in the WhitEst model, identifying the Marine Fishing Areas of which they are comprised.

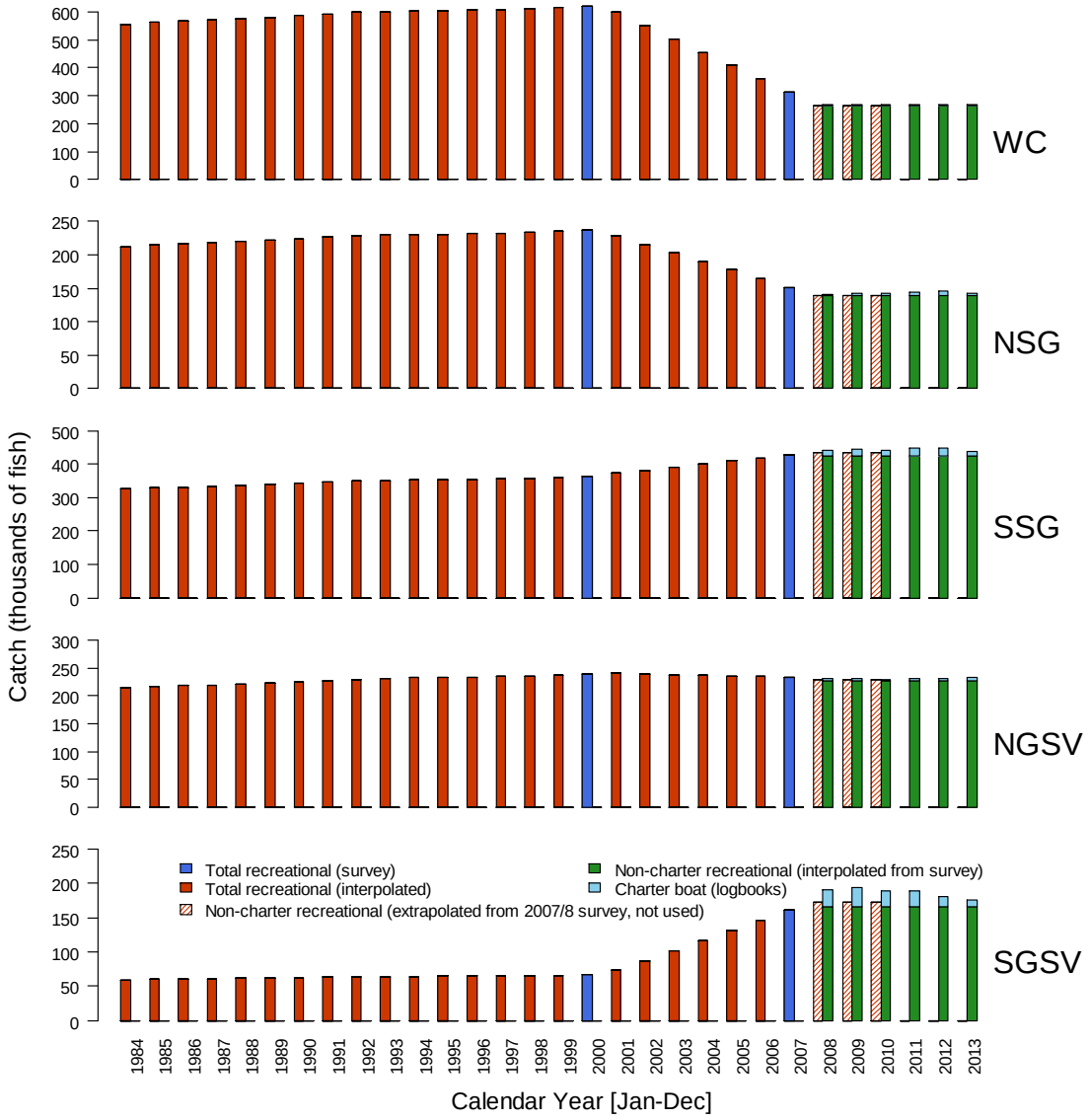

Fig. 5.2. Model input data for recreational catch, in estimated numbers of fish landed, by year and spatial cell. Telephone and diary surveys giving monthly estimates of recreational catch and effort for all recreational fishing, including charter boats, were held in 2000/01 and 2007/08. A second data source, from charter logbooks, gives the reported numbers landed by charter boats shown as light blue bars. The red, blue, light blue, and green catches were used in the model. Actual recreational data are shown for survey (dark blue) or charter logbooks (light blue). The cross-hatched red bars show what the 2007/08 survey estimates for total recreational catch in 2008-2010. For how these permit a direct comparison of survey and logbooks charter catches in 2007/08, see Methods of Section 5.2, p. 49.

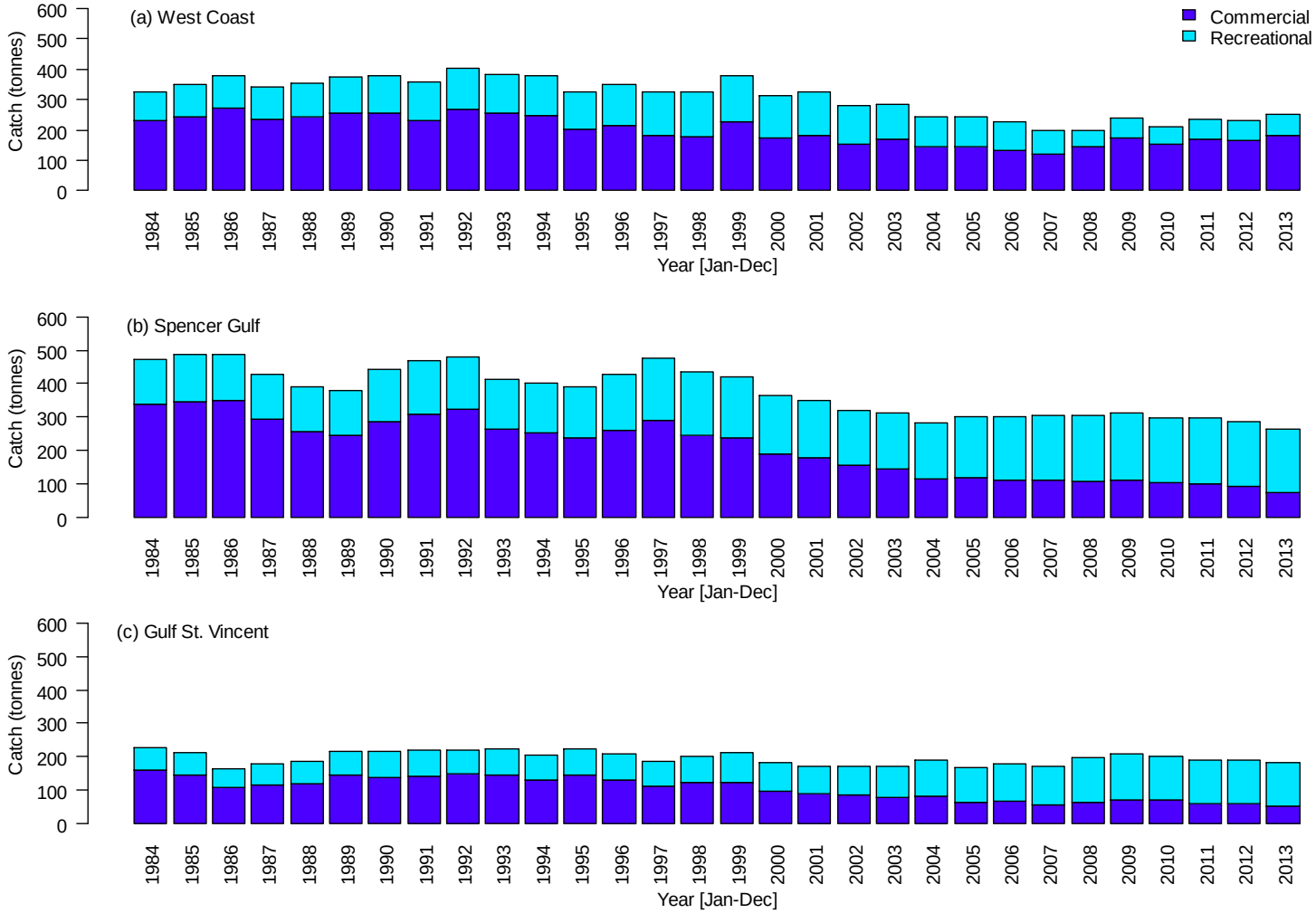

Fig. 5.3. Model estimated catches of King George whiting, in landed weight, by commercial and (total) recreational fishing.

5.3. Results

Trends in State-wide estimates of output parameters

The time-series of State-wide estimates of model output parameters are presented in Fig. 5.4. From 1984 onwards, the model-estimated values for recruitment and fishable biomass varied over cycles that involve a number years, but have also shown consistent increasing trends over time. As such, the estimated values in 2013 for both variables were close to the highest ever. In contrast, State-wide, model-estimated exploitation rates have shown a steady and substantial decline over a number of decades to the minimum value estimated for 2013.

Trends in stock-wide estimates of output parameters

The trends in output parameters for the three model stocks of WC, SG and GSV/KI differed considerably (Fig. 5.5). Recruitment has always been higher for the WC, while the estimates for this stock have increased considerably since 2002 (Fig. 5.5a). Recruitment levels were estimated to be considerably lower in the two gulfs. For SG, they were marginally higher than for GSV/KI. Also, for SG, there was a period of declining recruitment from the high value for 1997 until 2004, followed by another strong year class in 2005, and then another period of declining recruitment to 2013. Model-estimated recruitment has been relatively consistent in GSV/KI, but has declined marginally to 2013 from the high values estimated for 2008 and 2009.

The trends in model-estimated fishable biomass largely reflect the trends in recruitment (Fig. 5.5b). The WC supports the highest levels of biomass amongst the three stocks. Whilst estimated biomass for this stock fell between 1999 and 2004, it has subsequently increased considerably to the highest estimated level in 2013. Clearly, the results for this stock have driven the State-wide estimates of biomass (Fig. 5.4b). This is because the estimates of fishable biomass for both SG and GSV/KI are substantially lower.

There are also differences amongst stocks in the trends in exploitation rate (Fig. 5.5c). Exploitation rate has always been lower for the WC than for the two gulf stocks. Furthermore, it has declined from 1984 to 2008, and subsequently remained consistently low. Exploitation rate has always been higher in SG than for the WC, and has declined considerably over the same period of decline. For GSV, exploitation rate showed a slowly decreasing trend until 2006, before increasing significantly in 2008 and subsequently remaining high.

The time-series of output parameters for the two gulf stocks are further divided spatially in Fig. 5.6, which shows the model outputs for the northern and southern regions of each stock. The declining recent trends in recruitment and biomass from 2008 onwards are evident for both NSG and SSG. Furthermore, the lower recruitment and biomass from 2010 to 2013, relative to 2008 and 2009, are evident for both NGSV and SGSV. Similarly large estimated increases in exploitation rate from 2007 are evident for NGSV and exploitation rate remains at a high level in SGSV.

Monthly estimates of biomass and also commercial exploitation rates show significant seasonal variation for the three stocks (Fig. 5.7). Recreational exploitation is also seasonal, with a different temporal pattern to that of the commercial sector (Fig. 5.7).

5.4. Discussion

The model estimates of output parameters were considered at several spatial and temporal scales. At the State-wide spatial scale, the estimates of fishable biomass increased considerably after the downturn between 1999 and 2002. This reflected the combination of increasing recruitment rates and declining exploitation. The latter reflected declining commercial fishing effort and numbers of licence holders, as discussed in Chapter 3. Nevertheless, consideration of the model outputs at the stock level indicates that the State-wide trends were significantly influenced by those from the WC. The model outputs for this stock indicated that it has always supported the highest fishable biomass of the three stocks. Furthermore, fishable biomass for this stock has experienced a significant increasing trend through the 2000s that reflected increasing levels of recruitment as well as long-term declining exploitation rate. The declining exploitation is a consequence of commercial fishing effort having declined by >50% since 1984.

The trends in output parameters were very different for the SG and GSV/KI stocks compared to the WC stock. For both these stocks, estimated recruitment demonstrated marginal declines, at least over the most recent four years. Furthermore, estimated biomass had trended downwards since 2008, although from relatively low levels. Exploitation rates for both gulf stocks were higher than for the WC, particularly for GSV. The increase in exploitation rate for GSV/KI between 2007 and 2008 relates to the increase in recreational catch and effort recorded for the GSV/KI stock between the recreational surveys in 2000/01 and 2007/08 (Fowler et al.

2011). Given that this sector accounted for >60% of the total catch from this stock (Fig. 5.3), it indicates the dominant influence that the recreational sector has on exploitation rates of King George whiting in the two gulfs .

There are currently only two temporal data points for estimates of recreational catch and effort from the recreational sector, i.e. for 2000/01 and 2007/08 (Fowler et al. 2011). A conservative approach was used in applying WhitEst in 2013 to estimate recreational fishery statistics for the other years between 1984 and 2013 to downplay their influence. Nevertheless, the reality is that the recent trends in recreational statistics are unknown, which impacts on the extent to which the model outputs can depict reality. As such, despite the significance of recreational catch and effort for King George whiting, the lack of reliable catch and effort data for this sector remains the principal data gap in the modelling and assessment for this species. A third State-wide, telephone-diary recreational survey is currently underway in South Australia, which will help to determine the recent trends in the spatial and temporal aspects of recreational activity. Nevertheless, the most reliable information on catch and effort for King George whiting in South Australia comes from the commercial sector.

There was seasonal variation in the estimates of biomass of King George whiting for the three stocks. This species is most abundant in late summer, autumn and early winter subsequent to the late summer and early autumn season of fastest growth when each age-3 cohort predominantly recruits to harvestable size. Seasonal peaks in commercial catch occur in mid-winter, when effort is principally targeted on this newly recruited year class of 3-year-olds. In the two gulfs, the commercial exploitation rates lagged behind the seasonal trend in biomass by several months. The model estimates that the catchability of age-3 fish is more than twice that of other age classes, which is consistent with this seasonal variation, whereby commercial effort increases during winter to target the enhanced biomass of the newly recruited age-3 cohort. Recreational exploitation is also seasonal, with spikes evident in the months of school holidays.

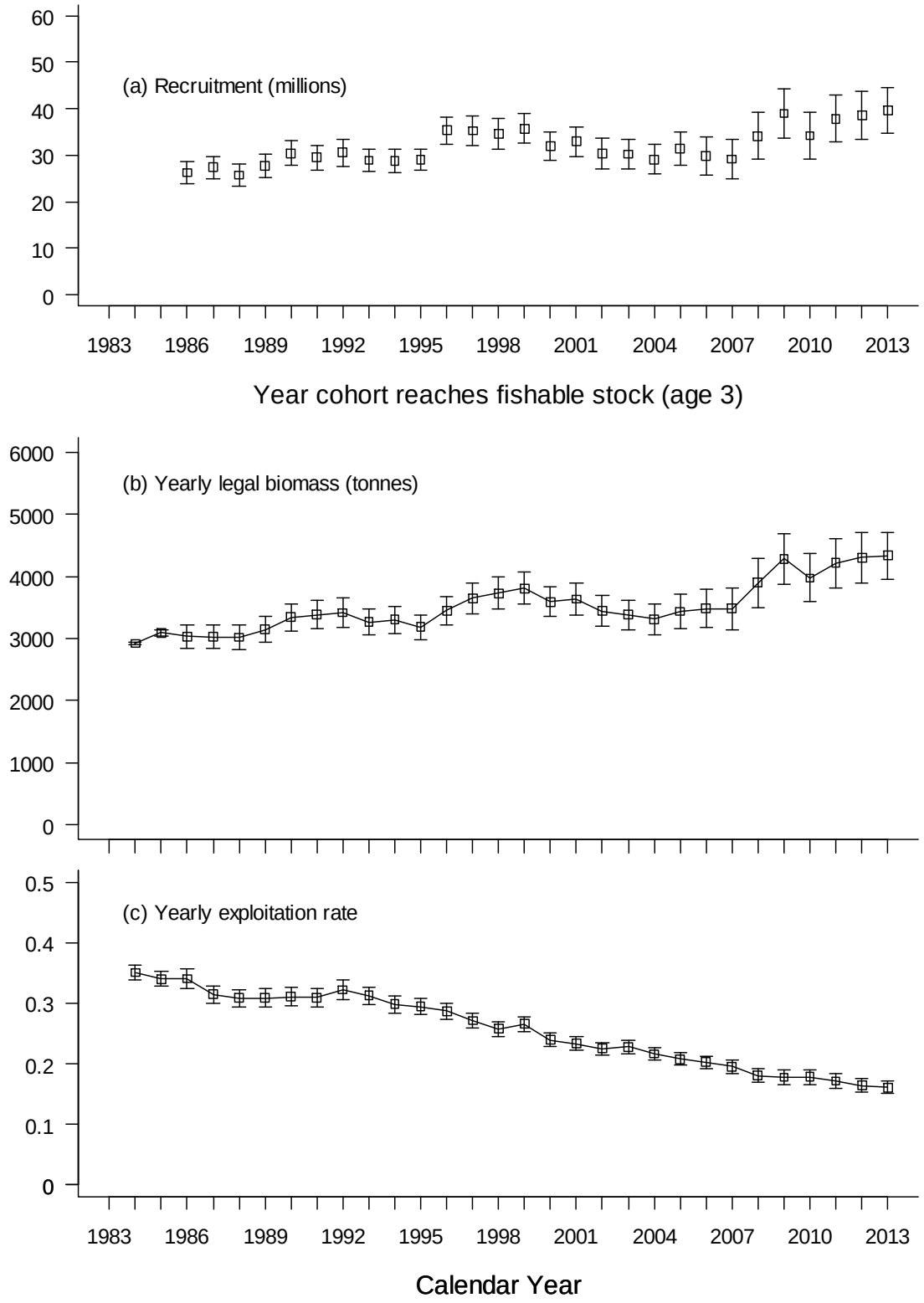

Fig. 5.4 Yearly State-wide (excluding spatial cell 6) model biological indicators 1984-2013 for South Australian King George whiting: (a) yearly recruit numbers, (b) legal biomass averaged over the 12 months of each calendar year, and (c) harvest fraction as the yearly model-estimated catch divided by the yearly average legal biomass. These performance indicators were estimated by the spatial dynamic stock assessment model (WhitEst). Error bars show 95% model estimate confidence intervals.

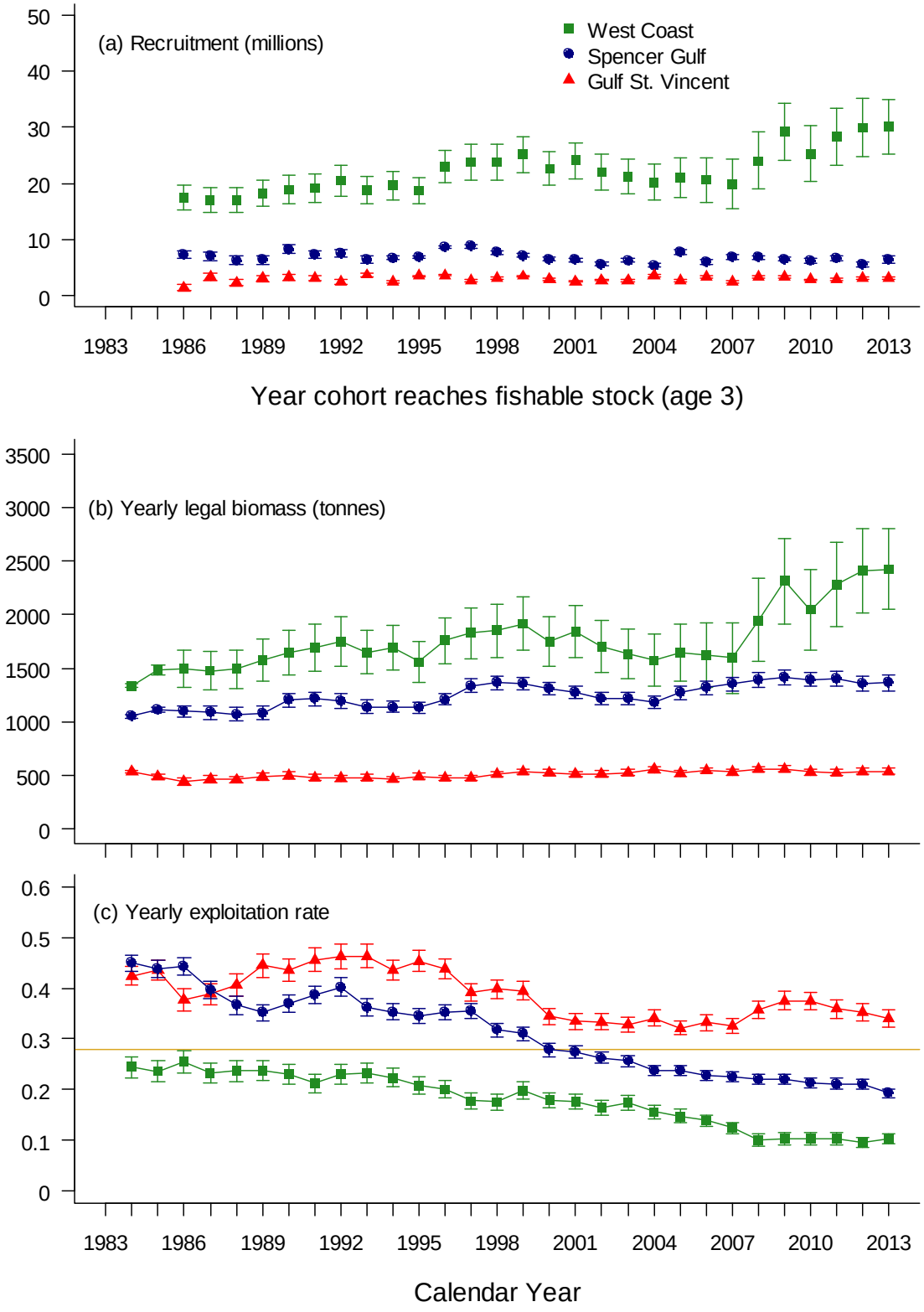

Fig. 5.5 Yearly model biological indicators 1984-2013 by stock. Stocks are the West Coast (including Far and Mid West Coast, and Coffin Bay, spatial cell 1 shown in Fig. 5.1), Spencer Gulf (spatial cells 2 and 3), and Gulf St. Vincent/ Kangaroo Island (spatial cells 4 and 5). Error bars show 95% confidence intervals. The yellow horizontal line in (c) shows the 28% upper bound target reference point for exploitation rate.

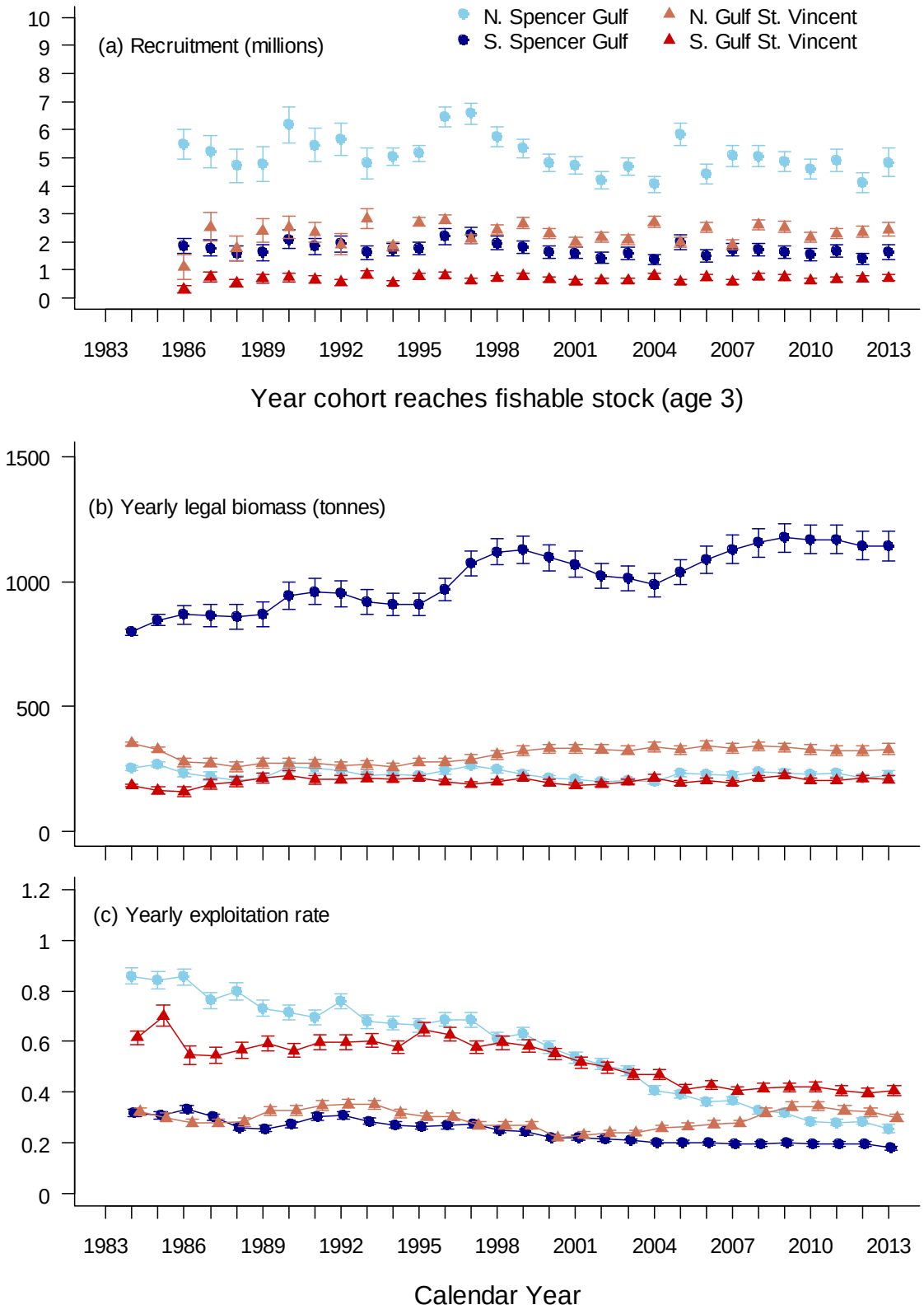

Fig. 5.6 Yearly model biological indicators 1984-2013 by region within the two gulfs. Error bars show 95% confidence intervals.

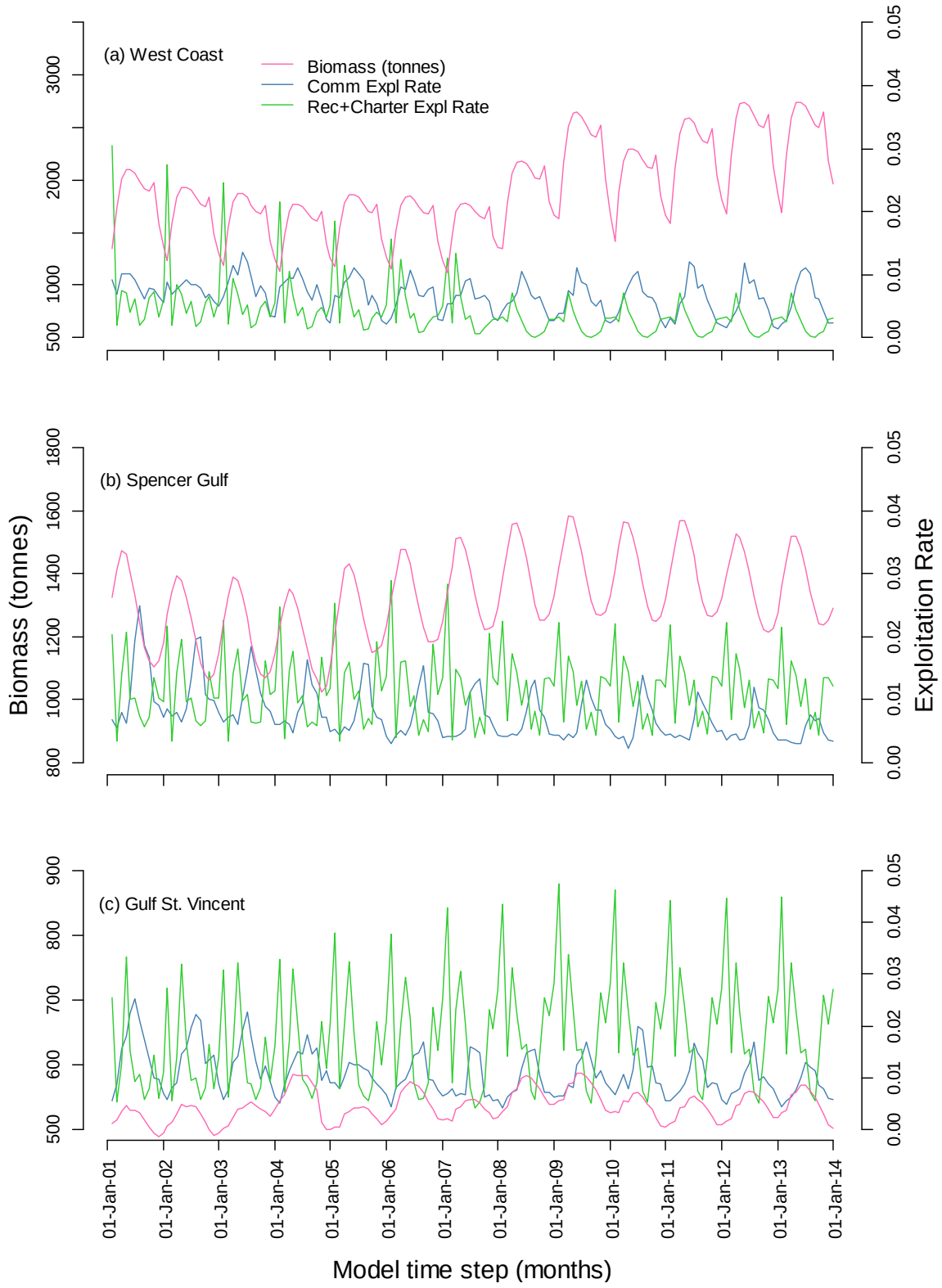

Fig. 5.7 Monthly estimates of fishable biomass and exploitation rate (here, as monthly proportion removed) by the recreational and commercial sectors from 2001 to 2013 for the three stocks of West Coast, Spencer Gulf and Gulf St Vincent/Kangaroo Island.

6. ASSESSMENT OF FISHERY PERFORMANCE INDICATORS

6.1. Introduction

The Management Plan for the commercial sector of the Marine Scalefish Fishery (PIRSA 2013) includes a harvest strategy for the King George whiting fishery, which outlines the processes for monitoring and assessment of the performance of the fishery, thereby providing a pointer to the effectiveness of current management arrangements. The harvest strategy specifies: the operational objectives for the management of the fishery; the performance indicators; and the trigger reference points against which the indicators are assessed. The aim of this chapter is to assess the status of South Australia's King George whiting fishery by considering the two operational objectives:

1. ensure the long-term sustainable harvest of King George whiting;
2. maintain catches within agreed allocations for each sector.

In order to address the first operational objective, two sets of fishery performance indicators have been established, i.e. 'general' and 'biological' (Table 6.1 based on Tables 21 and 22 and Appendix 4 in PIRSA 2013). The former are based entirely on commercial fishery statistics whilst the latter are based on output from the computer fishery model 'WhitEst', as well as population age structures from market sampling. The harvest strategy also re-categorises these 'general' and 'biological' indicators into 'primary' and 'secondary' ones (Table 6.1). The primary indicators are considered the most significant determinants of fishery performance, whilst the secondary ones are considered less reliable as indicators of fishery status but nevertheless augment the primary indicators in a weight of evidence approach (PIRSA 2013).

With respect to addressing the second operational objective, the share allocated to a particular sector is that to which it had access at the time the Minister requested the Fisheries Council prepare the Management Plan, based on the most recent information available (PIRSA 2013). For the Marine Scalefish Fishery, the most recent data were those from 2007/08, i.e. the year when the last recreational survey was done (Jones 2009). In the current assessment, the recent catches of the different fisheries that comprise the commercial sector were compared against their allocations that are specified in the Management Plan (PIRSA 2013).

6.2. Methods

General Fishery Performance Indicators

In order to address the first operational objective regarding the long-term sustainability of the King George whiting fishery, both the 'general' and 'biological' performance indicators were assessed at two spatial scales. These scales were; State-wide and for the three stocks for which the fishery statistics were summarised in Chapter 3. The general fishery performance indicators considered here were; total catch, handline effort, and handline CPUE (Table 6.1). At the State-wide scale and for each of the three stocks, the time series of data from 1984 to 2013 for each indicator was prepared. Then, the value for 2013 was compared against a number of trigger reference points calculated for the 'reference period', i.e. the historical data time series back to 1984 (Table 6.1). This comparison was done by addressing four questions:

- was the value of the indicator in 2013 among either the top three or bottom three values over the reference period of 1984 to 2013?;
- was the change in the indicator between 2012 and 2013, i.e. the two most recent years, the greatest inter-annual increase or decrease over the reference period?;
- was the slope of the linear trend over the last three years to 2013, the greatest rate of increase or decrease over three-year periods throughout the reference period?;
- and did the indicator decrease over the last five consecutive years?

Then separate 'results' tables were prepared that showed the outcomes of these comparisons, indicating whether or not the target reference points had been breached.

Biological Fishery Performance Indicators

For King George whiting, there are four biological performance indicators: fishable biomass; harvest fraction; recruitment; and age structure (Table 6.1). The first three are yearly time-series outputs from the WhitEst model (Chapter 5), whilst the age structures are measured catch proportions by age from market sampling (Chapter 4). The estimates of output indicators were computed and compared with for the three main fishery stocks, i.e. WC, SG and GSV/KI, as well as for the State overall, i.e. for the three regions combined. For each time-series of biomass estimates, the average biomass from the most recent three years (2011-2013) was compared with the average calculated across the earlier years (i.e. 1984-2010). For recruitment, the abundance of pre-recruits from the 2010 year class was compared with the average

recruitment from the preceding five years. For harvest fraction, the estimated value from the last year was chosen for consideration as it would be expected to not differ meaningfully from the average of the last three years since it is likely that this indicator changes slowly over time. In each case, this estimated value of harvest fraction was compared against the trigger reference point of 28%, as specified in the Management Plan (PIRSA 2013). The trigger reference points for the last indicator, i.e. the most recent annual age structure, are; significant change over the previous five years, and significant change over the long-term (Table 6.1).

Table 6.1 Fishery performance indicators and trigger reference points used to assess South Australia's King George whiting fisheries (from Tables 21, 22 and Appendix 4 in PIRSA 2013). Note that the general indicators relate only to the commercial fishery statistics.

Type	Performance Indicator	Category	Trigger Reference Point
General	Total catch	Secondary	3rd lowest/3rd highest Greatest interannual change (±) Greatest 5-year trend Decrease over five consecutive years ?
	Handline effort	Primary	3rd lowest/3rd highest Greatest interannual change (±) Greatest 5-year trend Decrease over five consecutive years ?
	Handline CPUE	Primary	3rd lowest/3rd highest Greatest interannual change (±) Greatest 5-year trend Decrease over five consecutive years ?
Biological	Fishable biomass	Primary	Most recent 3-yr average is +/-10% of average of previous years
	Exploitation rate	Primary	Exceeds 28% (international standard)
	Recruitment	Secondary	Abundance of pre-recruits is +/-10% of average of previous five years
	Age structures	Primary	Significant change in long-term or previous 5 years

Comparison with allocations for commercial sectors

The comparisons between reported catches and allocations for the different commercial fisheries were done using the fishery statistics from 2009 to 2013. For the comparisons, trigger limits are specified in the Management Plan that provide for some variability in the proportional contributions to total catch between years, allowing limited ability for sectors to exceed allocations without triggering a review. The assessment was done by addressing the following questions about relative contributions to the total commercial catch:

- did a fishery's contribution to total commercial catch at the State-wide scale exceed its allocation by the percentage nominated as Trigger 2 in Table 6.2,

(from Table 8 in PIRSA 2013), in three consecutive years or in four of the five previous years up to 2013?;

- did the fishery's contribution in 2013 exceed its allocation by the amount nominated as Trigger 3 in Table 6.2?

The total annual catches for each commercial fishery were determined for each year from 2009 to 2013. From these, their percentage contributions in these years were calculated. These were then assessed against the trigger limits specified below in Table 6.2, according to the criteria specified above.

Table 6.2 Allocation triggers for commercial fisheries. The table shows the commercial allocation to each commercial fishery (%), and their trigger reference points for each of Triggers 2 and 3. Note that for the MSF fishery, no trigger limits are set as allocation is >95%. Fisheries are identified as MSF = Marine Scalefish Fishery; SZRL = Southern Zone Rock Lobster Fishery; NZRL = Northern Zone Rock Lobster Fishery.

Fishery	MSF	SZRL	NZRL
Commercial allocation (%)	98.1	0.00	1.9
Trigger 2	na	0.5	2.97
Trigger 3	na	0.75	3.96

6.3. Results

General Performance Indicators

For the State-wide fishery statistics, three general performance indicators exceeded the trigger reference points (Table 6.3). These reflected that 2013 produced the lowest ever commercial catch, attracted the lowest handline effort whilst producing the highest recorded handline CPUE.

Table 6.3 Summary of comparisons between general performance indicators and trigger reference points for 2013 for the State-wide data.

Performance Indicator	Trigger Reference Point	Breached ?	Details
Total commercial catch	3rd lowest/3rd highest	**Yes**	**Lowest**
	Greatest interannual change (+)	No	
	Greatest 3-year trend (+)	No	
	Decrease over five consecutive years?	No	
Handline effort	3rd lowest/3rd highest	**Yes**	**Lowest**
	Greatest interannual change (+)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	
Handline CPUE	3rd lowest/3rd highest	**Yes**	**Highest**
	Greatest interannual change (+)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	

Whilst the State-wide results presented in Table 6.3 are relatively positive, nevertheless different trigger reference points were activated for the three stocks, suggesting different levels of stock status (Tables 6.4 to 6.6).

For the West Coast (WC) stock two trigger reference points were activated (Table 6.4). These related to the record level of handline CPUE as well as the 2nd lowest handline effort ever recorded.

Table 6.4 Summary of comparisons between general performance indicators and trigger reference points for 2013 for the WC stock.

Performance Indicator	Trigger Reference Point	Breached ?	Details
Total commercial catch	3rd lowest/3rd highest	No	
	Greatest interannual change (+)	No	
	Greatest 3-year trend (+)	No	
	Decrease over five consecutive years?	No	
Handline effort	3rd lowest/3rd highest	**Yes**	**2nd lowest**
	Greatest interannual change (+)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	
Handline CPUE	3rd lowest/3rd highest	**Yes**	**Highest**
	Greatest interannual change (+)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	

In contrast to the results from the WC, for each of the Spencer Gulf (SG) and Gulf St. Vincent/Kangaroo Island (GSV/KI) stocks two trigger reference points were activated. In both cases these related to the lowest total catch ever captured and lowest handline effort ever expended (Tables 6.5, 6.6).

Table 6.5 Summary of comparisons between general performance indicators and trigger reference points for 2013 for the SG stock.

Performance Indicator	Trigger Reference Point	Breached ?	Details
Total commercial catch	3rd lowest/3rd highest	**Yes**	**Lowest**
	Greatest interannual change (+)	No	
	Greatest 3-year trend (+)	No	
	Decrease over five consecutive years?	No	
Handline effort	3rd lowest/3rd highest	**Yes**	**Lowest**
	Greatest interannual change (+)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	
Handline CPUE	3rd lowest/3rd highest	No	
	Greatest interannual change (+)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	

Table 6.6 Summary of comparisons between general performance indicators and trigger reference points for 2013 for the GSV/KI stock.

Performance Indicator	Trigger Reference Point	Breached ?	Details
Total commercial catch	3rd lowest/3rd highest	**Yes**	**Lowest**
	Greatest interannual change (±)	No	
	Greatest 3-year trend (±)	No	
	Decrease over five consecutive years?	No	
Handline effort	3rd lowest/3rd highest	**Yes**	**Lowest**
	Greatest interannual change (±)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	
Handline CPUE	3rd lowest/3rd highest	No	
	Greatest interannual change (±)	No	
	Greatest 3-year trend	No	
	Decrease over five consecutive years?	No	

Biological Performance Indicators

Overall, the outcomes from consideration of the biological performance indicators were mixed (Table 6.7). The biomass indicator triggered positively for the WC stock, with 40% higher biomass in the last three years compared to previous years, reflecting the strong rising trend for the WC (Fig. 5.5b). Biomass was also 12% higher in the last three years in SG, just exceeding the 10% reference point. A total of 56% of the State's estimated biomass of King George whiting is now accounted for by the WC stock with SG and GSV/KI accounting for 32% and 12%, respectively. As such, the high biomass for the WC stock caused the State-wide estimate to also exceed the trigger reference point at 25% higher overall.

Recruitment for the last year class (2010) was compared with the average calculated across the previous five years. This biological performance indicator triggered for the WC stock, as estimated recruitment in 2010 was the second highest value ever estimated (Table 6.7).

The estimates of exploitation rate (i.e. yearly harvest fraction) for the WC and SG stocks in 2013 were 10% and 19%, respectively, and did not exceed the trigger reference point of 28% (Table 6.7). Alternatively, the high value of 34% exploitation rate for GSV/KI exceeded the trigger reference point. In contrast to the other two stocks, exploitation rate in GSV/KI has remained relatively high, despite trending marginally lower since 2009 (Fig. 5.5c). There has been no apparent change in population age structure over the past five years.

Table 6.7 Yearly biological performance indicators, including three estimated by the WhitEst model, for the three stocks and for the State overall (excluding offshore cell 6). Limit reference points that have been breached are highlighted in yellow.

Biological performance indicator	Category	Trigger reference point	WC	SG	GSV/KI	State-wide
Fishable Biomass	Primary	3 yr average is +/- 10% of previous years	2011-2013 biomass 40% above average of previous years (1984-2010)	2011-2013 biomass 12% above average of previous years (1984-2010)	2011-2013 biomass 6% above average of previous years (1984-2010)	2011-2013 biomass 25% above average of previous years (1984-2010)
Harvest fraction	Primary	Exceeds international standard (28% yearly)	10%	19%	34%	16%
Age structure	Primary	Significant change in long-term or previous 5 years	No change over time	No change over time	No change over time	No change over time
Recruitment	Secondary	Ref year +/- 10% of previous 5-yr average	2010 year class 10% above average of previous 5 years	2010 year class 2% above average of previous 5 years	2010 year class 2% below average of previous 5 years	2010 year class 8% above average of previous 5 years

Comparison with allocations for commercial sectors

The reported catches of King George whiting by the three commercial fisheries and their relative contributions to the total commercial catch in each year from 2009 to 2013 are shown in Table 6.8. The Marine Scalefish fishers dominated the catches in each year accounting for >97% of the reported catch. The reported catches from the Northern Zone Rock Lobster fishers accounted for <3% of the annual totals, whilst those of the Southern Zone Rock Lobster fishers were largely incidental at significantly less than 1% in each year. These contributions of the various commercial fisheries to total catch did not vary significantly from their allocations (Table 6.9).

Table 6.8 Comparison of catches of King George whiting (tonnes) and relative contribution to total catch (percentage) by the different commercial fisheries that reported taking King George whiting in each year between 2009 and 2013. Fisheries are identified as MSF = Marine Scalefish Fishery; NZRL = Northern Zone Rock Lobster; SZRL = Southern Zone Rock Lobster.

Year	MSF	NZRL	SZRL	Total	%MSF	%NZRL	%SZRL
2009	349.6	8.6	0.3	358.5	97.5	2.4	0.1
2010	317.9	8.6	0.2	326.7	97.3	2.6	0.1
2011	319.2	8.7	0.8	328.0	97.3	2.7	0.0
2012	304.1	6.6	0.2	310.9	97.8	2.1	0.1
2013	284.2	8.3	0.0	292.5	97.2	2.8	0.0

Table 6.9 Comparisons between the catches of King George whiting by the different commercial fisheries in 2013 with trigger limits specified in the Management Plan (PIRSA 2013). Fisheries are identified as MSF = Marine Scalefish Fishery; NZRL = Northern Zone Rock Lobster; SZRL = Southern Zone Rock Lobster.

Commercial sector	Draft Trigger Limit	Breached?
MSF	Trigger 2 – no trigger limit set as allocation >95%	n.a.
	Trigger 3 – no trigger limit set as allocation >95%	n.a.
NZRL fishery	Trigger 2 – exceeds allocation of 2.97% in multiple years	No
	Trigger 3 – exceeds allocation of 3.96% in 2013	No
SZRL fishery	Trigger 2 – exceeds allocation of 0.5% in multiple years	No
	Trigger 3 – exceeds allocation of 0.75% in 2013	No

6.4. Discussion

The first management objective of ensuring the long-term sustainable harvest of King George whiting was assessed using the general fishery performance indicators at two spatial scales, i.e. State-wide and at the level of stock. Breaches of reference points at the larger scale are difficult to interpret in terms of stock status as different reference points were breached for the different stocks. For the WC stock, in 2013 the highest level of handline CPUE was recorded, relating to a moderate level of catch and the 2nd lowest level of handline fishing effort (Fig. 3.3). These are positive indicators of status for this stock. In contrast, for SG, the lowest ever catch was recorded in 2013, having attracted the lowest annual handline fishing effort. These resulted in a relatively low level of CPUE that had declined since 2007. The results were similar for GSV/KI with the lowest ever handline catch and effort, and CPUE having declined since 2007. Such results suggest weaker levels of stock status for these two stocks than is the case for the WC.

There were several biological performance indicators that breached trigger reference points. Firstly, for WC, the average estimated biomass from 2011 to 2013 was 40% above the long-term average, which resulted in the State-wide estimates also being substantially above the long-term average. Also, for this stock, recruitment of the 2010 year class was 10% above the average of the previous five years. These strongly positive indicators are consistent with outcomes for the general performance indicators for the same stock as discussed above. For SG, there was one biological performance indicator that breached the trigger reference point. Estimated biomass in 2011-13 was marginally above the average through the years of 1984 to 2010. However, for GSV/KI, the high exploitation rate of 34% exceeded the trigger reference point (PIRSA 2013). This was the result of greatest concern for these biological performance indicators. Estimated exploitation rate has not trended downward for GSV/KI over the long-term as has occurred for the other two stocks. Rather, it increased substantially in 2008 and has remained high since. In Chapter 5 it was suggested that this resulted from the substantial increase in recreational catch and effort for this stock that occurred between 2000/01 and 2007/08 (Fowler et al. 2011).

