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Marine Conservation Program
Department of Primary Industries, Parks, Water and Environment

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Foreword

Seabirds are attracted to fishing vessels through the availability of fishery discards, increasing the risk of injury or mortality from interactions with fishing gear. However, it is difficult to estimate what proportion of the population may be at risk. We use DNA metabarcoding of scats to characterise the intra- and inter-annual variability in the diet of Shy Albatross at Albatross Island, and combine this dietary data with foraging range estimates to examine spatial overlaps and species overlaps between albatross and fisheries in the region. Shy Albatross diet consisted predominantly of fish (93% of samples) and cephalopods (38% of samples), with 84 fish and 11 cephalopod species detected. The majority of food was sourced naturally, however, at least 13% of the population overall is sourcing food from fisheries, with up to 29% during some breeding stages. There were spatial overlaps between Shy Albatross and six Commonwealth managed fisheries operating in South-East Australia and two Tasmanian managed fisheries. There was considerable intra-annual variation in the level of engagement with the Commonwealth fishery, but little inter-annual variability. Blue Grenadier, Ling and Warehou sp. were the main Commonwealth managed fishery discard species consumed. This study highlights that fisheries still pose a risk for Shy Albatross in Australian waters. As the majority of albatross food is sourced naturally, it shows that albatross are unlikely to be reliant on discards, therefore a reduction in discard availability would benefit shy albatross populations and improve the sustainability of fisheries in the region. DNA dietary analysis in conjunction with spatial foraging data provides a valuable tool to assess the proportion of a population at risk from fishing operations.

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Acknowledgments

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This project would not have been possible without the support and logistics provided by the Department of Primary Industries, Parks, Water and Environment for the long-term Shy Albatross Monitoring Program.

Abbreviations

ACAP - Agreement for the Conservation of Albatross and Petrels
AFMA - Australian Fisheries Management Authority
FMR - Field metabolic rate
FOO - Frequency of Occurrence
GHT - Gillnet Hook and Trap
GLS - Geolocation
GPS - Global Positioning System
HSN - High seas non-trawl
PCR- Polymerase Chain Reaction (a genetic diagnostic test)
PTT - Platform Terminal Transmitter
qPCR - Quantitative PCR (also known as real time PCR)
RRA - Relative (sequence) read abundance
SBT - Southern Bluefin Tuna
SCA - Scallop
SET - South East Trawl
SETFIA - South East Trawl Fishing Industry Association
SPF - Small Pelagic Fishery
SQJ - Southern Squid Fishery
VIT - Victorian Inshore Trawl

Executive Summary

This project was carried out by researchers in the Marine Conservation Program at DPIPWE (Tasmania) in collaboration with the CSIRO, AFMA, SETFIA, IMAS and the AAD. We use novel DNA dietary analysis methods, seasonal seabird foraging ranges and fishery catch data to establish a baseline of data from which we can evaluate the impact and efficacy of future management/operational or other changes to fisheries with regard to seabird interactions. Shy Albatross (*Thalassarche cauta*) scats were collected from Albatross Island in Bass Strait every three months from 2014-2018 and the food DNA identified in each. This study provides the longest and highest resolution dietary data set for Shy Albatross and gives new insights into species occurrence in the region, potential fishery engagement and establishes a baseline of dietary data to assess changes over time.

Background

Seabirds are attracted to fishing vessels through the supplementary food resource provided by fishery discards. This engagement with fishing vessels may lead to interactions with fishing gear, increasing the risk of injury or mortality. Shy Albatross are endemic to Tasmania and are listed as threatened under the *EPBC Act* and are recognised as a medium residual risk in the Ecological Risk Assessments conducted on multiple fisheries operating in South East (SE) Australia. One key priority of Australian Fisheries Management Authority (AFMA) is for Australian fisheries to operate sustainably, including improving ways to detect and document vessel interactions with threatened species through bycatch and discard monitoring. However, it is difficult to determine whether, and to what extent, seabird engagements with fisheries occur and more data are required to identify risk, and to support informed and targeted management. There is limited recent information available on the spatial or dietary overlap between Shy Albatross and fisheries operating in SE Australia. Due to the invasive nature of previous dietary analysis methods, there has been no diet data collected for over 20 years. The recent development of DNA dietary analysis methods provides a non-invasive alternative to study the diet of Shy Albatross and investigate the prevalence of fishery discards in their diet.

Aims/objectives

This study uses DNA metabarcoding of scats to characterise the diet of Shy Albatross. With samples collected over multiple years and breeding stages, we examine the intra- and inter-annual variability in food species consumed. Using this dietary data combined with spatial foraging range estimates, we examine spatial overlaps and species overlaps between albatross and fisheries in the region and estimate the volume of prey consumed. We quantify the proportion of the population that are likely engaging with fisheries through consumption of discarded species. This project will improve our understanding of any potential engagement or resource overlaps between a threatened species and fisheries operating in SE Australia.

Methodology

A database of potential Shy Albatross dietary species was constructed using published literature on top predator diets in the region, and data on the main fishery catch and bycatch species. This database was compared to an online genetic database that contains DNA reference sequences, to identify any potential gaps in genetic information for species that may be consumed by Shy Albatross. The list of missing species was distributed to researchers and fishery observers to help fill these data gaps and was refined and updated throughout the project. Shy Albatross scat samples were collected from Albatross Island, in Bass Strait, Tasmania in March 2013 and 2014 and then every three months from September 2014 to March 2018. Sample collections from 2014 covered the three main breeding stages each year (incubation, brood and chick-rearing) as well as during the non-breeding period. DNA was extracted from scat samples

and amplified using a broad universal marker that provides information on all prey groups (to Class or Order), and two group specific markers that provide information on the fish and cephalopod component of the diet (to genus or species). Samples were sequenced using Next Generation Sequencing technology and resulting dietary sequences were compared to reference sequences on Genbank for classification. The relative read abundance of sequences and frequency of occurrence of each species was assessed for each breeding stage and season.