7. GENERAL DISCUSSION

7.1. Context of this assessment

In the early 2000s there was considerable concern about the long-term sustainability of the South Australian King George whiting fishery (McGarvey et al. 2003). It was apparent from several indicators that the abundances in each of the three South Australian stocks had declined considerably between 1999 and 2002. This concerning status prompted a review of the management of the fishery through 2004 that culminated in significant changes that came into force on the 1st October 2004. This is the fourth stock assessment undertaken since then. Each triennial stock assessment has provided the opportunity to assess whether stock status has improved following implementation of these management changes. The first of these reports suggested that there had been a turn-around in the downward trend for each stock (McGarvey et al. 2005). The second report in 2008 indicated that the status of the fishery had improved considerably and that there was no immediate concern about the status of the fishery (Fowler et al. 2008). The third report indicated that for a number of years up to 2010, the fishery had been relatively stable and there remained no concern about the status of the fishery (Fowler et al. 2011). Largely on the basis of the latter assessment, the three South Australian stocks were assigned the status of 'sustainable' in the national stock status report completed in 2012 (Kemp et al. 2012).

This current stock assessment provides opportunity to assess the status of the three South Australian stocks of King George whiting, based on data collected up to the end of 2013, i.e. over nine years after implementation of the new management arrangements. There were several sets of data considered here to assess stock status. Firstly, the commercial catch, effort and CPUE data were considered at the State-wide and stock-wide scales up to December 2013. Secondly, the size and age structures of populations in the various regions across the fishery were considered. Finally, these two independent datasets were integrated with historic recreational fishery data using the WhitEst fishery assessment model, to generate a number of output parameters as indicators of stock status. Overall, five primary and two secondary fishery performance indicators were assessed against prescribed trigger reference points in a weight of evidence approach for each stock (PIRSA 2013).

7.2. Determination of stock status

Commercial fishery statistics

The most complete and informative data that relate the status of the King George whiting stocks are the estimates of catch, effort and CPUE from the commercial fishery statistics. Handline effort and CPUE are primary performance indicators, whilst total catch is a secondary indicator (PIRSA 2013). The considerable reductions in net fishing effort have eroded the value of data from that sector as fishery indicators. It is considered that commercial handline CPUE provides the best index of relative abundance although it must be interpreted cautiously as it can provide an optimistic view of relative abundance. This is because raw catch rates do not take into consideration the increasing 'effective' effort in the fishery that is associated with technological advancements adopted by the fishing industry. The advancements in fishing gear, power of vessels and electronic equipment has significantly increased the capacity of fishers to find and catch fish since fishery statistics were first recorded in 1984 (Jones and Luscombe 1993a, b). Furthermore, the unit of fishing effort used in this fishery, i.e. 'fisherday' is relatively course, as it contains no information about the numbers of hours fished or travelling times and distances. As such, declines in CPUE are considered to reliably indicate decreases in abundance of King George whiting, but can underestimate the magnitude of reductions.

Commercial handline fishing effort is also a primary performance indicator of the relative abundance of the stock (PIRSA 2013). This is based on the fact that King George whiting remains the premium species that returns the highest value per unit weight to the commercial fishers. As such, high levels of biomass should attract considerable effort, whilst declining levels of biomass will result in lower effort as the fishers shift their effort to other Marine Scalefish species. The challenge, with respect to this indicator, is to differentiate the effects of shifting effort away from King George whiting from declining effort associated with decreases in numbers of fishers.

The overwhelming trends in the commercial handline fishery statistics for King George whiting were significant declines in catch and effort. Such declines were apparent for each of the seven regional fisheries and consequently also in the integrated data at both the stock-wide and State-wide levels. Fishery statistics from the net sector for the two regions of NSG and GSV, where the majority of hauling net activity remains, also showed declining hauling net effort for King George whiting. This resulted in net catches having fallen to approximately one third of those of the 1980s and 1990s.

These declining trends must, at least partly, relate to the effective halving of numbers of commercial licence holders since 1984, which has contributed to fewer targeted handline fishing days across the State and fewer hauling net fishing days in the northern gulfs. However, the fall in numbers of fishers does not fully account for the declines in catch and effort. Fishing effort has also been directed away from King George whiting onto snapper and southern calamary (Fowler et al. 2013). Furthermore, for King George whiting, changes in catch rates have also contributed to changes in catches. Prior to 1999, declining levels of catch and effort for the three stocks were generally associated with rising levels of CPUE. However, around 1999 to 2002, there were declines in stock-wide estimates of CPUE that were associated with accelerated declines in catch and effort. Such results are consistent with declining levels of fishable biomass. Nevertheless, after 2004, the stock-wide rates of decline in handline catch and effort slowed down, whilst handline CPUE increased for several years, suggesting some recovery in the biomass of the stocks.

The trends in CPUE since 2007 are significant in determining the current stock status. For the WC stock, the declining fishing effort flattened out, catch increased for a number of years and the handline CPUE increased to 2013, resulting in the highest ever recorded level of handline CPUE. In contrast, for the SG stock, total catch decreased from 2007 to the lowest recorded level in 2013, whilst handline fishing effort also declined between 2009 and 2013. Furthermore, handline CPUE has been on a declining trajectory since 2007. For the GSV/KI stock, total catch and handline effort declined considerably from 2010 to 2013 and CPUE declined from 2007. These results are consistent with declining levels of biomass for both the SG and GSV/KI stocks. Recent concomitant declines in catch, effort and CPUE for both SG and GSV/KI are consistent with declining levels of biomass.

Population structure

The second set of data considered as indicators of stock status were population size and age structures. Through broad-scale population sampling during the 1990s it became evident that King George whiting in South Australia are not distributed evenly with respect to size and age (Fowler and McGarvey 2000, Fowler et al. 2000). Whilst some populations primarily involve relatively small, young fish, others support broader age and size distributions. The latter form the spawning aggregations during the reproductive season (Fowler et al. 1999), which are supplemented by movement of small, young adults from inshore areas (Fowler et al. 2002). The different size and age distributions of fish in different regions are the culmination of a complicated

sequence of life history and demographic processes. As such, the regional estimates of population structure provide indicators of stock status (PIRSA 2013). In this study, market sampling for King George whiting was undertaken across the geographic range of the fishery during each financial year of 2006/07, 2008/09, 2009/10, 2011/12 and 2012/13 and the size and age distributions from these years were considered against historical data. The within-region comparisons did not show any evidence of significant change in population structure that might be attributable to the fishery. As such, the trigger reference points for this indicator were not activated for any of the three stocks.

Fishery assessment model

The computer fishery assessment model 'WhitEst' integrates the fishery and biological data to provide annual estimates of recruitment, fishable biomass and annual exploitation rate. These represent the remaining fishery performance indicators, of which the latter two are considered primary indicators (PIRSA 2013). Up to 2002, these output parameters presented some concerning trends (McGarvey et al. 2003). Since then, there have been considerable changes in the trends that differ amongst the three stocks.

For the WC stock, estimated recruitment increased considerably from 2002 onwards, culminating in the highest ever estimate in 2013. The trend in fishable biomass for this stock also increased appreciably between 2007 and 2013, culminating in the highest ever estimate in 2013. Furthermore, the time series of exploitation rates declined from 1984 and by 2008 had fallen to around 10% of the fishable biomass. In 2013, two limit reference points were activated, i.e. fishable biomass and recruitment were above average. These are positive indicators of stock status.

The trends in output parameters from WhitEst for SG differed considerably from those for the WC. From 2005 to 2013, estimated recruitment declined marginally with the lowest ever value estimated for 2012. Estimated fishable biomass also declined marginally between 2009 and 2013. These declines occurred despite a trend of declining exploitation rate that fell from >40% in 1992 to around 20% in 2013. No negative trigger reference points were activated for any of the biological performance indicators for this stock.

For the GSV/KI stock, the estimates of fishable biomass have always been much lower than for the other two stocks, reflecting lower recruitment levels. The estimated

fishable biomass showed a general trend of slowly increasing biomass over time, although this slowed from 2009. Recruitment has been flat for the last decade, with marginal increases in 2006, 2008 and 2009. Since 2003, the estimated exploitation rates have been higher than for the other two stocks. In 2013, the exploitation rate remained high at 34%, which activated the trigger reference point.

Stock status

In this report, the status of each of South Australia's three King George whiting stocks was classified using the national system that involves four classification levels: sustainable; transitional depleting; transitional recovering; and overfished (Flood et al. 2012). However, the Management Plan for the Marine Scalefish Fishery (PIRSA 2013) does not identify performance indicators or reference points that differentiate between these classification levels. Rather, stock status is determined based on seven fishery performance indicators using a weight of evidence approach. This approach was adopted for the national stock status report in 2012, when the three South Australian stocks were classified as 'sustainable' (Kemp et al. 2012). Those classifications were based on the largely positive findings of the stock assessment at that time (Fowler et al. 2011), although that assessment highlighted concerning signs of declining catches and catch rates for two regions (i.e. NSG and KI).

Catches and handline CPUE for the West Coast stock have been increasing since 2004. The stock assessment model WhitEst indicated trends of increasing biomass and recruitment over this period. Between 1984 and 2013, the exploitation rate fell from 22% to 10%. Evidence suggests that the current level of fishing mortality is unlikely to cause this stock to become recruitment overfished. The stock is classified as **sustainable**.

The current situation is different for both the SG and GSV/KI stocks, where the previously raised concerning signs of declining catches and catch rates have continued. King George whiting is the premium species in the Marine Scalefish Fishery and attracts the highest price per unit weight for commercial fishers. Despite this high incentive to catch King George whiting, catch and effort in 2013 fell to their lowest recorded levels in both gulfs. This reflects declining trends in both catch and effort in both gulfs since 2007. We interpret the switch of effort away from King George whiting towards lower value species as, at least partly, a response by commercial fishers to reduced availability of King George whiting. The declines in handline CPUE in both gulfs since 2007 suggest that fishable biomass has most likely

declined. As our current estimates of CPUE do not take into account likely increases in 'effective' effort, we believe that the decline in fishable biomass may be greater than suggested by the reduction in raw CPUE alone. Increases in effective effort associated with improvements in vessel speed and navigational equipment mean that comparisons of CPUE over the last decade with those recorded in the first 20 years of the catch history are difficult, particularly with respect to interpreting relative abundance during those two periods. If 'effective' effort has continued to increase over the last decade, then the declines in fishable biomass over the last decade may be greater than suggested by the observed reductions in CPUE.

Estimates of fishable biomass in the two gulfs from the WhitEst stock assessment model were relatively flat or have trended downwards since 2009. We consider that these trends may under-estimate declines in fishable biomass for two reasons. Firstly, they are largely driven by commercial CPUE, which has not been corrected for increases in 'effective' effort. Secondly, total catch and effort used in the WhitEst model are based on estimates of recreational catches that have been extrapolated from surveys done in 2000/01 and 2007/08. These extrapolated catches have not changed over time. If recreational catches have increased since 2007/08, the decline in fishable biomass would be greater than suggested by WhitEst.

The status of each of the SG and GSV/KI stocks was not easily defined. It is difficult to distinguish whether these stocks should be classified as 'sustainable' or 'transitional depleting'. This difficulty relates in part to the absence of a defined trigger reference point that separates the two categories. However, the difficulty also reflects limitations in the reliability of the primary indicator of fishable biomass, i.e. CPUE, as an index of abundance for a schooling species in which CPUE is likely to display hyper-stability. The interpretation of trends in CPUE is also complicated by the crude nature of the current measure of effort (fisherdays) and the most likely increased effectiveness of fishing effort over time in the Marine Scalefish Fishery. A precautionary interpretation of the data suggests that both stocks are best described as **transitional depleting**.

7.3. Uncertainties about stock status

As indicated above, there are uncertainties in our data and their interpretation that affects our understanding of the influence of the fishery on the population biology of King George whiting, and the outcomes of the stock assessment process. Firstly, the estimates of commercial CPUE considered here were not corrected for increasing 'effective' effort that results from technology creep. Although there is some

understanding of the timing of the uptake of electronic navigational and fish detecting devices on Marine Scalefish vessels (Jones and Luscombe 1993a, b), the influences of these and subsequent developments on the rate of increase in effective effort are unknown. As such, the recent declining levels of commercial handline CPUE in SG and GSV/KI and the declining trends in model-estimated biomass, may underestimate the true rate of decline in fishable biomass of these stocks.

A further significant uncertainty relates to the poor understanding of temporal trends in catch and effort by the recreational sector. It is apparent from the two State-wide telephone/diary surveys undertaken through the 2000s that this sector accounts for a significant proportion of the total catch of King George whiting (Jones and Doonan 2005, Jones 2009). The estimates of recreational catch and effort used in the WhitEst model were extrapolated from the limited data available from 2000/01 and 2007/08. In reality, it is unlikely that such extrapolated values provide a satisfactory time series of recreational catch and effort. Yet, this extrapolated dataset is likely to have had considerable impact on the output parameters from WhitEst. The recent declines in model-estimated biomass were considerably less than those in the estimates of commercial CPUE, possibly reflecting that they may be conservative compared to real trends in changing biomass.

Finally, there is also uncertainty about whether reproductive output and successful recruitment in the two gulfs may have declined in recent years. These may have been impacted by the targeted fishing of spawning aggregations that are located in the deep, off-shore waters of south east Spencer Gulf, Investigator Strait and south west Gulf St. Vincent. In recent years such places have become accessible to commercial and recreational fishers due to technological advancements in fishing boats and electronic equipment. The fishing of spawning aggregations may have disrupted the spawning activity and reduced egg production by the fish in such areas.

7.4. Future work

The various monitoring programs for the King George whiting fishery will continue into the future. These include the monitoring of the commercial catch and effort data and that from the Charter Boat sector by SARDI's Information Systems and Database Support Program. Market sampling for King George whiting is currently planned to resume in October 2014 and to continue until September 2016. These data will be used to inform the WhitEst fishery assessment model for future assessments, and to monitor for possible truncation in the size and age structures. There is a State-wide

recreational fishing survey underway through 2014, whose results, in association with those from the surveys done in 2000/01 and 2007/08, will help to better understand the trends in recreational catch and effort for King George whiting. The results will be reported and used in the next stock assessment scheduled for 2017.

There are a number of ways by which the research program for King George whiting could be augmented to improve certainty in the status of the stocks in SG and GSV/KI. The surveys that were undertaken in the nursery areas of the northern parts of both gulfs during the late 1980s and 1990s to quantify post-larval and pre-recruit abundances could be re-established (Fowler and Short 1996, Fowler and McGarvey 2000). This might help determine whether recruitment rates have declined since the 1990s. The size and age structures at known spawning aggregation sites could be determined and compared with those from the 1990s and early 2000s, to determine whether truncation of spawners has occurred. Furthermore, it might be possible to develop methods to estimate the biomass of the spawning stock using the daily egg production method (DEPM). It is highly likely that the genetic methods that will soon be developed to identify snapper eggs, thereby making the DEPM methodology tractable for this species, could also be applicable for King George whiting. This would overcome the issues of egg identification that were confronted when this method was attempted for King George whiting in the late 1990s (Fowler 2000). Finally, consideration should be given to collecting more refined data on commercial fishing effort. Herein lies the opportunity to work with this sector to determine appropriate measures of fishing effort and to revise the commercial logbook and database to report and record such refined data on a daily basis.

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9. APPENDIX: MODEL FITS TO DATA

Parameters and thus stock indicators in the WhitEst model are estimated by fitting to data for commercial catch totals by weight, recreational catch total numbers for some years (see Methods Chapter 5), and to commercial catch proportions by age and sex, in each month when sampling occurred. In this Appendix, graphs comparing fitted model and data indices are presented.

In Fig. 5.1, model fits to the reported monthly King George Whiting catch totals are plotted for commercial catch in weight landed for the 5 model spatial cells. In Fig. 5.2, the model fits to catches in number by the recreational sector are shown for the two gulfs and West Coast. This fit is nearly perfect by design, sufficient additional catchability parameters having been added to the model to guarantee a close fit, in effect achieving a catch-conditioned outcome for catch in this effort-conditioned model formulation. Fig. 9.3 shows the extent of agreement between model-predicted biomass and the principal informing indicator for trends in biomass, namely targeted handline CPUE, noting that this (effort-conditioned) model does not fit to CPUE directly. Plots of fit to the proportions landed by age (Fig. 9.4) and to sex ratios (Fig. 9.5) from catch sampling are also plotted below. Age data were obtained for most combinations of the five spatial cells and both sexes, and for each month of the four age and length sampling programs which ran from September 1994 to June 1997, July 2004 to June 2007, July 2008 to December 2010, and October 2011 to September 2013. We present only the 24 most recent fits to these age and sex catch proportions.

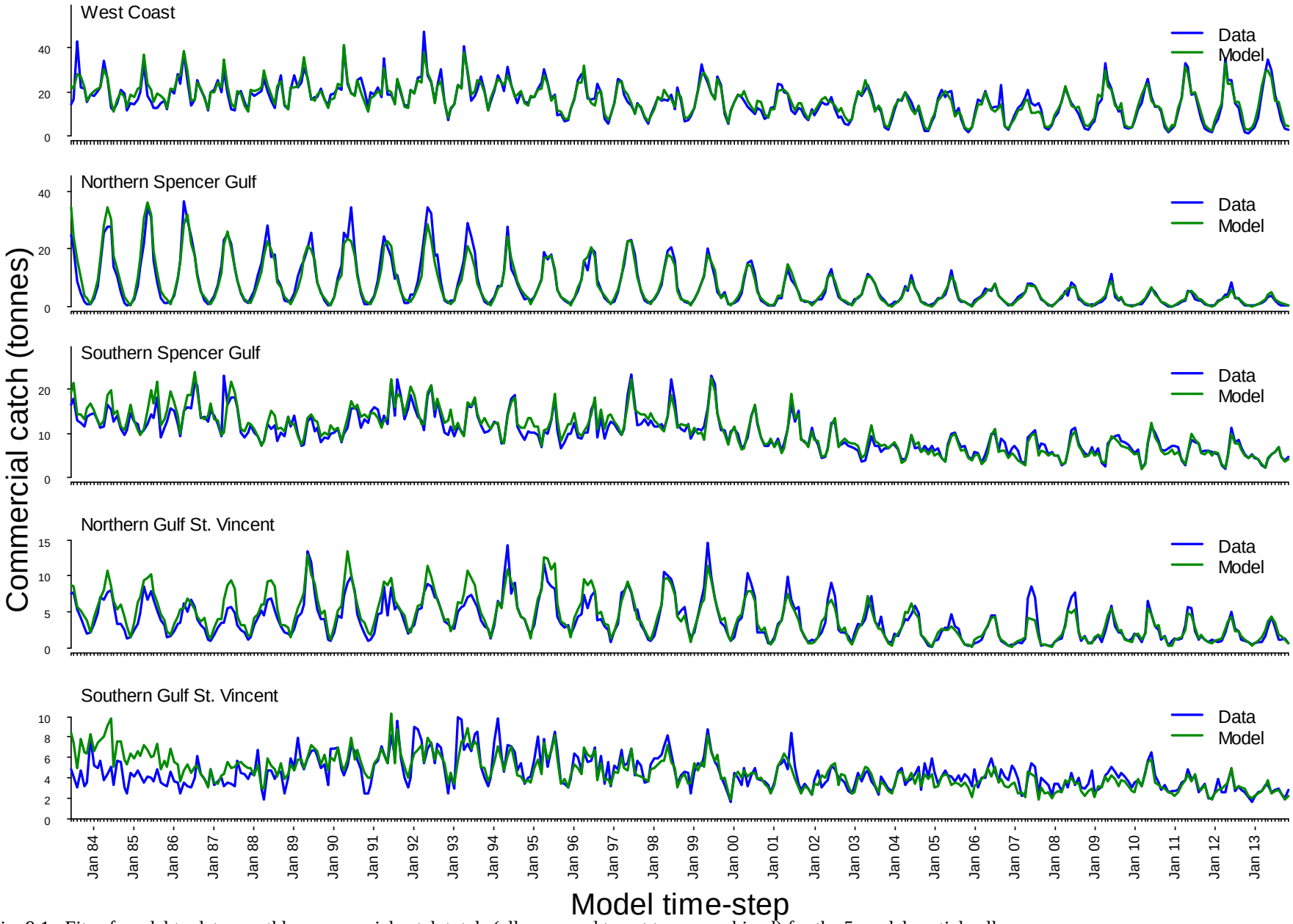

Fig. 9.1. Fits of model to data monthly commercial catch totals (all gears and target types combined) for the 5 model spatial cells.

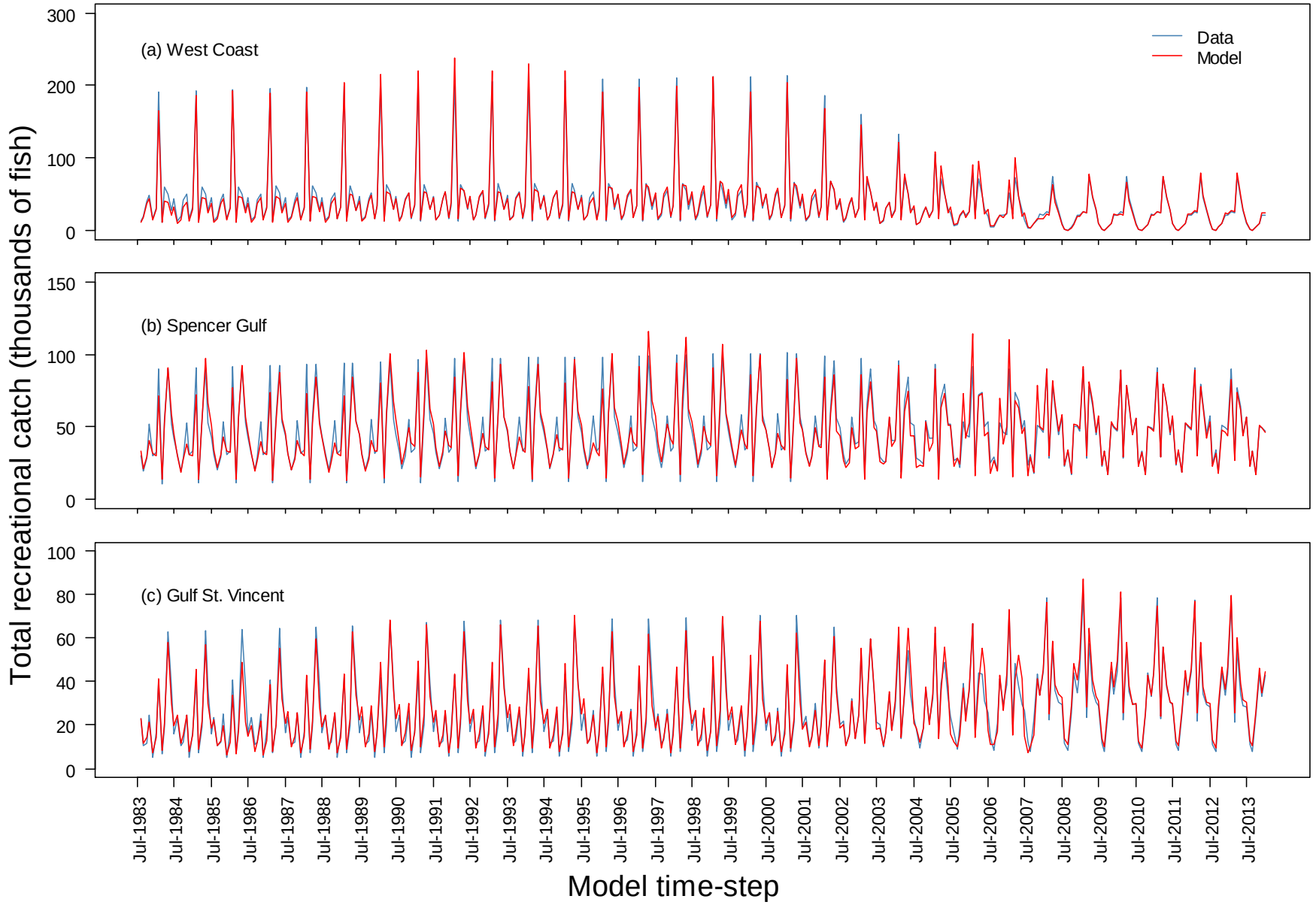

Fig. 9.2. Fits of model to data monthly recreational catch totals, for the 3 principal King George whiting regions.

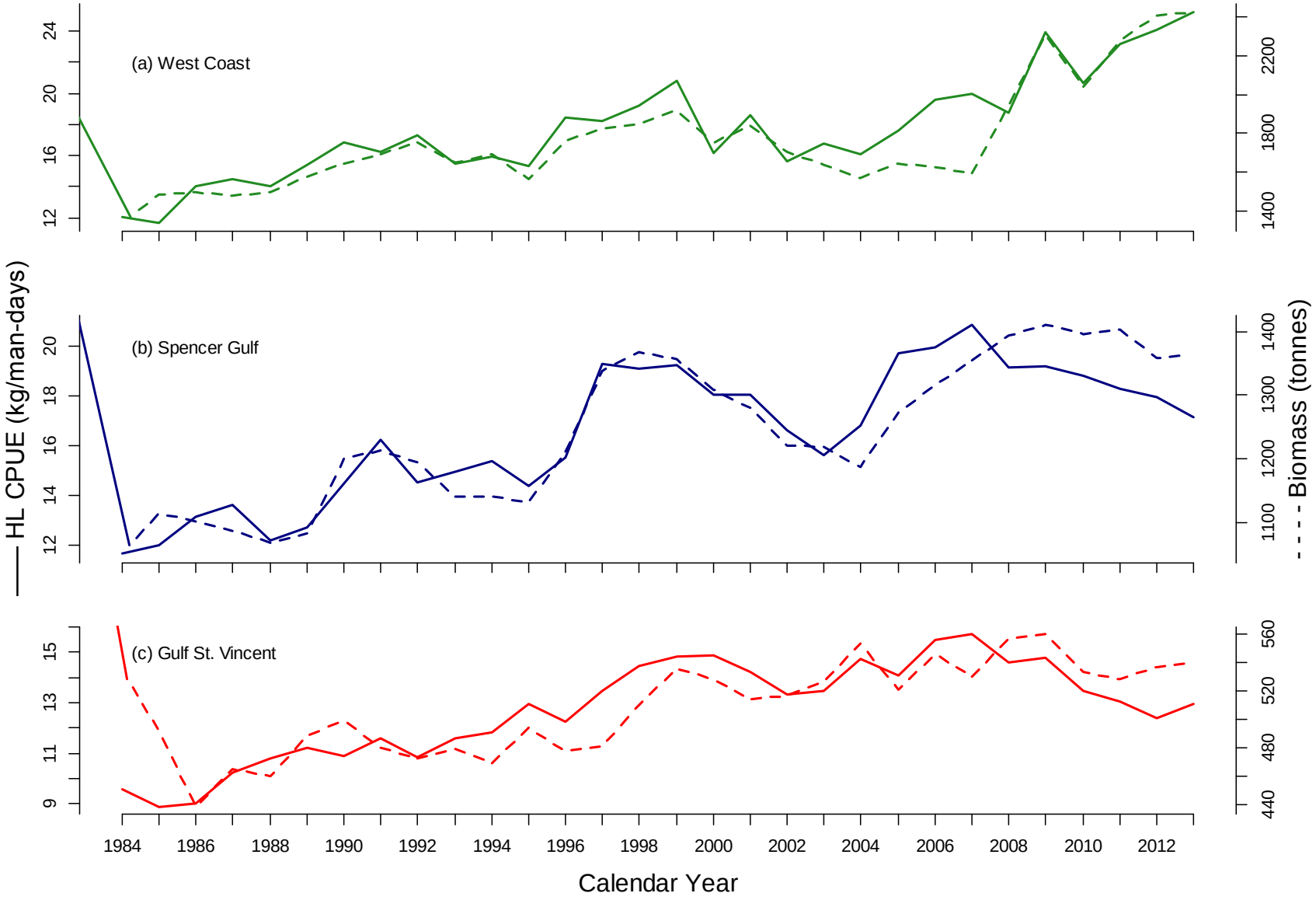

Fig. 9.3. Yearly comparison of model-estimated legal-size biomass (dashed line) with the principal indicator of commercial catch rate (targeted handline) for the three principal King George whiting regions.

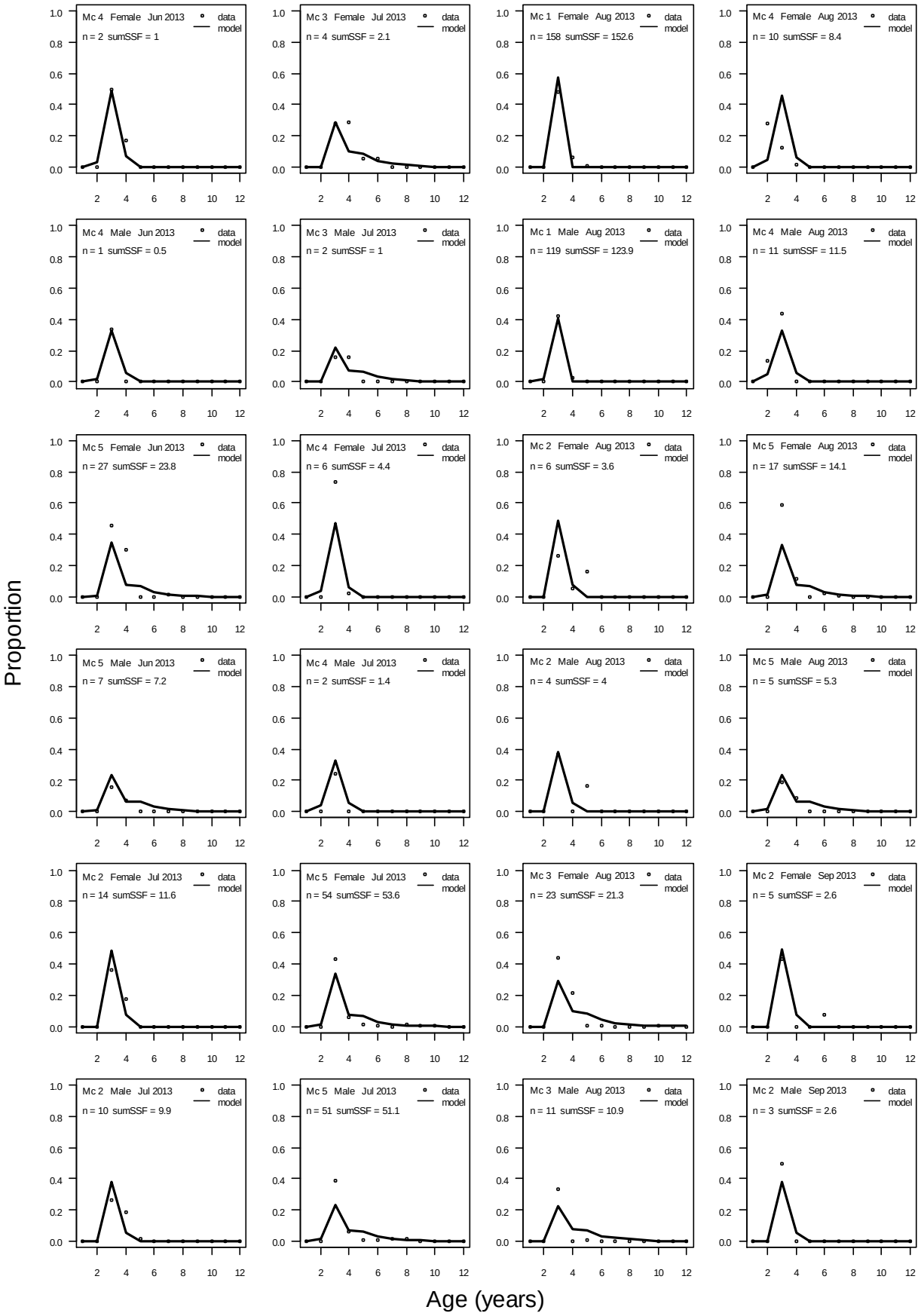

Fig. 9.4. Model fits to age proportions from catch samples. Of 591 age proportion data sets, by month, sex, and spatial cell since the mid 1990's, here the 24 most recent data sets are shown.

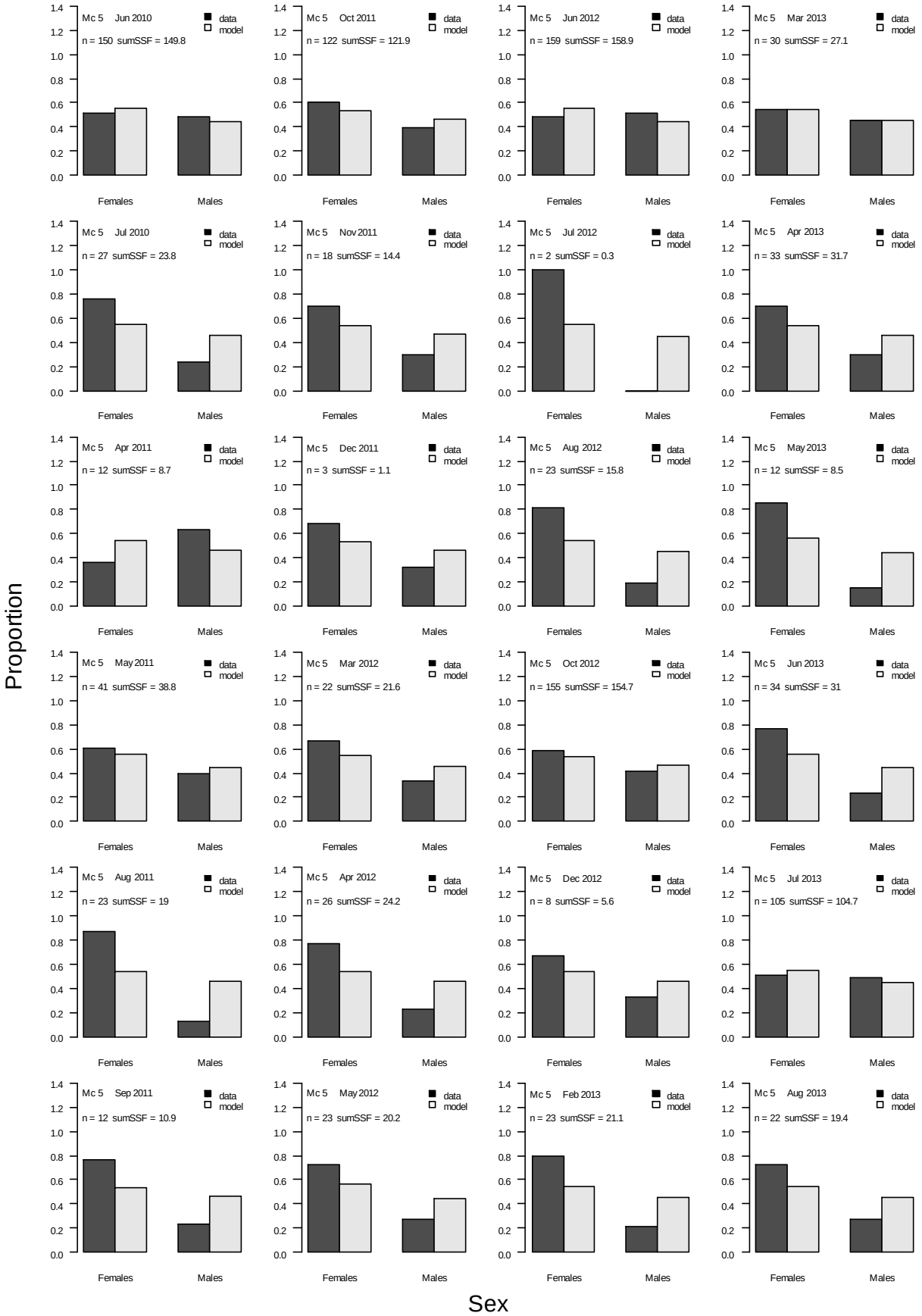

Fig. 9.5. Model fits to sex ratios from SAFCOL market samples. Of 305 sex proportion data sets, by month and spatial cell since the mid 1990's, here the 24 most recent are shown.

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EXECUTIVE SUMMARY

STOCK	Northern Spencer Gulf	Northern Gulf St. Vincent	Southern Spencer Gulf	Southern Gulf St. Vincent	West Coast	South East
Status	↑ Transitional - Recovering	Overfished	Sustainable	Sustainable	Undefined	Undefined
Indicators	Harvest Fraction Biomass Egg Production Recruitment Age Structure *Biomass (20%)*	Harvest Fraction Biomass Egg Production Recruitment Age Structure *Biomass (20%)*	Trends in Catch & Effort	Trends in Catch & Effort	Limited Data	Limited Data

Stock assessments for the South Australian Southern Garfish Fishery have been produced since 1997; this is the sixth report in that 18-year period. The current status of South Australia's Garfish resource was determined through the analysis of several long-term monitoring programs, including: the commercial catch and effort data from 1984 to 2014; recreational fisheries statistics obtained from three State-wide telephone/diary surveys carried out over the last 20 years; and data on the population size and age structures collected since 2005. Data from these three sources were integrated into the 'GarEst' fishery assessment model to produce a time series of estimated biological performance indicators. The current status of the stock was determined through the assessment of the fishery against the general and biological limit reference points outlined in the Management Plan for the Marine Scalefish Fishery (PIRSA 2013).

Assessment of South Australia's Garfish fishery relies heavily on data obtained from the hauling net sector which accounts for approximately 90% of the State-wide commercial catch. Similarly, the assessment places considerable emphasis on catch and effort trends in the northern gulfs where most commercial hauling net fishing is undertaken.

Historically, Northern Spencer Gulf (NSG) has been the most productive region in South Australia and in 2014 contributed 55% of the State-wide catch. The assessment shows that long-term management changes have resulted in a reduction in the exploitation rate below the operational target of 60%; sustained increases in egg production and fishable biomass; and improved recruitment. Management measures (i.e. further increases in mesh size and legal minimum length (LML)) are also in place to promote stock recovery. On this basis the current status of the NSG Garfish stock is classified as **transitional-recovering**.

Northern Gulf St. Vincent (NGSV) accounted for 35% of the State-wide catch in 2014. The assessment shows that the management regime that has been established in NGSV appears to have been insufficient to recover the stock as evidenced by negative breaches in fishable biomass

and recruitment against the trigger reference points (TRPs); persisting low rates of egg production; relatively high exploitation rates coupled with increased effort and declining catch rates. On this basis the NGSV Garfish stock is classified as recruitment **overfished**.

The spatial resolution of the current 'GarEst' fishery assessment model is too broad to assess the key biological performance indicators for Southern Spencer Gulf (SSG) and Southern Gulf St. Vincent (SGSV). However, their relatively low levels of fishing activity and commercial catch, extensive netting closures and a population structure that includes relative old (3+) Garfish, suggests that these stocks are unlikely to be over-exploited. Consequently, these stocks are classified as **sustainable**.

Negligible amounts of Garfish were landed by the commercial sector in the South East (SE) and West Coast (WC), with the State-wide contribution of these regions rarely exceeding 0.3%. Consequently, there is insufficient information available to confidently classify the status of these stocks. On this basis these stock are classified as **undefined**.

The dynamic management approach established to rebuild Garfish stocks and ensure their long-term sustainable harvest appears to be succeeding in NSG but not in NGSV. The amount of fishable area for commercial net fishers is markedly different between the two regions, and may explain the divergence in their relative performance.

The current assessment of South Australia's Garfish Fishery is based entirely on fishery-dependent data collected from spatially limited areas. There remains considerable uncertainty about the relative abundances and population size and age structures in the 'unfished', off-shore and southern waters of the gulfs. This is because there is limited fishery-based information, from the commercial and recreational sectors, that can be used to inform assessment of their relative status. Furthermore, the population connectivity between adjacent unfished and fished areas in the two gulfs is unknown. Consequently, it is not clear whether the commercial fishery data used in this assessment accurately reflects the status of the broader resource. A new jointly funded (FRDC, PIRSA and industry) Garfish project began in 2015/16 to resolve this uncertainty.

1. INTRODUCTION

1.1. Overview

Stock assessments for the South Australian Southern Garfish (*Hyporhamphus melanochir*, hereafter referred to as Garfish) Fishery have been produced triennially since 1997 (McGlennon and Ye 1999); this is the sixth report in that 18-year period. These reports have two aims: (1) to present information from the fishery and biology of the species; and (2) to provide a current assessment of the status of the Garfish stocks. The last stock assessment was completed in October 2012 (Steer et al. 2012) and reported data up to June 2011. Unlike previous reports, which assessed the stocks over financial years, this report analyses catch and effort and biological data over calendar years, extending the assessment up to the end of December 2014.

1.2. Description of the fishery

1.2.1. Access

Garfish is a significant inshore fishery species of southern Australia, with fisheries in Victoria, Tasmania, South Australia and Western Australia. Historically, the national commercial catch for this species has been dominated by that from South Australia where the catch has usually exceeded 400 t per annum, with an approximate value of $1.8 million (Econsearch 2014). This species is also a popular target amongst South Australian recreational anglers (Jones 2009).

In South Australia, licence holders from four different commercial fisheries have access to Garfish within their respective fishery areas. These are the Marine Scalefish Fishery, Northern Zone Rock Lobster Fishery, Southern Zone Rock Lobster Fishery, and Lakes and Coorong Fishery. The Garfish fishery is principally located in Spencer Gulf and Gulf St. Vincent (Figure 1.1) and managed as part of the multi-species, multi-gear Marine Scalefish Fishery (MSF) through a series of input and output controls. Commercial fishers typically target Garfish using hauling nets and dab nets. Hauling net fishers account for the majority (~90%) of the commercial catch even though their fishing activities are restricted by regulation to waters <5 m deep. Recreational fishers are permitted to use dab nets but predominantly use traditional hook and line as they fish from boats and shore-based platforms throughout the State.

1.2.2. Management arrangements

The MSF is managed by the South Australian State Government's Primary Industries and Regions South Australia (PIRSA) Fisheries and Aquaculture in accordance with the legislative framework provided within the *Fisheries Management Act 2007, Fisheries Management (General)*

Regulations 2007, Fisheries Management (Marine Scalefish Fisheries) Regulations and licence conditions.

The commercial MSF has undergone considerable management changes over the past 40 years that has seen the fishery restructured and limited through gear restrictions and configuration, licensing, spatial and temporal closures, and size limits. Although most of these management changes have been generic in nature there have been a few that have largely impacted the Garfish fishery. The most notable of these have been a series of net fishing spatial closures. Areas closed to netting were first implemented on the West Coast in 1958 and were subsequently followed by a depth-delimited ban in the early 1970s when net fishers were restricted to operate in coastal waters <5 m deep. Further netting closures were implemented in 1983, 1994, 1995, 1997 and 2005. In addition, deep water netting exemptions for a few commercial operators were revoked in 2006. These closures have significantly restricted the commercial Garfish hauling net fishers to relatively small areas within the northern gulfs. Currently, it is estimated that net fishers in Northern Gulf St. Vincent have access to 465 km^2 of fishable area, which is approximately 55% less than the 1,028 km^2 available in Northern Spencer Gulf (Table 1.1; Figure 1.1).

In 2001, the legal minimum length (LML) for Garfish was increased from 210 mm to 230 mm total length (TL). This increase was made to ensure that at least 50% of Garfish at that size would be reproductively mature (Ye et al. 2002). Despite this increase, no corresponding changes to the mesh size regulations for hauling nets were implemented. Reductions in the recreational bag and boat limits were also implemented in 2001.

In May/June 2005, the State Government implemented a voluntary net buy-back scheme that aimed to reduce fishing effort amongst the commercial haul netters with a particular emphasis on those that harvest Garfish. Of the 113 MSF hauling net licence holders, 61 (54%) accepted the offer and their endorsements or licences were surrendered. The licences bought back accounted for approximately 45% of commercial hauling net fishing effort during 2000 to 2003.

More recently, specific harvest strategies for each of the primary Marine Scalefish species were developed as part of a new Management Plan for the South Australian Commercial Marine Scalefish Fishery which was released in October 2013 (PIRSA 2013). The principal aim of the Garfish harvest strategy was to ensure the long-term sustainable harvest of Garfish. Although no specific management arrangements were prescribed in the Management Plan to achieve these targets, a range of tools were identified and an adaptive management approach outlined to consider the management arrangements needed to meet the targets over time. These included gear modifications, spatial and temporal closures, and effort/catch management (PIRSA 2013).

Through collaborative research and consultation amongst PIRSA, SARDI and the commercial fishing industry it was agreed that a combination of effort and gear-based management strategies should be adopted to reach the operational targets. Furthermore, it was agreed that these strategies should be dynamic and altered in response to the status of the fishery. Initially, two 20-day seasonal closures that alternated between the gulfs were implemented in 2012. The duration of these closures were subsequently increased to 38 days in 2013 and 40 days in 2014. Similarly, the minimum regulated mesh size of the pocket component of the hauling nets was sequentially increased from 30 mm to 32 mm in 2013 and to 35 mm in 2015. Furthermore, the LML of Garfish for commercial fishers was increased from 230 mm to 250 mm in 2015, with a further increase to 260 mm planned to commence from 1 April 2016.

1.2.3. Marine parks

In alignment with international and national commitments, the South Australian Government introduced 19 multiple-use marine parks on 1 October 2014. This network covers a total area of 27,526 km^2, encapsulating approximately 46% of South Australia's waters (DEH 2009). The overarching aim of these parks is to protect and conserve marine biological diversity. The marine park network includes four levels of protection. They are: general and managed use zones, habitat protection zones, sanctuary zones and restricted zones. Of these the sanctuary and restricted zones are the most relevant to fisheries as they are areas of high conservation status and prohibit any forms of fishing within their boundaries. These zones account for approximately 6% of the State's waters (Figure 1.1). Twelve MSF licences were surrendered as part of the implementation process.