Shy Albatross foraging areas were defined for each breeding stage using existing tracking data and new fine-scale data that were collected during the project timeframe to create foraging range polygons. These polygons were overlayed with Commonwealth fisheries catch data to identify: 1) spatial overlaps between Shy Albatross and fisheries, and 2) overlaps between species consumed by Shy Albatross and species caught by a fishery operating in the area. The likely source of each fish and cephalopod species were assessed based on the species' accessibility (using information on species depth and behaviour) and whether they were caught by a fishery operating in the albatross foraging area. From these data, the proportion of the population likely to be engaging with fisheries (where Shy Albatross were consuming a species caught by a fishery that were not naturally accessible) were identified and from which fisheries these were potentially sourced. To identify potential resource competition between Shy Albatross and Commonwealth fisheries in SE Australia, each food species was assessed as to whether it was a shared resource (i.e. was naturally consumed by Shy Albatross and also caught by a fishery). The estimated volume consumed was calculated for each major food group overall (e.g. all fish species overall) as well as individually for the main fish and cephalopod species. To achieve this we used Shy Albatross metabolic rates, activity patterns and food proportions. Information was compiled on which Tasmanian-managed fisheries were operating during the study, the gear type used and which of these overlapped spatially with albatross. The availability of discards was assessed for each fishing method where spatial overlaps occurred.

Results/ Key findings

A SE Australian diet reference database was compiled containing 1294 individual taxa. From this list, 209 Actinopterygii (bony fishes), Chondrichthyes (sharks, skates and rays) and Cephalopoda (squid, octopus and cuttlefish) species were identified as likely dietary items for Shy Albatross. Sequence data were sourced for 191 (91%) of these species through this project.

A total of 1655 Shy Albatross scats were collected during the project, for which DNA were extracted and sequenced. Molecular dietary analysis using the universal markers revealed that overall, Shy Albatross diet consisted predominantly of fish (78% of sequences and 93% of samples) and cephalopods (15% of sequences and 38% of samples). There was greater variation in the diet throughout the year than between years, with cephalopods more common during incubation (September) than the other time periods. Using the group specific markers, there were 84 species of fish detected and 11 species of cephalopods. The main fish species detected was Redbait (*Emmelichthys nitidus*), with Jack Mackerel (*Trachurus declivis*), barracouta *(Thyrsites atun*) and Blue Mackerel (*Scomber australasicus*) also commonly consumed. Giant cuttlefish (*Sepia apama*) and Gould's squid (*Nototodarus gouldi*) were the main cephalopod species detected. The majority of Shy Albatross food was sourced naturally (i.e. species were naturally accessible and not caught by a fishery in the foraging area) comprising 78% of DNA sequences and 83.3% of samples.

Shy Albatross overlapped spatially, to some extent, with six Commonwealth fisheries operating in SE Australia during the study. There were three fisheries where spatial overlaps occurred regularly: 1) the Southern Squid Fishery (during chick-rearing/March), 2) Scallop fishery (all stages except chick-rearing/March), and 3) Southern and Eastern Scalefish and Shark Fishery (SESSF, during all breeding stages). Overall, 12.7% of birds (9.7% of sequences) consumed species that were likely sourced from fisheries (likely engagement). This level of engagement varied between years and between breeding stages. Across all years, the incubation period (September/October samples), had the lowest proportion of likely fishery engagement (ranging between 4-6%), the brood period (December samples) was consistently higher (ranging between 14-18%), while chick-rearing (March samples) and inter-breeding (July samples) were more variable (ranging between 4-29%). The SESSF South-East Trawl vessels operating with bottom otter trawl gear and Danish seine most commonly had spatial and species overlaps with albatross, followed by the Gillnet Hook and Trap fishery operating with demersal gillnets and demersal auto-longline. The most common species that were likely sourced from fishing vessels were Blue Grenadier (*Macruronus novaezelandiae*), Ling (*Genypterus blacodes/tigerinus*) and Warehou (*Seriolella sp.*). Only eight species were considered a shared resource between Shy Albatross and SE Australian Commonwealth fisheries (i.e. species that were likely naturally obtained, but also targeted by a fishery in SE Australia), however these species made up over half the food sequences (51 ± 19%). Across all food species, an estimated volume of 2306 ± 682 t of food is estimated to be consumed annually by Shy Albatross at Albatross Island, including an estimated 764 ± 193 t of Redbait and 195 ± 61 t of fishery sourced species.

Shy Albatross overlapped spatially with six Tasmanian managed fisheries during the study, however, discards or bycatch were only available from two: 1) the Southern Rock Lobster fishery and 2) the Tasmanian Scalefish fishery (hand-line). There was minimal overlap with albatross diet for the latter, however bait species from the Rock Lobster fishery occurred regularly in the diet of Shy Albatross.

Implications and Recommendations

The analyses and products of this work provide a range of end-users with data and supporting information for a variety of management and conservation applications, including sustainable fisheries management, ecological risk assessments, and continued conservation and management of Shy Albatross populations. We recommend the Department of Environment consider the inclusion of data and key findings from this report when revising and compiling information for the next Albatross and Giant Petrel Recovery Plan. We also recommend that AFMA consider the project findings when revising management plans and ecological risk assessments for the fisheries operating in the South East of Australia. Fishers in the Southern Rock-Lobster fishery should be discouraged from feeding baits and bycatch to Shy Albatross, as this behaviour can lead to habituation and encourage birds to approach vessels.

The next phase of this research should investigate what factors contribute to the inter- and intra-annual variability in engagements between Shy Albatross and Commonwealth fisheries, and if shy albatross from southern colonies exhibit similar patterns of engagement.

Keywords
Seabird, engagement, discards, *Thalassarche cauta*, resource requirements, Albatross Island, Bass Strait, Blue Grenadier, Ling.

Introduction

Seabirds, particularly albatrosses and petrels, are of high conservation concern globally (Phillips et al. 2016). Due to their high trophic position and restricted foraging range during breeding, seabirds are highly susceptible to changes in marine ecosystems (Frederiksen et al. 2006). Changes in prey availability can influence a variety of seabird demographic parameters including breeding success, recruitment and survival. Monitoring of these higher order predators is therefore important not only for their conservation and management, but they also provide a mechanism to monitor broader changes in marine ecosystems, as they can act as bioindicators (Cairns 1987). Seabirds are threatened primarily by human activities, both in the marine environment and at their breeding sites on land. One of the main key processes causing population declines globally are interactions with commercial fisheries (Tuck et al. 2001, Croxall et al. 2002, Alderman et al. 2011, Phillips et al. 2016).

The foraging behaviour of seabirds can bring them into close proximity with fishing vessels, which may lead to incidental mortality, food supplementation or resource overlaps. Incidental mortality of seabirds can occur through interaction with both long-line (Brothers et al. 1999, Tuck et al. 2011) and trawl fishing gear (Sullivan et al. 2006, Watkins et al. 2008). In longline fisheries, seabirds risk being caught on hooks and drowned, while in trawl fisheries they risk hitting warp or net sonde cables or being caught in nets (Weimerskirch et al. 2000, Gonzalez-Zevallos and Yorio 2006, Bull 2009). These interactions can be major drivers of population change, and incidental mortality has been linked to substantial declines in several seabird species globally (Weimerskirch and Jouventin 1987, Berrow et al. 2000, Nel et al. 2002, Phillips et al. 2016).

Birds are attracted to the supplementary food source provided by baits, by animals as they are hauled in, and by animals discarded overboard during processing (Gonzalez-Zevallos and Yorio 2006). These discards can include the heads, tails and offal of target species, whole undersized target species, or whole non-target species (bycatch). These discards are often species that may not be naturally accessible to seabirds. These engagements with fishing vessels can increase the risk of seabird interactions with fishing gear (Bull 2009).

During the breeding season, seabirds are central place foragers as they must return to a central place to incubate eggs and feed chicks. Consequently, they are restricted in how far they can travel from the breeding site to obtain resources. If these food resources are scarce, birds may need to forage further from the breeding site, increasing the energetic costs of raising chicks (Kitaysky et al. 2000), or consume and provision chicks with lower quality resources, potentially reducing chick mass and breeding success (Wanless et al. 2005). Understanding which resources are important for seabirds and identifying where potential resource overlaps occur with fisheries is important for assessing catch quotas and undertaking Ecological Risk Assessments (Hobday et al. 2011).

A range of national and international frameworks require that fisheries are managed sustainably to protect seabirds. In Australia, these include the Threat Abatement Plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations (Commonwealth of Australia 2018), National Recovery Plan for threatened albatrosses and giant petrels (DSEWPAC 2011), National Plan of Action (NPOA) for Minimising the Incidental Catch of Seabirds in Australian Capture Fisheries (DAWR 2017), and the international Agreement on the Conservation of Albatrosses and Petrels (ACAP).

In Australia, mitigation measures are employed by Commonwealth fisheries to reduce the risk of incidental seabird mortality (AFMA 2018). For longline vessels these can include weighting to increase bait sink rates or hook shields, restricted operating times through night setting or season/area closures, offal management and physical barriers during setting and hauling, such as scaring lines. In trawl fisheries, warp deflectors (pinkies) on the warp cable, bafflers and water sprays are the main mitigation measures used, in conjunction with discard management (Pierre et al. 2014, Koopman et al. 2018). An AFMA facilitated Seabird Workshop (2016), acknowledged the difficulties in determining whether and to what extent seabird engagements with fisheries occur, with the participants agreeing there was a need for more data to be collected to identify risk, and support informed and targeted management. Quantification of seabird engagements with vessels would assist the development of the Seabird Strategy for Commonwealth fisheries and ensure fisheries are managed sustainably, one of the key strategic priorities of FRDC and AFMA.

Seabird dietary studies facilitate the quantification of seabird engagement with fisheries, by using data to estimate the proportion of a population consuming fishery species. These dietary data can provide detailed information on potential resource overlaps between seabirds and fisheries and, with the use of metabolic rates, enable the estimation of prey volumes consumed. Current, reliable diet information can provide AFMA with data to allow risk assessment tools such as trophic models to be developed, and to provide a baseline of diet information from which it is possible to identify what drives dietary changes in threatened species. A recent international review of albatross diets highlighted the need to: 1) incorporate appropriate dietary studies as an integral component of species recovery and management plans, and 2) elevate the importance of dietary studies in long-term monitoring plans to link observed demographic parameters to ecological drivers (McInnes et al. 2016a). With changing environmental conditions and improvements to mitigation measures used by fisheries, it is important to monitor how threatened species may adapt to these changes. The National Recovery Plan for threatened albatrosses and giant petrels specifies the need for "*research to quantify the scale and nature of dietary requirements of albatrosses*" and "*provide this data to AFMA and other agencies managing fisheries that overlap with albatross*" to "*promote the incorporation of total dietary requirements of albatross populations into fisheries assessments and the development of improved management strategies*".