Table 1.1. Availability of area (km^2) to commercial hauling net fishers in South Australia in 2015.

Region	< 5m	Netting Closures	Sanctuary Zones	Restricted Access Zones	Available	%
Northern Spencer Gulf	1,501.3	440.7	32.2	0.0	1,028.4	68.5
Northern Gulf St. Vincent	736.6	134.5	50.9	85.8	465.4	63.2
South East	287.5	5.2	11.7	0.0	270.5	94.1
Southern Spencer Gulf	980.5	916.2	2.8	0.0	61.5	6.3
Southern Gulf St. Vincent	313.9	250.3	6.1	0.0	57.4	18.3
West Coast	1,211.8	1,117.6	12.0	26.7	55.5	4.6

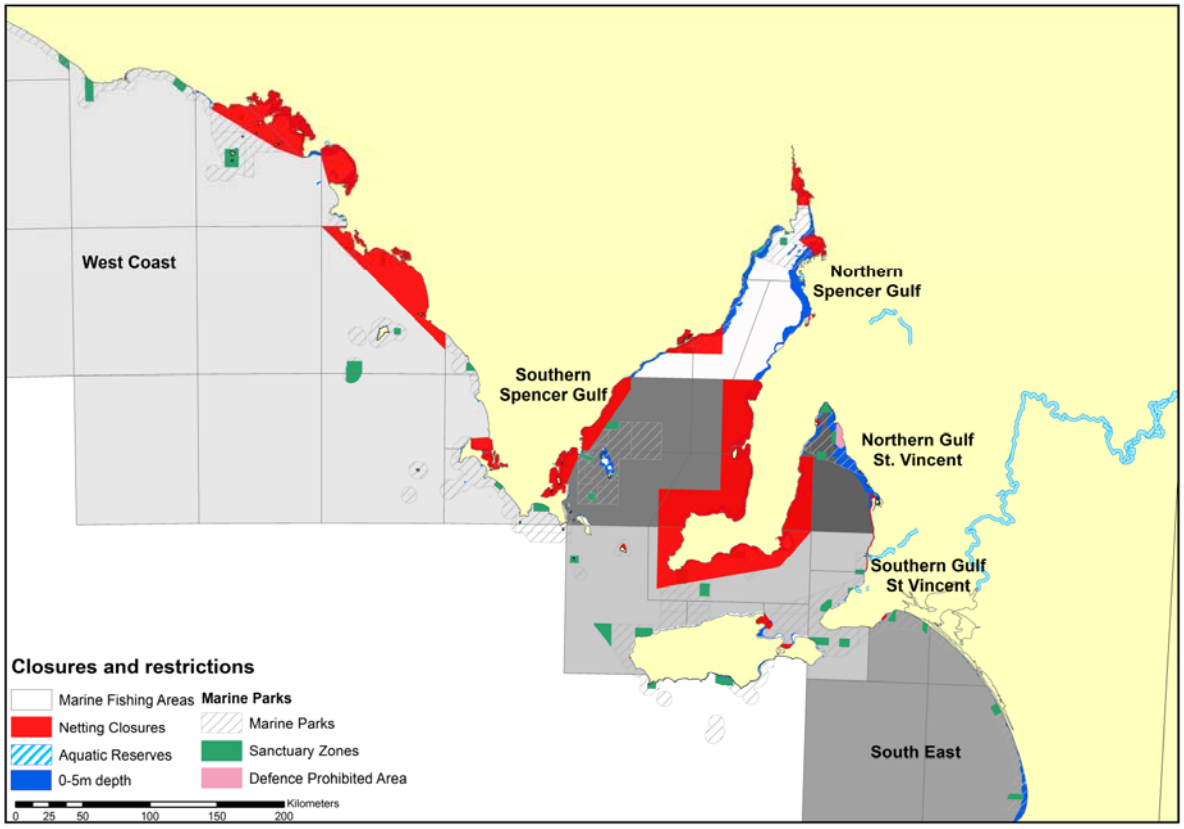

Figure 1.1. Map of the netting closures and restrictions relevant to South Australia's MSF hauling net sector. Note: the dark blue (0-5m depth) areas indicate where commercial haul netters are permitted to operate.

1.3. Biology of Southern Garfish

1.3.1. Distribution

The geographic distribution of Garfish extends from Shark Bay in Western Australia, along the southern coast of mainland Australia and up the east coast to Eden in southern New South Wales, as well as the surrounding waters of Tasmania (Kailola 1993, Noell and Ye 2008). Throughout its distribution this schooling species occurs in sheltered bays and shallow, inshore, marine waters to depths of approximately 20 m. They are particularly abundant throughout the gulf regions of South Australia.

1.3.2. Reproductive biology

Spatial and temporal analysis of gonadosomatic indices indicated that Garfish have an extended spawning season that spans approximately six months (from October to March) and within this season only a small proportion (10 – 20%) of the population are in spawning condition at any given time (Giannoni 2013). This indicates that reproductive activity within the population is asynchronous, consequently the extended spawning season is sustained by a series of small pockets of spawning activity.

The estimated size at maturity ($L_{50\%}$) for female Garfish in South Australia is 215 mm TL, which is equivalent to the mean age of 17.5 months (Ye et al. 2002). This is smaller in comparison to Victorian and West Australian Garfish.

1.3.3. Early life history

There have been several attempts to find Garfish eggs in the field (Ling 1958, Noell 2003). In northern Gulf St. Vincent (GSV), samples of a variety of seagrass species, including *Zostera muelleri, Posidonia sinuosa, P. angustifolia, Amphibolis antarctica* and *Heterozostera tasmanica* were collected and examined for adhering Garfish eggs. However, no eggs were found. Garfish eggs have, however, been consistently sampled using a beam trawl in Great Oyster Bay, Tasmania (Jordan et al. 1998).

1.3.4. Age structure

Natural demographic processes such as growth, recruitment and mortality govern the relative strength and age composition of fish populations. For an unexploited species, losses due to mortality are generally balanced by gains through recruitment, and stock abundance would typically fluctuate around a mean level (King 1995). For highly exploited species, the composition of the population may become unbalanced, as the harvesting of adult fish may be at a level where

reproduction and recruitment are unable to replace the numbers lost. Fishers generally harvest the larger and older fish from a population (or stock) and it is a challenge for fishery managers and scientists to ensure that the quantity of the harvest does not reach a level that compromises the sustainability of the stock. Reduced biomass and truncation in the size and age structures of a population are indications that the fishery has been over-exploited. Consequently, understanding the life history of a species and tracking population demography trends in terms of size and age data are fundamental components of fishery assessment.

During the 1990s, a total of 2,079 Garfish were sampled from commercial catches in South Australia and successfully aged for a study on age and growth (Ye et al. 2002). There were seven age classes that contributed to the commercial catches (0+ to 6+), however, the catches were dominated (89%) by one- and two-year-old fish. Less than 2% were from 4+ to 6+ age classes. A more recent study which compared the size and age structures of the fishery with that of the 1950s indicated that historically the fishery was once dominated by 4+ and 5+ Garfish, but over numerous years of exploitation the fishery has become considerably truncated to consist of primarily one- and two-year-old Garfish (Fowler and Ling 2010).

1.3.5. Stock structure

In 2009, a study adopted a combined approach to delineate potential Garfish sub-populations, and determine the extent of mixing within South Australia's coastal waters, through the integration of multiple otolith-based techniques (Steer et al. 2009a). Spatial differences in otolith chemistry (trace elements and stable isotopes) and morphometrics indicated that there were several groups of Garfish that had spent significant parts of their lives in different environments and that there was some level of restriction that prevented complete mixing among the regions (Steer et al. 2009b, 2010; Steer and Fowler 2015). At least five regional divisions were identified. Three of these were clearly defined as they exhibited negligible levels of inter-regional mixing: West Coast; Northern Spencer Gulf; and South-Western Spencer Gulf. The remaining two, however, were less distinct: Northern Gulf St. Vincent and Southern Gulf St. Vincent, but demonstrated a level of population structuring that would regard them as separate as a precautionary management measure. A concurrent study examining the spatial variation in parasite abundance in Garfish inferred a similar population structure (Hutson et al. 2011). This level of population structuring was sufficient to suggest that the historical management framework of two discrete, gulf-specific, stocks should be restructured to align with these five smaller, semi-discrete, regional units.

1.4. Research program

SARDI maintains an on going catch sampling program for three of the four primary marine scalefish species (i.e. Snapper, King George Whiting and Garfish). This program largely relies on routinely collecting biological samples from the South Australian Fishermen's Co-operative Limited (SAFCOL) fish market, however, samples are also collected opportunistically either from the recreational sector or fishery-independent research programs. There have been numerous projects that have focused on addressing key knowledge gaps in our understanding of Garfish biology and ecology over the years. They have covered aspects of Garfish population dynamics (Jones 1990; Ye et al. 2002; Fowler et al. 2008; Noell 2005; Earl 2007; Fowler and Ling 2010; Earl et al. 2011; Giannoni 2013); stock structure (Steer et al. 2009a; Hutson et al. 2011); gear selectivity (Steer et al. 2011) and fisheries modeling (McGarvey and Feenstra 2004; McGarvey et al. 2007). Current research, funded through the Fisheries Research and Development Corporation (FRDC), Primary Industries and Regions, South Australia (PIRSA) and industry, is investigating whether the commercial fishery data used in the stock assessment process accurately reflects stock status in South Australia's Garfish fisheries (FRDC Project 2015/018).

1.5. Information sources used for assessment

1.5.1. Commercial catch and effort data

The South Australian Marine Scalefish Fishery (MSF) is divided into 58 Marine Fishing Areas (MFAs) for the purpose of statistical reporting and monitoring of commercial fishing activity (Figure 1.1). All licenced fishers are required to log their fishing activities, recording specific details such as 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 satisfy management and research needs. The current database is a compilation of catch and effort data collected from 1983/84 to the present and provides the primary source of data used for stock assessment of the primary MSF species. The data used in this assessment were finalised up to 31 December, thus providing a 30 calendar-year dataset.

1.5.2. Recreational catch and effort data

Quantifying the recreational sector's contribution to the State's total catch is important in determining the overall status of fish stocks and resolving resource allocation issues. There have

been four extensive recreational fishing surveys carried out in South Australia over the past 20 years. The first was a creel survey that was undertaken throughout 1994 to 1996 (McGlennon and Kinloch 1997) and State-wide telephone/diary surveys in 2000/01 (Henry and Lyle 2003), 2007/08 (Jones 2009) and 2013/14 (Giri and Hall 2015). Of these four surveys, only the results from the three most recent can be reliably compared as these data were collected using the same methodology.

1.5.3. Size and age data

SARDI has relied heavily on the SAFCOL market to access the commercial catch and gain valuable biological information that is used to determine the population structure for South Australia's primary marine scalefish species. There have been several market sampling programs for Garfish throughout the history of the fishery that have provided demographic data. Size and age data have been previously collected for Garfish in 1954/55 for both GSV and Spencer Gulf (SG) (Ling 1958); 1977/78 for SG (Jones 1979); 1986/87 for GSV (Jones et al. 1990); and 1998/99 for both gulfs (Ye et al. 2002). In 2005/06, SARDI initiated a new market-measuring program as part of the core research activities of the MSF (McGarvey et al. 2006). With the exception of a six month hiatus from July to December 2008 and again in 2012, SARDI's market sampling program for Garfish has occurred almost weekly since July 2005 and has primarily targeted samples from the northern gulfs (i.e. NGSV and NSG).

1.5.4. 'GarEst' stock assessment model

A computer-based fishery stock assessment model, 'GarEst', was developed for the South Australian Garfish fishery as part of an FRDC-funded project (McGarvey and Feenstra 2004). This model covers the fisheries in the two South Australian gulfs, which have accounted for 96% of the State-wide Garfish catch over the past five years. The GarEst model accounts for fish numbers broken down into length bins within each age group, through time. Representing fish population numbers by both age and length through time considerably improves the accuracy of the model, as it accounts for the ongoing gradual recruitment of Garfish into the fishery and so more accurately estimates their growth and mortality rates (McGarvey et al. 2007). This dynamic, age- and length-structured model is used to assess the performance of the fishery in terms of its total fishable (legal) biomass, egg production, estimated recruitment and harvest fraction (i.e. exploitation rate). These four outputs are assessed against the biological performance indicators and trigger reference points that are identified in the Management Plan (PIRSA 2013; Table 1.2) to ensure the long-term sustainable harvest of Garfish.

1.6. Harvest strategy

1.6.1. Management plan

A new Management Plan for the South Australian Commercial Marine Scalefish Fishery was released in October 2013 with a scheduled revision in 2022 (PIRSA 2013). A draft harvest strategy was developed in 2011 by the Garfish Working Group (GWG), which consists of representatives from industry, PIRSA and SARDI and implemented prior to the approval of the Management Plan in 2013. The Plan includes specific harvest strategies for the four primary species (Snapper, King George Whiting, Southern Garfish and Calamary). The aim of these harvest strategies is to set a process for monitoring the performance of the species and to measure the effectiveness of the management arrangements which govern the commercial harvest. Species-specific performance indicators, operational objectives and reference points have been developed to assess the respective fisheries and ensure their long-term sustainable harvest.

Two key objectives for managing the harvest of Garfish within the commercial MSF will be considered in this assessment, they are: (1) ensure the long-term sustainable harvest of Garfish by rebuilding stocks during specified time frames; and (2) maintain catches within agreed allocations for each sector.

1.6.2. Performance indicators

Three tiers of indicators have been established to monitor the performance of the fishery over time and address the first management objective. Each performance indicator explicitly identifies a set of operational targets and trigger reference points that, if breached, elicits a management response. The nature of this response will be determined by fisheries management. Trends in model estimates of 'harvest fraction' and 'egg production' constitute the primary performance indicators within the Garfish fishery, with their operational objectives set to reach $\leq$30% and $\geq$30% by 2020, respectively (Table 1.2). The secondary performance indicators relate to rebuilding Garfish stocks through improving the overall age structure of the population and reducing effort within the fishery. The specific operational objectives are to display an increasing trend in the relative proportion of older (ages 3+) Garfish within the population through each triennial stock assessment cycle and to reduce total hauling net effort by $\geq$13% by 2014 (Table 1.2). There are also a range of other performance indicators and trigger reference points relating to trends in commercial catch and effort statistics and biological metrics (Table 1.2). Although there is no formal management response linked to these indicators, they provide triggers for the development

of further management actions to meet the objectives of the harvest strategy. In addition, the indicators provide measures for assessing the stock rebuilding strategy that can be relied on to measure the relative performance of the fishery through a 'weight-of-evidence' approach (PIRSA 2013).

Table 1.2. Performance indicators used to monitor the performance of South Australia's Garfish fishery as prescribed in the MSF Management Plan (PIRSA 2013). Biological (B) and General (G) indicators are identified.

	PERFORMANCE INDICATOR	TYPE	OPERATIONAL OBJECTIVE	TRIGGER REFERENCE POINT
PRIMARY	HARVEST FRACTION	B	≤ 60% 2014	> 60% 2014
		B	≤ 45% 2017	> 45% 2017
		B	≤ 30% 2020	> 30% 2020
	EGG PRODUCTION	B	25% 2017	< 20% 2017
		B	30% 2020	< 30% 2020
SECOND.	AGE COMPOSITION	B	↑ Prop. Age 3+	No change
	TOTAL HAULING NET EFFORT	G	↓ ≥ 13% 2014	↓ < 10% 2014
OTHER	TOTAL CATCH	G	No Target	3rd Lowest / 3rd Highest
		G	No Target	Greatest % interannual change (+/-)
		G	No Target	Greatest 5 year trend
		G	No Target	Decrease over 5 consecutive years
	TARGET HAULING NET CPUE	G	No Target	3rd Lowest / 3rd Highest
		G	No Target	Greatest % interannual change (+/-)
		G	No Target	Greatest 5 year trend
		G	No Target	Decrease over 5 consecutive years
	TARGET DAB NET CPUE	G	No Target	3rd Lowest / 3rd Highest
		G	No Target	Greatest % interannual change (+/-)
		G	No Target	Greatest 5 year trend
		G	No Target	Decrease over 5 consecutive years
	FISHABLE BIOMASS	B	No Target	3 year average is +/- 10% of previous years
	RECRUITMENT	B	No Target	+/- 10% than the average of previous 5 years

1.6.3. Allocation of access

The *Fisheries Management Act 2007* states that the Management Plan must specify the allocation of the resource among the various sectors within the MSF. Allocated shares were derived from the catch data collected in 2007/08, as this year also contained the most recent recreational survey catch information (Jones 2009). Three trigger limits have been determined for the primary species. The first trigger limit (Trigger 1) relates to the allocated shares of the entire fishery and is assessed at least once every five years to encompass up-dated recreational catch and effort statistics (Table 1.3). The remaining two trigger limits (Trigger 1 and 2) consider the commercial shares only and can be assessed on an annual basis. The trigger limits have been set at levels that are commensurate with the initial allocation and allows for variability in catches. Trigger 2 relates to exceeding the commercial sector allocation by the relevant percentage in three consecutive years or in four of the previous five years. Trigger 3 relates to exceeding the commercial sector allocation by the relevant percentage in any one year. The recreational fishery triggers will be described in the Management Plan for the Recreational Fishery, which is currently being drafted.

Table 1.3. Commercial allocation of Garfish among the sectors as prescribed in the MSF Management Plan (PIRSA 2013).

FISHERY ALLOCATION	**MSF**	**SZRL**	**NZRLF**	**REC.**	**CHARTER**	**ABT**
	79.30%	**0.13%**	**0.04%**	**19.50%**	**-**	**1.00%**
TRIGGER 1	*84.00%*	*1.00%*	*1.00%*	-	-	-
COMMERCIAL ALLOCATION	**MSF**	**SZRL**	**NZRLF**	**REC.**	**CHARTER**	**ABT**
	99.79%	**0.16%**	**0.05%**	**n/a**	**n/a**	**n/a**
TRIGGER 2	*na*	*0.75%*	*0.75%*	-	-	-
TRIGGER 3	*na*	*1.00%*	*1.00%*	-	-	-

1.7. Stock status classification

A national stock status classification system was recently developed for the consistent assessment of key Australian fish stocks (Flood et al. 2014). It considers whether the current level of fishing pressure is adequately controlled to ensure that the stock abundance is not reduced to a point where the production of juveniles is significantly compromised. The system combines information on both the current stock size and level of exploitation into a single classification for each stock against defined biological reference points. Each stock is then

classified as either: 'sustainable', 'transitional-recovering', 'transitional-depleting', 'overfished', 'environmentally limited', or 'undefined' (Table 1.4). PIRSA has adopted this classification system to determine the status of all South Australian fish stocks (PIRSA 2015). This classification system was not referred to in previous stock assessments for Garfish.

Table 1.4 Stock status terminology (Flood et al. 2014).

	Stock status	Description	Potential implications for management of the stock
	Sustainable	Stock for which biomass (or biomass proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (i.e. not recruitment overfished) and for which fishing pressure is adequately controlled to avoid the stock becoming recruitment overfished	Appropriate management is in place
↑	Transitional–recovering	Recovering stock—biomass is recruitment overfished, but management measures are in place to promote stock recovery, and recovery is occurring	Appropriate management is in place, and the stock biomass is recovering
↓	Transitional–depleting	Deteriorating stock—biomass is not yet recruitment overfished, but fishing pressure is too high and moving the stock in the direction of becoming recruitment overfished	Management is needed to reduce fishing pressure and ensure that the biomass does not deplete to an overfished state
	Overfished	Spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced (i.e. recruitment overfished). Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements	Management is needed to recover this stock; if adequate management measures are already in place, more time may be required for them to take effect
	Environmentally limited	Spawning stock biomass has been reduced to the point where average recruitment levels are significantly reduced, primarily as a result of substantial environmental changes/impacts, or disease outbreaks (i.e. the stock is not recruitment overfished). Fisheries management has responded appropriately to the environmental change in productivity	Appropriate management is in place
	Undefined	Not enough information exists to determine stock status	Data required to assess stock status are needed

2. METHODS

2.1. Commercial catch and effort statistics

For this stock assessment the catch and effort data were aggregated across commercial fishers to provide annual totals (calendar year) and catch per unit of fishing effort (CPUE) at the State and stock level. State waters were partitioned into six regions; West Coast, Northern and Southern SG, Northern and Southern GSV and the South East (Figure 1.1). These data were also interrogated across the two main gear types; hauling nets and dab nets.

Fishing effort was reported in fisherdays, which relates to the number of days a licenced vessel fished multiplied by the number of personnel working on board. There are two components to fishing effort, targeted and untargeted. Targeted effort in this fishery is a more accurate indicator of fisher behaviour than total fishing effort. It is also the metric that is used, along with targeted catch, to calculate CPUE, which provides an index of the relative abundance of Garfish. Determining target effort in the hauling net sector, however, is problematic as fishers can catch multiple commercial species in a single fishing event and are sometimes non-specific in their target species. Although one species may dominate their catch, these fishers typically nominate "any species" (or record "000") as their fishing target in their catch returns. The effort category of the non-specific hauling net fishers was then determined on the basis of what they caught. This was calculated in relation to the contribution of Garfish by weight to the total catch in comparison to fishers who either targeted Garfish or other species. If Garfish constituted more than half (≥50%) of the non-specific fishers' total daily catch, then these records were re-defined as targeting Garfish ("Hauling Net Target Plus"). Although not as prevalent, there were situations where Dab net fishers were non-specific with their catch. For consistency, they were also re-defined as "Dab Net Target Plus" according to the ≥50% catch composition rule. These refined effort categories were included in all subsequent regional analysis of the commercial catch and effort statistics in this chapter, and could only be calculated from 2004 onwards as this was when fishers began reporting their daily fishing activities.

2.2. Recreational catch and effort statistics

The specific details of the methodology used in the three recreational surveys considered in this chapter can be found in their respective reports (2000/01: Henry and Lyle 2003, 2007/08: Jones 2009, 2013/14: Giri and Hall 2015). Unfortunately, not all of the regional reporting boundaries that were used in the surveys aligned with South Australia's MFAs. For consistency the recreational survey data were re-partitioned to correspond as closely as possible to the two gulfs

(SG and GSV), the West Coast and South East regions. The 2000/01 survey data have also been re-analysed using more precise expansion weights (used to scale-up the regional estimates in proportion to the local population) and, as a consequence, the results differ slightly from previous reports.

Although data were collected over 12 months in each survey, their timing did not correspond with either a calendar or financial year. The 2000/01 survey collected data from May 2000 to April 2001 and the 2007/08 and 2013/14 surveys from November to October. In order to accurately determine the relative contribution of the recreational sector to the State-wide Garfish catch, data from the commercial sector were extracted from the same time periods.

2.3. Biological sampling

Each week a small team of SARDI researchers accessed the commercial catch of Garfish at the SAFCOL market prior to the morning auction. Efforts were made to access the available catches from the northern regions of both gulfs to ensure that the information collected was representative of the fishery. Occasionally, samples from the southern gulfs were also obtained; however, these sample sizes were typically much lower than for the other two regions.

The sampling methodology followed the protocol developed by Ye et al. (2002). All Garfish purchased from the SAFCOL market were measured for both TL and standard length (SL) to the nearest mm, and weighed individually to the nearest 0.01 g. Each Garfish was dissected to determine its sex and stage of reproductive development using the criteria of Ling (1958). The largest pair of otoliths (i.e. sagittae) were removed and subsequently used for age determination, as per the methods described in Ye et al (2002).

2.4. Integrated stock assessment model

The principal input data for the GarEst model are (1) commercial catch and effort statistics; (2) population demographic information (i.e. sex, age and length composition) derived from the Garfish market sampling program; and (3) estimated recreational catch from the National Recreational and Indigenous Fishing Survey (NRFIS) (Henry and Lyle 2003) and South Australian Recreational Fishing Surveys (Jones 2009, Giri and Hall 2015). The model partitions the time-series of data into 'biological' years to align with the recruitment schedule of Garfish, extending from 1 October 1984 to 30 September 2014. The time-series is further resolved into half-yearly (6 monthly) time steps to account for the seasonal variation in the fishery.

Given the multi-gear and multi-sectorial nature of the fishery, the model partitions the catch and effort into four categories; (1) hauling net fishers who target Garfish; (2) hauling net fishers who

catch (non-target) Garfish; (3) dab net fishers; and (4) recreational fishers. Catch rates (CPUE) for the 'hauling net fishers who target Garfish' category incorporates the refined effort type "Target Plus" from October 2005 onwards, to reflect the changes in the reporting structure, when commercial fishers refined the resolution of their catch returns from monthly to daily (see section 2.1).

Three surveys of South Australia's recreational fishery (2000/01 - Henry and Lyle 2003; 2007/08 - Jones 2009; 2013/14 – Giri and Hall 2015) were used to model the contribution of this sector to the Garfish catches. Estimates of recreational catch in the intervening years between the three surveys were assumed to vary linearly between the estimates of 2000/01 and 20013/14. For all preceding years, estimates of recreational catch and effort were assumed to be constant at the 2000/01 level.

The model estimates four biological performance indicators; fishable biomass, egg production, recruitment and harvest fraction (i.e. exploitation rate). Fishable biomasses and harvest fractions are given as yearly averages. Annual fishable biomass is computed as the mean of the half-yearly estimates in each 'biological' year. The harvest fraction is the proportion of the fishable biomass harvested by the fishery. The annual harvest fraction is calculated as the sum of the model catch in weight of the fishery in each 'biological' year divided by the annual fishable biomass. Annual recruitment is defined as the number of Garfish spawned in each summer year class that survive to age 1. In the recruitment time-series figures, the year shown on the x-axis represents the year the cohort was spawned.

Percent virgin egg production was computed as a ratio of yearly egg production divided by a measure of average 'virgin' egg production that the fishery would produce in the absence of exploitation. Virgin egg production was computed from a run of GarEst with *F* (and so all fishing effort) set equal to 0 as the average egg production over the years from 2000 to 2011. For this run of the virgin population, recruitment was fixed at the average from the years 1988 to 2000, prior to the longer-term recruitment decline that occurred around 2001.

Further details of the GarEst Garfish stock assessment model are provided in McGarvey and Feenstra (2004), McGarvey et al. (2007) and Appendix A, B and C. The biological performance indicators generated by the GarEst model are estimated by fitting to commercial catch totals by weight, recreational catch data by numbers in the three survey years, and to commercial catch proportions by sex, length and age. The respective fits of the model to these data sources are presented in Appendix E.

2.5. Assessment of fishery performance

Two types of performance indicators, general and biological, are used to assess the fishery as specified by the Management Plan (PIRSA 2013).

2.5.1. General Performance Indicators

For Garfish, there are four general fishery performance indicators that were calculated from the commercial fishery statistics; total hauling net effort, total commercial catch, targeted hauling net CPUE, and targeted dab net CPUE. With the exception of total hauling net effort, the general performance indicators were assessed against the following trigger reference points:

1. the 3rd highest and 3rd lowest values of the reference period (1984 to 2014);
2. the greatest (%) inter-annual variation (+ and -) over the reference period;
3. the greatest rate of change (+ and -) over a five year period; and
4. decrease over five consecutive years.

Given South Australia's Garfish fishery is spatially segregated by gear, i.e. hauling nets predominantly operate in the northern gulfs and dab nets in the southern gulfs, it was necessary to assess the general performance indicators in each of the four key regions (NSG, SSG, NGSV and SGSV). Estimates of targeted CPUE were calculated for hauling nets in NSG and NGSV and for dab nets in SSG and SGSV. In each case, the trigger reference points were derived from the time-series of catch and effort data from the 1984 to 2014 (calendar years) reference period. Note that the new 'Target Plus' haul net effort type which was available from 2003 onwards, could not be used in the assessment of the general performance indicators, as the time series of catch and effort data does not cover the entire reference period.

A specific operational objective in the Management Plan was to reduce total hauling net effort by ≥13% since 2011 (i.e. the development of the Draft Management Plan) to promote the recovery of the resource. This indicator was assessed against a trigger reference point of <10% reduction by 2014.

2.5.2. Biological Performance Indicators

The spatial and temporal series of data considered by the 'GarEst' model to derive the biological performance indicators differs slightly from the data series used to generate the general performance indicators. It partitions the time-series into 'biological' years, extending from 1 October to 30 September, to align with the recruitment schedule of Garfish. Furthermore, given the lack of data to inform the model about the population size and age composition of Garfish

from the southern gulf regions, the model decreases its spatial resolution to the Gulf level, i.e. SG and GSV.

In this assessment, the five biological performance indicators that were assessed were harvest fraction, egg production, fishable biomass, recruitment, and population age structure. Harvest fraction was compared against the trigger reference point of <60% by 2014%. The indicator for yearly egg production is expressed as a percentage of virgin egg production. The trigger reference point for this indicator, however, does not come into effect until 2017 when the operational target is set at 25%. The trigger reference point for the fishable biomass performance indicator is triggered if the average value over the last three years was a $\pm$ 10% change from the average of the previous years (1984 – 2013). The trigger reference point for recruitment (model estimates of 1-year olds for each cohort), is triggered if the indicator is $\pm$ 10% change from the average of the previous five years (2009 – 2013). The final biological indicator is an evaluation of whether there had been no change or a reduction in the modeled population age structure over the past stock assessment cycle (since 2011).

2.6. Quality assurance of data

Validation of the MSF commercial catch and effort data is extensive and includes manual cross-checking during the collation and processing phases and code-driven queries which are activated during the data entry phases and reporting operations (see Knight and Vainickis 2009). Furthermore, regular random checks of current and historic data are carried out as standard procedure. Extracted commercial catch and effort data were aggregated and graphed into their necessary spatial/temporal/gear/effort categories and cross-checked with previous assessments (McGarvey et al. 2009, Steer et al. 2012). The contributing authors held regular meetings to discuss data handling procedures and interpretation. Tabulated results were further cross-checked against the computer 'GarEst' output. The draft stock assessment report was reviewed by two SARDI scientists and a PIRSA manager prior to release.

The processing of Garfish otolith and subsequent age estimation typically occurred in large batches and there were often significant time periods between processing events. To ensure that the readers were interpreting the otolith structure consistently through time, each reader was reacquainted with garfish methodology and otolith characteristics before an ageing session by testing their interpretations against a random selection of Garfish otoliths from the reference collection.

3. RESULTS

3.1. State-wide

3.1.1. Distribution of catch among sectors

Commercial Marine Scalefish sector has historically dominated (>75%) the fishery (Figure 3.1). Although Rock Lobster licence holders are permitted to harvest Garfish in State waters their relative contribution is negligible, with Southern Zone and Northern Zone Rock Lobster fishers accounting for less than 1.3% and 0.5% of the total catch, respectively (Figure 3.1). Estimates of the recreational harvest have ranged from 18% in 2000/01 to 23% in 2013/14.

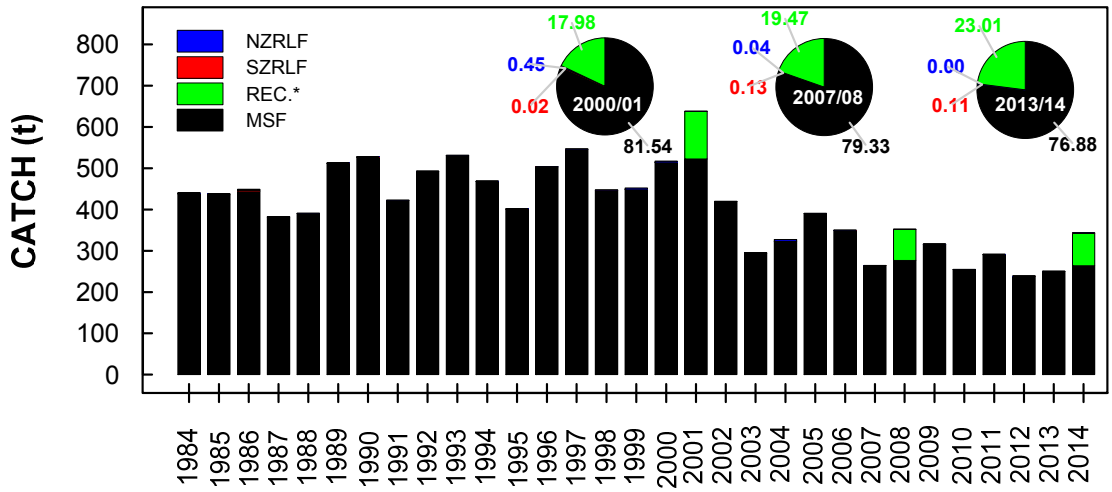

Figure 3.1. The relative contribution to the total statewide catch of Garfish across the shared sectors. * Recreational data are aggregated across financial years.

3.1.2. Commercial sector

Two management strategies have reduced the number of licence holders in South Australia's MSF. The first was the licence amalgamation scheme implemented in 1994, which has contributed significantly to the long term decline in the number of commercial fishers who land Garfish. The second was the voluntary hauling net buy-back initiative, implemented in 2005. These two strategies have contributed to the 57% reduction in the number of commercial fishers landing Garfish from 1995 to 2011 (Figure 3.2). There has, however, been an increase in the number of fishers landing and targeting Garfish over the last three years (98 and 78 licences, respectively). The relative proportion of commercial fishers that nominated Garfish as their specific target has remained relatively consistent at 75% of fishers landing Garfish throughout the last 20 years (Figure 3.2).

The total commercial catch of Garfish was 264.4 t in 2014, combined across all gear types, including both targeted and untargeted catch (Figure 3.2). This was the second consecutive year where catches increased from the historic low of 239.1 t in 2012, representing annual increases of 4.8% and 5.5%, in 2013 and 2014, respectively. The hauling net sector has traditionally dominated total catch, having consistently accounted for approximately 90% of the State-wide harvest since 1984 (Figure 3.2). Catches in this sector oscillated between 325 t to 500 t from 1984 to 2002, averaging 413 $t.yr^{-1}$ and has dropped to 263 $t.yr^{-1}$ since 2013. The dab net sector accounts for most of the remaining catch (~10%). This sector yielded higher than average catches throughout the 1990s (~62 $t.yr^{-1}$) compared to the last decade where catches have rarely exceeded 30 $t.yr^{-1}$ (Figure 3.2).

Total fishing effort for Garfish has steadily declined from a peak of 18,433 fisherdays in 1984 to a low of 4,855 fisherdays in 2012 (Figure 3.2). This represents a 73.7% decrease over 28 years declining at a rate of 487 fisherdays per year. This decline can largely be attributed to a sequential reduction in hauling net effort. Over the past two years fishing effort has slightly increased, rising 7% to 5,197 fisherdays in 2013 and a further 6.1% to 5,512 in 2014 (Figure 3.2). This trend was consistent for both gear types.

Catch rates have remained relatively high in the hauling net sector over the past decade averaging 50.2 $kg.fisherday^{-1}$, which was 11.9 $kg.fisherday^{-1}$ more than the average catch rates of the preceding decade (Figure 3.2). Catch rates in this sector peaked at 56.4 $kg.fisherday^{-1}$ in 2009 and have remained relatively stable over the past three years, declining by <4% from 51.3 $kg.fisherday^{-1}$ in 2012 to 49.2 $kg.fisherday^{-1}$ in 2014. Dab net catch rates displayed a long-term increasing trend from 1984 to 2002, rising from 18.9 $kg.fisherday^{-1}$ in 1984 to a peak of 58.6 $kg.fisherday^{-1}$ in 2001 (Figure 3.2). This increase, however, was not sustained dropping to 31.9 $kg.fisherday^{-1}$ in 2007. Contemporary catch rates in the dab net sector have remained below 41 $kg.fisherday^{-1}$.

Most of the State-wide catch of Garfish has historically been landed in the NGSV and NSG (Figure 3.1). Marine Fishing Areas 21 in SG and 35 in GSV have each consistently supported annual catches that have exceeded 60 t since 1984. During the 1980s and 1990s, the collective catch from these two MFAs accounted for approximately 45% of the State-wide commercial total. Since 2001, this relative contribution has increased to approximately 56% and has remained relatively steady, which emphasises the importance of these two areas to the commercial fishery. There has been a clear spatial contraction of the fishery over the past decade, catches from many regional centres in the WC (i.e. Venus Bay (MPA 17); Coffin Bay (MPA 27)) and SSG (i.e.

Wallaroo (MPA 32); and Port Victoria (MPA 33)) have substantially decreased. This was primarily a result of the implementation of spatial netting closures. The contemporary fishery is now largely confined to the NSG and NGSV (Figure 3.3).

The seasonality of Garfish catch is different for each of the gear types and has undergone considerable change over the past 30 years. From 1984 to 1999, most of the Garfish caught by the hauling net sector was landed during autumn (Figure 3.3). This was followed by two years during which high catches uncharacteristically peaked in mid–winter (July/August). Since then, overall monthly catches have declined considerably from the regular 40 t harvests during autumn, to 10 to 30 t monthly catches spread from January to August (Figure 3.3). Catches in the dab net sector, however, historically peaked during late spring and summer. This trend was most evident from 1992 to 2002, when peak catches in excess of 10 t were most frequent during November. Although dab net fishers are capable of targeting Garfish throughout the year, the temporal trends in their monthly catches have gradually diminished to < 4 t and appear to be constrained to the warmer half of the year (Figure 3.3).

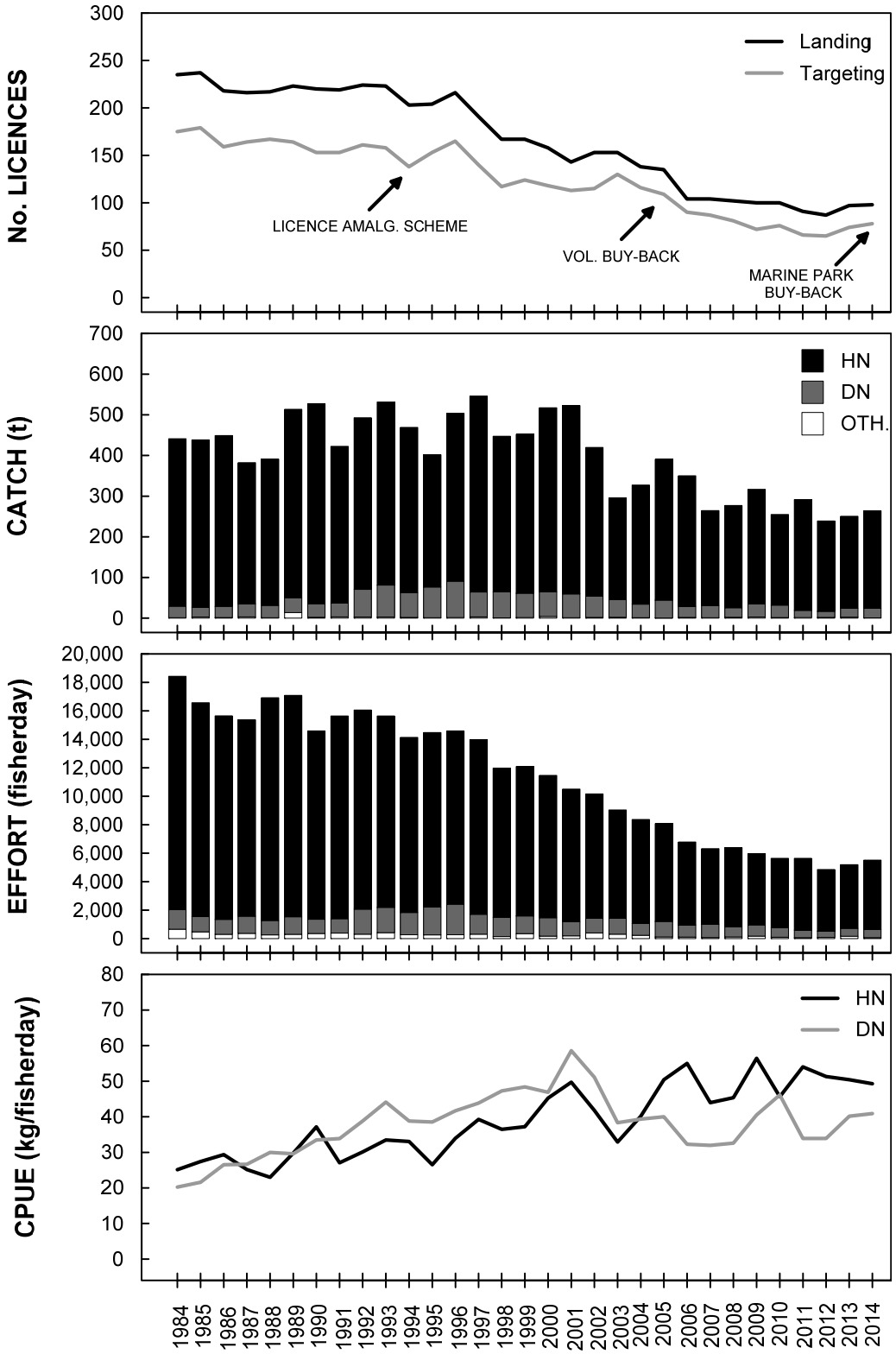

Figure 3.2. State-wide trends in the number of MSF licences landing or targeting Garfish; commercial Garfish catch, effort and CPUE by gear from 1984 until 2014.

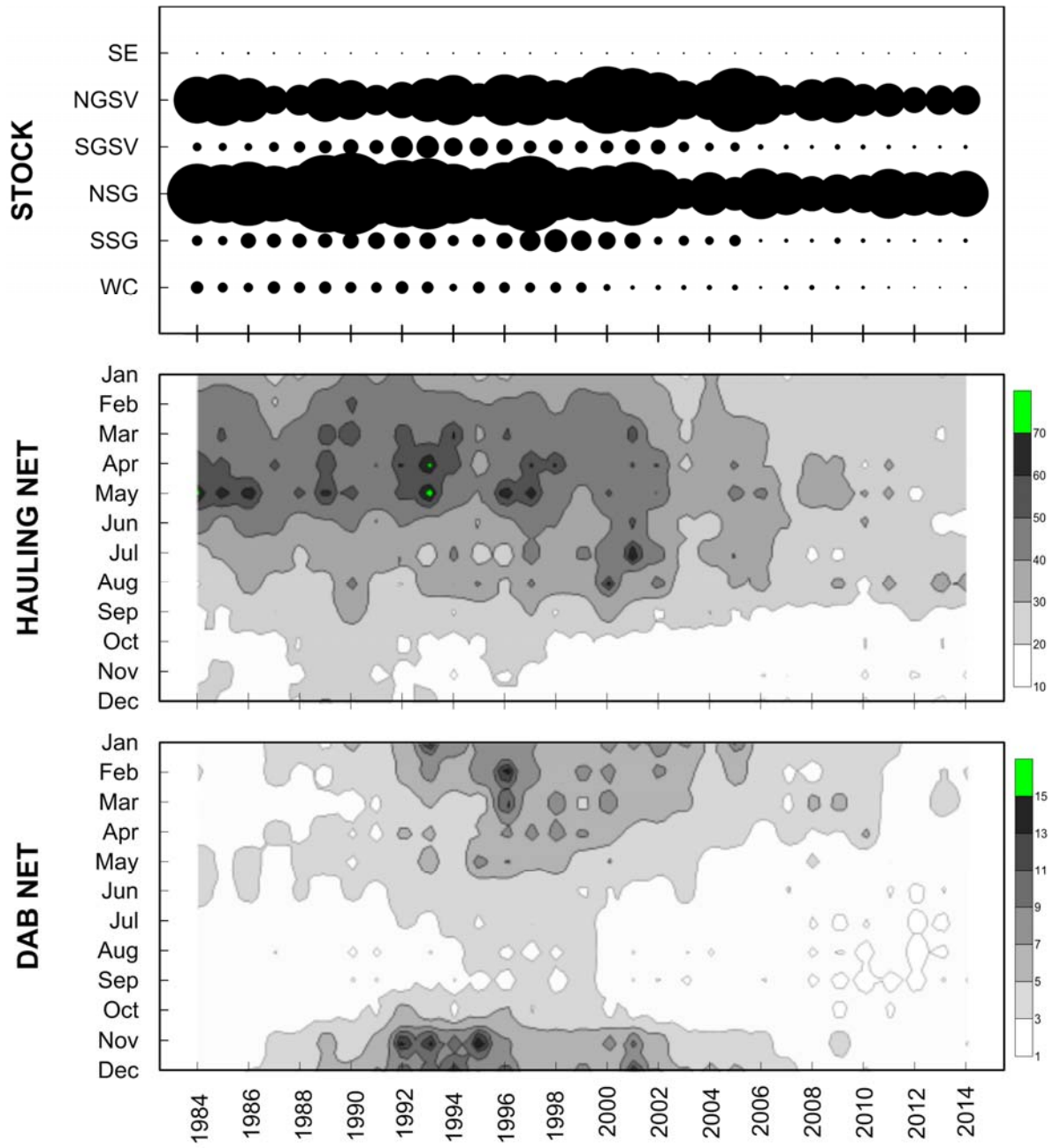

Figure 3.3. Relative proportion of the statewide commercial catch of Garfish by Region (top). The size of the bubble indicates its relative proportion of the total annual catch. Long-term trends in seasonal commercial catch (t) of Garfish by hauling net (middle) and dab net (bottom) from 1984 until 2014.

3.1.3. Recreational sector

The estimated State-wide recreational harvest of Garfish by South Australian residents in 2015 was 870,147 individuals with a combined weight of 79.18 t (Figure 3.4). This was 5.5% greater than the 2007/08 survey and 31.3% less than the estimate for 2000/01. Approximately half (49%) of the recreational harvest was taken from Spencer Gulf. Similar quantities (approximately 35 t) of Garfish were harvested from Spencer Gulf in the two previous surveys; however, Gulf St. Vincent provided most of the catch (57.6 t) in 2000/01.

The relative contribution of the recreational harvest of Garfish to the total State-wide catch has increased from 18% in 2000/01 to 23% in 2013/14 (Figure 3.4). The proportions of the Garfish catch harvested from Spencer Gulf increased from 5.2% to 11.3% over the three survey periods. The trend was reversed in Gulf St. Vincent. The relative contributions of the recreational catch of Garfish from the West Coast and South East have consistently accounted for <5% of the State-wide catch.