Shy Albatross (*Thalasarche cauta*) are endemic to Australia, breeding on three islands in Tasmania: Albatross Island to the north-west and Pedra Branca and the Mewstone in the south (Figure 1). They are listed as vulnerable under the Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act*) and have a restricted year-round foraging area that is concentrated in SE Australian waters (Hedd et al. 2001). The species is susceptible to a range of terrestrial and marine based-threats including disease (Woods 2004, Alderman and Hobday 2017), changing climate (Thomson et al. 2015) and incidental mortality in fisheries (Baker et al. 2007, Thomson et al. 2015).

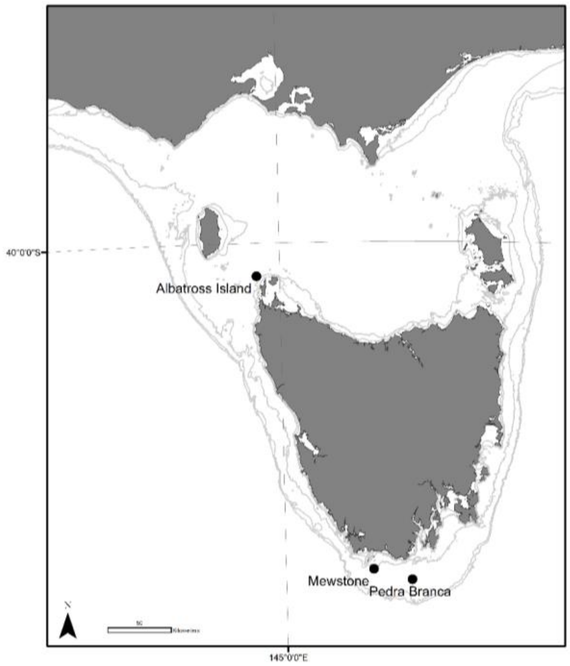


Figure 1: Breeding colonies of Shy Albatross

Shy Albatross overlap spatially and temporally with a range of fisheries in SE Australia. They are listed as a species of medium residual risk of incidental mortality in the Ecological Risk Assessments (ERAs) for the Small Pelagic Fishery, Southern Bluefin Tuna Fishery, Southern and Eastern Scalefish and Shark Fishery (AFMA 2009, 2010a, b, 2012).

The diet data required to inform many of the conservation and management decisions for Shy Albatross are currently lacking, with the most recent dietary data over 20 years old (Hedd et al 2001). This hiatus in sampling is primarily due to the lack of suitable dietary methods, as conventional stomach sampling can be invasive and difficult to justify (DSEWPAC 2011). Additionally, these methods can suffer significant biases in the food groups detected due to overestimation of species with hard-parts and underestimation of soft-bodied species, such as gelatinous species and offal (Barrett et al. 2007).

The development of non-invasive molecular diet analysis methods provides an avenue to fill the significant gap in Shy Albatross trophic information. DNA metabarcoding is a dietary method that enables the identification of food DNA in predator scats by using high-throughput sequencing of small, highly variable DNA regions that survive digestion (O'Rorke et al. 2012, Pompanon et al. 2012). The method is non-invasive, does not suffer from biases associated with retention of hard-parts, and can detect soft-bodied prey (McInnes et al. 2017b). By using a combination of genetic markers, it is possible to identify all food taxa (using universal metazoan markers) and species within a taxonomic group (using group-specific markers) (Deagle et al. 2009, Bowser et al. 2013, McInnes et al. 2017c, Stat et al. 2017).

This study uses DNA metabarcoding of scats to comprehensively characterise the diet of Shy Albatross. With samples collected over multiple years and breeding stages, we examine the intra- and inter-annual variability in food consumed. This trophic information, in combination with existing fine-scale tracking data enable the examination of spatial overlaps, the occurrence of potential fisheries engagement and the resource overlap between a threatened species and fisheries operating in SE Australia. We quantify the proportion of the population that are likely engaging with fisheries through consumption of discarded and bycaught species, directly addressing one of the major strategic directions of the FRDC and AFMA. Specifically, this information will enable us to:

i) characterise the range of species consumed by Shy Albatross
ii) estimate the spatial and temporal overlap between Shy Albatross and Commonwealth-managed fisheries
iii) estimate intra-and inter-annual level of engagement of Shy Albatross with fisheries,
iv) identify which fish and cephalopod species are shared resources between albatross and fisheries,
v) calculate the relative resource requirements of Shy Albatross
vi) estimate the approximate volume of naturally sourced and fishery sourced species consumed.

This project will provide baseline data for evaluating efficacy of future fisheries management changes, assist in fisheries management and ecological risk assessment processes, and showcase a tool that could be applied to other threatened species and fishing regions in Australia.

Objectives

Objective 1: Develop a south-east Australian marine diet reference database.

Objective 2: Characterise the range of food consumed by Shy Albatrosses to high taxonomic resolution (species or genus where possible) and the relative frequency of occurrence of each taxa within the diet.

Objective 3: Assess the extent to which the Shy Albatross potentially engage with fisheries by quantifying the frequency of target, secondary and bycaught species consumed.

Objective 4: Assess the spatial and temporal variability of Objective 2 and 3.