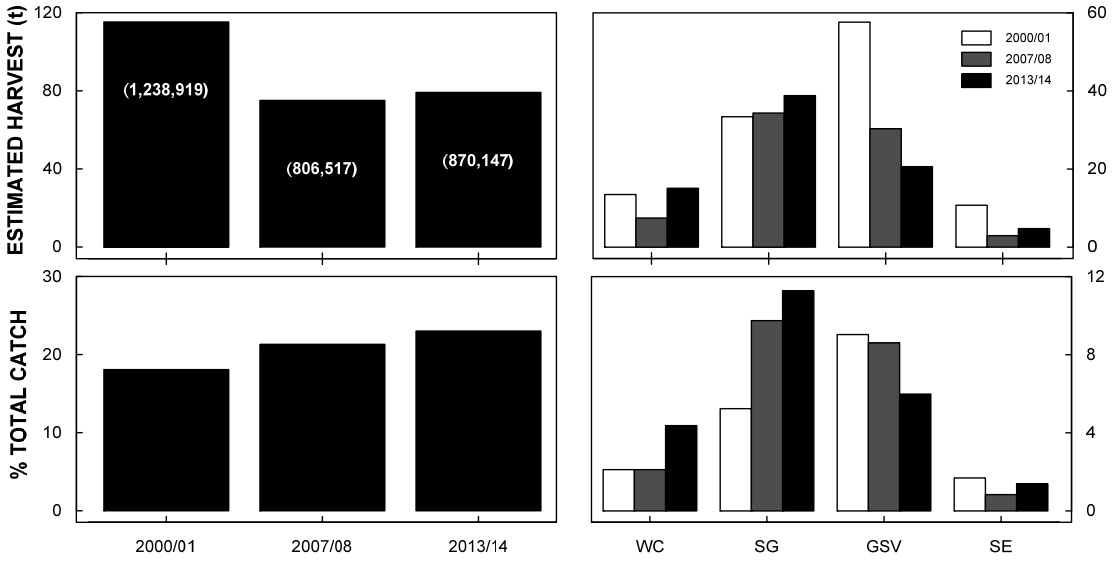

Figure 3.4. Estimated statewide and regional harvest of Garfish by the recreational sector as estimated through three telephone/diary surveys (Henry and Lyle 2003, Jones 2009, Giri and Hall 2015) and their relative contribution to the total state-wide catch.

3.2. Stocks

3.2.1. Northern Spencer Gulf

Northern Spencer Gulf has been the most productive fishing ground for Garfish in South Australia since 1984. The highest recorded catch was 256.8 t in 1990 and the lowest 98.3 t in 2003 (Figure 3.5). There was a relatively rapid decline in catch from 1997 to 2003, where it dropped 61% from 250 t to 98 t. Annual catches exceeded 160 t twice since 2003 (2006 and 2011) and remained relatively stable at approximately 145 t from 2012 until 2014. There has been a long-term trend of decreasing fishing effort in this region, declining from a peak of 7,500 fisherdays in 1988 to 2,129 fisherdays in 2012, at a rate of approximately 215 fisherdays.yr^{-1}. This trend has been driven by the hauling net sector, which has consistently contributed to >95% of the fishing activity. Catch rates for target hauling net fishers have trended upwards since 2003 rising from 44.5 kg.fisherday^{-1} to 109 kg.fisherday^{-1} in 2012, representing a 144% increase over nine years. Catch rates have reduced to 94.8 kg.fisherdays^{-1} in 2014.

There has been virtually no change in the modelled age structure over the past three stock assessment cycles, with estimates indicating that two year-old Garfish have consistently accounted for approximately 60% of the population. Similarly the relative composition of three and four year-old Garfish has remained stable at approximately 23% and 6%, respectively (Figure 3.5). Similar proportions of three-year old Garfish were evident in 'unfished' population, however there was considerably greater representation of older Garfish, indicating the capacity of the current population's age structure to expand.

The harvest fraction has historically been high exceeding 100%[1] but declined to 51.3% in 2013 and 53.5% in 2014, well below the 60% operational objective set in the MSF Management Plan (PIRSA 2013) (Figure 3.5). Egg production remained consistent from 1984 to 2006 at approximately 8% of 'unfished' levels; however it increased to peak at 12.9% in 2014, increasing at a rate of approximately 0.3% per year.

The fishable biomass declined 29.9% between 2001 and 2003, from 321.9 t to 225.7 t (Figure 3.5). Since then, the fishable biomass has increased at a rate of approximately 7.3 t per year, culminating to 320.8 t in 2014. The marked decrease in fishable biomass in 2001 was linked to poor recruitment in 2000, which dropped 39% from 7.6 to 3.5 million recruits (Figure 3.5).

[1] This value exceeds 100% because it accounts for the full year, rather than the half-yearly time step used in the model (i.e. sum of half-yearly catches/average of half-yearly biomasses). For some half-years well over half of the recruits were harvested during peak exploitation (winter).

Recruitment has since remained relatively stable at approximated 4 million recruits per year, increasing to a 10 year peak of 4.3 million recruits in 2013.

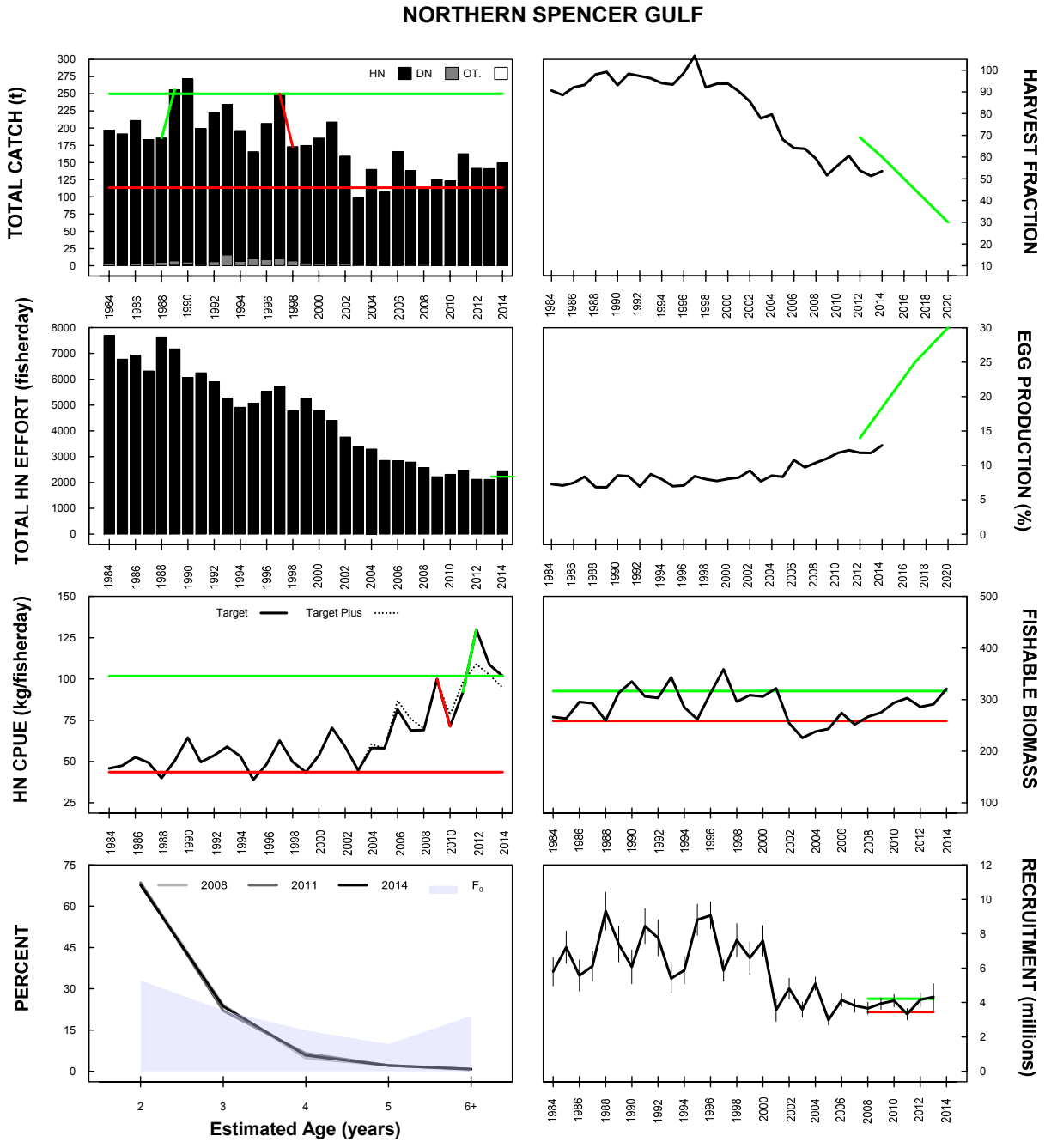

Figure 3.5. Key outputs used to assess the status of the NSG Garfish stock. (Left) Trends in total catch, total hauling net effort, catch rates (CPUE) and modelled age composition. (Right) Model output: Harvest fraction, egg production (%), fishable biomass and average (± sd) recruitment. Green and red lines represent the upper and lower trigger reference points identified in Table 1.2. HN = Hauling Net, DN = Dab Net, OT = Other, F_0 = Unfished age structure.

3.2.2. Northern Gulf St. Vincent

Northern Gulf St. Vincent is the second most productive region in the State, accounting for ~35% of the State's annual catch. Annual catches have exceeded 200 t twice in the past 31 years; 221.4 t in 2000 and 209.6 in 2005 (Figure 3.6). Annual catch fell to 96.7 t in 2007, a 53.9% decline over three years. This decline corresponded with a 22% decline in hauling net effort and a 35% reduction in CPUE. Annual catch and effort were at their lowest in 2012 (81.9 t and 2,156 fisherdays, respectively) when winter closures were first implemented and increased by approximately 15% to 93.8 t and 2,515 fisherdays in 2014. Targeted CPUE within the hauling net sector exceeded 110 kg.fisherday^{-1} for two consecutive years in 2000 and 2001, followed by minor peaks of 75.9 kg.fisherday^{-1} in 2005 and 71.7 kg.fisherday^{-1} in 2009 and stabilising at approximately 60 kg.fisherday^{-1} from 2010 to 2013. In 2014, catch rates within this sector declined by 11% to 49.8 kg.fisherday^{-1}.

There have been minor changes in the modelled age structure over the past three stock assessment cycles, with the relative proportions of the three and four year-old Garfish increasing by approximately 13% and 5%, respectively (Figure 3.6). The relative proportion of two-year-olds, however, has declined by approximately 20% over the same time period. Approximately 8% of the 2014 Garfish population consists of fish older than four years of age; this is 37% less than the 'unfished' population.

Harvest fraction peaked at 91.4% in 2002 and again at 90.0% in 2005 (Figure 3.6). Since then, rates of exploitation have decreased, falling to a record low of 55.3% in 2013, before inflecting upwards to 57.6% in 2014, 2.4% lower than the operational objective of 60% prescribed in the MSF Management Plan (PIRSA 2013). Egg production has remained within 7.8% to 13.5% of 'unfished' levels since 1984, and has stabilised at approximately 10% over the past seven years (Figure 3.6).

Like Northern Spencer Gulf, fishable biomass in Northern Gulf St. Vincent declined steeply from 2001 to 2003, declining 33.2% from a peak of 391.1 t to 261.1 t (Figure 3.6). With the exception of a minor peak of 293.3 t in 2005, fishable biomass has trended downwards to a record low of 200.8 t in 2014. This most recent estimate represents 13.7% of the 'unfished' biomass and is the lowest on record. Similarly, with the exception of a moderate peak in 2004, estimates of recruitment have also trended downwards from a peak of 7.08 million recruits in 1999 to a record low of 1.8 million recruits in 2014 (Figure 3.6).

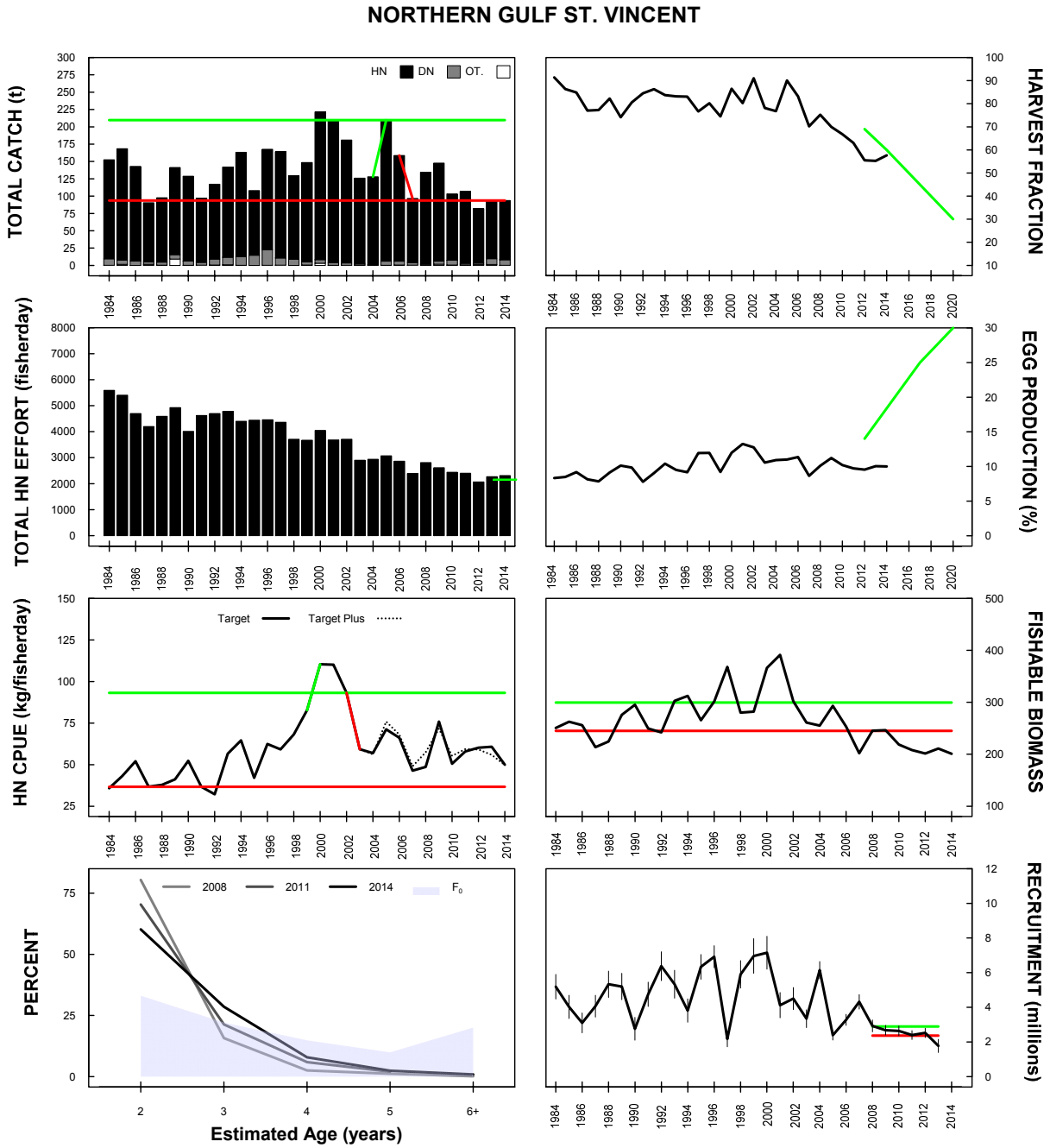

Figure 3.6. Key outputs used to assess the status of the NGSV Garfish stock. (Left) Trends in total catch, total hauling net effort, catch rates (CPUE) and modelled age composition. (Right) Model output: Harvest fraction, egg production (%), fishable biomass and average (± sd) recruitment. Green and red lines represent the upper and lower trigger reference points identified in Table 1.2. HN = Hauling Net, DN = Dab Net, OT = Other, F_0 = Unfished age structure.

3.2.3. Southern Spencer Gulf

Large areas of Southern Spencer Gulf have been closed to commercial hauling net fishing since 2005, and as a result the relative contribution of this region to the state-wide catch has decreased from approximately 10% up to 2005 to 3% over the past nine years. Most hauling net fishers (up to 90%) who operated in this region were non-specific in their target species. This sector historically accounted for >60% of the total catch which peaked at 71.2 t in 1998 (Figure 3.7). However, it has been considerably eroded through spatial restrictions imposed in 2005 to become almost exclusively fished by the dab net sector. Total catch of Garfish in this region has not exceeded 10 t since 2009 (Figure 3.7). Dab net effort has remained relatively stable at approximately 130 fisherdays over the same period. Close to all dab netters (>90%) have specifically recorded Garfish as their fishing target. Targeted dab net CPUE recently peaked at 55.6 kg.fisherdays^{-1} in 2010, dropping to 38.5 kg.fisherdays^{-1} in 2012 before returning to 51.7 kg.fisherdays^{-1} in 2014 (Figure 3.7).

A total of 695 Garfish have been measured from this region over the past ten years, 64% of which were sampled from 2012 to 2014. Despite the low sample sizes, the age structure of Garfish caught from this region have consistently included high proportions of three year-olds, accounting for up to 31% of the sample in 2014 (Figure 3.7).

There are no model-based estimates of fishable biomass, recruitment, egg production and harvest fractions for the Southern Spencer Gulf stock.

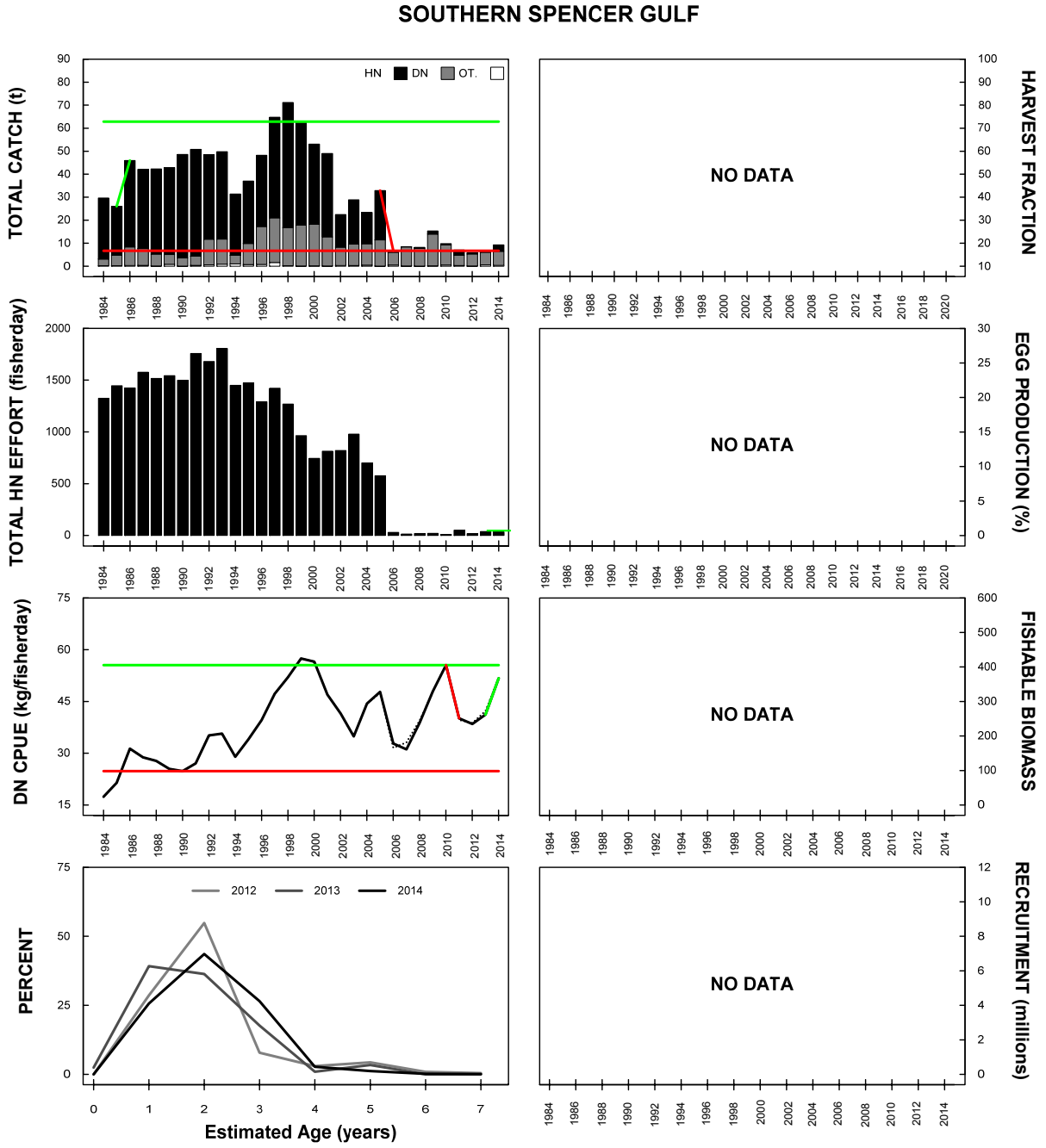

Figure 3.7. Key outputs used to assess the status of the SSG Garfish stock. (Left) Trends in total catch, total hauling net effort, catch rates (CPUE) and age composition. (Right) Model output: Harvest fraction, egg production (%), fishable biomass and average (± sd) recruitment. Green and red lines represent the upper and lower trigger reference points identified in Table 1.2. . HN = Hauling Net, DN = Dab Net, OT = Other.

3.2.4. Southern Gulf St. Vincent

The relative contribution of the commercial Garfish catch from this region to the annual state-wide total has rarely exceeded 10%. Annual catches steadily increased from 24 t in 1984 to 70 t in 1993 with both the hauling net and dab net sectors contributing equally (Figure 3.8). From 1993, the contribution of Garfish catch by the hauling net sector declined as a result of a steady reduction in effort (Figure 3.8). From 2005 onwards the dab net sector accounted for >75% of annual commercial fishing effort in this region as the implementation of netting restrictions virtually removed all hauling net activity from the region. Dab net effort has also recently declined, dropping from 329 fisherdays in 2010 to a record low of 196 fisherdays in 2014. Consequently, total catches in this region have remained <10 t over the past four years. Catch rates within the dab net sector have slightly increased over this time period, increasing 35%, from 37 to 50 kg.fisherdays^{-1} (Figure 3.8).

Like Southern Spencer Gulf, accessing commercial catches of Garfish in Southern Gulf St. Vincent is challenging, as there is relatively little fishing activity in this region and most of the catch is distributed outside of the SAFCOL market. Consequently, no Garfish were sampled in 2014 as part of the market sampling program, however a moderate quantity (n = 389) were accessed in 2013. The age structure of the Garfish population in 2013 was similar to that observed in NGSV (Figure 3.8). Both regional populations contained relatively high proportions (approximately 15%) of three years old.

There are no model-based estimates of fishable biomass, recruitment, egg production and harvest fractions for the Southern Gulf St. Vincent stock.

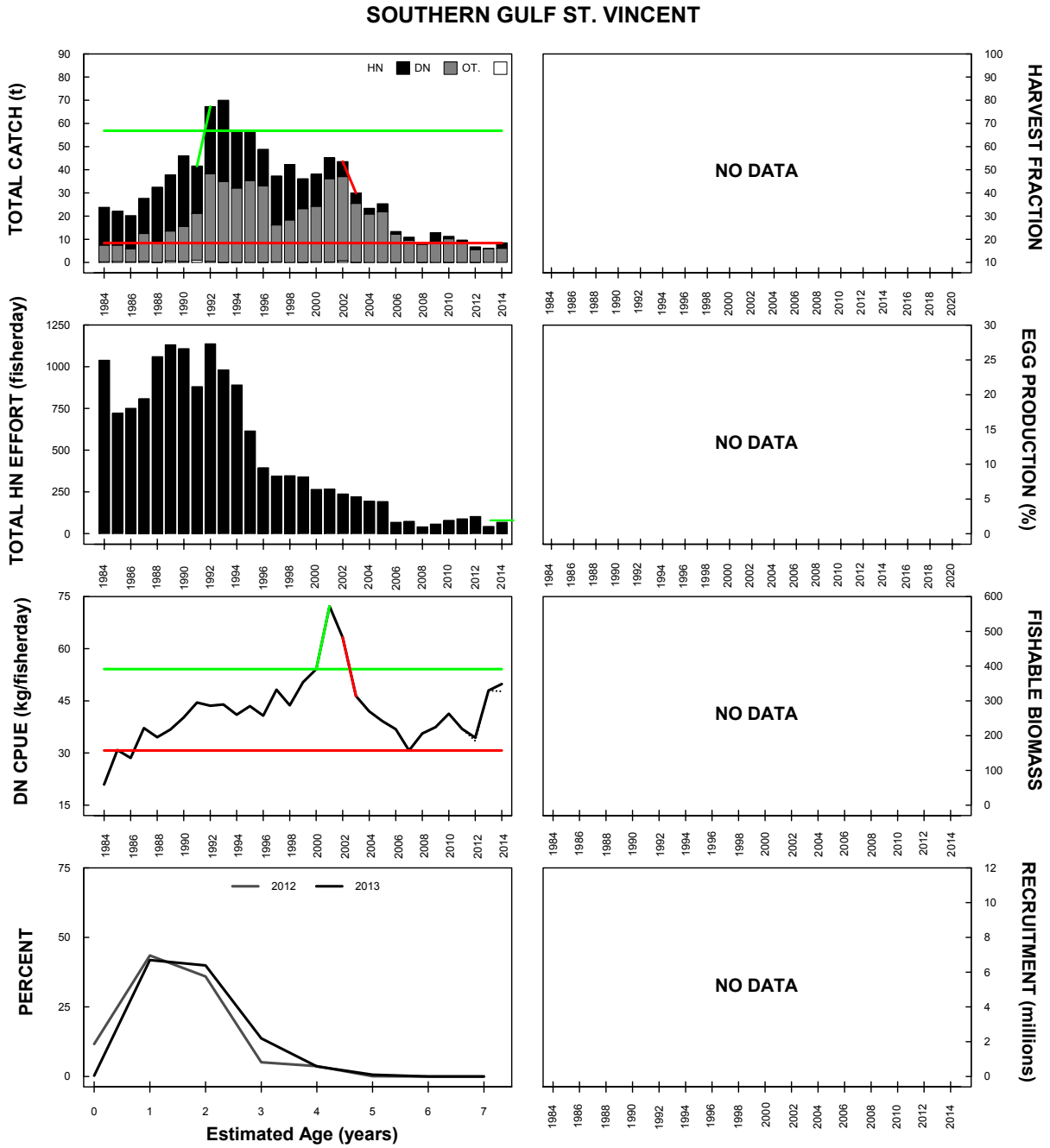

Figure 3.8. Key outputs used to assess the status of the SGSV Garfish stock. (Left) Trends in total catch, total hauling net effort, catch rates (CPUE) and age composition. (Right) Model output: Harvest fraction, egg production (%), fishable biomass and average (± sd) recruitment. Green and red lines represent the upper and lower trigger reference points identified in Table 1.2. . HN = Hauling Net, DN = Dab Net, OT = Other.

3.2.5. West Coast

From 1984 to 1999, the annual commercial catch of Garfish from the West Coast accounted for approximately 7% of the State's catch. This has since declined to <1% in 2014 and has been driven by a continuous reduction in hauling net effort through the implementation of commercial netting restrictions (Figure 3.9). Annual Garfish catch peaked at 37.2 t in 1992 of which hauling net sector landed 86% (Figure 3.9). Over the past three years, catches have remained below 3 t, falling to the lowest recorded level of 1.3 t in 2013, before increasing by 90% in 2014 to 2.5 t. Dab nets emerged as the dominant gear type in 2006, and in 2014 this sector accounted for a record high 86% of the total regional catch (Figure 3.9). Most of the remaining hauling net activity in this region have targeted Garfish, and their relative catch rates peaked at 111.3 kg.fisherdays^{-1} in 2007 and again in 2011 at 101.0 kg.fisherdays^{-1}. Dab netters have consistently landed approximately 35 kg.fisherdays^{-1} since 2000 (Figure 3.9).

There was no biological sampling, nor model output for the WC Garfish stock.

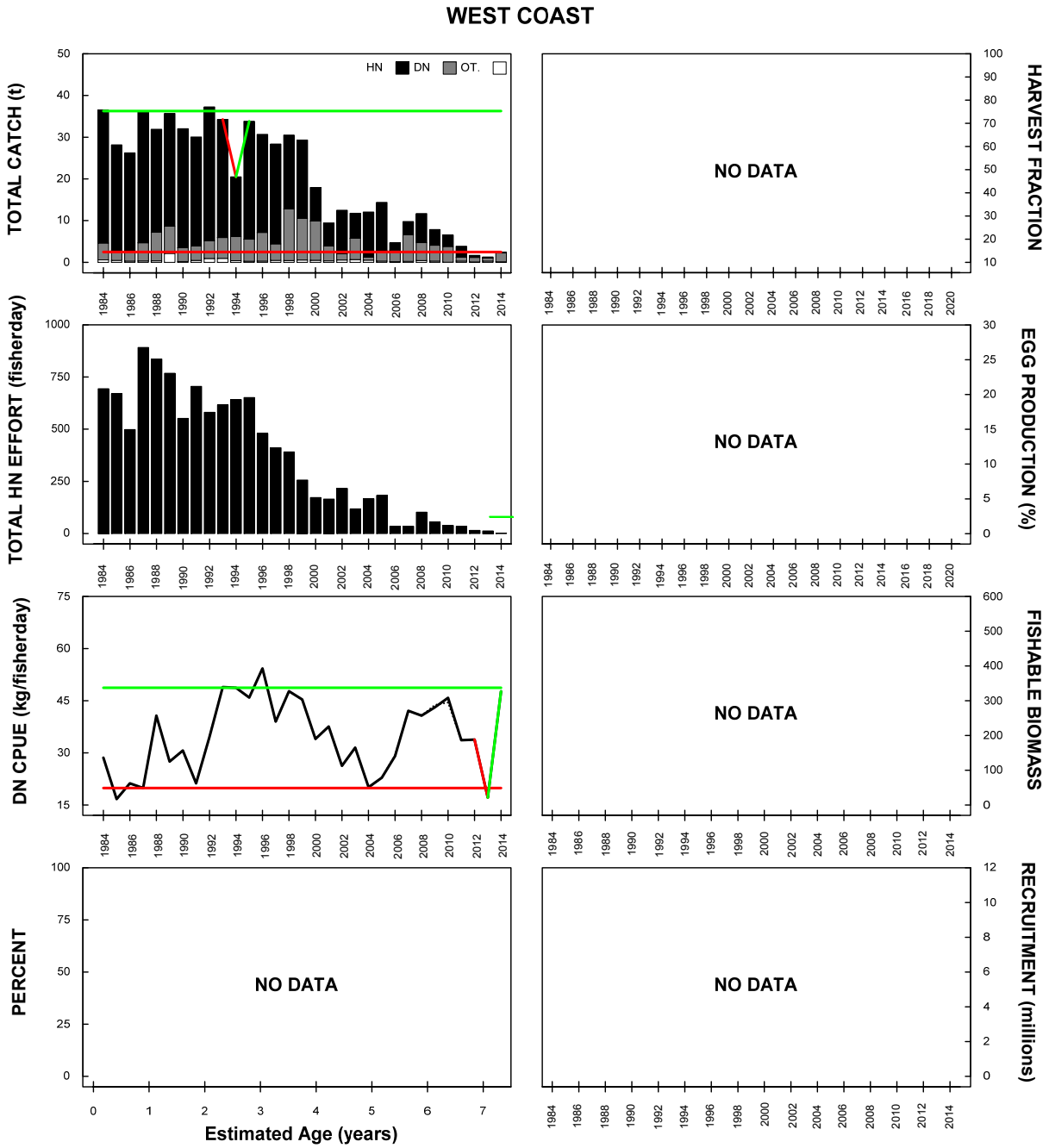

Figure 3.9. Key outputs used to assess the status of the WC Garfish stock. (Left) Trends in total catch, total hauling net effort, catch rates (CPUE) and age composition. (Right) Model output: Harvest fraction, egg production (%), fishable biomass and average (± sd) recruitment. Green and red lines represent the upper and lower trigger reference points identified in Table 1.2. . HN = Hauling Net, DN = Dab Net, OT = Other.

3.2.6. South East

A negligible amount of Garfish is landed by the commercial sector in the South East, with the annual State-wide contribution rarely exceeding 0.3%. Despite some low level hauling net activity during the 1980s and 1990s, most the Garfish has been landed by dab net fishers (Figure 3.10). Annual catch peaked at 2.7 t in 1986 and have subsequently fluctuated below 1 t. Catch rates within the dab net sector peaked at 31.7 kg.fisherdays^{-1} in 2007, but have susequently declined to 10.6 kg.fisherdays^{-1} in 2014 (Figure 3.10).

There was no biological sampling, nor model output for the SE Garfish stock.

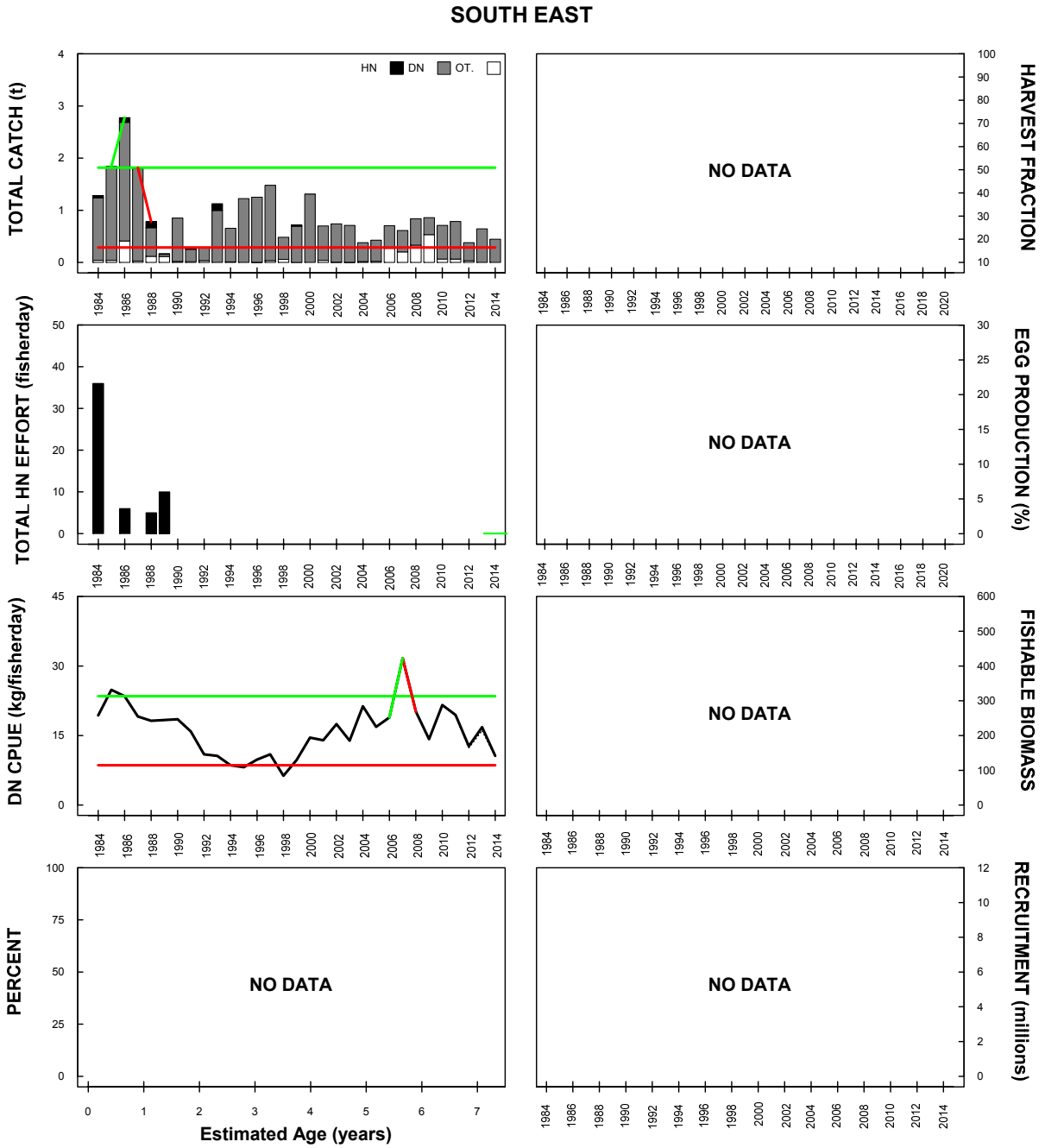

Figure 3.10. Key outputs used to assess the status of the SE Garfish stock. (Left) Trends in total catch, total hauling net effort, catch rates (CPUE) and age composition. (Right) Model output: Harvest fraction, egg production (%), fishable biomass and average (± sd) recruitment. Green and red lines represent the upper and lower trigger reference points identified in Table 1.2. . HN = Hauling Net, DN = Dab Net, OT = Other.

3.3. Fishery performance

3.3.1. Allocation of access

The relative contributions to the total Sate-wide catch from the three commercial fisheries have been relatively stable over the past five years (Table 3.1). The two notable, yet minor, exceptions were SZRLF which exceeded 0.2% in 2013 and the NZRLF which exceeded 0.15% in 2011. These minor irregularities were not large enough to breach any of the prescribed trigger limits (Table 3.2).

3.3.2. General Performance Indicators

The general performance indicators were assessed at regional and gulf-wide scales. A reduction of the hauling net effort by ≥13% in 2014 since 2011 was the highest priority for the general performance indicator; this was not achieved at either spatial scale. The trigger reference point (TRP) of achieving an effort reduction of greater than 10% by 2014 was breached, with decreases in hauling net effort of 0.5% and 3.8% in NGSV and NSG, respectively. As hauling net effort in the southern gulfs was negligible, these breaches do not warrant the same level of concern as the northern gulfs. From a gulf-wide perspective, total hauling net effort declined by 1.2% in Spencer Gulf and 4.5% in Gulf St. Vincent (Table 3.3).

Two other general performance TRPs were breached in 2014 at the regional level. The total catch of Garfish in 2014 was the third lowest on record in NGSV. Targeted catch rates of Garfish within the hauling net sector were the third highest on record in NSG (Table 3.3). Overall catch of Garfish in GSV was also the third lowest on record (Table 3.3).

3.3.3. Biological Performance Indicators

Modeled estimates of harvest fraction and egg production are the primary performance indicators used in this assessment to determine the status of South Australia's Garfish fishery. Although both indicators have clear operational objectives and TRPs, only the harvest fraction estimate is relevant in the current assessment. Egg production targets come into effect in the following 2017 stock assessment where levels are required to exceed 20% of virgin biomass. The operational objective of achieving a harvest fraction of ≤60% by 2014 was accomplished in both gulfs, estimated at 57.7% and 53.7% for GSV and SG, respectively (Table 3.3).

No improvement in the age structure of the Garfish population was observed in 2014 in SG, whereas a minor increase (6.6%) in the relative proportion of three year-old Garfish was observed in GSV. Given that 'no change' in the age structure is identified as the TRP for this secondary

performance indicator, the observed changes indicate a negative breach for SG and positive breach for GSV (Table 3.3).

Estimates of fishable biomass and recruitment constitute the remaining biological performance indicators and contribute to the 'weight-of-evidence' approach in determining the status of the resource. Average fishable biomass over the past three years was reduced by 26.8% in GSV in comparison to the average of the preceding years, negatively breaching the TRP (Table 3.3). Similarly estimates of recruitment declined by 33.0% in GSV, in comparison to the preceding five-year average, also negatively breaching the TRP. Estimates of recruitment in SG, however, increased by 12.4%, positively breaching the TRP.

Table 3.1. Southern Garfish Fishery allocation.

FISHERY ALLOCATION	MSF 79.30%	SZRL 0.13%	NZRLF 0.04%	REC. 19.50%	CHARTER n/a	ABT 1.00%
TRIGGER 1	*84.00%*	*1.00%*	*1.00%*	-	-	-
2000/01	81.54	0.02	0.45	17.98	-	-
2007/08	79.33	0.13	0.04	19.47	-	-
2013/14	76.88	0.11	0.00	23.01	-	-

Table 3.2. Commercial allocation within the Southern Garfish Fishery.

COMMERCIAL ALLOCATION	MSF 99.79%	SZRL 0.16%	NZRLF 0.05%	REC. n/a	CHARTER n/a	ABT n/a
TRIGGER 2	*na*	*0.75%*	*0.75%*	-	-	-
TRIGGER 3	*na*	*1.00%*	*1.00%*	-	-	-
2010	99.82%	0.18%	0.00%	-	-	-
2011	99.68%	0.15%	0.17%	-	-	-
2012	99.86%	0.11%	0.04%	-	-	-
2013	99.72%	0.25%	0.03%	-	-	-
2014	99.89%	0.11%	0.01%	-	-	-

Table 3.3. Comparison of trends in South Australia's Garfish fishery against the performance indicators prescribed in the MSF Management Plan (PIRSA 2013). Red = negative breach; green = positive breach, grey = not applicable; arrows indicate directional shift.

	PERFORMANCE INDICATOR	TYPE	OPERATIONAL OBJECTIVE	TRIGGER REFERENCE POINT	NSG	SSG	NGSV	SGSV	SG	GSV
PRIMARY	HARVEST FRACTION	B	≤ 60% 2014	> 60% 2014					53.5%	57.6%
		B	≤ 45% 2017	> 45% 2017					-	-
		B	≤ 30% 2020	> 30% 2020					-	-
	EGG PRODUCTION	B	25% 2017	< 20% 2017					*12.9%**	*10.0%**
		B	30% 2020	< 30% 2020					-	-
SECOND.	AGE COMPOSITION	B	↑ Prop. Age 3+	No change or reduction	↓1.1%		↑6.6%		↓1.1%	↑6.6%
	TOTAL HAULING NET EFFORT	G	↓ ≥ 13% 2014	↓ < 10% since 2011	↓0.5 %	×	↓3.8 %	×	↓1.2%	↓4.5 %
OTHER	TOTAL CATCH	G	No Target	3rd Lowest / 3rd Highest	×	×	3rd	×	×	3rd
		G	No Target	Greatest % interannual change (+/-)	×	×	×	×	×	×
		G	No Target	Greatest 5 year trend	×	×	×	×	×	×
		G	No Target	Decrease over 5 consecutive years	×	×	×	×	×	×
	TARGET HAULING NET CPUE	G	No Target	3rd Lowest / 3rd Highest	3rd		×		×	×
		G	No Target	Greatest % interannual change (+/-)	×		×		×	×
		G	No Target	Greatest 5 year trend	×		×		×	×
		G	No Target	Decrease over 5 consecutive years	×		×		×	×
	TARGET DAB NET CPUE	G	No Target	3rd Lowest / 3rd Highest		×		×	×	×
		G	No Target	Greatest % interannual change (+/-)		×		×	×	×
		G	No Target	Greatest 5 year trend		×		×	×	×
		G	No Target	Decrease over 5 consecutive years		×		×	×	×
	FISHABLE BIOMASS	B	No Target	3 year average is +/- 10% of previous years					↑4.0%	↓24.9%
	RECRUITMENT	B	No Target	+/- 10% than the average of previous 5 years					↑12.6%	↓32.7%

4. DISCUSSION

4.1. Stock status

The overall assessment of South Australia's Garfish fishery relies heavily on data obtained from the hauling net sector which accounts for approximately 90% of the State-wide commercial catch. Similarly, the assessment places considerable emphasis on analysing catch and effort trends in the northern gulfs since commercial hauling net fishers are restricted to these regions. The current harvest strategy for Garfish (PIRSA 2013) does not provide a pre-defined limit reference point that determines when the stock is recruitment overfished (i.e., when the adult biomass no longer has the reproductive capacity to replenish itself). Instead, the performance of the fishery is assessed against the modeled trends in the harvest fraction of the fishable biomass and egg production.

4.1.1. Northern Spencer Gulf

Historically, Northern Spencer Gulf has been the most productive region for Garfish in South Australia and, in 2014, contributed 55% of the State-wide catch. Annual catch in this region has been relatively stable over the past three years averaging approximately 145 t. Targeted catch rates in the dominant hauling net sector have also remained high, with each fisher harvesting an average of 94.8 kg.day^{-1} in 2014, and although this is a 6.3% decline from the 2013 estimate, it still represented the third highest catch rate on record. Despite the predetermined objective to reduce total hauling net effort by ≥13% since the 2011 assessment, effort levels decreased by 0.5%, and was largely counteracted by a 17% increase in targeted hauling net effort. Fishers have suggested that this increase in targeted effort was an indirect function of the seasonal closure which allowed Garfish to accumulate into large schools over favourable grounds, and because of their increased market demand and catchability, were heavily targeted once the fishery re-opened. This dynamic fishing behaviour appeared to negate the expected effect of the seasonal closures on total fishing effort, rendering them ineffective. The schooling nature of this species also reduces our confidence in using CPUE as an index of relative abundance.

The sharp decline in catch in 2001, coupled with high exploitation rates, declines in fishable biomass, relatively poor recruitment and truncated age structures were identified as concerns in previous stock assessment reports (McGarvey et al. 2006, 2009, Steer et al. 2011) culminating in the fishery being classified as 'transitional-depleting' in the most recent State-wide and national assessments (Flood et al. 2014, PIRSA 2015).

Modeled estimates of exploitation rate and egg production constitute the primary performance indicators in this fishery. Over the past decade both proxies have trended favourably, with harvest fractions declining at a rate of 3% per year to 53.5% and virgin egg production gradually increasing by 0.4% per year, to 12.9%. Consequently, this stock has achieved the operational objective of reducing the harvest fraction to ≤60% by 2014. Although this rate of decline is indicative of the success of long-term management strategies implemented to sustain marine scalefish resources (i.e. licence amalgamations scheme, net-buy backs), it is unlikely to be sufficient to achieve the operational target of reducing the harvest fraction to ≤30% by 2020. Similarly, the trajectory of increase in egg production will require considerable improvement if it is to achieve its operational objective of 25% by 2017 (Figure 3.5). According to these indicators the NSG stock has demonstrated sustained improvement since 2003; however, this recovery is off a low base and has occurred despite the fact that effort has not declined as intended under the harvest strategy.

The changes in the minimum mesh size of hauling net pockets was specifically implemented to promote the recovery of the resource by reducing fishing mortality rates of small Garfish (Steer et al. 2011). It was expected that, over time, this change would contribute to the accumulation of fishable biomass, concomitant improvement in recruitment and a population structure that consists of older, larger Garfish (Steer et al. 2011). The flow-on population effects have only had 18 months to occur (prior to this assessment) and given this short time frame the results are unlikely to be detected in the current assessment. Fishable biomass has, however, steadily increased since 2003 and was most likely in response to declining exploitation rates. The stock size was estimated to be 18.3% of virgin biomass, and although still 1.7% below the theoretical threshold of 20%, this is the highest level since 2001. Recruitment also increased to a level that positively breached the prescribed trigger reference point, exceeding 10% above the average of the previous five years. Although positive, from a historical context, contemporary rates of recruitment were 50% less than those observed pre-1999 further indicating the fishery has considerable capacity to increase. The fact that recruitment appears relatively stable despite increasing egg production and fishable biomass is indicative of a poor stock-recruitment relationship and suggests that environmental processes may be influencing recruitment levels. The anticipated improvement in the age structure, where the population was expected to consist of a greater proportion of three and four year-old Garfish, was not observed. In fact, the population composition has remained virtually identical over the last three stock assessment cycles (i.e. 2008, 2011 and 2014), with two year-old Garfish continuing to dominate samples. This stability in the population structure reaffirms the consistent levels of recruitment within the stock, as the

relative proportion of young (one- and two-year-old) Garfish would be expected to increase with increasing recruitment levels and conversely decline with poor recruitment.

A previous management strategy evaluation exercise indicated that increases in the hauling net mesh size were likely to promote stock recovery through increases in biomass, value and egg production (Steer et al. 2011). The benefits were projected to increase with increasing mesh size and could be further enhanced by combining effort reduction strategies. Additional management changes have been implemented in response to the status of the fishery and include further increases in the minimum mesh size of the hauling net pockets from 32 mm to 35 mm in 2015, and increases in the LML from 230 mm to 250 mm in 2015 and from 250 mm to 260 mm in 2016.

Long-term management changes have resulted in a reduction in the exploitation rate below the operational target of 60%; sustained increases in egg production and fishable biomass; and improved recruitment. Management measures (i.e. further increases in mesh size and LML) are also in place to promote stock recovery. On this basis the current status of the NSG Garfish stock is classified as **transitional-recovering**.

4.1.2. Northern Gulf St. Vincent

Northern Gulf St. Vincent is the second most productive region in the State, accounting for 35% of the commercial catch. Historically, the performance of this fishery has followed a similar pattern to Northern Spencer Gulf. This is because they share similar environments, have experienced comparable fishing pressure and were exposed to equivalent management strategies. Like NSG, hauling net effort in NGSV had only marginally decreased (3.8%) since 2011, failing to meet the operational objective of reducing by ≥13% by 2014. It also indicates that the seasonal closures have been ineffective for this region. Total catch has remained relatively stable, but is still the 3rd lowest on record and unlike NSG, targeted catch rates have declined by 18% over the last year to 50 kgs.fisherdays^{-1}.

High exploitation rates have also been a major concern for this stock peaking at 90.0% in 2006. Since, then the annual harvest fraction has steadily declined to 57.6% in 2014, satisfying the operational objective to drop below 60% by 2014. Although this reduction in exploitation rate is encouraging, the overall performance of this stock remains concerning as the trajectories of the key biological performance indicators remain unfavourable. Rates of recruitment and estimates of fishable biomass are the lowest on record, both falling well below their respective trigger reference points. Fishable biomass has steadily decreased over the past six years to 200.8 t in 2014, contributing to a three-year average that is 24.9% lower than the historical average.

Similarly, recruitment levels have declined 32.7% below the average of the previous five years. This decline is clearly reflected in the comparative age structure where there has been a sequential reduction in the relative proportion of two-year-olds over the past three assessment cycles. Furthermore, egg production remains low, but stable, at 10% of virgin levels with little indication that it will achieve its operational target of 25% by 2017.

A clear divergent trend now exists between the two gulf fisheries, indicating that the current level of fishing pressure in NGSV may be at a point where the resilience of the Garfish stock has been compromised (Figure 4.1). Research into the stock structure of South Australian Garfish has indicated that individuals tend to be relatively site attached during their first two years of life (Steer et al. 2009a) and, as such, are susceptible to localised fishing pressure. Since the enforced netting closures in 2005 that encompassed a relatively large proportion of shallow waters off Yorke Peninsula, the remaining net fishers within Gulf St. Vincent have been concentrated within a small area (approximately 515 km^2) in the northern gulf (see Table 1.1; Figure 1.1). It is possible that the reduction in the biological performance indicators in GSV is indicative of the depletion of Garfish on the key fishing grounds in the small accessible area. The same outcome is not apparent in NSG where fishers have access to more extensive fishing grounds (approximately 1,028 km^2, Table 1.1) and are capable of distributing their effort more widely. The available fishing area in NGSV was further reduced to approximately 465 km^2 through the implementation of a marine park sanctuary zone in the upper gulf on 1 October 2014 (Table 1.1; Figure 1.1). This zone is estimated to account for approximately 7.5% of the State's total hauling net effort (Ward et al. 2012). It is unknown at this stage whether the new sanctuary zone will benefit the fishery by providing a spawning refuge for a component of the local stock, or will be detrimental to the surrounding area through displaced fishing effort. However, 12 MSF licences (including 4 net licences) were removed in a State-funded Marine Parks voluntary catch and effort buy-back with the intention of mitigating any increase in displaced effort. The ramifications of this closure will become clear over time.

The management regime that has been established in NGSV appears to have been insufficient to recover the stock as evidenced by negative breaches in fishable biomass and recruitment against the TRPs; persisting low rates of egg production; relatively high exploitation rates coupled with increased effort and declining catch rates. On this basis the NGSV Garfish stock is classified as recruitment **overfished**.

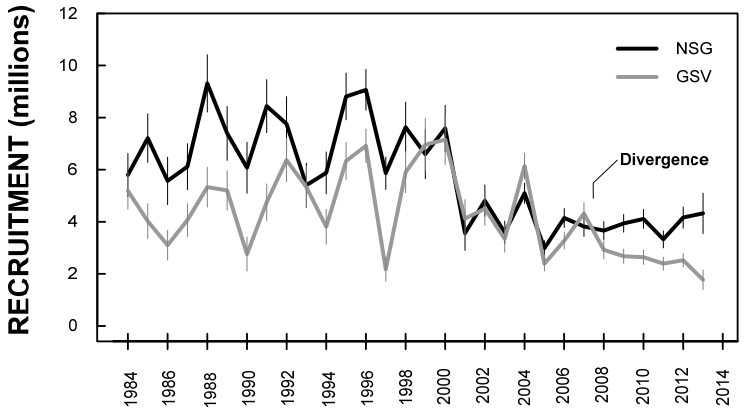

Figure 4.1. Comparison of average annual recruitment levels (±1.96*SE) for both Gulfs.

4.1.3. Southern Spencer Gulf

Large areas of Southern Spencer Gulf have been closed to hauling net fishing, with the most recent closure being implemented around southern Yorke Peninsula in 2005. Consequently, the hauling net sector has been effectively removed from this region and it has become predominantly fished commercially by dab netters. The relative contribution of this region to the statewide catch has consequently decreased to <5%. The commercial catch of Garfish from this region was 9.3 t increasing from 2013 by 38%. Fishing effort and catch rates in the dab net sector have remained relatively stable since the 2005 management restructure. Given the relatively small size of this regional fishery it is generally difficult to sample meaningful quantities of Garfish to ascertain trends in the local population demography. Opportunistic biological samples collected in 2013 and 2014, however, have indicated the commercial resource consists of greater proportions of larger and older (>3+) Garfish in comparison to the northern Spencer Gulf stock.

Although the spatial resolution of the current 'GarEst' fishery assessment model is too broad to assess the key biological performance indicators for this region, its relatively low levels of fishing activity and commercial catch, extensive netting closures and a population structure that consists of older (3+) Garfish, indicates that this stock is unlikely to be over-exploited. Consequently, this stock is classified as **sustainable**.

4.1.4. Southern Gulf St. Vincent

Prior to 1993, the commercial catch of Garfish from Southern Gulf St. Vincent was equally shared between the hauling net and dab net sectors. Since then, the hauling net sector declined as a function of a steady reduction in fishing effort and in 2006 dab nets became the dominant gear

type. Hauling nets were removed from his region by the implementation of the voluntary net buy-back scheme and spatial netting closures in 2005. Prior to this management restructure, the commercial Garfish catch from this region rarely exceeded 10% of the statewide harvest, however, after its implementation this was considerably reduced to <5%. The history of this regional fishery and its current status is almost identical to SSG, characterised by relatively low levels of fishing activity and commercial catch, extensive netting closures and a population structure that consists of relative old (3+) Garfish. On this basis the SGSV stock is classified as **sustainable**.

4.1.5. West Coast

A negligible amount of Garfish is landed by the commercial sector on the West Coast, with the statewide contribution rarely exceeding 2%. Consequently, there is insufficient information available to confidently classify the status of this stock. On this basis the West Coast Garfish stock is classified as **undefined**.

4.1.6. South East

Like the West Coast, a negligible amount of Garfish is landed by the commercial sector in the South East, with the statewide contribution rarely exceeding 0.3%. Consequently, there is insufficient information available to confidently classify the status of this stock. On this basis the South East Garfish resource is classified as **undefined**.

4.2. Management implications

The management strategy established in NSG appears to be achieving its aim of rebuilding the Garfish stocks to ensure its long-term sustainability. The rate of recovery is currently meeting the operational objectives outlined in the harvest strategy; however, this improvement will need to be accelerated if subsequent objectives are to be met (i.e. harvest fraction $\leq$45% and egg production >20% by 2017). The decision to partition future seasonal closures into multiple short-term blocks to counter a 'gold rush' response once the fishery re-opens seems logical. The decision to further increase hauling net mesh sizes and the legal minimum length of Garfish in 2016 is likely to enhance the stock recovery which is already occurring under the current management regime. Similarly, the pre-existing gear and effort-based management changes implemented in 2013 are yet to manifest in the fishery.

The situation is different in NGSV. Despite achieving the desired reduction in harvest fraction, fishable biomass and recruitment are continuing to decline and egg production rates are not

displaying any signs of improvement. It is clear that the current management strategies which have been successful in NSG have not been sufficient to facilitate the recovery in NGSV. The fishable area available to net fishers is markedly different between the two stocks, and may explain the divergence in their relative performance. Concentrating fishing effort within a small area, where Garfish are known to be relatively site attached (see Steer et al. 2009a; 2009b; 2010; Steer and Fowler 2015) poses the risk of localised depletion. This is of particular concern for a schooling species such as Garfish in which CPUE is considered hyperstable (i.e. catch rates remain high despite actual declines in abundance as fishers continue to target a diminishing school until the last fish is caught (Erisman et al. 2011)).

The most recent estimate of catch by the South Australian recreational fishing sector has been included in this assessment (Giri and Hall 2015). There was a minor increase (5.5%) in its relative contribution to the total State-wide catch of Garfish in comparison to the last survey. Similarly, the relative contribution of the various sectors within the commercial fishery (i.e. NZRLF, SZRLF, and MSF) has remained stable, maintaining their respective allocations.

4.3. Current performance indicators and reference points

Assessing the status of the Garfish fishery through multiple lines of evidence that describe fishery performance from a combination of general and biological indicators is of considerable value. Tracking the relative trends in these indicators is particularly informative, and the trigger reference points serve as 'precautionary limits' that indicate further management action may be required.

The reference period used to assess trends in recruitment which compares the latest estimate against the average of the previous five years appears too short. This is clearly evident for Northern Spencer Gulf; where recruitment historically oscillated around 8 million recruits and was halved in 2000 and has since remained relatively stable (Figure 3.5). The contemporary five-year reference period does not adequately capture these early years and consequently constrains the trigger reference points (±10%) to a narrow range. Extending the reference period to account for all previous years, similar to that used to assess fishable biomass (Table 1.2) may provide more informative trigger reference points.

Tracking the mean proportion of three-year-old Garfish in the population over successive stock assessment cycles is misleading. Ideally, this metric was developed to assess the flow-on benefits of the imposed increases in hauling net mesh size which reduces the mortality of small (young) Garfish. The lack of young Garfish in the population due to poor recruitment, however, masks the interpretation of this performance indicator, as the proportion of older fish will be

artificially inflated. So although it would appear that the population is responding well to the gear-based changes, the age structure is actually altered by unfavourable recruitment of young fish into the population. It would be more informative to compare the model derived number of Garfish in each of the age classes over the successive assessment cycles, rather than their relative proportions.

4.4. Future directions

The current assessment of the Garfish Fishery is entirely based on fishery-dependent data. The relative abundances and age structures of Garfish in areas not accessed by commercial fishers are unknown. Consequently, it is not known whether recruitment from outside key fishing areas may help explain the resilience of Garfish to prolonged and intense fishing pressure. A new jointly funded (FRDC, PIRSA and industry) Garfish project began in July 2015. It aims to resolve the relative abundance and population structure of Garfish outside of the spatially limited fishing areas to determine whether the commercial fishery data used to assess the resource accurately reflects the status of the broader resource. It is expected that the data obtained from this project will considerably improve the spatial resolution of the GarEst fishery model, increasing its capacity to provide key biological outputs for the hauling net dominated fisheries in the northern gulfs (i.e. NSG and NGSV), as well as for the dab net dominated fisheries in the south (i.e. SSG and SGSV). Such segregation will also align with the structure of the Garfish biological stocks (Steer et al. 2009a). In addition, it is planned that the GarEst model will be modified to increase its temporal resolution, refining the model time steps from half-yearly to finer scale quarterly intervals.

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6. APPENDIX A: ANNUAL SIZE AND AGE STRUCTURE

SARDI has relied heavily on the South Australian Fisherman's Co-Operative Limited (SAFCOL) market to access the commercial catch and gain valuable biological information that is used to determine the population structure for South Australia's primary Marine Scalefish Species. This section displays the annual size and age structure of Garfish for each of the key regions.

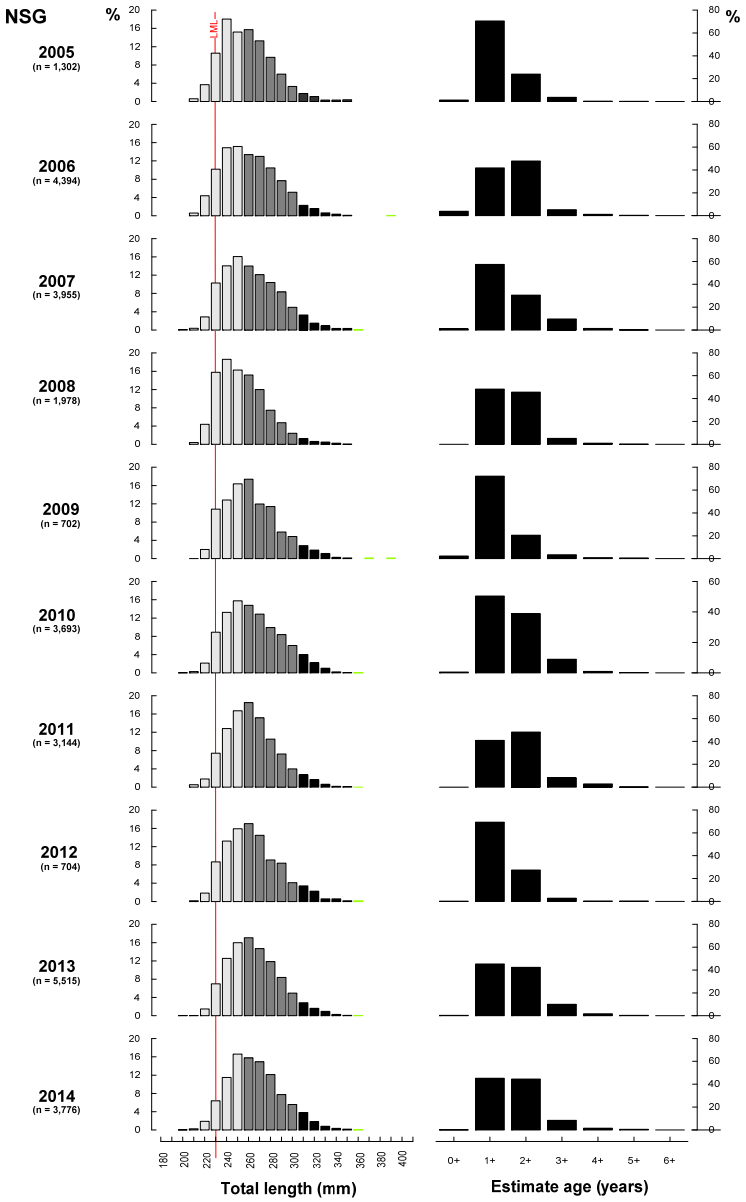


Figure 6.1. Annual size and age structures for Garfish sampled from Northern Spencer Gulf from 2005 to 2014. The red line denotes the legal minimum length (LML).

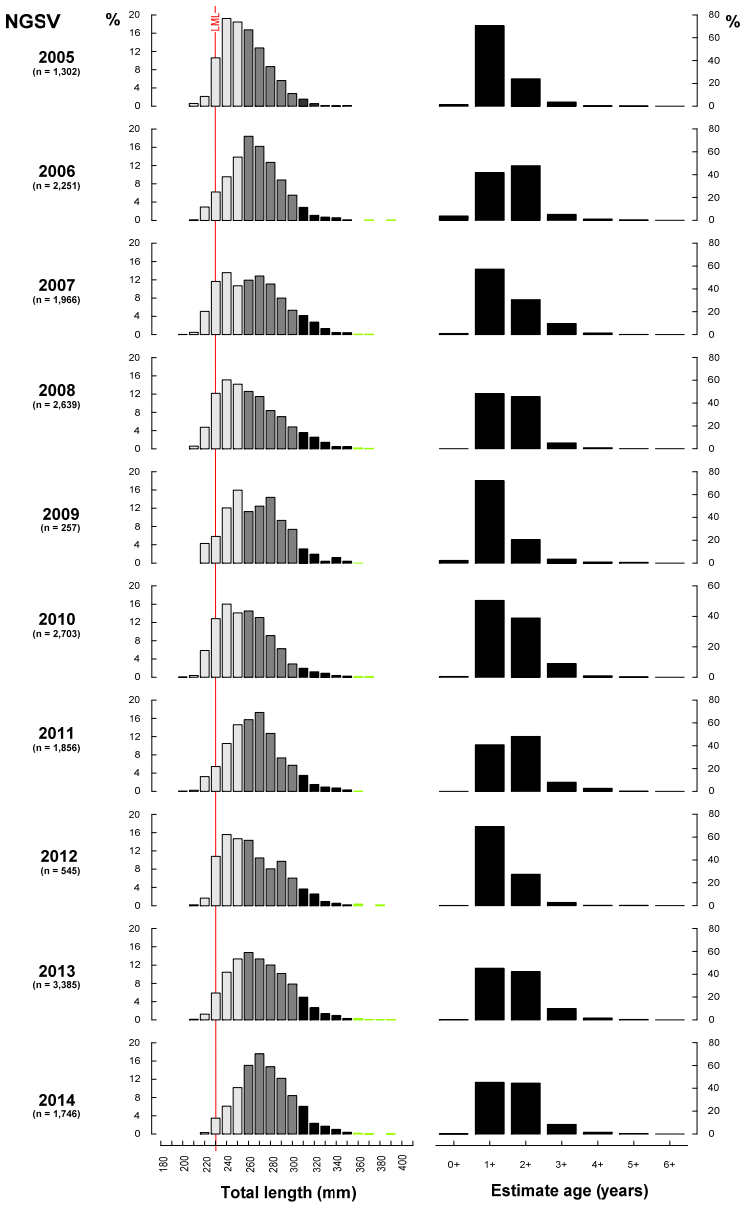


Figure 6.2. Annual size and age structures for Garfish sampled from Northern Gulf St. Vincent from 2005 to 2014. The red line denotes the legal minimum length (LML).

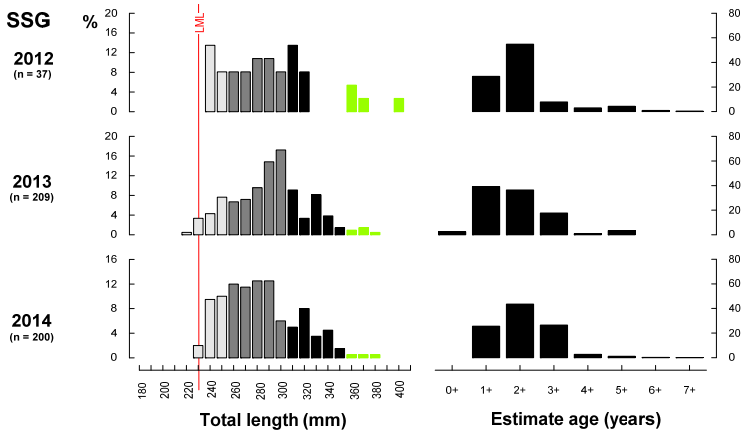


Figure 6.3. Annual size and age structures for Garfish sampled from Southern Spencer Gulf from 2012 to 2014. The red line denotes the legal minimum length (LML).

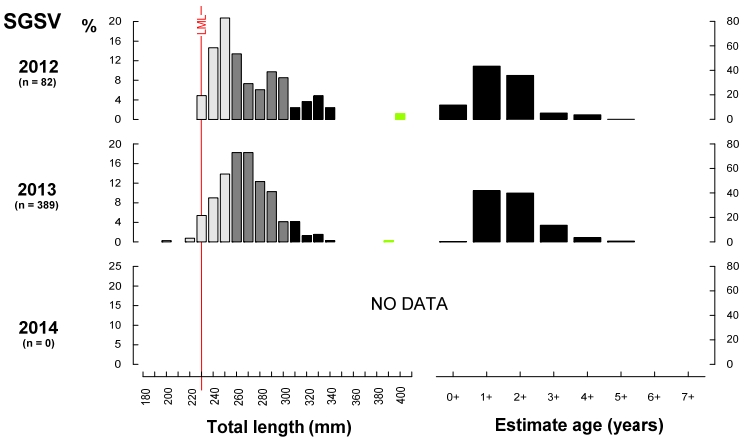


Figure 6.4. Annual size and age structures for Garfish sampled from Southern Gulf St. Vincent from 2012 to 2013. The red line denotes the legal minimum length (LML).

7. APPENDIX B: EFFORT STANDARDISATION

In previous assessments, 2012 and earlier, effort data were not standardised. Two changes in the fishery have increased the benefit of an external GLM-based standardisation procedure: (1) some Garfish hauling net operators have changed the target species reported, in some cases reporting 'Any' when the proportions of Garfish taken are high, and (2) in the management restructure of 2005, more than half of the hauling net endorsements were removed, introducing a break in the CPUE time trend. A GLM-based standardisation procedure where the effect of individual licences is explicit was implemented this year (2015) to account for the removal of those licences.

Because GarEst is an effort-conditioned model, a standardised effort time series is required. The method (Maunder and Punt 2004) is to estimate a half-yearly standardised CPUE using conventional GLM methods, and obtain the standardised effort by dividing data catches by the standardised CPUE. We standardised effort for only the target-plus hauling net (EType=1) effort type, but not for non-target hauling nets, dab nets, or recreational effort types.

The procedure followed to generate a half-yearly time series of standardised hauling net plus effort, separately for each gulf, is as follows:

1. For EType=1, include all hauling net records where Garfish was the reported target species and also any hauling net records where Garfish constituted 50% or more of the landed catch.
2. In R, fitting to all EType=1 records, run the GLM fit to these catch records. The model that predicts the catch rate of each record was CPUE ~ 0 + HalfYear + ModelMonth + LicenceNo + MFABlock with a Gamma residual error structure and an inverse (canonical) link function. We note:
    a. The "0" indicates that no overall intercept was fitted.
    b. All four data covariates are treated as factors, meaning an intercept is estimated for each level of each factor. So for each LicenceNo, the relative catching power was a freely estimated intercept.
    c. The standardised CPUE value taken for use in the assessment is the back-transformed HalfYear intercept for each half-yearly model time step and region.
3. Divide each standardised CPUE value by the reported effort for EType=1.

8. APPENDIX C: AGE-LENGTH 'SLICE' PARTIONING METHOD

The GarEst model is based on a method for representing the population structure of Garfish numbers, for each region, gulf and time step, broken down by age, and also by the lengths of fish within each age group, each recruited cohort. Representing population structure by both age and length improves model accuracy in a stock such as Garfish, where legal minimum length separates fish of very high fishing mortality from those incurring only natural mortality. As shown in Figure 7.2, faster growing Garfish, because they reach legal size sooner, incur 60-70% exploitation rates one or two years sooner than the slower growing fish in each cohort. The slice-partition stock assessment model formalism was developed (McGarvey and Feenstra 2004; McGarvey et al. 2007) to account for this length-asymmetric mortality explicitly, in a dynamic fashion, with a method that is computationally efficient. In addition, the three principal data sources, catch totals in weight, age proportions, and length proportions, are from the catch, and so include only Garfish above legal size. Cleanly separating sublegal from legal fish in the slice partition method thus permits a much more accurate prediction of these data quantities to be fitted.

The programming steps for calculating the three slice partition quantities used by GarEst are outlined in this appendix, summarizing the coding algorithm for implementing a slice partition in an age-based model. The main difference of this approach is that fish are not moved between fixed length bins. Rather it is the length bins themselves that grow. The Garfish within each bin, once assigned to it as they reach legal size, incur only mortality. This greatly improves model computational efficiency.

Additional computational efficiency was achieved by (1) employing the normal score for each slice partition point (fish lengths separating each slice), and (2) making midpoint approximations in place of more exact integrals under the pdf (for mean weights). (1) As the cohort of lengths grows to the right with each model time step, a standardized normal variate (the *z*-score or normal score) is assigned to each slice in the time step when it is first created, as that segment of the length-at-age pdf grows in the legal size range, each *z* given by the position of legal minimum length (LML) along the standardized normal length-at-age pdf, designating the left boundary of that new slice. This normal score value for each slice is unchanged thereafter as the mean and standard deviation of the cohort length pdf's grow with age. Thus, given the mean and standard deviation for all subsequent cohort ages, the fish lengths specifying slice left-hand partition points are calculated from the *z*-scores. The use of the normal score obviates the need for solving integral equations for lower limits of integration. However, this short-cut requires an assumption of

normally distributed fish lengths. A fixed P_{slice} probability under the pdf curve for each slice, which remains unchanged for all subsequent ages underlies the definition of slices, and also explains why the *z*-scores uniquely specify the slice partition for any chosen model age. (2) The fish mean weight in each slice is approximated by the weight-length function evaluated at the midpoint length of each slice (or, for the upper tail slice, the median probability length) rather than numerically integrating weight versus length across each slice subinterval.

The slice partition algorithm has 6 basic steps, coded by 6 iteration loops in ADMB. In each loop, calculations iterate over cohort age (for each region and sex, that is, for each distinct set of length-at-age growth parameters):

Step 1. Calculate the (1.1) mean length, $\bar{l}(a)$, and (1.2) standard deviation, $\sigma(a)$, and thus, also, the (1.3) *z*-score, $z(a) = (LML - \bar{l}(a))/\sigma(a)$, for every age (a) of growth. This step requires the input of growth submodel parameters specifying $\bar{l}$ and σ, given *a*. In this loop, calculate also (1.4) $P_{sublegal}(a) = \int_{-\infty}^{LML} p(l \mid \theta; a)\, dl$, and (1.5) $P_{legal}(a) = 1 - P_{sublegal}(a)$. For calculating the $P_{sublegal}(a)$ normal cumulative probabilities, we used the AD Model Builder cumd_norm function, which encapsulates the Abramowitz and Stegan (1965, formula 26.2.17) polynomial approximation and takes the standardized *z*-score as input.

Step 2. Calculate slice probabilities, $P_{slice}(a)$, the proportions of the cohort reaching legal size in each model age, $P_{slice}(a) = P_{legal}(a) - P_{legal}(a-1)$, $a = a_b+1, \ldots, a_{max}$, where, for GarEst, the birth age of cohort creation, $a_b = 3$, at the start of the third half-year (1 October in the summer following the summer of spawning) for all cohorts.

Step 3. Calculate the first of 3 output quantities, the fish transfer coefficients, $f_{transfer}(a) = P_{slice}(a) / P_{sublegal}(a-1)$, $a = a_b+1, \ldots, a_{max}$. No transfer coefficient is needed for birth age a_b cohorts, the population number for their one legal (upper-tail) slice given by $P_{slice}(a_b)$ (= $P_{legal}(a_b)$) times the total recruit number estimated for that cohort.

Step 4. Calculate the slice partition points, specifically the left-hand sides of each slice subinterval, specified as a triangular matrix by age and slice number, $l_{lhs}(a, s)$. The number of slices, for each legal cohort age, is given by $n_s(a) = a - a_b + 1$, $a = a_b, \ldots, a_{max}$. (4.1.) For newly created slices, whose slice subscript number equals the total number of legal slices, $n_s(a)$, the

left-hand-side partition point is, by definition, the legal minimum length (LML): $l_{lhs}(a,\ s = n_s(a))$ = LML, $a = a_b, \ldots, a_{max}$. (4.2) Looping over all other slices in each cohort age group, s = 1 to $n_s(a)-1$, the slice left-hand-sides are derived using the z-scores: $l_{lhs}(a,s) = \overline{l}\,(a) + \sigma(a)\cdot z(s-1+a_b)$.

Step 5. Calculate the second slice partition output quantity, the triangular matrix of central lengths for each slice, $l(a,s)$. (5.1) For all slices except upper-tail slices, the midpoints were used: $l(a,s) = \left(l_{lhs}(a,s) + l_{lhs}(a,\ s-1)\right)/2$. (5.2) For the upper tail slices, the central length was chosen to be the median probability value of the upper tail, whose z-score was calculated by $z_{median}(a, s=1) = \text{inv\_cumd\_norm}\left(1 - P_{legal}(a_b)/2\right)$. The inv_cumd_norm function in AD Model Builder (Abramowitz and Stegan 1965, formula 26.2.23) gives a standardized normal z-value for any given probability.

Step 6. Calculate the mean weights, evaluating the weight-length formula at each slice central length: $w(a,\ s) = \alpha\left(l(a,s)\right)^{\beta}$.

A graphical description of how these slice partition length bins are constructed is given in Figures 7.1 and 7.2.

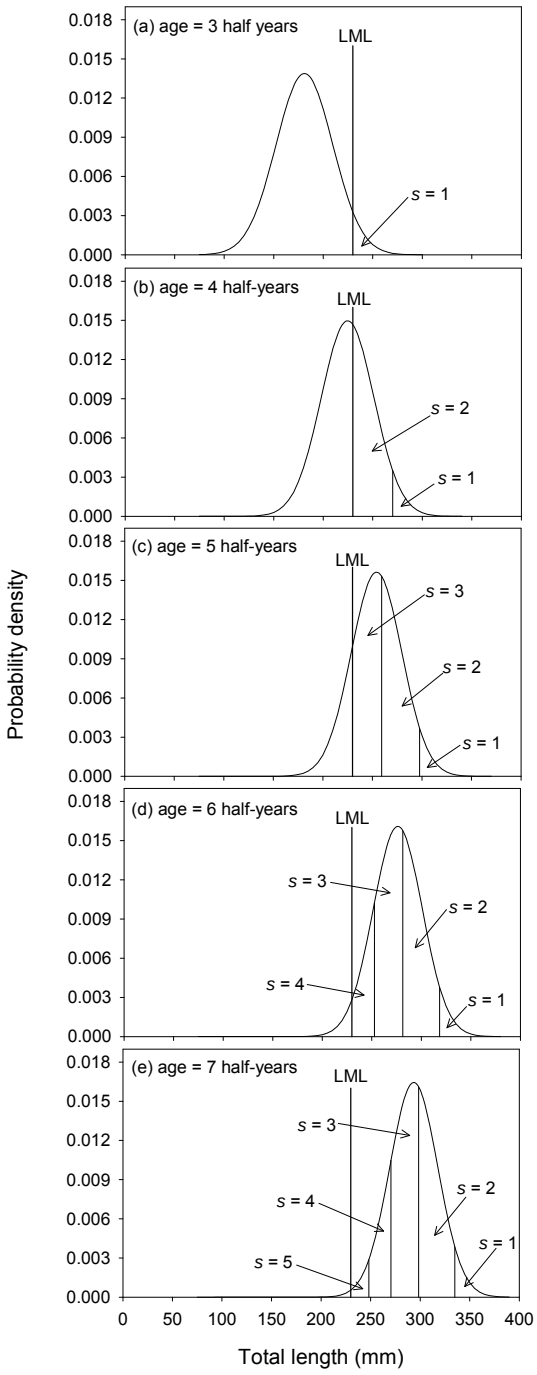


Figure. 7.1. The growth of a normal length-at-age Garfish cohort is shown in successive panels. With each time step, a new slice, as the fish of length newly grown above LML, numbered *s*=1, 2, etc., is created as shown. See Steps 1 and 2 above.

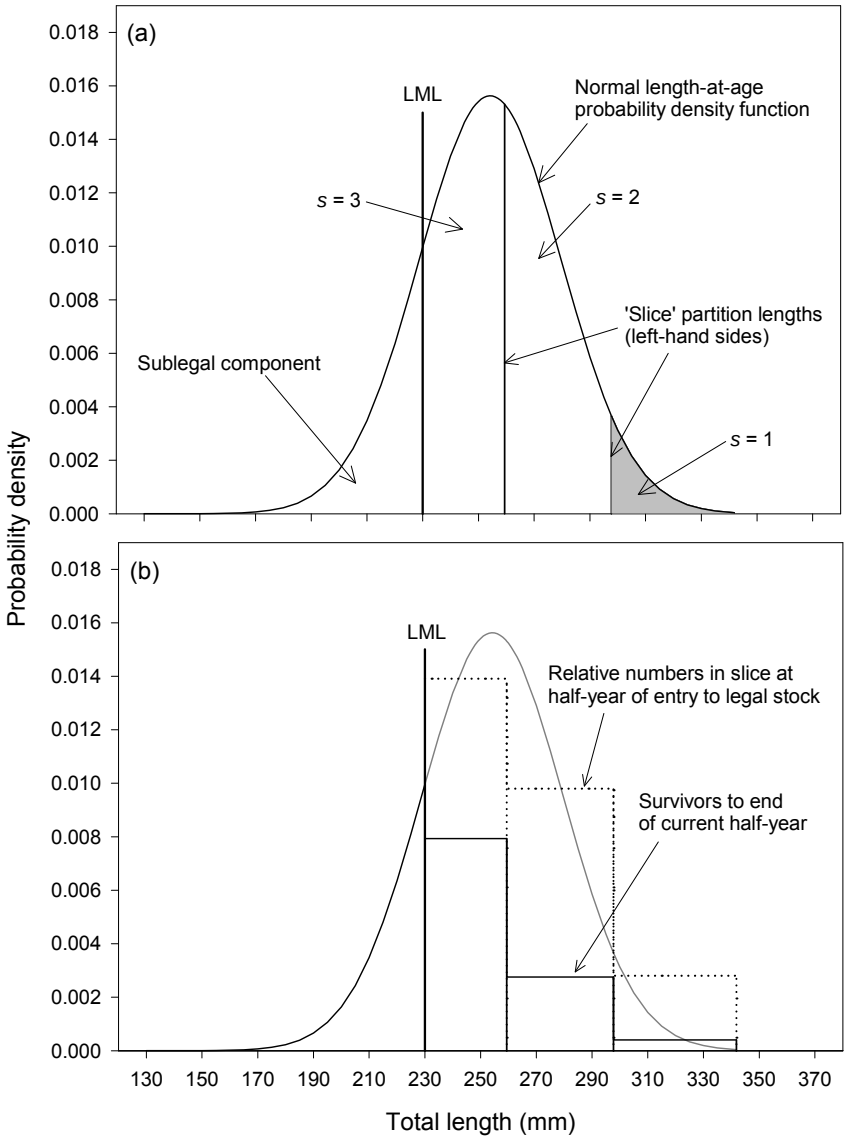


Figure. 7.2. (a) The transfer of Garfish from sublegal sizes (left of LML) to each newly created slice, is done using Step 3. (b) Subsequently, the proportional reductions in the population number in each slice differ depending on how long it has been exposed to fishing mortality, and on the length selectivity applying to each slice, in each model time step. In this Garfish stock, high fishing mortality causes population numbers the faster growing slice (s = 1, farthest slice to the right) to be greatly reduced compared to the more slowly growing members of their cohort.

9. APPENDIX D. GARFISH STOCK ASSESSMENT MODEL

In this section we summarise the following components of the stock assessment model: (1) growth, (2) recruitment, (3) the population array including length slices, (4) mortality, and (5) the likelihood function relating model to data. The slice-partition method was described in Appendix B.

9.1. Growth

The starting point and basis of the slice method for partitioning fish cohorts by length is the length-at-age growth submodel. A statistical growth submodel is needed which fully specifies the probability density function (pdf) of fish lengths for each model age. This represents the (normal) distribution of fish by length in each cohort age that would be observed in the absence of length-asymmetric mortality, because length-selective capture mortality will subsequently be imposed on these model cohorts, after they are partitioned into slices. To model mean fish length $\bar{l}$, the mean of the normal length-at-age pdf, for any cohort age, a, we employed a 4-parameter exponent-generalized von Bertalanffy mean length-at-age curve: $\bar{l}(a) = L_\infty \left\{1 - \exp\left[-K\left(\frac{a-t_0}{12}\right)\right]\right\}^r$ (McGarvey and Fowler 2002). Using two additional parameters, the dependence of the length-at-age standard deviation $\sigma(a)$ is modelled as an allometric function of mean length: $\sigma(a) = \sigma_0 \cdot \left(\bar{l}(a)\right)^{\sigma_1}$.

The growth parameters can be estimated by fitting to length-at-age samples (1) previous to, or (2) by integrating growth estimation into, the stock assessment likelihood. We undertook both in that order. First we fitted the growth submodel directly to catch lengths-at-age to obtain approximate growth parameter estimates. A likelihood probability of observation truncated at LML was assumed to make explicit the absence of sublegal Garfish in these catch samples (McGarvey and Fowler 2002). A second growth estimation was integrated into the stock assessment likelihood, re-estimating the two parameters that most directly determine the mean rate of growth and spread of lengths at each age, von Bertalanffy K and the normal length-at-age standard deviation coefficient σ_0.

Starting from this growth submodel, an algorithm (described in Appendix B) was devised to effectively 'slice off' the length subintervals of fish which have grown past legal minimum length (LML) in each model time step. Once this population number is assigned to each newly created

slice bin by transferring these fish from the sublegal component, there is no subsequent further exchange of fish between length bins. Fish within slices incur only mortality. The simplification of neglecting growth diffusion among length bins affords the slice approach large reductions in computation time compared with, for example, a length-transition approach, which requires $(n_L)^2$ growth-transition multiplications in each model time step and for each cohort, where n_L is the number of length bins. In a slice partition model, growth is quantified as the increasing length range with age of each slice subinterval, and no computation is needed to shift fish among bins.

9.2. Recruitment

Recruitment is defined as the creation of the (normal) length-at-age cohort at age a_b = 3 half-years (at age 1 year) when the fastest growing fish first reach legal size. The number of fish in each cohort at the birth age, a_b, is the model estimate of yearly recruitment. Each yearly recruit number is a freely estimated model parameter. The numbers of Garfish above legal minimum length at age a_b (in the upper tail of the length at age pdf) are computed (Appendix B) and defined as the first newly created slice. In subsequent model time steps, new slices are created as the calculated proportion of sublegal fish in each cohort that have grown into legal size since the previous time step, thereby modelling the gradual recruitment of each cohort to fishable sizes over the number of model time steps required, as determined by the growth submodel (Appendix B).

9.3. Model population array

The model Garfish population array $N(t,r,x,c,s)$ is 5-dimensional, fish numbers broken down by (1) half-yearly model time step, t, (2) spatial region, r, (3) sex, x, (4) cohort (i.e. year-class, given by year of spawning), c, and (5) slice, s.

Variable subscripts for winter or summer half-year (t_{season}), and cohort age in half-years (a), were calculated as functions of model time step, t, and cohort year, c. Ages ran from 3 to 12+ half-years, the oldest age being a 'plus' group. Garfish catch and effort, for data and model, were divided into four effort types, i_E: (i) hauling nets targeting Garfish, (ii) hauling nets not targeting Garfish, (iii) dab nets and minor gears, and (iv) recreationals. The two commercial gears, g, each with separate length selectivity, are hauling net and dab net. Data quantities, such as reported effort $\tilde{E}$, are denoted by a tilde.

9.4. Mortality

Mortality is differentiated for legal and sublegal fish. Legal-size fish, partitioned into length slices, are subject to both fishing and natural mortality. Length-dependent gear selectivity, and any other length-dependent mortality processes, are applied to the length-partitioned fish numbers, specifically in the legal size range. In addition to the knife-edge cut-off below legal minimum length, gear-specific length selectivity is modelled for legal size Garfish. Sublegal population numbers (fish below the legal size limit) incur only natural mortality.

The catch equations were effort conditioned. Thus, fishing mortality was written as a linear proportion of reported fishing effort for each component of catch:

(B.1) $$F(t,r,x,c,s,i_E) = q(r,\ t_{season},\ x,\ i_E)\ \cdot \tilde{E}(t,r,i_E)\ \cdot s_{len}(g(i_E),s)\,.$$

The catchability, q, was assumed to vary with region, season, sex, and effort type. Length selectivity, s_{len}, by gear type, followed a logistic function of fish length, the latter specified by the midpoint of each slice.

(B.2) $$s_{len}(g(i_E),s) = 1\Big/\left\{1+\exp\left[-r_{sel}\left(g(i_E)\right)\cdot\left(\bar{l}\,(s)-l_{50}\left(g(i_E)\right)\right)\right]\right\}.$$

Logistic length selectivity is varied in time to model recent regulated increases in hauling net pocket mesh size from 30 mm to 32 mm implemented in winter 2013 to reduce capture rates of undersize Garfish. Prior to winter 2013, hauling nets were assumed to retain all legal size Garfish. With the mesh size increase in winter 2013, the $l_{50}\left(g(i_E=1\ \&\ 2)\right)$ for hauling net gear (first two effort types) is given by regressions relating mesh size to l_{50} derived from a series of mesh selectivity experiments undertaken by SARDI and industry:

(B.3) $$l_{50}\left(g(i_E=1\ \&\ 2)\right) = \begin{cases} 7.9684\cdot meshsize - 29.203 & \text{in summer} \\ 6.4785\cdot meshsize + 32.246 & \text{in winter} \end{cases}.$$

For commercial effort, the catchability was written:

(B.4) $$q(r,t_{season},x,i_E) = q_{CSE}(r,t_{season},i_E)\cdot\ s_{SS}(t_{season},x)\cdot\left(1+q'\cdot(t-t_{mid})\right)$$

with q_{CSE} being the absolute catchability given as function of region, season, and effort type, a relative selectivity coefficient $s_{SS}(t_{season},x)$ describing the specifically sex-dependent seasonality of catchability, notably strong differences in sex ratios in the catch between summer and winter.

A linear time trend in catchability (changing effective effort) from the model start in 1983 to winter of 2001 was estimated as q', the rate of catchability increase relative to the time step t_{mid} = 22 half-years; q' = 0.01065 or 1.06% increase per half year, is retained from the 2012 estimate.

The instantaneous fishing mortality rate for each element of the population array is given by a sum of fishing mortalities over all fishing effort types:

$$F(t,r,x,c,s) = \sum_{i_E=1}^{n_E} F(t,r,x,c,s,i_E)\,. \tag{B.5}$$

The Baranov depletion equation for each element of the population array was written:

$$N(t+1,r,x,c,s) = N(t,r,x,c,s)\cdot\exp\left[-\left(M+F(t,r,x,c,s)\right)\cdot p_{yr}(t)\right] \tag{B.6}$$

where $p_{yr}(t)$ quantifies the proportion of a year spanned by the days in each half-yearly time step. Instantaneous natural mortality rate was taken as constant, M = 0.4 yr^{-1} (Jones 1990).

9.5. Estimation: Parameters and model likelihood

The model likelihood (Fournier and Archibald 1982) is fitted to (1) half-yearly catch totals by weight, (2) market sample catch proportions by age and sex, and (3) market sample catch moment properties of fish length for each age and sex.

9.5.1. Parameters

Estimated parameters for the model fall into seven categories: (1) yearly recruit numbers by region, (2) recruitment sex proportion (of females) by region, (3) catchabilities, (4) relative selectivities by sex and season, (5) logistic length selectivity, (6) growth, and (7) likelihood standard deviations of fits to half-yearly catch totals.

9.5.2. Likelihood for catch totals by weight

Model commercial catch totals by weight (kg) are fitted to data using a lognormal likelihood. The catch by weight is calculated using the standard Baranov formula as:

$$\hat{C}(t,r,x,c,s,i_E) = N(t,r,x,c,s)\cdot w(a(t,c),s)\cdot \frac{F(t,r,x,c,s,i_E)}{M+F(t,r,x,c,s)}\cdot\left\{1-\exp\left[-\left(M+F(t,r,x,c,s)\right)\cdot p_{yr}(t)\right]\right\} \tag{B.7}$$

where the weights by age and slice $w(a(t,c),s)$ are derived in Appendix B.

The likelihood factor for each combination of region, *r*, and commercial effort type (i_E up to $n_E - 1$), is written:

$$(B.8) \quad L_C = \prod_{t=1}^{n_t} \prod_{i_E=1}^{n_E-1} \prod_{r=1}^{n_r} \frac{1}{\sqrt{2\pi} \cdot \sigma_C \cdot \tilde{C}(t,r,i_E)} \exp\left[-\frac{1}{2} \left(\frac{\ln\left(\hat{C}(t,r,i_E)\right) - \ln\left(\tilde{C}(t,r,i_E)\right)}{\sigma_C} \right)^2 \right]$$

where

σ_C = the single estimated catch-likelihood standard deviation parameter;

$\tilde{C}(t,r,i_E)$ = reported catch by weight for each time step, *t*, region, *r*, and effort type, i_E;

$\hat{C}(t,r,i_E)$ = model-predicted catch by weight for each *t*, *r*, and i_E.