Methods

SE Australian diet reference database

To be able to identify DNA from diet items in the Shy Albatross scat samples, we require a comprehensive library of possible fish and cephalopod reference sequences. Genbank is a publically available genetic database that contains millions of sequences of a range of taxa, however there are species gaps. To identify which species may be missing that are important for this study, we developed a local database of likely diet species that we could cross-check with Genbank. This SE Australian diet reference database comprises species in the diets of top predators in the region obtained from published literature and also target, bycatch and bait species obtained from Commonwealth and State fishery catch reports.

Specifically, this database contains a list of species that were:

1. Found in the diet of marine predators in Bass Strait.
2. Species caught in Commonwealth fisheries bounded by latitudes -35 to -45 and longitudes 135 to 155, from in 2014- 17 (Figure 2).
3. Species caught in recreational fishing as reported in IMAS Recreational Fishing Reports (2010-13)
4. Species caught in Tasmanian Scalefish Fishery as reported in the IMAS Fishery Assessment Reports (2014-17)

A subset of the database was taken which included species in the classes: Chondrichthyes (sharks, skates and rays), Actinopterygii (bony fishes) and Cephalopoda (squid, octopus and cuttlefish) that were either a) in the diet of a top predator, or b) species with a fishery catch amount greater than 1 tonne in any year. Sequences for these species were downloaded from Genbank for the 16S gene region and aligned with the primer sets used in the study (see genetic methods below). A list of species with missing sequence data were provided to SETFIA and AMFA with the aim to collect samples using observers, and provided to CSIRO to see if DNA was available from the Australian National Fish Collection.

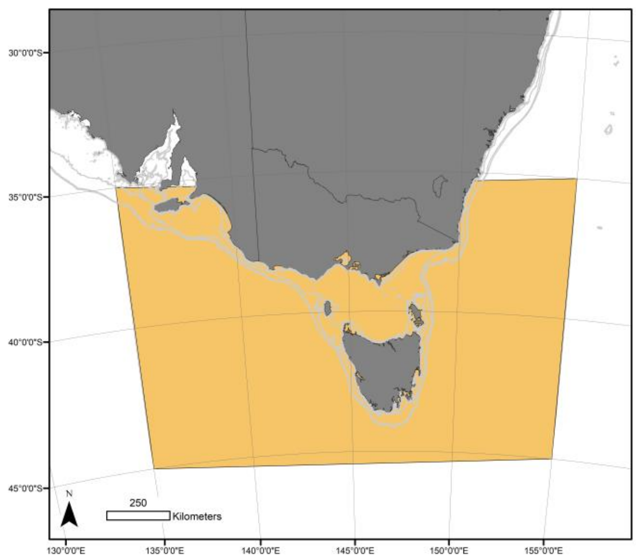
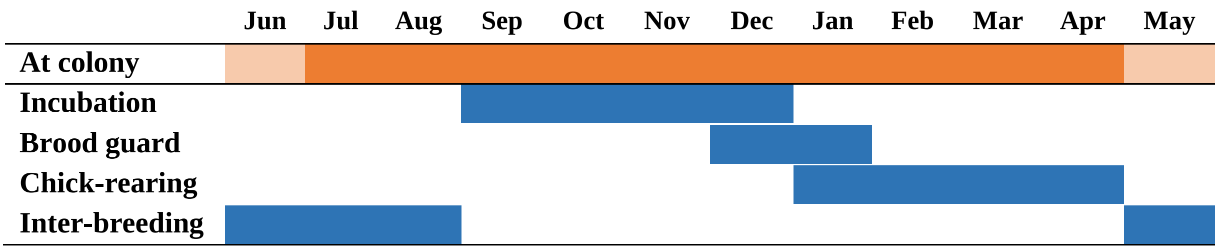


Figure 2: Area extent used to identify the common fishery species for the SE Australian diet reference database

Case study species

Shy Albatross typically lay one egg from early September to early October. The egg is incubated for 10 weeks (incubation stage) and the hatched chicks are brooded for 3-4 weeks (brood stage). During these two breeding stages, parents alternate nest attendance and foraging trips. After brooding, chicks are left unattended while both parents forage independently at sea to complete chick rearing (chick-rearing stage, Table 1). At Albatross Island, incubation foraging trips may last from one to ten days, with an average of three days (Hedd et al. 2001, Mason et al. 2018). Foraging trip durations during the brood stage are short at around one day and increase slightly during chick-rearing to two-three days (Brothers et al. 1998, Hedd and Gales 2005). After chicks fledge, many adults remain in the vicinity of Bass Strait and return to the island to add to their nests and maintain pair-bonds (inter-breeding period).

Table 1: The breeding cycle of Shy Albatross at Albatross Island. The dark orange indicates when birds are typically at the colony. The light orange highlights when adults are often at sea for a period of six weeks in May-June. The blue bars indicate the extent of each breeding stage.



Field methodology

Shy Albatross scat samples were collected at Albatross Island, Tasmania, Australia (40°23′S, 144°39′E). Scat samples were collected at fifteen time periods over six years, which included two early samplings (March 2013 and 2014) and then samplings approximately every three months from September 2014 to March 2018. Collections were timed to overlap with key breeding stages; incubation (late September), brood stage (mid December), chick-rearing (late March) and inter-breeding (July, Table 2). Samples were collected from albatross observed defecating. A small fragment of the non-uric acid portion of the scat (dark part) was collected using tweezers or a plastic straw. The sample was stored in 80% ethanol and shaken on collection to mix with the ethanol.

Table 2: The number of Shy Albatross scat samples collected at Albatross Island for each time period during the study.

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	Total
Incubation			184	145	38	55	**422**
Brood			175	80	122	43	**420**
Chick-rearing	53	121	92	100	94	104	**564**
Inter-breeding			98	111	40		**249**
Total	**53**	**121**	**549**	**436**	**294**	**202**	**1655**

Molecular methodology

DNA extraction, PCR amplification and amplicon sequencing

The following workflow was used to produce the dietary datasets used in this project (Figure 3). DNA was extracted from albatross scat samples and flesh samples using a Promega ‘Maxwell 16' instrument and a Maxwell® 16 Tissue DNA Purification Kit. PCR inhibitor concentrations were diluted by mixing a small amount (~30mg) of the faecal samples in 250ul of STAR buffer (Roche Diagnostics) prior to extraction.

Three different DNA markers were amplified. The first was a metazoan primer set that is highly conserved and amplifies a region of the nuclear small subunit ribosomal DNA (rDNA) 18S gene (18S_SSU, McInnes et al. 2017a, Table 3). For this marker the taxonomic resolution is relatively low; however, it recovers DNA from all animal lineages and provides a broad overview of the diet. The other two primer sets each amplified a region of the 16S rDNA gene specifically from fish (16S_Fish, McInnes et al. 2017c) and cephalopoda (16S_Ceph, this study). These two 16S primers have enough variation in the target region to allow species-level identification for most species. As the 16S_Fish and 16S_Cephalopoda primers used the same amplification conditions, these were multiplexed and run in one reaction. A blocking primer was not used to block bird DNA amplified with the 18S_SSU primer set as it may inadvertently block some fish DNA (Piñol et al. 2015). Consequently a number of samples were likely to contain high amounts of albatross DNA.

PCR reactions for each primer set were carried out separately as a two stage process. Stage one PCR reactions (10 µL) were performed with 5 µL 2 x Phusion HF (NEB), 1 µL 100 x Bovine Serum Albumin (NEB), 0.1 µL 5 µM of each 18S_SSU or 10 µM 16S amplification primers (Table 3), 0.5 µL of Evagreen, 2 µL faecal DNA and 1.3 µL of water. Thermal cycling conditions were 98ºC, for 2 mins; followed by 35 cycles (18S) or 45 cycles (16S), of 98ºC for 5 s, 67ºC (18S) or 64ºC (16S) for 20 s, 72ºC for 20s, with an extension of 72ºC for 1 min. Each sample was run on a LightCycler 480 (Roche Diagnostics). A negative control containing no template DNA and positive control were included in each PCR amplification run. In each reaction the negatives did not amplify and the positives successfully amplified. PCR product from each sample were diluted 1:10 for the second stage PCR. In the second stage PCR, a unique tag was attached to each sample (Table 3). PCR reactions (10 µL) were performed with 5 uL 2 x Phusion HF (NEB), 1 µL of water, 1 µL of 1 µM of each tag primer, and 2 µL of diluted PCR product from stage one. Thermal cycling conditions were 98ºC, for 2 min; followed by 10 cycles of 98ºC for 5 s, 55ºC for 20 s, 72ºC for 20 s, with an extension of 72ºC for 1 min. Samples were pooled and purified from unincorporated reaction components by washing, utilising reversible binding to Ampure (Agencourt) magnetic beads, with 0.8 µL of Ampure per microlitre of DNA product. Sequencing of PCR products was performed over two runs on an Illumina NextSeq 500 high throughput sequencer at the Ramaciotti Centre for Genomics, using 2x 150bp Mid Output kit. DNA from collected flesh samples was extracted as per the methods below for scat samples.

DNA from flesh samples were amplified for 615 bp of mitochondrial DNA from the 16S gene (Table 3). These markers were sequenced in both directions using BigDye Terminator v.3.1 (Applied Biosystems, Inc.) on an ABI 3130 sequencer.

Table 3: Oligonucleotides used in this study. Underlined bases in PCR Round 1 are the Miseq tag primer. Bolded bases in PCR Round 2 are an example of the unique tags attached to each sample.

PCR Round	Primer Name	Primer sequence (5'-3')	Fragment length	Reference
1	18S_SSU_F	TCGTCGGCAGCGTCAGATGTGTATAAGAG ACAGGGTCTGTGATGCCCTTAGATG	~170bp	McInnes et al. (2017a)
1	18S_SSU_R	GTCTCGTGGGCTCGGAGATGTGTATAAGA GACAGGGTGTGTACAAAGGGCAGGG		McInnes et al. (2017a)
1	16S_Fish_F	TCGTCGGCAGCGTCAGATGTGTATAAGAG ACAGAGCGYAATCACTTGTCTYTTAA	~200bp	McInnes et al. (2017b)
1	16S_Fish_R	GTCTCGTGGGCTCGGAGATGTGTATAAGA GACAGCRBGGTCGCCCCAACCRAA		McInnes et al. (2017b)
1	16S_Ceph_F	TCGTCGGCAGCGTCAGATGTGTATAAGAG ACAGTACGCTGTTATCCCTATGGTAAC	~143bp	This study
1	16S_Ceph_R	GTCTCGTGGGCTCGGAGATGTGTATAAGA GACAGGGACGARAAGACCCTAWTGAGC		This study
2	SSU3_Tag_F 1	AATGATACGGCGACCACCGAGATCTACAC **AGTTCGGACT**TCGTCGGCAGCGTC	~150bp	Jarman et al. (2013)
2	SSU3_Tag_R 1	CAAGCAGAAGACGGCATACGAGAT**AGCTT** **AGGCT**GTCTCGTGGGCTCGG		Jarman et al. (2013)
Fish reference sequence	16Sar-5	CGCCTGTTTATCAAAAACAT	~615bp	Palumbi (1996)
Fish reference sequence	16Sbr-3′	CCGGTCTGAACTCAGATCACGT		Palumbi (1996)

Bioinformatics

Amplicon pools were de-multiplexed based on unique 10 bp Multiplex IDentifiers (MIDs) incorporated in the Illumina two-step MID protocol. Fastq files were processed using USEARCH v8.0.1623 (Edgar 2010). Reads R1 and R2 from the paired end sequencing were merged using the fastq_mergepairs function, retaining only merged reads flanked by exact matches to the primers and primer sequences were trimmed. Reads from all samples were pooled and dereplicated, then clustered into broad Operational Taxonomic Units (OTUs) using the cluster_otus command (-otu_radius_pct = 10). Sequences shorter than 100bp were excluded and potentially chimeric reads were discarded during this step. Reads for each sample were assigned to these OTUs (usearch_global -id 0.99) and a summary table generated using a custom R script.