This lognormal likelihood form is also fitted to recreational ($i_E = n_E$) catch survey numbers (Section 2.2), from telephone and diary surveys run in 2001/02, 2007/08 and 2013/14. Between those survey years, recreational catch and effort totals, by region and season, were assumed to vary linearly between the survey-estimated values, and to retain the values of 2001/02 prior to that first survey, and retain the values of 2013/14 subsequently. Only catch number data for the full year by region were available from the 2013/14 survey recently completed, for which we assumed (1) survey catches by year were broken down into two half-years using proportions taken in winter of 15% for Spencer Gulf and 20% for Gulf St. Vincent, and (2) effort varied relative to 2007/08 values with the same slopes by gulf and season observed for catches.

9.5.3. Likelihood for catch samples by age and sex

A two-dimensional multinomial likelihood is used to fit to catch-sample proportions by sex and age, since both are attributes of a single catch sample data set. The fitted data, from the principal gear, hauling nets, in the two time steps and regions where catch was monitored, consists of the counts of sampled fish falling into each possible combination of sex and half-yearly age, $\tilde{n}(a, x;\ t,r)$. The multinomial likelihood factor is written:

(B.9) $$L_{AX} = \prod_{i_{AX}=1}^{n_{AX}} \prod_{a=a_b}^{12+} \prod_{x=0}^{1} \hat{p}(a, x; i_{AX})^{\tilde{n}(a, x; i_{AX})}$$

where

i_{AX} = index over the set of n_{AX} catch samples of fish age and sex;

$\hat{p}(a, x; i_{AX})$ = two-dimensional array of model-predicted fish proportions captured by age and sex, for each sampled half-year and region, indexed by i_{AX} ;

$\tilde{n}(a, x; i_{AX})$ = fish numbers for each age and sex, observed in the catch-at-age sample i_{AX} .

9.5.4. Likelihood for catch samples by length

A normal likelihood is applied to fit the model to data moment 'properties', mean length, standard deviation of length, skewness, and kurtosis. Fournier and Doonan (1987) first proposed fitting to length moments and also fitted a normal likelihood, but to the central moments rather than moment properties. The likelihood for the length moments fit is written:

(B.10) $$L_{mp} = \prod_{i_{AX}=1}^{n_{AX}(i_{mp})} \prod_{i_{mp}=1}^{4} \prod_{sex=0}^{1} \prod_{a=a_b}^{12+} \prod_{g=1}^{2} \left\{ \frac{\exp\left[-\frac{1}{2} \left(\frac{\left\{ \tilde{b}(i_{mp}, x, a, g; i_{AX}) - \right\}}{\sigma_{mp}(g)} \right)^2 \right]}{\sqrt{2\pi} \cdot \sigma_{mp}(g)} \right\}^{\tilde{n}_a(x,a,g; i_{AX})} .$$

We weighted each factor in the log-likelihood by the uncorrected sample size ($\tilde{n}_a(x,a,g; i_{AX})$), that is by the actual number of aged fish. Higher moment properties require more data to be

informative. We therefore set criteria for exclusion of smaller catch sample data sets, i_{AX} , from the L_{mp} likelihood, depending on the moment property fitted. Thus the number of qualifying data sets, $n_{AX}(i_{mp})$, decreased with increasing moment property i_{mp}. We required at least 16 aged fish for kurtosis, 8 for skewness, 4 for standard deviation, and 1 for fitting to mean length. Similarly we required 4 model slices for kurtosis, 3 for skewness, 2 for standard deviation, and 1 for fitting mean length.

10. APPENDIX E. MODEL FITS TO DATA

Parameters and thus stock performance indicators in the GarEst model are estimated by fitting to data for commercial catch totals by weight, recreational catch total numbers for years when recreational surveys are run (see Methods Section 2.4), and to commercial catch proportions by age and sex, in each half-yearly time step when sampling occurred. In this Appendix, graphs comparing fitted model and data indices are presented.

In Figure 9.1, model fits to the reported monthly Garfish catch totals are plotted for commercial catch in weight landed, for the 4 Garfish effort types in the two gulfs. Plots of fit to the proportions landed by age (Figure 9.2) and to sex ratios (Figure 9.3) from catch sampling are also shown below.

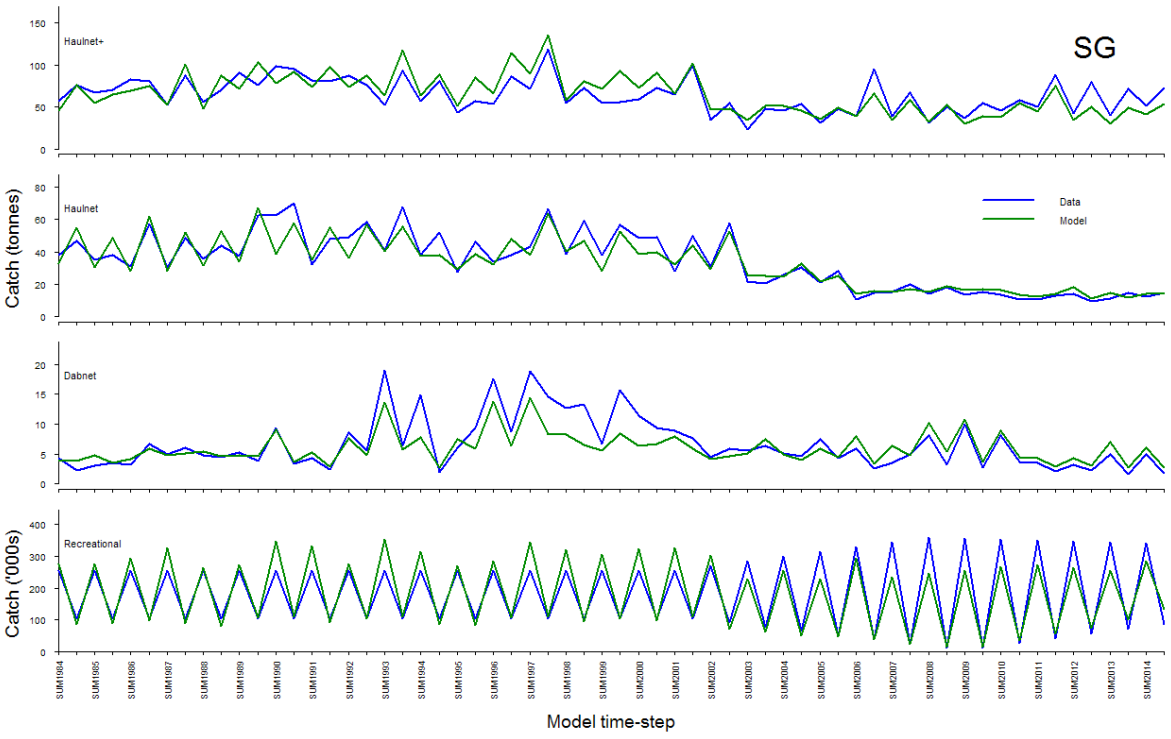


Figure 9.1a. Fits of Spencer Gulf model to data half-yearly catch totals for the 4 effort types.

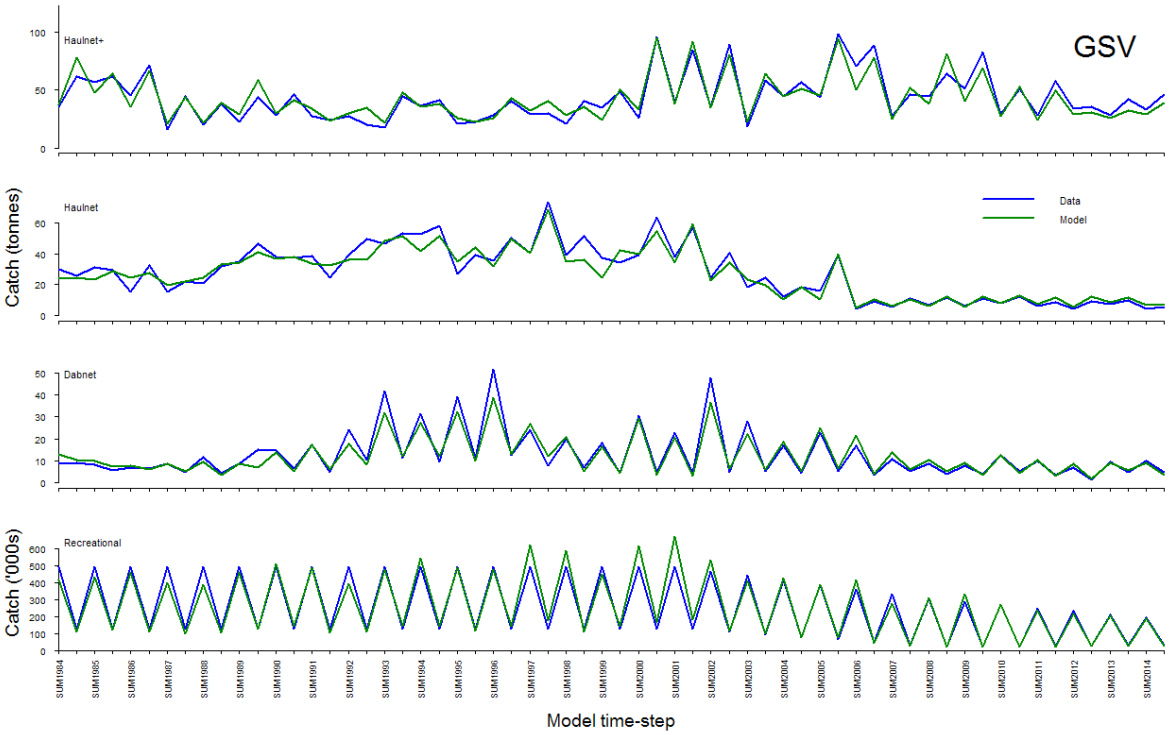


Figure 9.1b. Fits of Gulf St. Vincent model to data half-yearly catch totals for the four effort types.

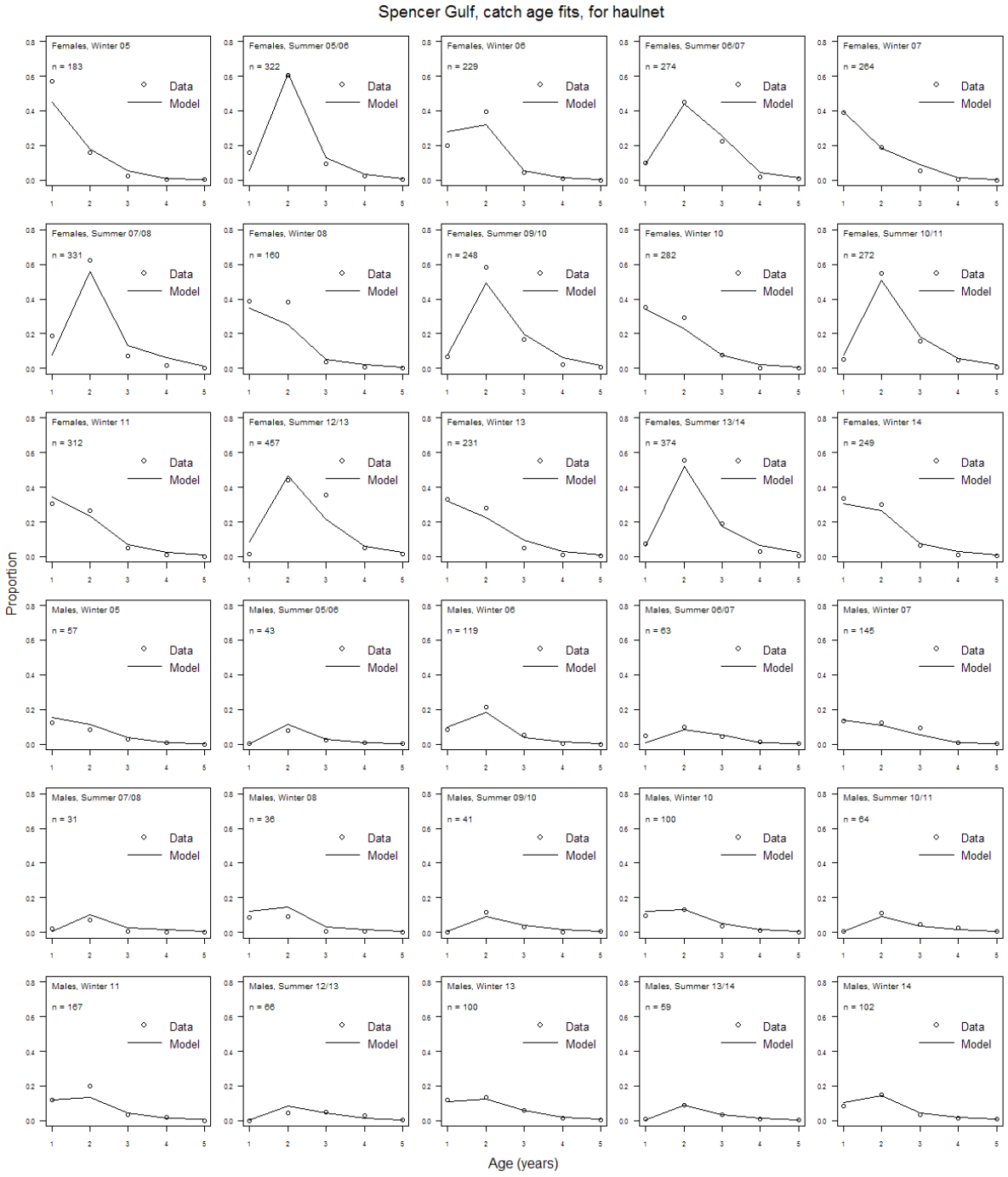


Figure 9.2a. Model fits to age proportions from catch samples. The 30 most recent Spencer Gulf data sets are shown by sex and half-yearly model time step.

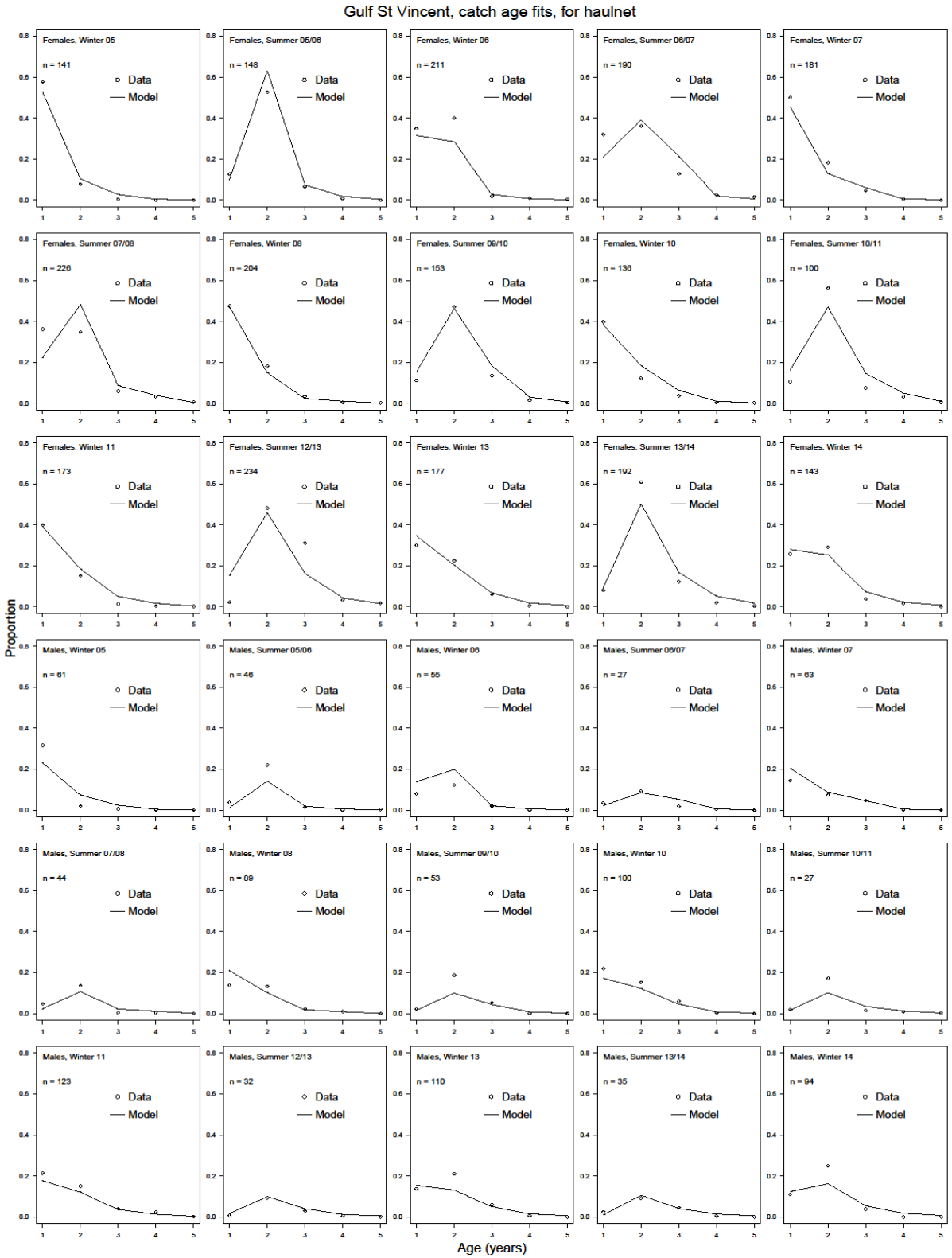


Figure 9.2b. Model fits to age proportions from catch samples. The 30 most recent Gulf St. Vincent data sets are shown by sex and half-yearly model time step.

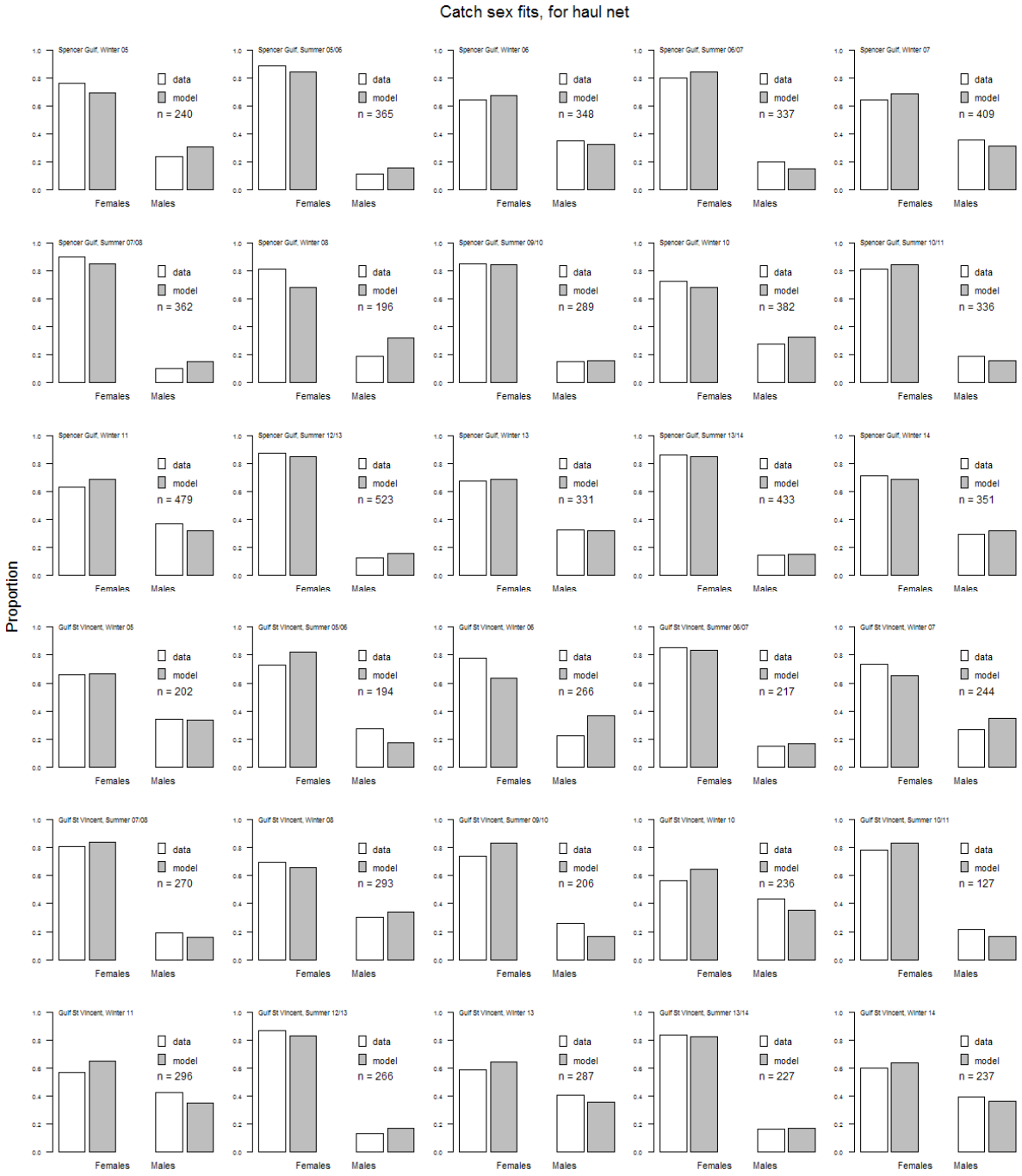


Figure 9.3. Model fits to sex ratios from SAFCOL market samples. The 30 most recent for Spencer Gulf are shown by gulf and half-yearly model time step.

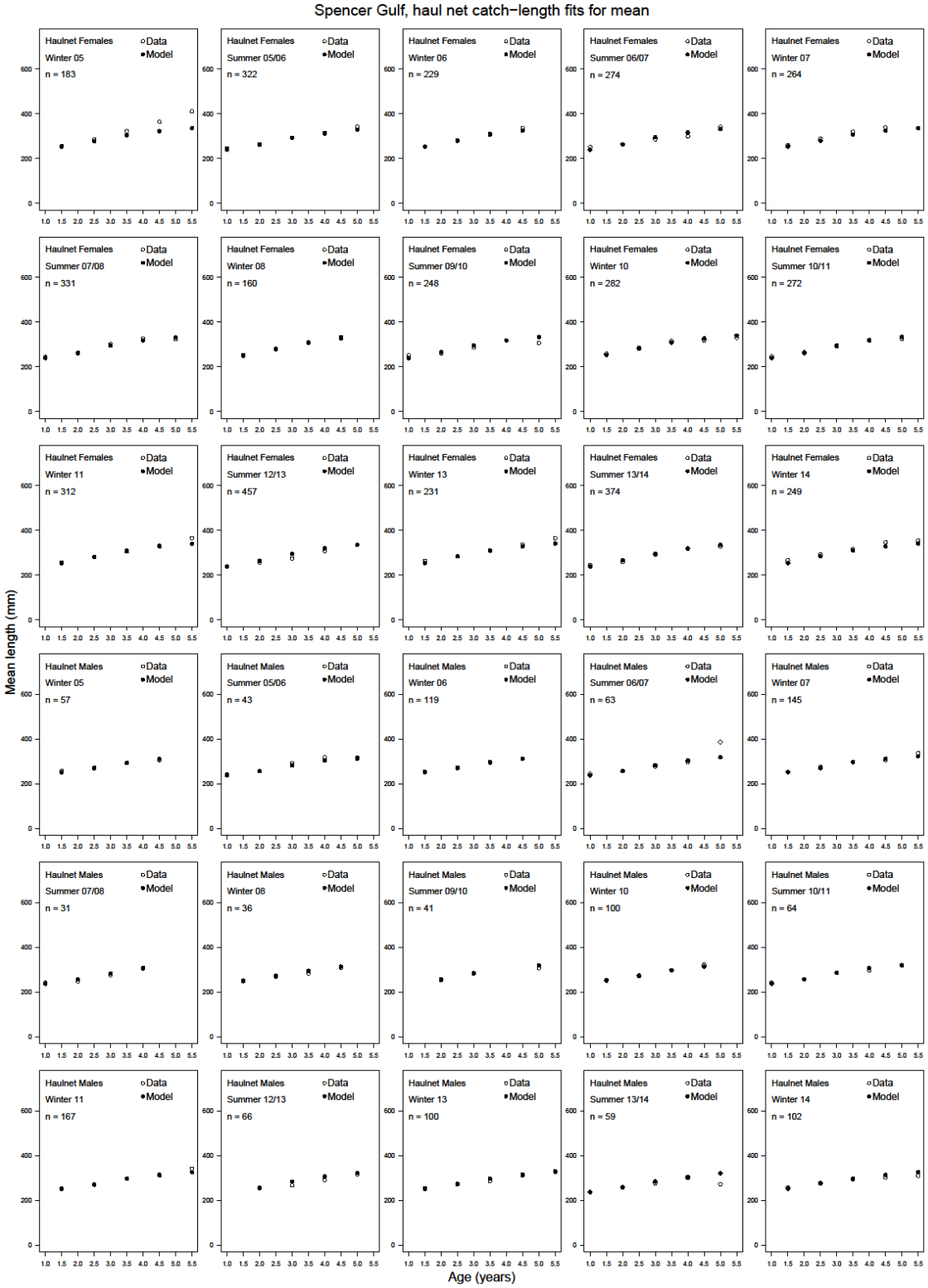


Figure 9.4a. Model fits to catch mean lengths of modelled cohorts from catch samples. The 30 most recent Spencer Gulf data sets are shown by sex and half-yearly model time step.

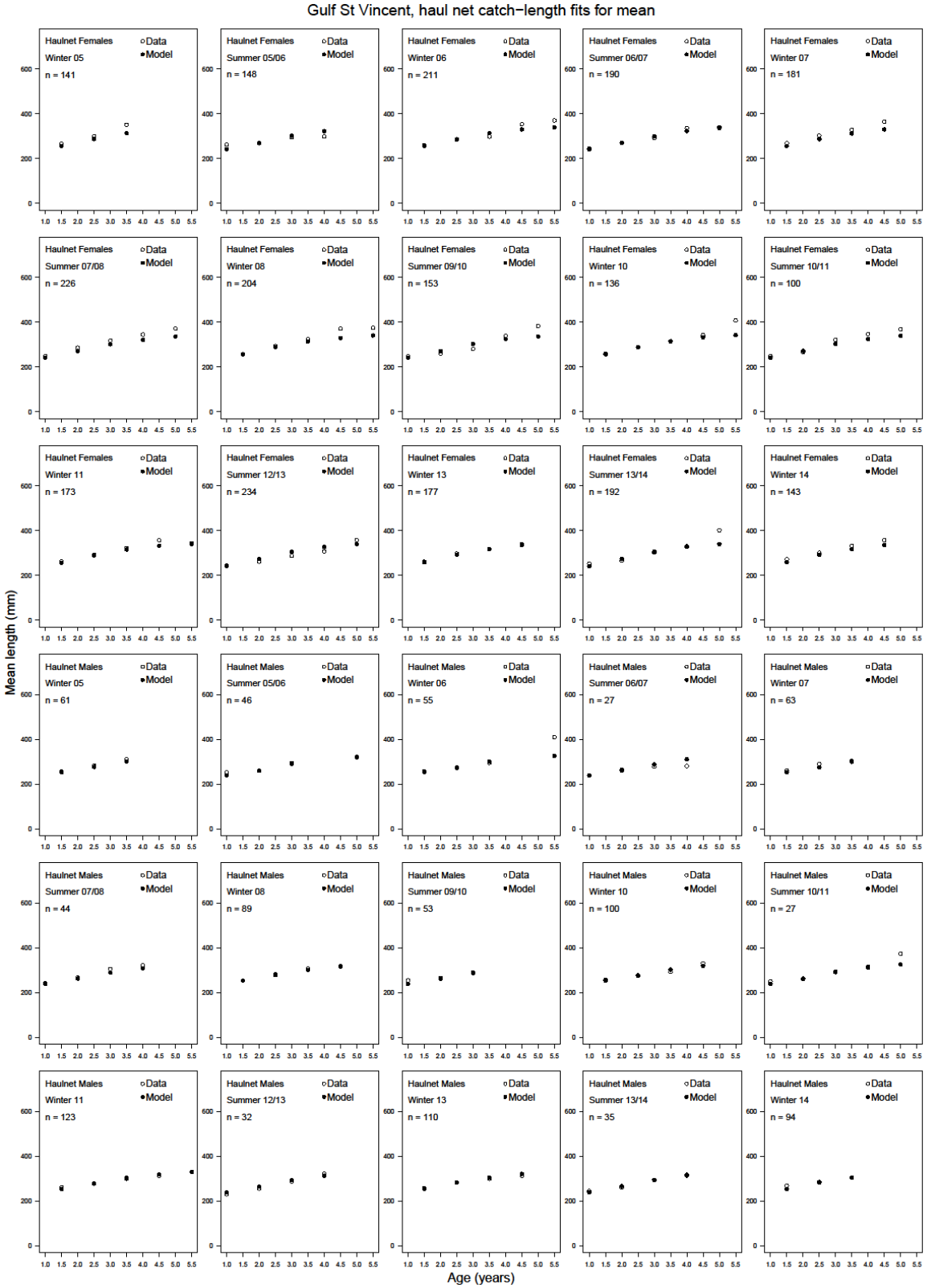


Figure 9.4b. Model fits to catch mean lengths of modelled cohorts from catch samples. The 30 most recent Gulf St. Vincent data sets are shown by sex and half-yearly model time step.

FRIEND OF THE SEA
Sustainable Seafood

Corrective Action Form	Recommendation ☐ to be checked during the following audit Minor NC X proposal within three weeks Major Nc ☐ implementation within 3/6 months	Form 08.01 Rev.01 18/01/2016

Ref. Check list :		Company name: **Ferguson Australia Proprietary Ltd** Site(s) audited: Adelaide, Kangaroo Island & Point Lincoln Contact person: Eliza Ferguson Sustainability manager: Contact details: eliza@fergusonaustralia.com Signature of the company representative:
Audit date: 14/12/2016	CB: **RINA SERVICES S.P.A.**	
Ref. Requirement: Point Checklist: **FOS - Wild – Non-Freezer Vessels Sustainable fishing Requirements**	Auditor : **Mr. Harry Owen**	

NC notification date	Deadline	Date of implementation/proposal
25/02/2017		
Notified by Mr. **Harry Owen**	Checked by _____	Accepted Yes ☐ No ☐

NC or recommendation description	Req. N. 3.1
3.1 Bycatch does include some ICUN red list species in some fisheries. However the main ICUN listed bycaught species is listed as vulnerable.	

AC proposal ☐ implementation ☐	Req. N.
Remark for the auditor: In case of implementation the auditor is kindly asked to provide evidences in attachment to this form	
All Ferguson Australia Gummy Shark is line-caught, so there is no bycatch or discard, as all fish are released. If any are caught an die, then these are recorded and are very low <0.25% of the total catch. See attachments	

Auditor comments (not mandatory)
Bycatch is of school shark is considered very rare. And although unrecorded it is therefore considered likely to be <0.25% of the total catch.

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

General Information and Instructions for Holders of Fishing Concessions

Purpose

This logbook is to be used when trawl fishing in Commonwealth Fisheries. It is designed to provide a continuous record of trawl fishing operations undertaken by Commonwealth fishing concession holders.

Accurate data collected in this logbook is essential to provide information for research into and management of Australian trawl fisheries.

Important Information and Instructions

Completing the logbook

- This logbook must be completed for every day that the fishing concession is in force, regardless of whether or not fishing takes place on that day (see the "Instruction Page" section).
- All logbook information must be recorded on a shot by shot and daily basis and details for the last day of the trip must be recorded before the boat docks at the end of each trip.
- The pages in this logbook are self-carbonating. Please use a ballpoint pen when completing forms. Place the fold-out flap under the original and duplicate pages to prevent writing transferring to the next set of forms.

Location of the logbook

- This logbook must be on board the boat that is nominated in respect of the fishing concession and named on the front of the logbook during trawl fishing operations.
- This logbook must remain within a 50 metre radius of the boat.

Who should use this logbook?

- The holder of the fishing concession is responsible for ensuring that this logbook is completed and that it is certified as complete and correct.
- The holder can do these things personally. Alternatively, the holder can ensure these things are done on their behalf by a person authorised in writing to do so by the fishing concession holder in the approved form. Contact AFMA on 02 6225 5555 (free call 1300 723 621) for details of how to authorise another person to complete the logbook.

Submitting logsheets

This logbook contains numbered pages in duplicate which are referred to as logsheets. Original copies must be returned to AFMA in date order in either the reply paid envelope provided or posted to:

The Logbook Co-ordinator
Australian Fisheries Management Authority
BOX 7051
Canberra Business Centre ACT 2610

For quota managed fisheries and/or fisheries that require the completion of a catch disposal record (CDR) the original copies of logsheets must be returned with the CDR for that trip within the time stipulated in the CDR instructions.

For all other fisheries the original copies of logsheets must be returned within 3 days of the completion of each fishing trip.

All duplicate copies of logsheets should be retained.

Penalties

Concession holders and persons completing this logbook on their behalf are advised that;

(i) a failure by a concession holder to ensure the completion of the logbook in accordance with these instructions;

(ii) the giving of false or misleading information in the logbook by the concession holder or a person completing the logbook on their behalf; or

(iii) the recording or communicating by the concession holder or anyone else of information in a logbook concerning the affairs of another person, or the giving by the concession holder or anyone else to another person of a part of a logbook in which information is recorded, (unless the recording, communicating or giving is done in accordance with the Fisheries Management Act 1991, Fisheries Administration Act 1991 or the Fisheries Management Regulations 1992 or an order of court, tribunal or a person authorised to receive evidence) may constitute serious offences under Commonwealth laws.

Concession holders are also advised that failure to ensure the completion of the logbook in accordance with the instructions may lead to suspension or cancellation of their concession.

Help Available

There is an example of a completed logsheet and further information and instructions about how to complete the logbook at the front of this logbook. If you have any questions or problems, please contact an AFMA Logbook Officer on 02 6225 5555 (free call 1300 723 621).

Australian Fisheries Management Authority
SWT01A
May 2008

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Instruction Page

Vessel, Gear and Contact Details

To be completed by the Concession Holder or Authorised Person and submitted to AFMA within 14 days of receipt of the logbook. A second Vessel, Gear and Contact Details Form is located in the middle of the logbook. Please complete and submit this form if any of the vessel and/or gear details change, or if the contact person for the vessels logbook has changed

Catch and Effort Log Page

When fishing, record details on a shot by shot basis.

Page Header

Enter the **Vessel Name** and **Distinguishing Symbol** here.

Date

Record the date when shot(s) were conducted.

Extended Non-Fishing Period

If you are not fishing for an extended period within the month(s), please specify the **non-fishing dates** and circle the appropriate **non-fishing code**. This will reduce the number of logsheets needed to account for every day your fishing concession is valid. Do not use single pages for single sequential non-fishing days.

Trip Dates

On the first sheet used for a trip record the date of departure, on the last page used for a trip record the date of return.

Trawl Details

Fishery
Circle the relevant code to indicate which fishery you are operating in.
Gear number
This is the number you allocated to different ground gears and nets on your vessel, gear and contact details sheet. Record the corresponding number of the ground gear and net you are using for that shot.
Cod end mesh size/ mesh orientation
Record the mesh size and indicate the orientation of the mesh by circling either **S** for square or **D** for diamond.
Ground gear height
Record the height of the largest part of the ground gear (ie. the largest bobbins or disks).
Trawl method
Circle the relevant code (one from each section) to indicate what trawl method you are using. A midwater trawl is considered to be a trawl where the gear intentionally does not go near the bottom for the duration of the tow.
Start and end shot times
Start times are when the gear setting has stopped. End time is when hauling begins. Please record all times using the 24 hour clock (eg. 1:00pm = 1300).

Trawl Details (cont.)

Start and End position
Start position is the position of the vessel when the gear setting has stopped. End position is the position of the vessel when gear hauling begins.
Average trawl depth
This is the average depth at which the net is towed during a shot. Please circle **m** (metres) or **fath** (fathoms) depending on which unit you are using.
Average temperature
This is the average temperature recorded at trawl depth during the shot. Please record it in degrees celsius. If you do not have a net monitor that records temperature put a dash in this space.
Shot valid
Circle '**Yes**' if the gear was deployed successfully or '**No**' if you had gear problems, ie. net was pinned up.

Catch Details

The accurately estimated weight in kilograms for all fish retained must be recorded on a shot by shot basis. The accurately estimated weight in kilograms for all fish discarded may also be recorded in the column provided on a shot by shot basis. The appropriate form code or discard code also needs to be recorded (see fold out flap). The common names of species caught but not pre-listed should be recorded in the blank spaces provided. Please be specific and record each species separately. If you run out of space, cross out the names of pre-listed species you did not catch and write in the new names.

Listed Marine and Threatened Species

Please circle **YES** or **NO** to indicate if your gear came into contact with or caught a listed marine or threatened species.
If you did have an interaction with a listed marine or threatened species please complete the Listed Marine and Threatened Species Form at the back of the logbook and submit it with the relevant log page.

Time Box

Time box – all Commonwealth Departments are required to have time boxes included on their forms. This initiative forms a part of the Government's regulatory reform strategy to reduce the paperwork and compliance burden on business.

Comments

Comments - This section is provided for any further information that you think may be important such as:
gear failure, weather, damaged fish, size of fish, loss of catch to seals etc.

Signature and Date Box

Each logsheet requires the date and signature of the Concession holder or Authorised Person (person authorised to act on behalf of the concession holder). The signature verifies that the information recorded in the logbook is an accurate record of the fishing operation including estimated landed weights.

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date: 15 / 10 / 06

Boat Name: Deep Blue

Dist. Symbol: LFB123

TRIP DATES

Departed: 15/10/06

Returned: 15/10/06

EXTENDED NON-FISHING

I did not work between 6/10/06 and 14/10/06

NON-FISHING CODE (Circle)

(In Port)	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	(GAB) WDW SPF HS Other	GAB (WDW) SPF HS Other	GAB WDW (SPF) HS Other
Gear No. (from gear sheet)	Ground 1 Net 2	Ground 1 Net 1	Ground Net
Cod end mesh size (mm) / Mesh (square or diamond)	100 S (D)	100 S (D)	40 S (D)
Ground gear disc height	9 inch/~~cm~~	9 inch/~~cm~~	— inch/cm
Trawl method (circle one from each section)	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 DEM (MID)
Start time of shot	0400	1700	1715
Start position degrees:minutes Latitude	32 25	29 17	41 17
Start position degrees:minutes Longitude	129 58	112 23	148 40
End time of shot	0550	1920	2230
End position degrees:minutes Latitude	32 29	29 27	41 40
End position degrees:minutes Longitude	130 05	112 26	148 43
Average trawl depth	420 m/~~fath~~	240 m/~~fath~~	120 m/~~fath~~
Trawl depth average temp	8	14	14
Shot valid (circle)	(Yes) No	(Yes) No	(Yes) No

CATCH DETAILS

Estimate weight (kg) of each species		Shot 1 Weight Kept	Shot 1 Form Code	Shot 1 Weight Discarded	Shot 1 Dis. Code	Shot 2 Weight Kept	Shot 2 Form Code	Shot 2 Weight Discarded	Shot 2 Dis. Code	Shot 3 Weight Kept	Shot 3 Form Code	Shot 3 Weight Discarded	Shot 3 Dis. Code
Deepwater Flathead	FLD	320	W										
Bight Redfish	REB	10	W										
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC					300	W	10	DM				
Yellowspot Boarfish	BOP					80	W						
Big Spine Boarfish	BOB												
Knifejaw	KNI					100	W						
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA					40	W						
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH	60	TR										
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY									4000	W		
Redbait	PEA									1000	W		
Wobbegong						20	TR						
Whiskery sharks						30	TR						
Rankin Cod													
Red Emporer													
Barracouta				100	UM					200	W	50	DM

Please provide an estimate of the time taken to complete this form: 20 mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes (No)

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name: Amos Poulas

Comments:

Signature: Amos Poulos Date 15/10/06

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date:

Boat Name:

Dist. Symbol:

TRIP DATES

Departed: / /

Returned: / /

EXTENDED NON-FISHING

I did not work between / / and / /

NON-FISHING CODE (Circle)

In Port	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	GAB WDW SPF HS Other	GAB WDW SPF HS Other	GAB WDW SPF HS Other
Gear No. (from gear sheet)	Ground / Net	Ground / Net	Ground / Net
Cod end mesh size (mm) / Mesh (square or diamond)	S D	S D	S D
Ground gear disc height	inch/cm	inch/cm	inch/cm
Trawl method (circle one from each section)	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID
Start time of shot			
Start position degrees:minutes – Latitude			
Start position degrees:minutes – Longitude			
End time of shot			
End position degrees:minutes – Latitude			
End position degrees:minutes – Longitude			
Average trawl depth	m/fath	m/fath	m/fath
Trawl depth average temp			
Shot valid (circle)	Yes No	Yes No	Yes No

CATCH DETAILS

Estimate weight (kg) of each species		SHOT 1 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 2 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 3 Weight Kept	Form Code	Weight Discarded	Dis. Code
Deepwater Flathead	FLD												
Bight Redfish	REB												
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC												
Yellowspot Boarfish	BOP												
Big Spine Boarfish	BOB												
Knifejaw	KNI												
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA												
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH												
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY												
Redbait	PEA												

Please provide an estimate of the time taken to complete this form: ____ mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes No

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name:

Comments:

Signature: Date / /

Please remember

- The details for a shot must be recorded before hauling the next shot. Details for the last shot of the trip must be completed before the vessel enters port.
- In this logbook you must account for every day that your Fishing Concession is in force, regardless of whether or not you fish on that day.

Trawl Method Codes	Form (Processing) Codes
OT = Otter board trawl	**W** = Whole
DS = Danish seine	**HG** = Headed and gutted
PA = Pair trawl	**F** = Filleted
OT2 = Twin rig	**GG** = Gilled and gutted
DEM = Demersal trawl	**G** = Gutted
MID = Midwater trawl	**TR** = Trunked (shark)
	FB = Trunked and belly flaps off (shark)
	TA = Tails (scampi, bugs and lobsters)

Discard Codes
NQ = No Quota
MP = Market Price
US = Under Size
UM = Un-marketable
DM = Damaged

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Listed Marine and Threatened Species List

Under the *Environment Protection and Biodiversity Conservation Act 1999* the following species are listed as protected. This list is current at the date of publishing. For further information about Listed Marine and Threatened Species or to check updates to these lists please go to **www.deh.gov.au.**

Please be as specific as you can with regard to the species identification.

LISTED MARINE SPECIES

Fish
All species of Syngnathid (Pipefish, Seahorses & Sea Dragons).

Marine Reptiles
All species of Turtle, Sea Snake and Crocodile.

Seals
All species of Seal and Sea Lion.

Cetaceans
All species of Dolphin, Whale, Porpoise and Dugong.

Sea Birds
All species of Seabird.

THREATENED FISH SPECIES

Grey Nurse Shark *(Carcharias taurus)* - East and west coast population

Speartooth Shark *(Glyphis sp. A)*

Northern River Shark *(Glyphis sp. C)*

Great White Shark *(Carcharodon carcharias)*

Freshwater Sawfish *(Pristis microdon)*

Whale Shark *(Rhincodon typus)*

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Vessel, Gear and Contact Details

SWT01A – Daily Fishing Log

Original Copy – Send to AFMA

Log No:	Boat Name:	Dist. Symbol:

Vessel Details

Length (LOA)	metres	Main engine/s power	kw / hp
Beam	metres	Kort nozzle	Yes / No
Draught	metres	Variable pitch prop	Yes / No
Fish hold capacity	cubic metres	Processing facilities (type)	
Principal operation of vessel (circle)		Freezer Vessel (circle)	Yes / No
Finfish Trawl Prawn Trawl Other:		Homeport	

Gear Details

Ground gear

	Gear 1	Gear 2	Gear 3	Gear 4
Type (from diagram)				
Length	m/f	m/f	m/f	m/f
Weight	kg	kg	kg	kg

Bycatch Reduction Devices

Description

Nets

	Net 1	Net 2	Net 3	Net 4
Type (from descriptions below)				
Headrope length	m/f	m/f	m/f	m/f
Footrope length	m/f	m/f	m/f	m/f
Headline height	m/f	m/f	m/f	m/f
Estimated wing spread	m/f	m/f	m/f	m/f
Max wing mesh size	cm/in	cm/in	cm/in	cm/in

Sweep length	m/f
Bridle length	m/f
Maximum depth vessel can fish	m/f

Contact Details for Vessel's Logbook

Preferred contact person		Other contact person	
Name		Name	
Person's role (eg. skipper)		Person's role (eg. skipper)	
Mobile		Mobile	
Business Phone		Business Phone	
Fax			
Email			
Address			

Skipper's experience (years)

Please provide an estimate of time to complete this form.

Concession Holder or Authorised Person to complete

Printed Name	Signature
	/ /

Net Types

WT = Wing trawl
2 seam net, moderate headline height (3-5m)

CWT = Cutaway wing trawl
Wing trawl with the wing length shortened

SN = Scratch net (commonly referred to by fishers as a "spag" net)
2 seam net, long wings and low headline height (2-4m)

HL = High lift net
or "Balloon Trawl" "Box Trawl" "Sea Star" or "Champion"
4 seam net, high opening (5m +)

OT = Other
Describe:

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name	
Distinguishing Symbol	

Date of Interaction	/ /		
Corresponding logsheet no.			
Observer on board (tick box)	Yes	No	

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each **individual**, except for Syngnathids (Sea Horses)	No. of Sea Horses	**Time at which Interaction occurred** (24hr)	**Latitude/Longitude** of interaction		**Caught During Fishing Operation** (tick one box only)			**Band or Tag Number**	**Life Status** (tick one box only)		
			dd mm	ddd mm	Haul	Set	Other		Alive	Dead	Injured
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person **Signature and Date:** / /

Concession Holder/Authorised Person **Printed Name:**

WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form **min.**

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name

Distinguishing Symbol

Date of Interaction / /

Corresponding logsheet no.