OTUs derived from each primer set were assigned to the lowest possible functional group using the Genbank online database with the Basic Local Alignment Search Tool (BLAST). For 18S_SSU primers this was usually class or order, whereas OTUs derived from the 16S primers were classified to genus or species. Sequences from the 18S_SSU primer were categorised to closest match using MEGAN 5 (Huson et al. 2007) and the Lowest Common Ancestor (LCA) assignment algorithm. LCA parameters were set at a minimum score of 250 and a top-percent of 5%. These cut-offs were determined by manually checking a subset of samples against BLAST. Sequences from the 16S primers were manually checked on Genbank, then the species and genus cross-checked with online species distribution databases: Fishes of Australia (www.fishesofaustralia.net.au) and the Atlas of Living Australia (www.ala.org.au) to ensure that sequences from all species from that genus in the region were represented. When a sequence exactly matched multiple species, they are both listed. If any species within the region were missing from Genbank for a genus, they are displayed in brackets.

Samples amplified with the 18S_SSU primers were included if they contained at least 100 sequences of food DNA, whereas samples amplified for the 16S primers were included if they contained at least 100 sequences of fish or cephalopod DNA (Jarman et al. 2013). Results are presented as the number of samples with a food item (n), the relative read abundance of sequences (RRA), and the frequency of occurrence (FOO). The RRA for 18S was calculated as the total sequences for that taxonomic group divided by the total food sequences for that sample, whereas the RRA for the 16S was the number of sequences for an individual species divided by the total number of fish/cephalopod sequences for that sample. The RRA was averaged for each season and breeding stage. For FOO calculations, any food item or fish/cephalopod species was deemed present if it comprised >1% of food sequences for that sample. For 18S samples, the FOO was calculated as the total number of samples that had a food group present in a given time period, divided by the total number of samples containing food DNA. As the 16S primers positively amplified more samples with food (due to the lack of non-target DNA), the FOO was calculated at the number of samples with a given species, divided by the total number of samples that contained food DNA across the three primer sets for that time period. These multiple measures of diet composition are presented to reduce potential biases in interpretation that might result from consideration of only a single metric.