Observer on board (tick box) Yes No

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each individual, except for Syngnathids (Sea Horses) | No. of Sea Horses | Time at which Interaction occurred (24hr) | Latitude/Longitude of interaction (dd mm, ddd mm) | Caught During Fishing Operation (tick one box only) (Haul, Set, Other) | Band or Tag Number | Life Status (tick one box only) (Alive, Dead, Injured)

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person Signature and Date: / /

Concession Holder/Authorised Person Printed Name:

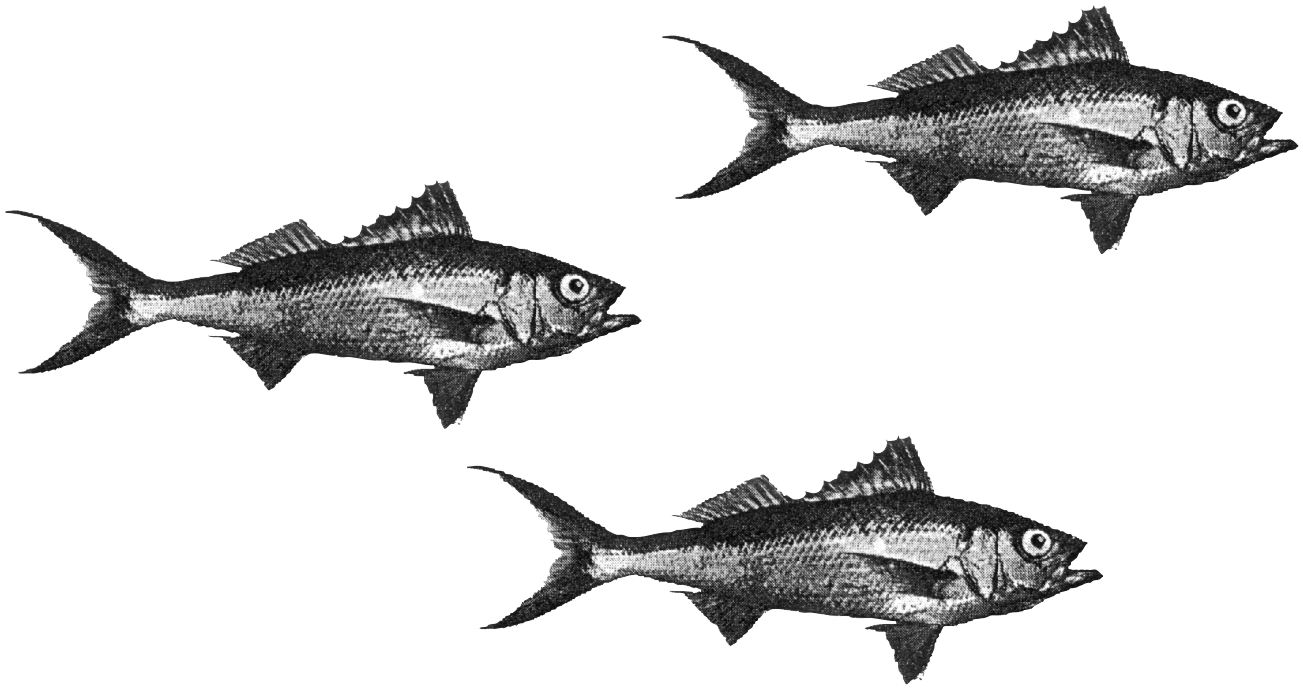
WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form min.

Australian Government

Australian Fisheries Management Authority

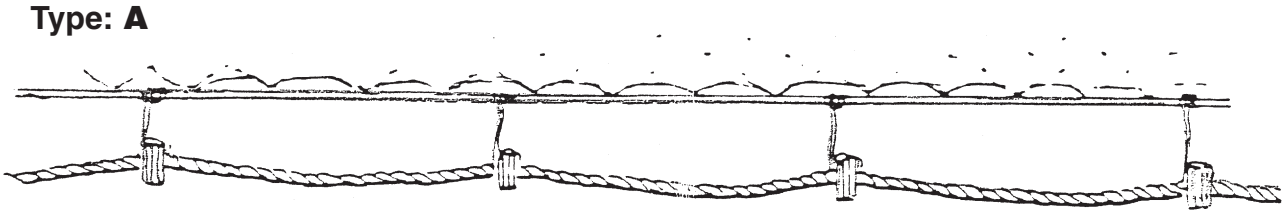
Southern and Western Finfish Trawl
Daily Fishing Log
SWT01A



Vessel Name

Ground Gear Types

Type: A



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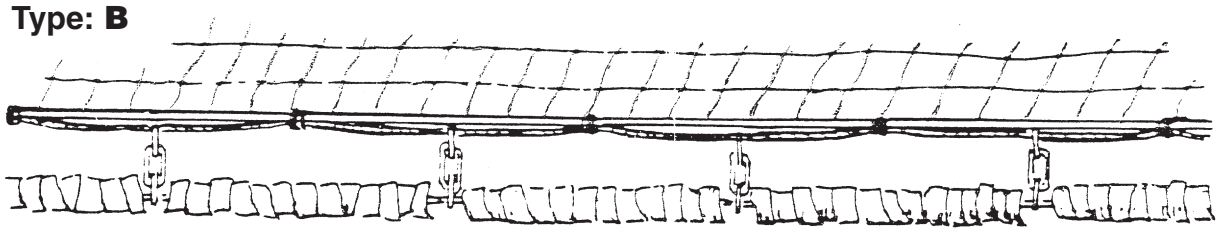

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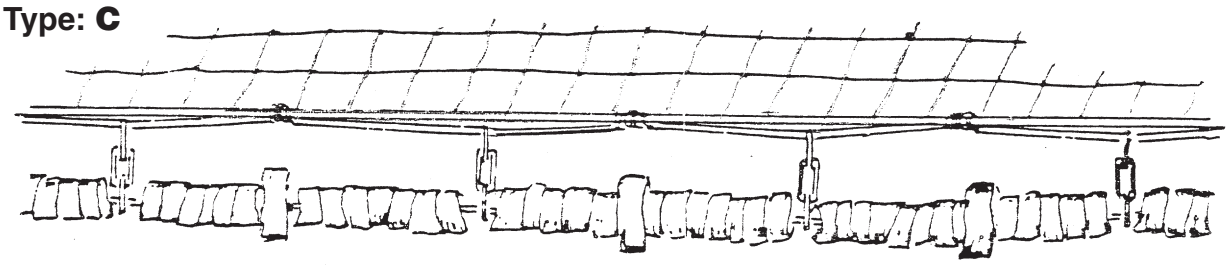

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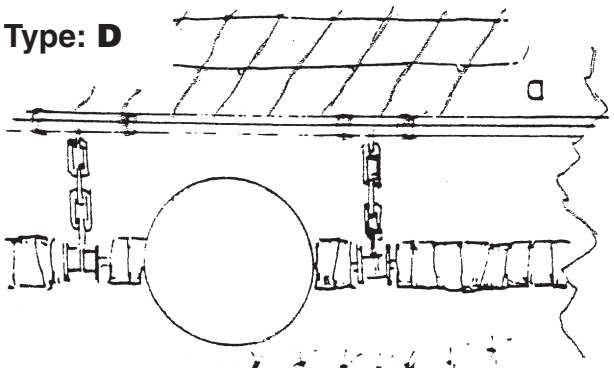

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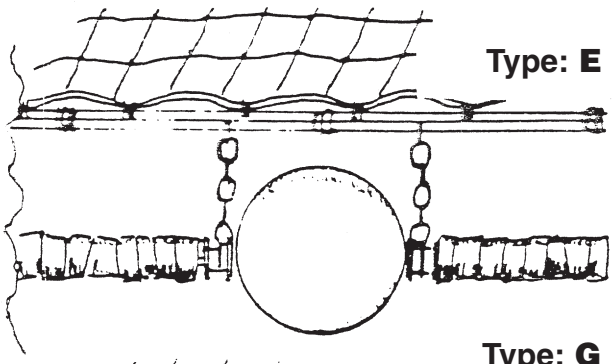

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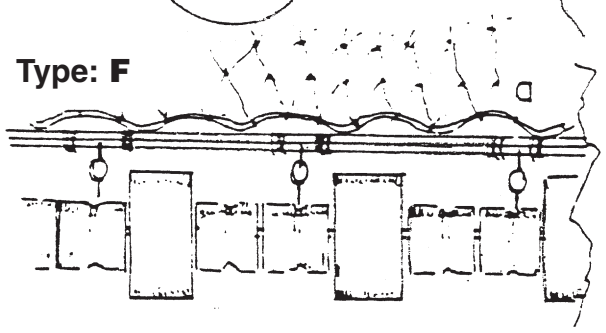

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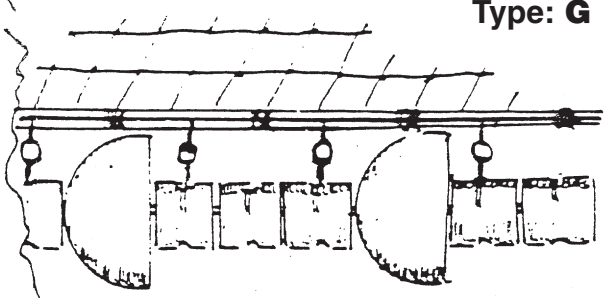


Diagram from Prado,J (1990). Fisherman's workbook.
Fishing Technology Service, FAO.

FRIEND OF THE SEA
Sustainable Seafood

Corrective Action Form	Recommendation ☐ to be checked during the following audit Minor NC X proposal within three weeks Major Nc ☐ implementation within 3/6 months	Form 08.01 Rev.01 18/01/2016

Ref. Check list :		Company name: **Ferguson Australia Proprietary Ltd** Site(s) audited: Adelaide, Kangaroo Island & Point Lincoln Contact person: Eliza Ferguson Sustainability manager: Contact details: eliza@fergusonaustralia.com Signature of the company representative:
Audit date: 14/12/2016	CB: **RINA SERVICES S.P.A.**	
Ref. Requirement: Point **3.2** Checklist: **FOS - Wild – Non-Freezer Vessels Sustainable fishing Requirements**	Auditor : **Mr. Harry Owen**	

NC notification date	Deadline	Date of implementation/proposal
25/02/2017		
Notified by Mr. **Harry Owen**	Checked by _____	Accepted Yes ☐ No ☐

NC or recommendation description	Req. N. **3.2**
3.2 Discards are not recorded for all fisheries so it is not possible to know if the rate is >8% however most fishing gears are selective so the rate is likely very low. For the Flathead fishery discards are around 9%.	

AC proposal ☐ implementation ☐	Req. N.
Remark for the auditor: In case of implementation the auditor is kindly asked to provide evidences in attachment to this form	
Most of Ferguson Australia's fish are line-caught, dap caught or trap caught so very small discard or bycatch rates. Flathead fishery is using net fishing gear but has low discards at 9%, which is all recorded by the fishermen and Australian Government. Commonwealth operators are required to record all bycaught species (see logbook attached)	

Auditor comments (not mandatory)

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

General Information and Instructions for Holders of Fishing Concessions

Purpose

This logbook is to be used when trawl fishing in Commonwealth Fisheries. It is designed to provide a continuous record of trawl fishing operations undertaken by Commonwealth fishing concession holders.

Accurate data collected in this logbook is essential to provide information for research into and management of Australian trawl fisheries.

Important Information and Instructions

Completing the logbook

- This logbook must be completed for every day that the fishing concession is in force, regardless of whether or not fishing takes place on that day (see the "Instruction Page" section).
- All logbook information must be recorded on a shot by shot and daily basis and details for the last day of the trip must be recorded before the boat docks at the end of each trip.
- The pages in this logbook are self-carbonating. Please use a ballpoint pen when completing forms. Place the fold-out flap under the original and duplicate pages to prevent writing transferring to the next set of forms.

Location of the logbook

- This logbook must be on board the boat that is nominated in respect of the fishing concession and named on the front of the logbook during trawl fishing operations.
- This logbook must remain within a 50 metre radius of the boat.

Who should use this logbook?

- The holder of the fishing concession is responsible for ensuring that this logbook is completed and that it is certified as complete and correct.
- The holder can do these things personally. Alternatively, the holder can ensure these things are done on their behalf by a person authorised in writing to do so by the fishing concession holder in the approved form. Contact AFMA on 02 6225 5555 (free call 1300 723 621) for details of how to authorise another person to complete the logbook.

Submitting logsheets

This logbook contains numbered pages in duplicate which are referred to as logsheets. Original copies must be returned to AFMA in date order in either the reply paid envelope provided or posted to:

The Logbook Co-ordinator
Australian Fisheries Management Authority
BOX 7051
Canberra Business Centre ACT 2610

For quota managed fisheries and/or fisheries that require the completion of a catch disposal record (CDR) the original copies of logsheets must be returned with the CDR for that trip within the time stipulated in the CDR instructions.

For all other fisheries the original copies of logsheets must be returned within 3 days of the completion of each fishing trip.

All duplicate copies of logsheets should be retained.

Penalties

Concession holders and persons completing this logbook on their behalf are advised that;

(i) a failure by a concession holder to ensure the completion of the logbook in accordance with these instructions;

(ii) the giving of false or misleading information in the logbook by the concession holder or a person completing the logbook on their behalf; or

(iii) the recording or communicating by the concession holder or anyone else of information in a logbook concerning the affairs of another person, or the giving by the concession holder or anyone else to another person of a part of a logbook in which information is recorded, (unless the recording, communicating or giving is done in accordance with the Fisheries Management Act 1991, Fisheries Administration Act 1991 or the Fisheries Management Regulations 1992 or an order of court, tribunal or a person authorised to receive evidence) may constitute serious offences under Commonwealth laws.

Concession holders are also advised that failure to ensure the completion of the logbook in accordance with the instructions may lead to suspension or cancellation of their concession.

Help Available

There is an example of a completed logsheet and further information and instructions about how to complete the logbook at the front of this logbook. If you have any questions or problems, please contact an AFMA Logbook Officer on 02 6225 5555 (free call 1300 723 621).

Australian Fisheries Management Authority
SWT01A
May 2008

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Instruction Page

Vessel, Gear and Contact Details

To be completed by the Concession Holder or Authorised Person and submitted to AFMA within 14 days of receipt of the logbook. A second Vessel, Gear and Contact Details Form is located in the middle of the logbook. Please complete and submit this form if any of the vessel and/or gear details change, or if the contact person for the vessels logbook has changed

Catch and Effort Log Page

When fishing, record details on a shot by shot basis.

Page Header

Enter the **Vessel Name** and **Distinguishing Symbol** here.

Date

Record the date when shot(s) were conducted.

Extended Non-Fishing Period

If you are not fishing for an extended period within the month(s), please specify the **non-fishing dates** and circle the appropriate **non-fishing code**. This will reduce the number of logsheets needed to account for every day your fishing concession is valid. Do not use single pages for single sequential non-fishing days.

Trip Dates

On the first sheet used for a trip record the date of departure, on the last page used for a trip record the date of return.

Trawl Details

Fishery
Circle the relevant code to indicate which fishery you are operating in.
Gear number
This is the number you allocated to different ground gears and nets on your vessel, gear and contact details sheet. Record the corresponding number of the ground gear and net you are using for that shot.
Cod end mesh size/ mesh orientation
Record the mesh size and indicate the orientation of the mesh by circling either **S** for square or **D** for diamond.
Ground gear height
Record the height of the largest part of the ground gear (ie. the largest bobbins or disks).
Trawl method
Circle the relevant code (one from each section) to indicate what trawl method you are using. A midwater trawl is considered to be a trawl where the gear intentionally does not go near the bottom for the duration of the tow.
Start and end shot times
Start times are when the gear setting has stopped. End time is when hauling begins. Please record all times using the 24 hour clock (eg. 1:00pm = 1300).

Trawl Details (cont.)

Start and End position
Start position is the position of the vessel when the gear setting has stopped. End position is the position of the vessel when gear hauling begins.
Average trawl depth
This is the average depth at which the net is towed during a shot. Please circle **m** (metres) or **fath** (fathoms) depending on which unit you are using.
Average temperature
This is the average temperature recorded at trawl depth during the shot. Please record it in degrees celsius. If you do not have a net monitor that records temperature put a dash in this space.
Shot valid
Circle '**Yes**' if the gear was deployed successfully or '**No**' if you had gear problems, ie. net was pinned up.

Catch Details

The accurately estimated weight in kilograms for all fish retained must be recorded on a shot by shot basis. The accurately estimated weight in kilograms for all fish discarded may also be recorded in the column provided on a shot by shot basis. The appropriate form code or discard code also needs to be recorded (see fold out flap). The common names of species caught but not pre-listed should be recorded in the blank spaces provided. Please be specific and record each species separately. If you run out of space, cross out the names of pre-listed species you did not catch and write in the new names.

Listed Marine and Threatened Species

Please circle **YES** or **NO** to indicate if your gear came into contact with or caught a listed marine or threatened species.
If you did have an interaction with a listed marine or threatened species please complete the Listed Marine and Threatened Species Form at the back of the logbook and submit it with the relevant log page.

Time Box

Time box – all Commonwealth Departments are required to have time boxes included on their forms. This initiative forms a part of the Government's regulatory reform strategy to reduce the paperwork and compliance burden on business.

Comments

Comments - This section is provided for any further information that you think may be important such as:
gear failure, weather, damaged fish, size of fish, loss of catch to seals etc.

Signature and Date Box

Each logsheet requires the date and signature of the Concession holder or Authorised Person (person authorised to act on behalf of the concession holder). The signature verifies that the information recorded in the logbook is an accurate record of the fishing operation including estimated landed weights.

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date: 15 / 10 / 06

Boat Name: Deep Blue

Dist. Symbol: LFB123

TRIP DATES

Departed: 15/10/06

Returned: 15/10/06

EXTENDED NON-FISHING

I did not work between 6/10/06 and 14/10/06

NON-FISHING CODE (Circle)

(In Port)	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	(GAB) WDW SPF HS Other	GAB (WDW) SPF HS Other	GAB WDW (SPF) HS Other
Gear No. (from gear sheet)	Ground 1 Net 2	Ground 1 Net 1	Ground Net
Cod end mesh size (mm) / Mesh (square or diamond)	100 S (D)	100 S (D)	40 S (D)
Ground gear disc height	9 inch/~~cm~~	9 inch/~~cm~~	— inch/cm
Trawl method (circle one from each section)	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 DEM (MID)
Start time of shot	0400	1700	1715
Start position degrees:minutes Latitude	32 25	29 17	41 17
Start position degrees:minutes Longitude	129 58	112 23	148 40
End time of shot	0550	1920	2230
End position degrees:minutes Latitude	32 29	29 27	41 40
End position degrees:minutes Longitude	130 05	112 26	148 43
Average trawl depth	420 m/~~fath~~	240 m/~~fath~~	120 m/~~fath~~
Trawl depth average temp	8	14	14
Shot valid (circle)	(Yes) No	(Yes) No	(Yes) No

CATCH DETAILS

Estimate weight (kg) of each species		Shot 1 Weight Kept	Shot 1 Form Code	Shot 1 Weight Discarded	Shot 1 Dis. Code	Shot 2 Weight Kept	Shot 2 Form Code	Shot 2 Weight Discarded	Shot 2 Dis. Code	Shot 3 Weight Kept	Shot 3 Form Code	Shot 3 Weight Discarded	Shot 3 Dis. Code
Deepwater Flathead	FLD	320	W										
Bight Redfish	REB	10	W										
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC					300	W	10	DM				
Yellowspot Boarfish	BOP					80	W						
Big Spine Boarfish	BOB												
Knifejaw	KNI					100	W						
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA					40	W						
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH	60	TR										
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY									4000	W		
Redbait	PEA									1000	W		
Wobbegong						20	TR						
Whiskery sharks						30	TR						
Rankin Cod													
Red Emporer													
Barracouta				100	UM					200	W	50	DM

Please provide an estimate of the time taken to complete this form: 20 mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes (No)

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name: Amos Poulas

Comments:

Signature: Amos Poulos Date 15/10/06

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date:

Boat Name:

Dist. Symbol:

TRIP DATES

Departed: / /

Returned: / /

EXTENDED NON-FISHING

I did not work between / / and / /

NON-FISHING CODE (Circle)

In Port	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	GAB WDW SPF HS Other	GAB WDW SPF HS Other	GAB WDW SPF HS Other
Gear No. (from gear sheet)	Ground / Net	Ground / Net	Ground / Net
Cod end mesh size (mm) / Mesh (square or diamond)	S D	S D	S D
Ground gear disc height	inch/cm	inch/cm	inch/cm
Trawl method (circle one from each section)	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID
Start time of shot			
Start position degrees:minutes – Latitude			
Start position degrees:minutes – Longitude			
End time of shot			
End position degrees:minutes – Latitude			
End position degrees:minutes – Longitude			
Average trawl depth	m/fath	m/fath	m/fath
Trawl depth average temp			
Shot valid (circle)	Yes No	Yes No	Yes No

CATCH DETAILS

Estimate weight (kg) of each species		SHOT 1 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 2 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 3 Weight Kept	Form Code	Weight Discarded	Dis. Code
Deepwater Flathead	FLD												
Bight Redfish	REB												
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC												
Yellowspot Boarfish	BOP												
Big Spine Boarfish	BOB												
Knifejaw	KNI												
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA												
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH												
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY												
Redbait	PEA												

Please provide an estimate of the time taken to complete this form: ____ mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes No

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name:

Comments:

Signature: Date / /

Please remember

- The details for a shot must be recorded before hauling the next shot. Details for the last shot of the trip must be completed before the vessel enters port.
- In this logbook you must account for every day that your Fishing Concession is in force, regardless of whether or not you fish on that day.

Trawl Method Codes	Form (Processing) Codes
OT = Otter board trawl	**W** = Whole
DS = Danish seine	**HG** = Headed and gutted
PA = Pair trawl	**F** = Filleted
OT2 = Twin rig	**GG** = Gilled and gutted
DEM = Demersal trawl	**G** = Gutted
MID = Midwater trawl	**TR** = Trunked (shark)
	FB = Trunked and belly flaps off (shark)
	TA = Tails (scampi, bugs and lobsters)

Discard Codes
NQ = No Quota
MP = Market Price
US = Under Size
UM = Un-marketable
DM = Damaged

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Listed Marine and Threatened Species List

Under the *Environment Protection and Biodiversity Conservation Act 1999* the following species are listed as protected. This list is current at the date of publishing. For further information about Listed Marine and Threatened Species or to check updates to these lists please go to **www.deh.gov.au.**

Please be as specific as you can with regard to the species identification.

LISTED MARINE SPECIES

Fish
All species of Syngnathid (Pipefish, Seahorses & Sea Dragons).

Marine Reptiles
All species of Turtle, Sea Snake and Crocodile.

Seals
All species of Seal and Sea Lion.

Cetaceans
All species of Dolphin, Whale, Porpoise and Dugong.

Sea Birds
All species of Seabird.

THREATENED FISH SPECIES

Grey Nurse Shark *(Carcharias taurus)* - East and west coast population

Speartooth Shark *(Glyphis sp. A)*

Northern River Shark *(Glyphis sp. C)*

Great White Shark *(Carcharodon carcharias)*

Freshwater Sawfish *(Pristis microdon)*

Whale Shark *(Rhincodon typus)*

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Vessel, Gear and Contact Details

SWT01A – Daily Fishing Log

Original Copy – Send to AFMA

Log No:	Boat Name:	Dist. Symbol:

Vessel Details

Length (LOA)	metres	Main engine/s power	kw / hp
Beam	metres	Kort nozzle	Yes / No
Draught	metres	Variable pitch prop	Yes / No
Fish hold capacity	cubic metres	Processing facilities (type)	
Principal operation of vessel (circle)		Freezer Vessel (circle)	Yes / No
Finfish Trawl Prawn Trawl Other:		Homeport	

Gear Details

Ground gear

	Gear 1	Gear 2	Gear 3	Gear 4
Type (from diagram)				
Length	m/f	m/f	m/f	m/f
Weight	kg	kg	kg	kg

Bycatch Reduction Devices

Description

Nets

	Net 1	Net 2	Net 3	Net 4
Type (from descriptions below)				
Headrope length	m/f	m/f	m/f	m/f
Footrope length	m/f	m/f	m/f	m/f
Headline height	m/f	m/f	m/f	m/f
Estimated wing spread	m/f	m/f	m/f	m/f
Max wing mesh size	cm/in	cm/in	cm/in	cm/in

Sweep length	m/f
Bridle length	m/f
Maximum depth vessel can fish	m/f

Contact Details for Vessel's Logbook

Preferred contact person		Other contact person	
Name		Name	
Person's role (eg. skipper)		Person's role (eg. skipper)	
Mobile		Mobile	
Business Phone		Business Phone	
Fax			
Email			
Address			

Skipper's experience (years)

Please provide an estimate of time to complete this form.

Concession Holder or Authorised Person to complete

Printed Name	Signature
	/ /

Net Types

WT = Wing trawl
2 seam net, moderate headline height (3-5m)

CWT = Cutaway wing trawl
Wing trawl with the wing length shortened

SN = Scratch net (commonly referred to by fishers as a "spag" net)
2 seam net, long wings and low headline height (2-4m)

HL = High lift net
or "Balloon Trawl" "Box Trawl" "Sea Star" or "Champion"
4 seam net, high opening (5m +)

OT = Other
Describe:

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name	
Distinguishing Symbol	

Date of Interaction	/ /		
Corresponding logsheet no.			
Observer on board (tick box)	Yes	No	

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each **individual**, except for Syngnathids (Sea Horses)	No. of Sea Horses	**Time at which Interaction occurred** (24hr)	**Latitude/Longitude** of interaction		**Caught During Fishing Operation** (tick one box only)			**Band or Tag Number**	**Life Status** (tick one box only)		
			dd mm	ddd mm	Haul	Set	Other		Alive	Dead	Injured
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person **Signature and Date:** / /

Concession Holder/Authorised Person **Printed Name:**

WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form **min.**

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name

Distinguishing Symbol

Date of Interaction / /

Corresponding logsheet no.

Observer on board (tick box) Yes No

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each individual, except for Syngnathids (Sea Horses) | No. of Sea Horses | Time at which Interaction occurred (24hr) | Latitude/Longitude of interaction (dd mm, ddd mm) | Caught During Fishing Operation (tick one box only) (Haul, Set, Other) | Band or Tag Number | Life Status (tick one box only) (Alive, Dead, Injured)

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person Signature and Date: / /

Concession Holder/Authorised Person Printed Name:

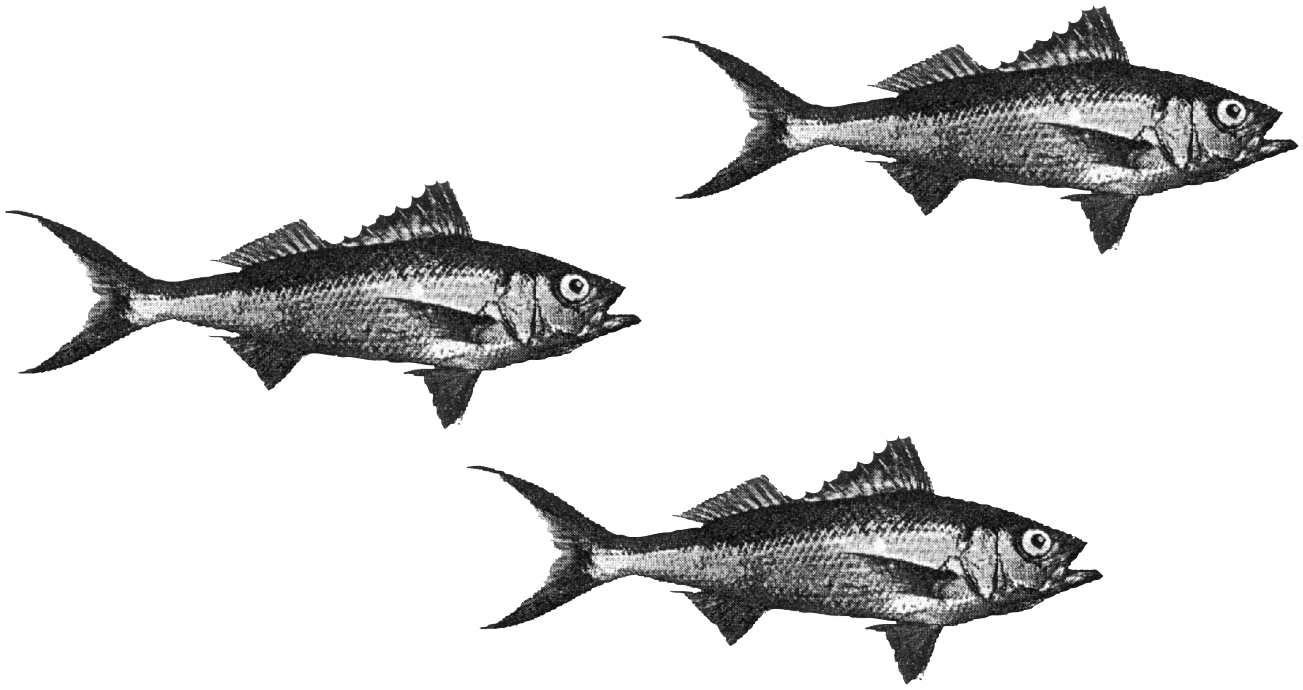
WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form min.

Australian Government

Australian Fisheries Management Authority

Southern and Western Finfish Trawl
Daily Fishing Log
SWT01A



Vessel Name

Ground Gear Types

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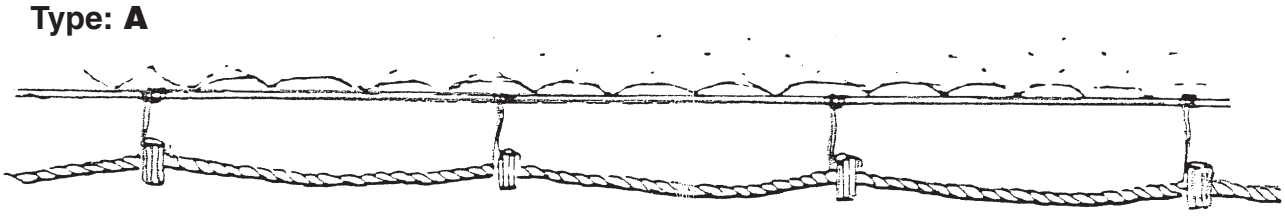

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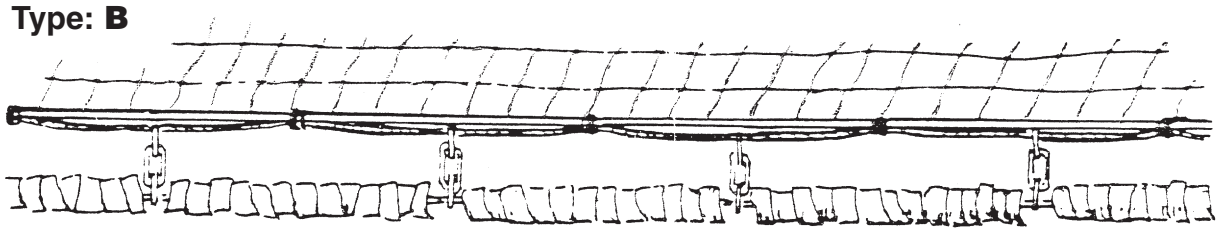

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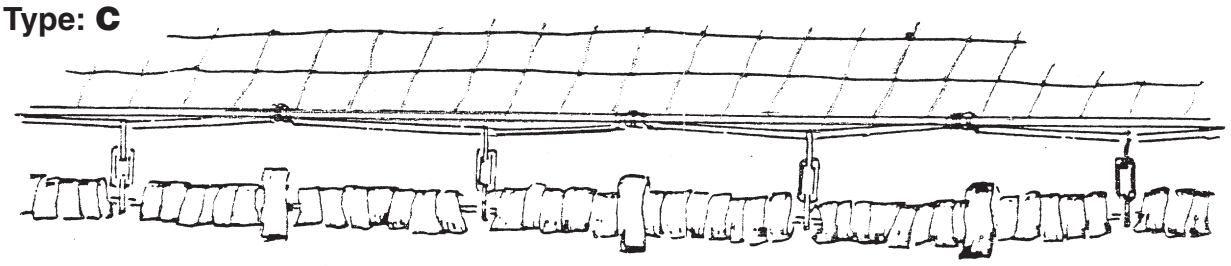

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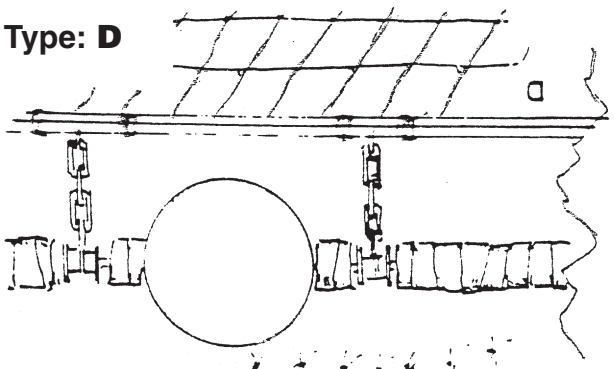

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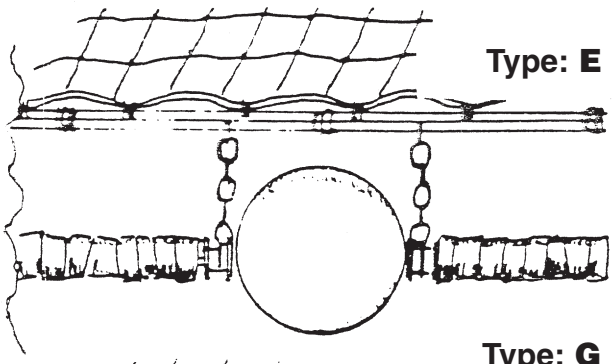

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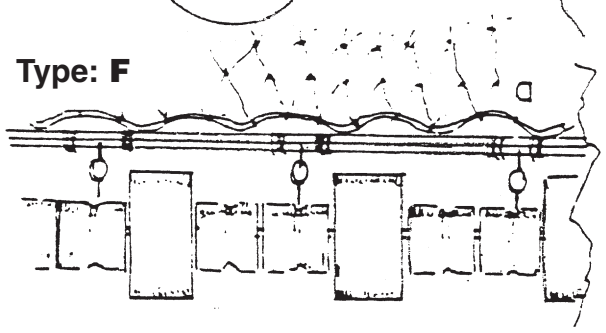

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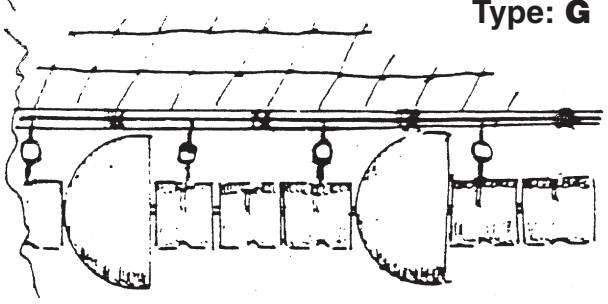


Diagram from Prado,J (1990). Fisherman's workbook.
Fishing Technology Service, FAO.

FRIEND OF THE SEA

Sustainable Seafood

Corrective Action Form	Recommendation ☐ to be checked during the following audit Minor NC X proposal within three weeks Major Nc ☐ implementation within 3/6 months	Form 08.01 Rev.01 18/01/2016

Ref. Check list :		Company name: **Ferguson Australia Proprietary Ltd** Site(s) audited: Adelaide, Kangaroo Island & Point Lincoln Contact person: Eliza Ferguson Sustainability manager: Contact details: eliza@fergusonaustralia.com Signature of the company representative: 
Audit date: 14/12/2016	CB: **RINA SERVICES S.P.A.**	
Ref. Requirement: Point **5.4** Checklist: **FOS - Wild – Non-Freezer Vessels Sustainable fishing Requirements**	Auditor : **Mr. Harry Owen**	

NC notification date 25/02/2017	Deadline	Date of implementation/proposal
Notified by Mr. **Harry Owen** 	Checked by _____	Accepted Yes ☐ No ☐

NC or recommendation description	Req. N. **5.4**
5.4 Vessels in the Marine scale fishery are not required to record discards and therefore not all bycatch is recorded.	

AC proposal ☐ implementation ☐	Req. N.
Remark for the auditor: In case of implementation the auditor is kindly asked to provide evidences in attachment to this form	
Commonwealth operators are required to record all bycaught species (see logbook attached)	

Auditor comments (not mandatory)
It is not mandatory under Australian law to record all bycatch, the fleet complies with all national regulations.

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

General Information and Instructions for Holders of Fishing Concessions

Purpose

This logbook is to be used when trawl fishing in Commonwealth Fisheries. It is designed to provide a continuous record of trawl fishing operations undertaken by Commonwealth fishing concession holders.

Accurate data collected in this logbook is essential to provide information for research into and management of Australian trawl fisheries.

Important Information and Instructions

Completing the logbook

- This logbook must be completed for every day that the fishing concession is in force, regardless of whether or not fishing takes place on that day (see the "Instruction Page" section).
- All logbook information must be recorded on a shot by shot and daily basis and details for the last day of the trip must be recorded before the boat docks at the end of each trip.
- The pages in this logbook are self-carbonating. Please use a ballpoint pen when completing forms. Place the fold-out flap under the original and duplicate pages to prevent writing transferring to the next set of forms.

Location of the logbook

- This logbook must be on board the boat that is nominated in respect of the fishing concession and named on the front of the logbook during trawl fishing operations.
- This logbook must remain within a 50 metre radius of the boat.

Who should use this logbook?

- The holder of the fishing concession is responsible for ensuring that this logbook is completed and that it is certified as complete and correct.
- The holder can do these things personally. Alternatively, the holder can ensure these things are done on their behalf by a person authorised in writing to do so by the fishing concession holder in the approved form. Contact AFMA on 02 6225 5555 (free call 1300 723 621) for details of how to authorise another person to complete the logbook.

Submitting logsheets

This logbook contains numbered pages in duplicate which are referred to as logsheets. Original copies must be returned to AFMA in date order in either the reply paid envelope provided or posted to:

The Logbook Co-ordinator
Australian Fisheries Management Authority
BOX 7051
Canberra Business Centre ACT 2610

For quota managed fisheries and/or fisheries that require the completion of a catch disposal record (CDR) the original copies of logsheets must be returned with the CDR for that trip within the time stipulated in the CDR instructions.

For all other fisheries the original copies of logsheets must be returned within 3 days of the completion of each fishing trip.

All duplicate copies of logsheets should be retained.

Penalties

Concession holders and persons completing this logbook on their behalf are advised that;

(i) a failure by a concession holder to ensure the completion of the logbook in accordance with these instructions;

(ii) the giving of false or misleading information in the logbook by the concession holder or a person completing the logbook on their behalf; or

(iii) the recording or communicating by the concession holder or anyone else of information in a logbook concerning the affairs of another person, or the giving by the concession holder or anyone else to another person of a part of a logbook in which information is recorded, (unless the recording, communicating or giving is done in accordance with the Fisheries Management Act 1991, Fisheries Administration Act 1991 or the Fisheries Management Regulations 1992 or an order of court, tribunal or a person authorised to receive evidence) may constitute serious offences under Commonwealth laws.

Concession holders are also advised that failure to ensure the completion of the logbook in accordance with the instructions may lead to suspension or cancellation of their concession.

Help Available

There is an example of a completed logsheet and further information and instructions about how to complete the logbook at the front of this logbook. If you have any questions or problems, please contact an AFMA Logbook Officer on 02 6225 5555 (free call 1300 723 621).

Australian Fisheries Management Authority
SWT01A
May 2008

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Instruction Page

Vessel, Gear and Contact Details

To be completed by the Concession Holder or Authorised Person and submitted to AFMA within 14 days of receipt of the logbook. A second Vessel, Gear and Contact Details Form is located in the middle of the logbook. Please complete and submit this form if any of the vessel and/or gear details change, or if the contact person for the vessels logbook has changed

Catch and Effort Log Page

When fishing, record details on a shot by shot basis.

Page Header

Enter the **Vessel Name** and **Distinguishing Symbol** here.

Date

Record the date when shot(s) were conducted.

Extended Non-Fishing Period

If you are not fishing for an extended period within the month(s), please specify the **non-fishing dates** and circle the appropriate **non-fishing code**. This will reduce the number of logsheets needed to account for every day your fishing concession is valid. Do not use single pages for single sequential non-fishing days.

Trip Dates

On the first sheet used for a trip record the date of departure, on the last page used for a trip record the date of return.

Trawl Details

Fishery
Circle the relevant code to indicate which fishery you are operating in.
Gear number
This is the number you allocated to different ground gears and nets on your vessel, gear and contact details sheet. Record the corresponding number of the ground gear and net you are using for that shot.
Cod end mesh size/ mesh orientation
Record the mesh size and indicate the orientation of the mesh by circling either **S** for square or **D** for diamond.
Ground gear height
Record the height of the largest part of the ground gear (ie. the largest bobbins or disks).
Trawl method
Circle the relevant code (one from each section) to indicate what trawl method you are using. A midwater trawl is considered to be a trawl where the gear intentionally does not go near the bottom for the duration of the tow.
Start and end shot times
Start times are when the gear setting has stopped. End time is when hauling begins. Please record all times using the 24 hour clock (eg. 1:00pm = 1300).

Trawl Details (cont.)

Start and End position
Start position is the position of the vessel when the gear setting has stopped. End position is the position of the vessel when gear hauling begins.
Average trawl depth
This is the average depth at which the net is towed during a shot. Please circle **m** (metres) or **fath** (fathoms) depending on which unit you are using.
Average temperature
This is the average temperature recorded at trawl depth during the shot. Please record it in degrees celsius. If you do not have a net monitor that records temperature put a dash in this space.
Shot valid
Circle '**Yes**' if the gear was deployed successfully or '**No**' if you had gear problems, ie. net was pinned up.

Catch Details

The accurately estimated weight in kilograms for all fish retained must be recorded on a shot by shot basis. The accurately estimated weight in kilograms for all fish discarded may also be recorded in the column provided on a shot by shot basis. The appropriate form code or discard code also needs to be recorded (see fold out flap). The common names of species caught but not pre-listed should be recorded in the blank spaces provided. Please be specific and record each species separately. If you run out of space, cross out the names of pre-listed species you did not catch and write in the new names.

Listed Marine and Threatened Species

Please circle **YES** or **NO** to indicate if your gear came into contact with or caught a listed marine or threatened species.
If you did have an interaction with a listed marine or threatened species please complete the Listed Marine and Threatened Species Form at the back of the logbook and submit it with the relevant log page.

Time Box

Time box – all Commonwealth Departments are required to have time boxes included on their forms. This initiative forms a part of the Government's regulatory reform strategy to reduce the paperwork and compliance burden on business.

Comments

Comments - This section is provided for any further information that you think may be important such as:
gear failure, weather, damaged fish, size of fish, loss of catch to seals etc.

Signature and Date Box

Each logsheet requires the date and signature of the Concession holder or Authorised Person (person authorised to act on behalf of the concession holder). The signature verifies that the information recorded in the logbook is an accurate record of the fishing operation including estimated landed weights.

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date: 15 / 10 / 06

Boat Name: Deep Blue

Dist. Symbol: LFB123

TRIP DATES

Departed: 15/10/06

Returned: 15/10/06

EXTENDED NON-FISHING

I did not work between 6/10/06 and 14/10/06

NON-FISHING CODE (Circle)

(In Port)	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	(GAB) WDW SPF HS Other	GAB (WDW) SPF HS Other	GAB WDW (SPF) HS Other
Gear No. (from gear sheet)	Ground 1 Net 2	Ground 1 Net 1	Ground Net
Cod end mesh size (mm) / Mesh (square or diamond)	100 S (D)	100 S (D)	40 S (D)
Ground gear disc height	9 inch/~~cm~~	9 inch/~~cm~~	— inch/cm
Trawl method (circle one from each section)	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 DEM (MID)
Start time of shot	0400	1700	1715
Start position degrees:minutes Latitude	32 25	29 17	41 17
Start position degrees:minutes Longitude	129 58	112 23	148 40
End time of shot	0550	1920	2230
End position degrees:minutes Latitude	32 29	29 27	41 40
End position degrees:minutes Longitude	130 05	112 26	148 43
Average trawl depth	420 m/~~fath~~	240 m/~~fath~~	120 m/~~fath~~
Trawl depth average temp	8	14	14
Shot valid (circle)	(Yes) No	(Yes) No	(Yes) No

CATCH DETAILS

Estimate weight (kg) of each species		Shot 1 Weight Kept	Shot 1 Form Code	Shot 1 Weight Discarded	Shot 1 Dis. Code	Shot 2 Weight Kept	Shot 2 Form Code	Shot 2 Weight Discarded	Shot 2 Dis. Code	Shot 3 Weight Kept	Shot 3 Form Code	Shot 3 Weight Discarded	Shot 3 Dis. Code
Deepwater Flathead	FLD	320	W										
Bight Redfish	REB	10	W										
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC					300	W	10	DM				
Yellowspot Boarfish	BOP					80	W						
Big Spine Boarfish	BOB												
Knifejaw	KNI					100	W						
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA					40	W						
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH	60	TR										
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY									4000	W		
Redbait	PEA									1000	W		
Wobbegong						20	TR						
Whiskery sharks						30	TR						
Rankin Cod													
Red Emporer													
Barracouta				100	UM					200	W	50	DM

Please provide an estimate of the time taken to complete this form: 20 mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes (No)

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name: Amos Poulas

Comments:

Signature: Amos Poulos Date 15/10/06

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date:

Boat Name:

Dist. Symbol:

TRIP DATES

Departed: / /

Returned: / /

EXTENDED NON-FISHING

I did not work between / / and / /

NON-FISHING CODE (Circle)

In Port	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	GAB WDW SPF HS Other	GAB WDW SPF HS Other	GAB WDW SPF HS Other
Gear No. (from gear sheet)	Ground / Net	Ground / Net	Ground / Net
Cod end mesh size (mm) / Mesh (square or diamond)	S D	S D	S D
Ground gear disc height	inch/cm	inch/cm	inch/cm
Trawl method (circle one from each section)	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID
Start time of shot			
Start position degrees:minutes – Latitude			
Start position degrees:minutes – Longitude			
End time of shot			
End position degrees:minutes – Latitude			
End position degrees:minutes – Longitude			
Average trawl depth	m/fath	m/fath	m/fath
Trawl depth average temp			
Shot valid (circle)	Yes No	Yes No	Yes No

CATCH DETAILS

Estimate weight (kg) of each species		SHOT 1 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 2 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 3 Weight Kept	Form Code	Weight Discarded	Dis. Code
Deepwater Flathead	FLD												
Bight Redfish	REB												
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC												
Yellowspot Boarfish	BOP												
Big Spine Boarfish	BOB												
Knifejaw	KNI												
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA												
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH												
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY												
Redbait	PEA												

Please provide an estimate of the time taken to complete this form: ____ mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes No

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name:

Comments:

Signature: Date / /

Please remember

- The details for a shot must be recorded before hauling the next shot. Details for the last shot of the trip must be completed before the vessel enters port.
- In this logbook you must account for every day that your Fishing Concession is in force, regardless of whether or not you fish on that day.

Trawl Method Codes	Form (Processing) Codes
OT = Otter board trawl	**W** = Whole
DS = Danish seine	**HG** = Headed and gutted
PA = Pair trawl	**F** = Filleted
OT2 = Twin rig	**GG** = Gilled and gutted
DEM = Demersal trawl	**G** = Gutted
MID = Midwater trawl	**TR** = Trunked (shark)
	FB = Trunked and belly flaps off (shark)
	TA = Tails (scampi, bugs and lobsters)

Discard Codes
NQ = No Quota
MP = Market Price
US = Under Size
UM = Un-marketable
DM = Damaged

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Listed Marine and Threatened Species List

Under the *Environment Protection and Biodiversity Conservation Act 1999* the following species are listed as protected. This list is current at the date of publishing. For further information about Listed Marine and Threatened Species or to check updates to these lists please go to **www.deh.gov.au.**

Please be as specific as you can with regard to the species identification.

LISTED MARINE SPECIES

Fish
All species of Syngnathid (Pipefish, Seahorses & Sea Dragons).

Marine Reptiles
All species of Turtle, Sea Snake and Crocodile.

Seals
All species of Seal and Sea Lion.

Cetaceans
All species of Dolphin, Whale, Porpoise and Dugong.

Sea Birds
All species of Seabird.

THREATENED FISH SPECIES

Grey Nurse Shark *(Carcharias taurus)* - East and west coast population

Speartooth Shark *(Glyphis sp. A)*

Northern River Shark *(Glyphis sp. C)*

Great White Shark *(Carcharodon carcharias)*

Freshwater Sawfish *(Pristis microdon)*

Whale Shark *(Rhincodon typus)*

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Vessel, Gear and Contact Details

SWT01A – Daily Fishing Log

Original Copy – Send to AFMA

Log No:	Boat Name:	Dist. Symbol:

Vessel Details

Length (LOA)	metres	Main engine/s power	kw / hp
Beam	metres	Kort nozzle	Yes / No
Draught	metres	Variable pitch prop	Yes / No
Fish hold capacity	cubic metres	Processing facilities (type)	
Principal operation of vessel (circle)		Freezer Vessel (circle)	Yes / No
Finfish Trawl Prawn Trawl Other:		Homeport	

Gear Details

Ground gear

	Gear 1	Gear 2	Gear 3	Gear 4
Type (from diagram)				
Length	m/f	m/f	m/f	m/f
Weight	kg	kg	kg	kg

Bycatch Reduction Devices

Description

Nets

	Net 1	Net 2	Net 3	Net 4
Type (from descriptions below)				
Headrope length	m/f	m/f	m/f	m/f
Footrope length	m/f	m/f	m/f	m/f
Headline height	m/f	m/f	m/f	m/f
Estimated wing spread	m/f	m/f	m/f	m/f
Max wing mesh size	cm/in	cm/in	cm/in	cm/in

Sweep length	m/f
Bridle length	m/f
Maximum depth vessel can fish	m/f

Contact Details for Vessel's Logbook

Preferred contact person		Other contact person	
Name		Name	
Person's role (eg. skipper)		Person's role (eg. skipper)	
Mobile		Mobile	
Business Phone		Business Phone	
Fax			
Email			
Address			

Skipper's experience (years)

Please provide an estimate of time to complete this form.

Concession Holder or Authorised Person to complete

Printed Name	Signature
	/ /

Net Types

WT = Wing trawl
2 seam net, moderate headline height (3-5m)

CWT = Cutaway wing trawl
Wing trawl with the wing length shortened

SN = Scratch net (commonly referred to by fishers as a "spag" net)
2 seam net, long wings and low headline height (2-4m)

HL = High lift net
or "Balloon Trawl" "Box Trawl" "Sea Star" or "Champion"
4 seam net, high opening (5m +)

OT = Other
Describe:

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name	
Distinguishing Symbol	

Date of Interaction	/ /		
Corresponding logsheet no.			
Observer on board (tick box)	Yes	No	

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each **individual**, except for Syngnathids (Sea Horses)	No. of Sea Horses	**Time at which Interaction occurred** (24hr)	**Latitude/Longitude** of interaction		**Caught During Fishing Operation** (tick one box only)			**Band or Tag Number**	**Life Status** (tick one box only)		
			dd mm	ddd mm	Haul	Set	Other		Alive	Dead	Injured
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person **Signature and Date:** / /

Concession Holder/Authorised Person **Printed Name:**

WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form **min.**

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name

Distinguishing Symbol

Date of Interaction / /

Corresponding logsheet no.

Observer on board (tick box) Yes No

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each individual, except for Syngnathids (Sea Horses) | No. of Sea Horses | Time at which Interaction occurred (24hr) | Latitude/Longitude of interaction (dd mm, ddd mm) | Caught During Fishing Operation (tick one box only) (Haul, Set, Other) | Band or Tag Number | Life Status (tick one box only) (Alive, Dead, Injured)

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person Signature and Date: / /

Concession Holder/Authorised Person Printed Name:

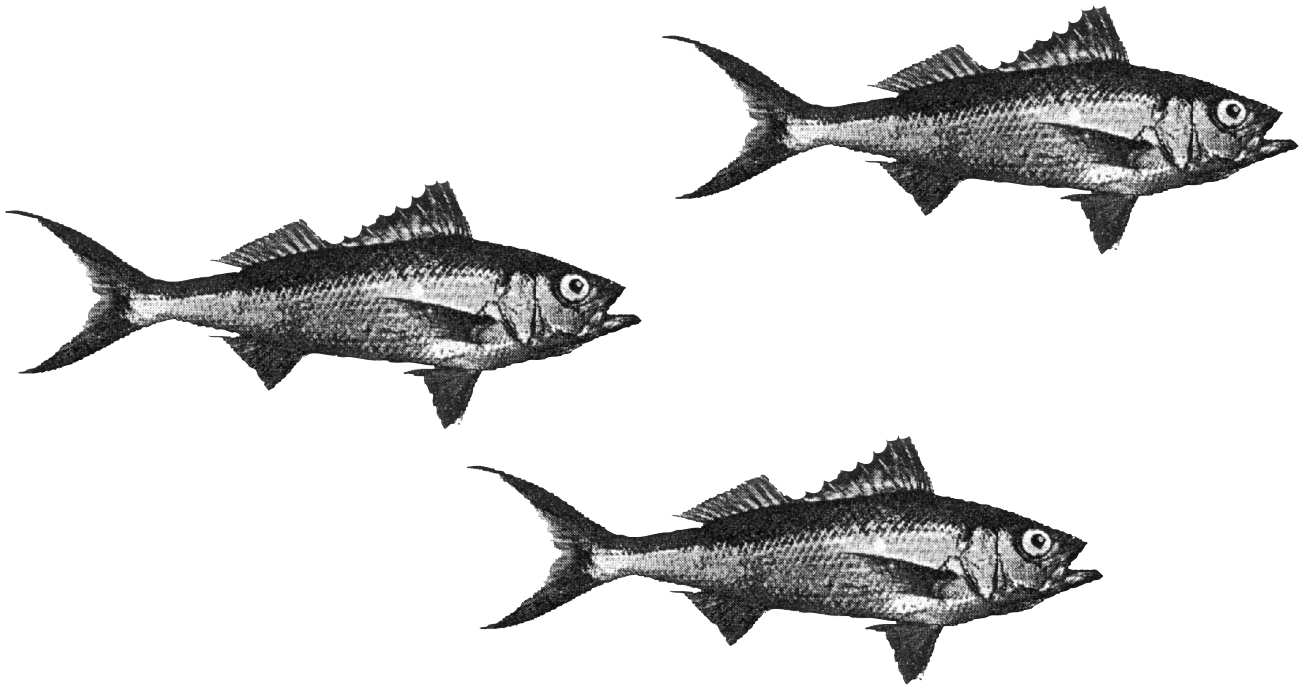
WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form min.

Australian Government

Australian Fisheries Management Authority

Southern and Western Finfish Trawl
Daily Fishing Log
SWT01A



Vessel Name

Ground Gear Types

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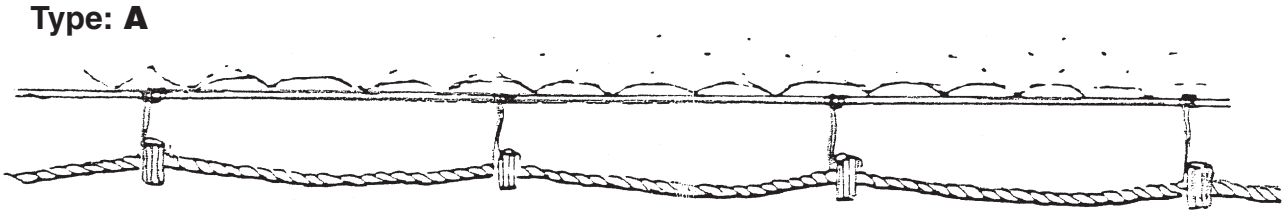

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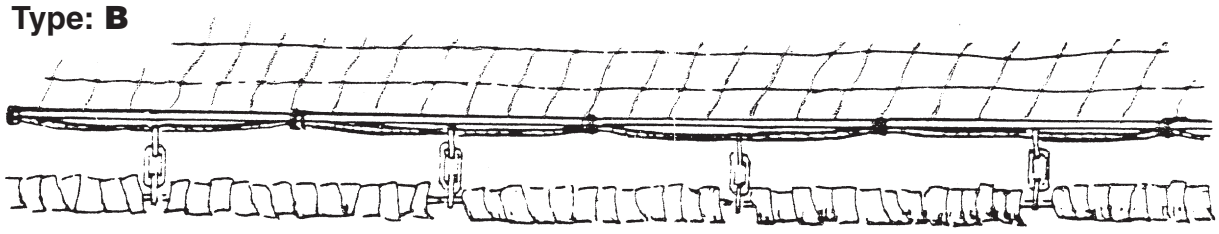

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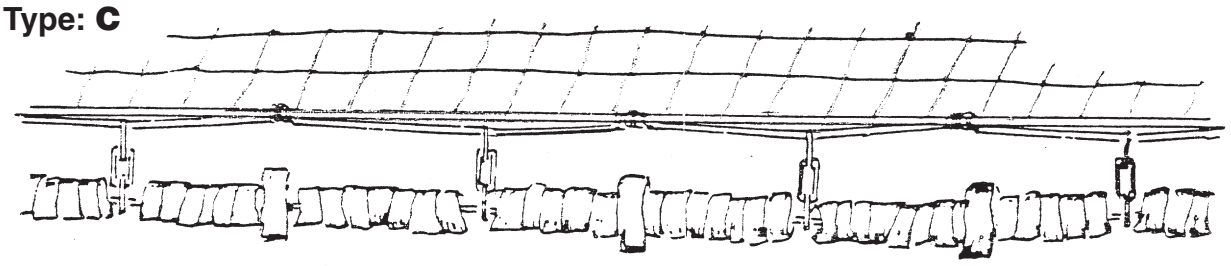

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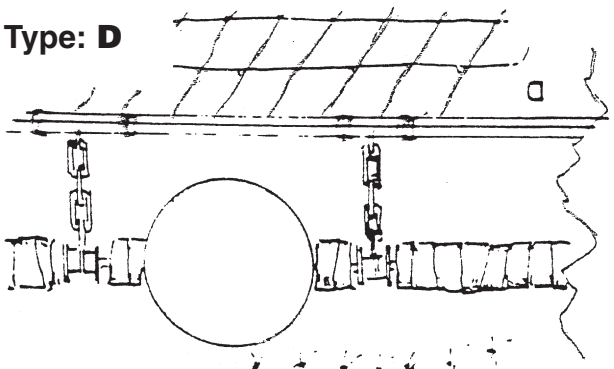

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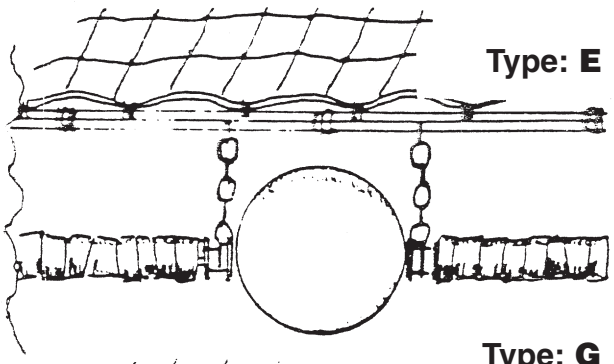

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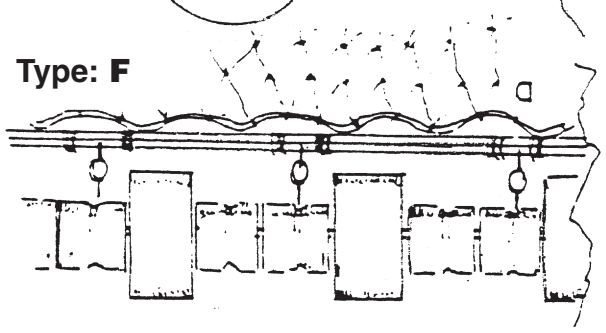

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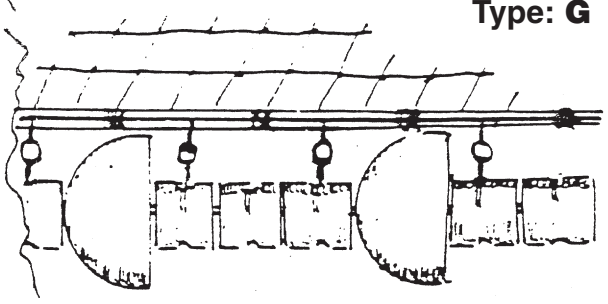

Diagram from Prado,J (1990). Fisherman's workbook.
Fishing Technology Service, FAO.

FRIEND OF THE SEA
Sustainable Seafood

Corrective Action Form	Recommendation ☐ to be checked during the following audit Minor NC X proposal within three weeks Major Nc ☐ implementation within 3/6 months	Form 08.01 Rev.01 18/01/2016

Ref. Check list :		Company name: **Ferguson Australia Proprietary Ltd** Site(s) audited: Adelaide, Kangaroo Island & Point Lincoln Contact person: Eliza Ferguson Sustainability manager: Contact details: eliza@fergusonaustralia.com Signature of the company representative:
Audit date: 14/12/2016	CB: **RINA SERVICES S.P.A.**	
Ref. Requirement: Point **5.5** Checklist: **FOS - Wild – Non-Freezer Vessels Sustainable fishing Requirements**	Auditor : **Mr. Harry Owen**	

NC notification date 25/02/2017	Deadline	Date of implementation/proposal
Notified by Mr. **Harry Owen**	Checked by _____	Accepted Yes ☐ No ☐

NC or recommendation description	Req. N. **5.5**
5.5 Vessels in the Marine scale fishery are not required to record discards.	

AC proposal ☐ implementation ☐	Req. N.
Remark for the auditor: In case of implementation the auditor is kindly asked to provide evidences in attachment to this form	
Commonwealth operators are required to record all bycaught species (see logbook attached)	

Auditor comments (not mandatory)
Fishery complies with the legal framework within which it must operate.

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

General Information and Instructions for Holders of Fishing Concessions

Purpose

This logbook is to be used when trawl fishing in Commonwealth Fisheries. It is designed to provide a continuous record of trawl fishing operations undertaken by Commonwealth fishing concession holders.

Accurate data collected in this logbook is essential to provide information for research into and management of Australian trawl fisheries.

Important Information and Instructions

Completing the logbook

- This logbook must be completed for every day that the fishing concession is in force, regardless of whether or not fishing takes place on that day (see the "Instruction Page" section).
- All logbook information must be recorded on a shot by shot and daily basis and details for the last day of the trip must be recorded before the boat docks at the end of each trip.
- The pages in this logbook are self-carbonating. Please use a ballpoint pen when completing forms. Place the fold-out flap under the original and duplicate pages to prevent writing transferring to the next set of forms.

Location of the logbook

- This logbook must be on board the boat that is nominated in respect of the fishing concession and named on the front of the logbook during trawl fishing operations.
- This logbook must remain within a 50 metre radius of the boat.

Who should use this logbook?

- The holder of the fishing concession is responsible for ensuring that this logbook is completed and that it is certified as complete and correct.
- The holder can do these things personally. Alternatively, the holder can ensure these things are done on their behalf by a person authorised in writing to do so by the fishing concession holder in the approved form. Contact AFMA on 02 6225 5555 (free call 1300 723 621) for details of how to authorise another person to complete the logbook.

Submitting logsheets

This logbook contains numbered pages in duplicate which are referred to as logsheets. Original copies must be returned to AFMA in date order in either the reply paid envelope provided or posted to:

The Logbook Co-ordinator
Australian Fisheries Management Authority
BOX 7051
Canberra Business Centre ACT 2610

For quota managed fisheries and/or fisheries that require the completion of a catch disposal record (CDR) the original copies of logsheets must be returned with the CDR for that trip within the time stipulated in the CDR instructions.

For all other fisheries the original copies of logsheets must be returned within 3 days of the completion of each fishing trip.

All duplicate copies of logsheets should be retained.

Penalties

Concession holders and persons completing this logbook on their behalf are advised that;

(i) a failure by a concession holder to ensure the completion of the logbook in accordance with these instructions;

(ii) the giving of false or misleading information in the logbook by the concession holder or a person completing the logbook on their behalf; or

(iii) the recording or communicating by the concession holder or anyone else of information in a logbook concerning the affairs of another person, or the giving by the concession holder or anyone else to another person of a part of a logbook in which information is recorded, (unless the recording, communicating or giving is done in accordance with the Fisheries Management Act 1991, Fisheries Administration Act 1991 or the Fisheries Management Regulations 1992 or an order of court, tribunal or a person authorised to receive evidence) may constitute serious offences under Commonwealth laws.

Concession holders are also advised that failure to ensure the completion of the logbook in accordance with the instructions may lead to suspension or cancellation of their concession.

Help Available

There is an example of a completed logsheet and further information and instructions about how to complete the logbook at the front of this logbook. If you have any questions or problems, please contact an AFMA Logbook Officer on 02 6225 5555 (free call 1300 723 621).

Australian Fisheries Management Authority
SWT01A
May 2008

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Instruction Page

Vessel, Gear and Contact Details

To be completed by the Concession Holder or Authorised Person and submitted to AFMA within 14 days of receipt of the logbook. A second Vessel, Gear and Contact Details Form is located in the middle of the logbook. Please complete and submit this form if any of the vessel and/or gear details change, or if the contact person for the vessels logbook has changed

Catch and Effort Log Page

When fishing, record details on a shot by shot basis.

Page Header

Enter the **Vessel Name** and **Distinguishing Symbol** here.

Date

Record the date when shot(s) were conducted.

Extended Non-Fishing Period

If you are not fishing for an extended period within the month(s), please specify the **non-fishing dates** and circle the appropriate **non-fishing code**. This will reduce the number of logsheets needed to account for every day your fishing concession is valid. Do not use single pages for single sequential non-fishing days.

Trip Dates

On the first sheet used for a trip record the date of departure, on the last page used for a trip record the date of return.

Trawl Details

Fishery
Circle the relevant code to indicate which fishery you are operating in.
Gear number
This is the number you allocated to different ground gears and nets on your vessel, gear and contact details sheet. Record the corresponding number of the ground gear and net you are using for that shot.
Cod end mesh size/ mesh orientation
Record the mesh size and indicate the orientation of the mesh by circling either **S** for square or **D** for diamond.
Ground gear height
Record the height of the largest part of the ground gear (ie. the largest bobbins or disks).
Trawl method
Circle the relevant code (one from each section) to indicate what trawl method you are using. A midwater trawl is considered to be a trawl where the gear intentionally does not go near the bottom for the duration of the tow.
Start and end shot times
Start times are when the gear setting has stopped. End time is when hauling begins. Please record all times using the 24 hour clock (eg. 1:00pm = 1300).

Trawl Details (cont.)

Start and End position
Start position is the position of the vessel when the gear setting has stopped. End position is the position of the vessel when gear hauling begins.
Average trawl depth
This is the average depth at which the net is towed during a shot. Please circle **m** (metres) or **fath** (fathoms) depending on which unit you are using.
Average temperature
This is the average temperature recorded at trawl depth during the shot. Please record it in degrees celsius. If you do not have a net monitor that records temperature put a dash in this space.
Shot valid
Circle '**Yes**' if the gear was deployed successfully or '**No**' if you had gear problems, ie. net was pinned up.

Catch Details

The accurately estimated weight in kilograms for all fish retained must be recorded on a shot by shot basis. The accurately estimated weight in kilograms for all fish discarded may also be recorded in the column provided on a shot by shot basis. The appropriate form code or discard code also needs to be recorded (see fold out flap). The common names of species caught but not pre-listed should be recorded in the blank spaces provided. Please be specific and record each species separately. If you run out of space, cross out the names of pre-listed species you did not catch and write in the new names.

Listed Marine and Threatened Species

Please circle **YES** or **NO** to indicate if your gear came into contact with or caught a listed marine or threatened species.
If you did have an interaction with a listed marine or threatened species please complete the Listed Marine and Threatened Species Form at the back of the logbook and submit it with the relevant log page.

Time Box

Time box – all Commonwealth Departments are required to have time boxes included on their forms. This initiative forms a part of the Government's regulatory reform strategy to reduce the paperwork and compliance burden on business.

Comments

Comments - This section is provided for any further information that you think may be important such as:
gear failure, weather, damaged fish, size of fish, loss of catch to seals etc.

Signature and Date Box

Each logsheet requires the date and signature of the Concession holder or Authorised Person (person authorised to act on behalf of the concession holder). The signature verifies that the information recorded in the logbook is an accurate record of the fishing operation including estimated landed weights.

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date: 15 / 10 / 06

Boat Name: Deep Blue

Dist. Symbol: LFB123

TRIP DATES

Departed: 15/10/06

Returned: 15/10/06

EXTENDED NON-FISHING

I did not work between 6/10/06 and 14/10/06

NON-FISHING CODE (Circle)

(In Port)	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	(GAB) WDW SPF HS Other	GAB (WDW) SPF HS Other	GAB WDW (SPF) HS Other
Gear No. (from gear sheet)	Ground 1 Net 2	Ground 1 Net 1	Ground Net
Cod end mesh size (mm) / Mesh (square or diamond)	100 S (D)	100 S (D)	40 S (D)
Ground gear disc height	9 inch/~~cm~~	9 inch/~~cm~~	— inch/cm
Trawl method (circle one from each section)	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 (DEM) MID	(OT) PA DS OT2 DEM (MID)
Start time of shot	0400	1700	1715
Start position degrees:minutes Latitude	32 25	29 17	41 17
Start position degrees:minutes Longitude	129 58	112 23	148 40
End time of shot	0550	1920	2230
End position degrees:minutes Latitude	32 29	29 27	41 40
End position degrees:minutes Longitude	130 05	112 26	148 43
Average trawl depth	420 m/~~fath~~	240 m/~~fath~~	120 m/~~fath~~
Trawl depth average temp	8	14	14
Shot valid (circle)	(Yes) No	(Yes) No	(Yes) No

CATCH DETAILS

Estimate weight (kg) of each species		Shot 1 Weight Kept	Shot 1 Form Code	Shot 1 Weight Discarded	Shot 1 Dis. Code	Shot 2 Weight Kept	Shot 2 Form Code	Shot 2 Weight Discarded	Shot 2 Dis. Code	Shot 3 Weight Kept	Shot 3 Form Code	Shot 3 Weight Discarded	Shot 3 Dis. Code
Deepwater Flathead	FLD	320	W										
Bight Redfish	REB	10	W										
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC					300	W	10	DM				
Yellowspot Boarfish	BOP					80	W						
Big Spine Boarfish	BOB												
Knifejaw	KNI					100	W						
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA					40	W						
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH	60	TR										
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY									4000	W		
Redbait	PEA									1000	W		
Wobbegong						20	TR						
Whiskery sharks						30	TR						
Rankin Cod													
Red Emporer													
Barracouta				100	UM					200	W	50	DM

Please provide an estimate of the time taken to complete this form: 20 mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes (No)

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name: Amos Poulas

Comments:

Signature: Amos Poulos Date 15/10/06

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

Catch and Effort – SWT01A Daily Fishing Log

Original Copy – Send to AFMA

Please use separate sheets for each fishing day

Log No:	Page No:

Date:

Boat Name:

Dist. Symbol:

TRIP DATES

Departed: / /

Returned: / /

EXTENDED NON-FISHING

I did not work between / / and / /

NON-FISHING CODE (Circle)

In Port	Bad Weather	Other fishery.
Searching	Steaming	Which?

TRAWL DETAILS

	SHOT 1	SHOT 2	SHOT 3
Fishery (circle)	GAB WDW SPF HS Other	GAB WDW SPF HS Other	GAB WDW SPF HS Other
Gear No. (from gear sheet)	Ground / Net	Ground / Net	Ground / Net
Cod end mesh size (mm) / Mesh (square or diamond)	S D	S D	S D
Ground gear disc height	inch/cm	inch/cm	inch/cm
Trawl method (circle one from each section)	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID	OT PA DS OT2 DEM MID
Start time of shot			
Start position degrees:minutes – Latitude			
Start position degrees:minutes – Longitude			
End time of shot			
End position degrees:minutes – Latitude			
End position degrees:minutes – Longitude			
Average trawl depth	m/fath	m/fath	m/fath
Trawl depth average temp			
Shot valid (circle)	Yes No	Yes No	Yes No

CATCH DETAILS

Estimate weight (kg) of each species		SHOT 1 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 2 Weight Kept	Form Code	Weight Discarded	Dis. Code	SHOT 3 Weight Kept	Form Code	Weight Discarded	Dis. Code
Deepwater Flathead	FLD												
Bight Redfish	REB												
Orange Roughy	ORO												
Chinaman Leatherjacket	LTC												
Yellowspot Boarfish	BOP												
Big Spine Boarfish	BOB												
Knifejaw	KNI												
Smooth Oreo	DOO												
Latchet	LAT												
King Dory	DOK												
Mirror Dory	DOM												
Gemfish	GEM												
Ruby Snapper	SNR												
Rosy Jobfish	JOR												
Tang Snapper	SNT												
Arrow Squid	SQA												
Deepwater Bugs	BUG												
Gummy Shark	SHG												
School Shark	SHS												
Saw Shark	SHW												
Elephant Shark	SHE												
Angel Shark	ASH												
Alfonsino	ALF												
Blue Mackerel	MAS												
Jack Mackerel	MAJ												
Yellowtail Scad	MAY												
Redbait	PEA												

Please provide an estimate of the time taken to complete this form: ____ mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes No

Further details of all listed marine and threatened species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised person - *I certify that the information provided on this form is a true and accurate record.*

Printed Name:

Comments:

Signature: Date / /

Please remember

- The details for a shot must be recorded before hauling the next shot. Details for the last shot of the trip must be completed before the vessel enters port.
- In this logbook you must account for every day that your Fishing Concession is in force, regardless of whether or not you fish on that day.

Trawl Method Codes	Form (Processing) Codes
OT = Otter board trawl	**W** = Whole
DS = Danish seine	**HG** = Headed and gutted
PA = Pair trawl	**F** = Filleted
OT2 = Twin rig	**GG** = Gilled and gutted
DEM = Demersal trawl	**G** = Gutted
MID = Midwater trawl	**TR** = Trunked (shark)
	FB = Trunked and belly flaps off (shark)
	TA = Tails (scampi, bugs and lobsters)

Discard Codes
NQ = No Quota
MP = Market Price
US = Under Size
UM = Un-marketable
DM = Damaged

Southern and Western Finfish Trawl Daily Fishing Log – SWT01A

Listed Marine and Threatened Species List

Under the *Environment Protection and Biodiversity Conservation Act 1999* the following species are listed as protected. This list is current at the date of publishing. For further information about Listed Marine and Threatened Species or to check updates to these lists please go to **www.deh.gov.au.**

Please be as specific as you can with regard to the species identification.

LISTED MARINE SPECIES

Fish
All species of Syngnathid (Pipefish, Seahorses & Sea Dragons).

Marine Reptiles
All species of Turtle, Sea Snake and Crocodile.

Seals
All species of Seal and Sea Lion.

Cetaceans
All species of Dolphin, Whale, Porpoise and Dugong.

Sea Birds
All species of Seabird.

THREATENED FISH SPECIES

Grey Nurse Shark *(Carcharias taurus)* - East and west coast population

Speartooth Shark *(Glyphis sp. A)*

Northern River Shark *(Glyphis sp. C)*

Great White Shark *(Carcharodon carcharias)*

Freshwater Sawfish *(Pristis microdon)*

Whale Shark *(Rhincodon typus)*

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Box 7051
Canberra Business Centre ACT 2610

Vessel, Gear and Contact Details

SWT01A – Daily Fishing Log

Original Copy – Send to AFMA

Log No:	Boat Name:	Dist. Symbol:

Vessel Details

Length (LOA)	metres	Main engine/s power	kw / hp
Beam	metres	Kort nozzle	Yes / No
Draught	metres	Variable pitch prop	Yes / No
Fish hold capacity	cubic metres	Processing facilities (type)	
Principal operation of vessel (circle)		Freezer Vessel (circle)	Yes / No
Finfish Trawl Prawn Trawl Other:		Homeport	

Gear Details

Ground gear

	Gear 1	Gear 2	Gear 3	Gear 4
Type (from diagram)				
Length	m/f	m/f	m/f	m/f
Weight	kg	kg	kg	kg

Bycatch Reduction Devices

Description

Nets

	Net 1	Net 2	Net 3	Net 4
Type (from descriptions below)				
Headrope length	m/f	m/f	m/f	m/f
Footrope length	m/f	m/f	m/f	m/f
Headline height	m/f	m/f	m/f	m/f
Estimated wing spread	m/f	m/f	m/f	m/f
Max wing mesh size	cm/in	cm/in	cm/in	cm/in

Sweep length	m/f
Bridle length	m/f
Maximum depth vessel can fish	m/f

Contact Details for Vessel's Logbook

Preferred contact person		Other contact person	
Name		Name	
Person's role (eg. skipper)		Person's role (eg. skipper)	
Mobile		Mobile	
Business Phone		Business Phone	
Fax			
Email			
Address			

Skipper's experience (years)

Please provide an estimate of time to complete this form.

Concession Holder or Authorised Person to complete

Printed Name	Signature
	/ /

Net Types

WT = Wing trawl
2 seam net, moderate headline height (3-5m)

CWT = Cutaway wing trawl
Wing trawl with the wing length shortened

SN = Scratch net (commonly referred to by fishers as a "spag" net)
2 seam net, long wings and low headline height (2-4m)

HL = High lift net
or "Balloon Trawl" "Box Trawl" "Sea Star" or "Champion"
4 seam net, high opening (5m +)

OT = Other
Describe:

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name	
Distinguishing Symbol	

Date of Interaction	/ /		
Corresponding logsheet no.			
Observer on board (tick box)	Yes	No	

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each **individual**, except for Syngnathids (Sea Horses)	No. of Sea Horses	**Time at which Interaction occurred** (24hr)	**Latitude/Longitude** of interaction		**Caught During Fishing Operation** (tick one box only)			**Band or Tag Number**	**Life Status** (tick one box only)		
			dd mm	ddd mm	Haul	Set	Other		Alive	Dead	Injured
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐
					☐	☐	☐		☐	☐	☐

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person **Signature and Date:** / /

Concession Holder/Authorised Person **Printed Name:**

WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form **min.**

Australian Fisheries
Management Authority.
Box 7051
Canberra Business Centre ACT 2610

LISTED MARINE AND THREATENED SPECIES FORM

Please use one form per day

Log No.

Boat Name

Distinguishing Symbol

Date of Interaction / /

Corresponding logsheet no.

Observer on board (tick box) Yes No

Great White Shark / Grey Nurse / Whale Shark / Seabird / Seal / Dolphin / Whale / Dugong

Species Name Be specific (refer to list), one line for each individual, except for Syngnathids (Sea Horses) | No. of Sea Horses | Time at which Interaction occurred (24hr) | Latitude/Longitude of interaction (dd mm, ddd mm) | Caught During Fishing Operation (tick one box only) (Haul, Set, Other) | Band or Tag Number | Life Status (tick one box only) (Alive, Dead, Injured)

Comments

Is there anything else that you believe to be important information, for example: Female, male, adult, juvenile?
Where was the animal tangled (flipper, mouth, wing, etc.)?
Where in the gear was the animal tangled (codend, wingend, warps, BRDs, etc.)?
How was the animal released (lowered by hand, lowered with a net into the water, cut out net, etc.)?

I certify the information, which I have provided on this form to be a complete and accurate record.

Concession Holder/Authorised Person Signature and Date: / /

Concession Holder/Authorised Person Printed Name:

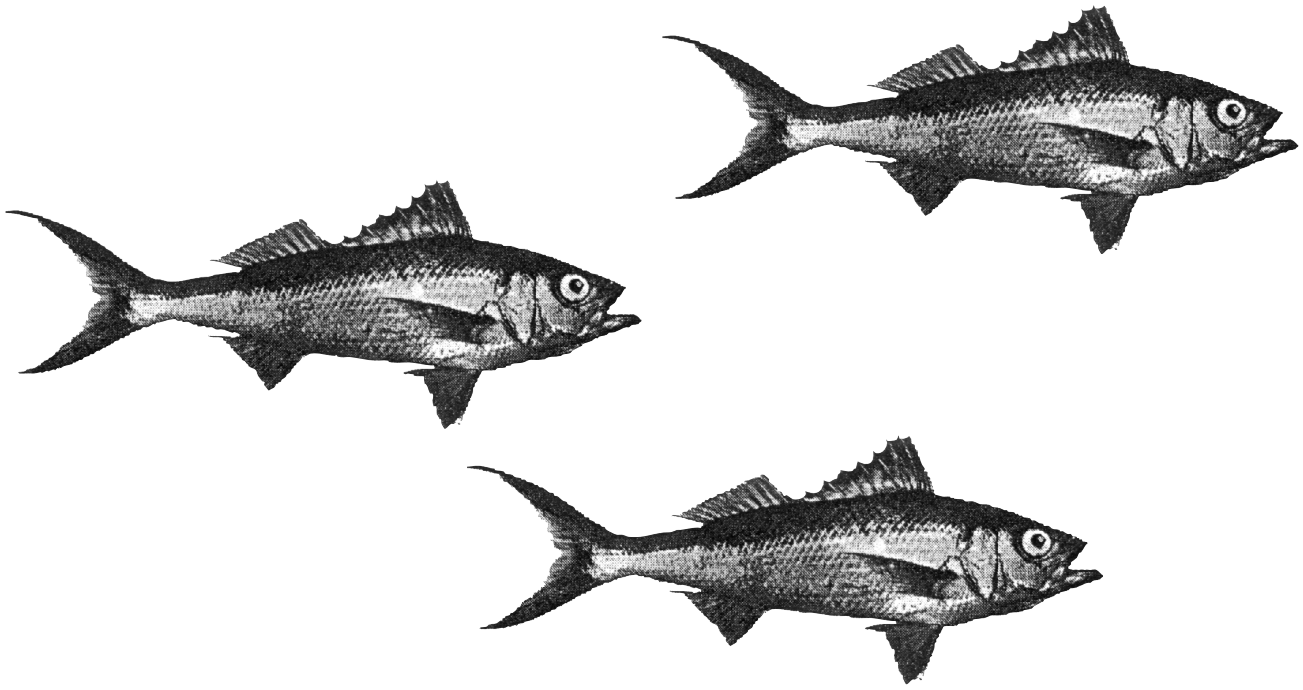
WHITE - Original - Send to AFMA

Please provide an estimate of the time taken to complete this form min.

Australian Government

Australian Fisheries Management Authority

Southern and Western Finfish Trawl
Daily Fishing Log
SWT01A



Vessel Name

Ground Gear Types

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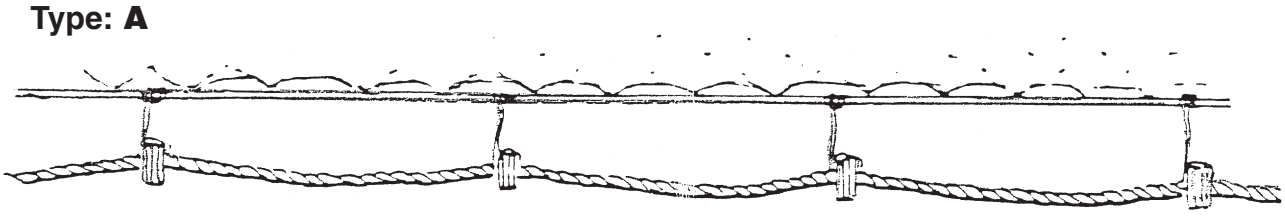

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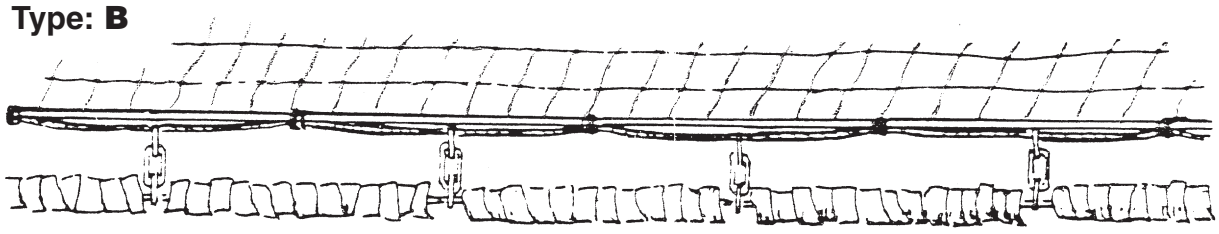

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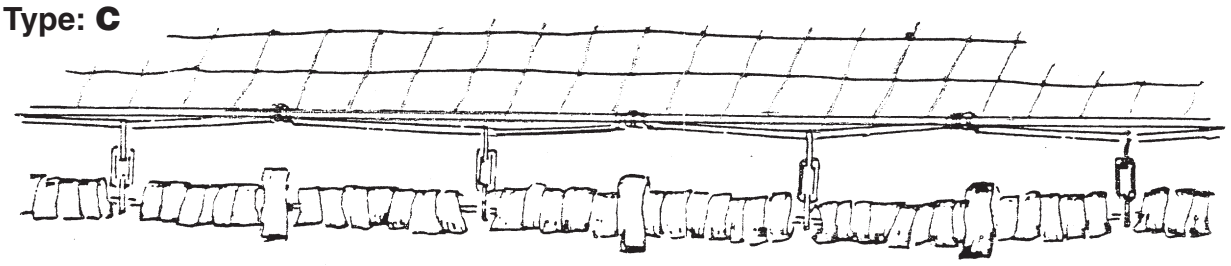

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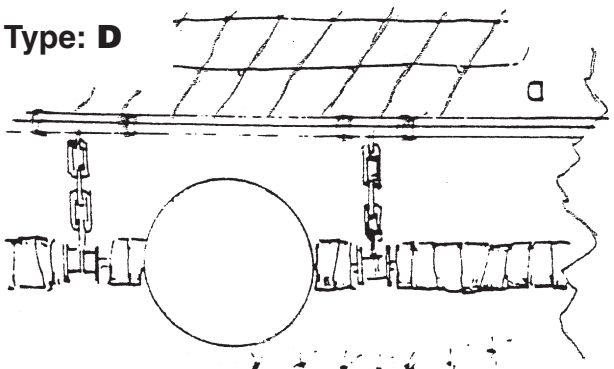

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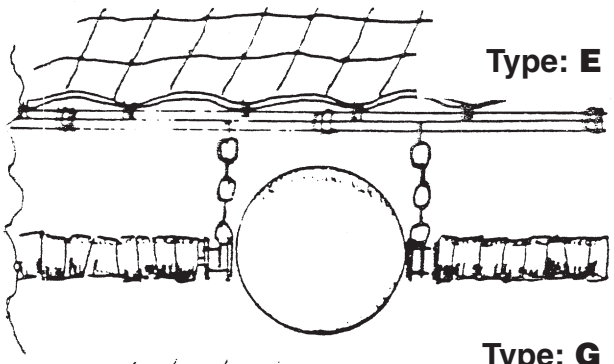

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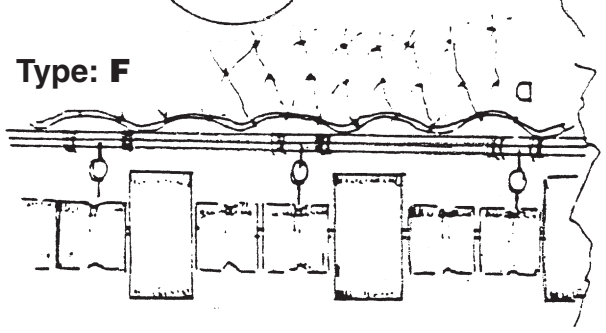

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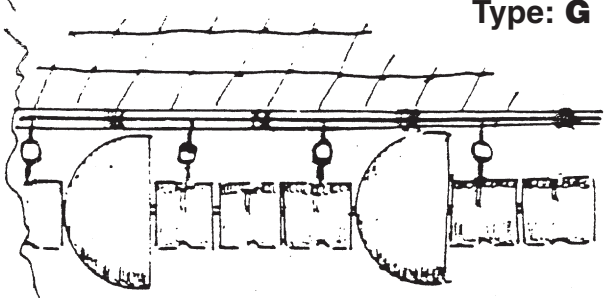

Diagram from Prado,J (1990). Fisherman's workbook.
Fishing Technology Service, FAO.

FRIEND OF THE SEA

Sustainable Seafood

Corrective Action Form	Recommendation ☐ to be checked during the following audit Minor NC X proposal within three weeks Major Nc ☐ implementation within 3/6 months	Form 08.01 Rev.01 18/01/2016

Ref. Check list :		Company name: **Ferguson Australia Proprietary Ltd** Site(s) audited: Adelaide, Kangaroo Island & Point Lincoln Contact person: Eliza Ferguson Sustainability manager: Contact details: eliza@fergusonaustralia.com Signature of the company representative:
Audit date: 14/12/2016	CB: **RINA SERVICES S.P.A.**	
Ref. Requirement: Point **5.9** Checklist: **FOS - Wild – Non-Freezer Vessels Sustainable fishing Requirements**	Auditor : **Mr. Harry Owen**	

NC notification date	Deadline	Date of implementation/proposal
25/02/2017		
Notified by Mr. **Harry Owen**	Checked by TOMASELLI 9/5/17	Accepted Yes ☐ No ☒

NC or recommendation description	Req. N. **5.9**
5.9 The ocean jacket fishery is not managed by specific reference points.	

AC proposal ☐ implementation ☐	Req. N.
Remark for the auditor: In case of implementation the auditor is kindly asked to provide evidences in attachment to this form	

Auditor comments (not mandatory)
This is a very new fishery and has therefore not had a lot of monitoring and management. However fishing mortality is low and the stock status is "sustainable" and AFMA do state that " AFMA monitor the amount of ocean jacket caught each year and , if needed, seek expert advice and recommendations from fisheries managers, industry members, scientist and researchers about management arrangements."

The above explanation is acceptable only if the Company send us evidence of the situation (literature, official information etc.)

Not acceptable

9/5/17

Vista mail di Ferguson 11/5/17 h 9,59
sembra che l'Ocean jacket abbia ~~uno~~ studi che dimostrano modeste quantità di pesca negli ultimi anni.
lo stock appare monitorato da AFMA annualmente e AFMA da indicazioni su pesca -

11/5/17 Accettabile

Allegare mail di spiegazione ed estratto dello studio -

FRIEND OF THE SEA

Sustainable Seafood

Corrective Action Form	Recommendation ☐ to be checked during the following audit Minor NC X proposal within three weeks Major Nc ☐ implementation within 3/6 months	Form 08.01 Rev.01 18/01/2016

Ref. Check list :		Company name: **Ferguson Australia Proprietary Ltd** Site(s) audited: Adelaide, Kangaroo Island & Point Lincoln Contact person: Eliza Ferguson Sustainability manager: Contact details: eliza@fergusonaustralia.com Signature of the company representative: 
Audit date: 14/12/2016	CB: **RINA SERVICES S.P.A.**	
Ref. Requirement: Point **6.4** Checklist: **FOS - Wild – Non-Freezer Vessels Sustainable fishing Requirements**	Auditor : **Mr. Harry Owen**	

NC notification date	Deadline	Date of implementation/proposal
25/02/2017		

Notified by Mr. **Harry Owen** 	Checked by _____	Accepted Yes ☐ No ☐

NC or recommendation description	Req. N. **6.4**
6.4 Ferguson is still using CFC's in its refrigeration units, however these are being phased out.	

AC proposal ☐ implementation ☐	Req. N.
Remark for the auditor: In case of implementation the auditor is kindly asked to provide evidences in attachment to this form	

Auditor comments (not mandatory)
CFC's are being phased out at all sites. This and many units now run on Non-CFC alternatives.