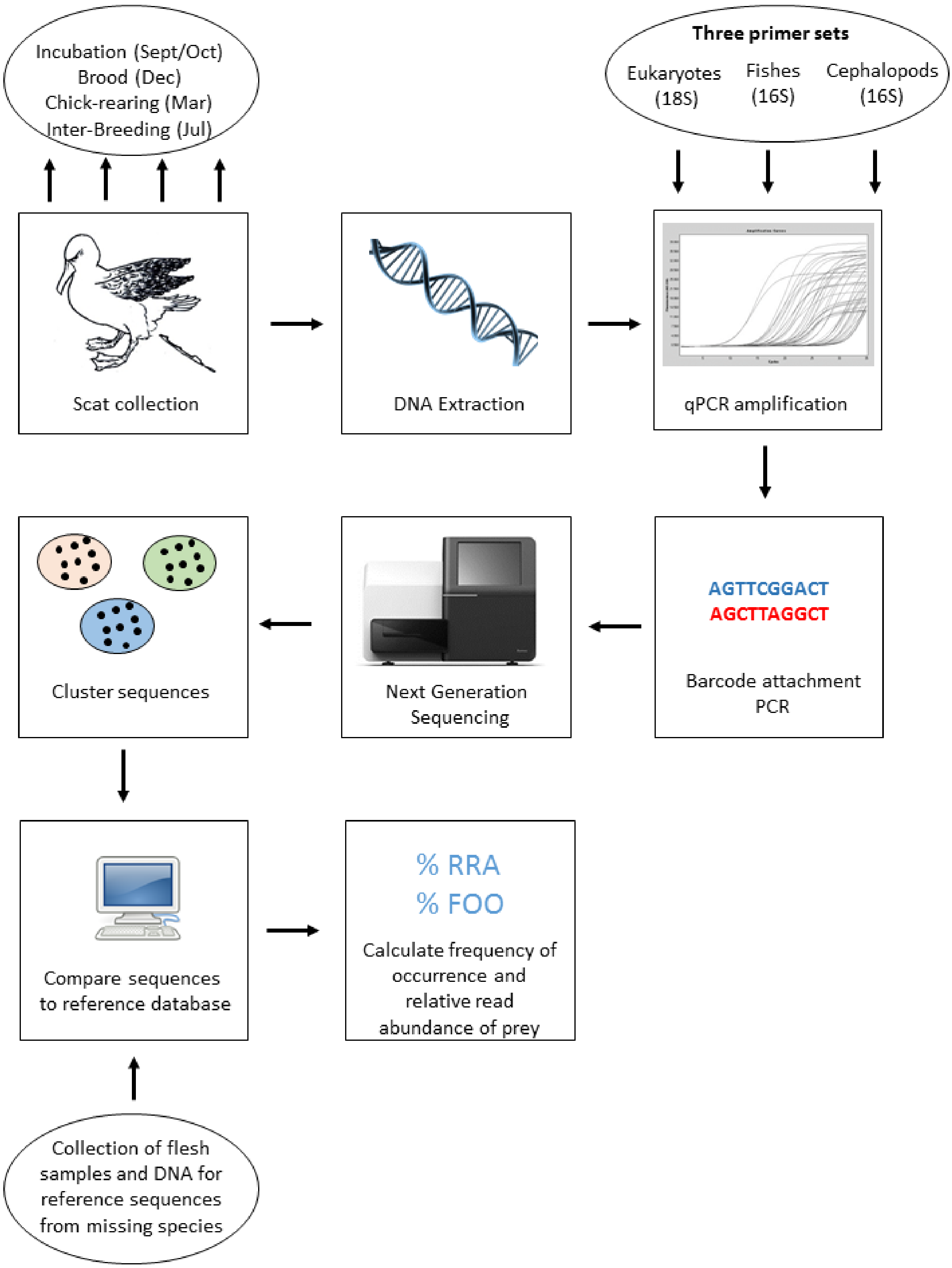


Figure 3: Workflow of molecular dietary analysis from sample collection to production of dietary data sets.

Assessing albatross and fishery spatial overlaps

Albatross spatial data

Foraging location data was based on existing data collections by the DPIPWE Marine Conservation Program and were used as a guide to indicate the foraging range of Shy Albatross during different breeding stages. This spatial data overlaps temporally with the dietary data during the Incubation period (September/October). The scats and spatial data were analysed at the population level, as scats weren't specifically from tracked birds. Spatial data collected prior to this study were used to estimate the main foraging areas for the other three breeding stages (brood, chick-rearing and inter-breeding) (**Table *4***).

Shy Albatross foraging ranges were estimated using foraging tracks recorded from birds fitted with Global Positioning System (GPS), Geolocation (GLS) or Platform Terminal Transmitter (PTT) tags. Foraging location data from incubation (September/October) correlated with the scat sample collections in each year of the study and was collected using GPS trackers (2014 n=15, 2015 n=15, 2016 n=14, 2017 n=13)(Mason et al. 2018, Mason et al. unpublished), however, due to the difficulty of tracking birds during brood and chick-rearing (Brothers et al. 1998), foraging areas for these stages were estimated from existing tracking data. Brood period (December) data was estimated using PTT tags deployed on 39 birds between 1993-96 and chick-rearing (March) foraging ranges were estimated using PTT tags deployed on seven birds between 1994-97. Inter-breeding period (May-August) foraging ranges were estimated using GLS tags deployed on eight birds during winter 2005-07.

Table 4: The number of shy albatross tracks used during the study.

Breeding Stage	Month	Tracking device	Temporal coverage (years)	Number of individuals tracked	Temporal overlap with diet samples
Incubation	September/October	GPS	2014-18	57	Yes
Brood	December	PTT	1993-96	39	No
Chick-Rearing	March	PTT	1994-97	7	No
Inter-breeding	May-August	GLS	2005-07	8	No

The foraging range of Shy Albatross was estimated: 1) across all breeding stages, 2) for each of the four breeding stages overall, and 3) for the Incubation period (September/October) in each year of the study. For GPS and PTT data, Brownian bridge kernel density estimations (Horne et al. 2007) were used to create a probability density distribution for each individual based on the location estimates and date-time stamps provided by the tracking data. For GLS data during the winter period GLS position information was calculated using the Twilight Free method of light based geolocation (Bindoff et al. 2017). For the GLS data, the standard kernel density estimation method was used to calculate probability distributions (Worton 1987), due to a single location being provided each day, rather than a track. For all tracking devices, the average cell values for each breeding stage and year grouping were calculated, and 50% and 95% probability contours were drawn (core foraging area and home range, respectively). There are variable error estimates between each of the tag types. GPS trackers have a high level of accuracy (± 10m), PTT have a lower accuracy, but still give reasonable resolution (± 100m), whereas GLS tags which use the pattern of light and dark to identify location have the poorest accuracy (± 100km). This inaccuracy of GLS trackers is particularly problematic for determining latitude. To account for errors in the coarse technology and limitations involved with processing the GLS data during this study, GLS data below -44.0 degrees latitude were removed from the analysis. Differences in accuracy between the PTT and GPS devices were mitigated by selection of parameters in analysis.

Commonwealth Fishery Catch Data

To determine when spatial overlaps occurred between albatross and Commonwealth Fisheries, AFMA catch data were overlayed with Shy Albatross home range polygons (95% probability contours) for each breeding stage. Although the core foraging area is known to change between seasons, the home range is relatively consistent between years (Mason et al. 2018). Therefore, although spatial data for some time periods does not overlap temporally with dietary data, the home range data used is likely to be representative of the current home range. Fishery catch data were restricted to within those polygons, with data clipped using the '*sp*' library in R (Pebesma and Bivand 2005). Fishery catch data were restricted to one week prior to the start of scat collections, through to the final day of collections on each field trip (Table 5).

Table 5: Approximate time periods that Shy Albatross dietary data likely covered and time span of fishery catch data included in analysis. This corresponds to the time period of sample collections and seven days prior.

		Incubation	Brood	Chick-rearing	Inter-breeding
2012/13	Start			21/3/2013	
	End			3/04/2013	
2013/14	Start			21/03/2014	
	End			31/03/2014	
2014/15	Start	15/09/2014	7/12/2014	22/03/2015	9/07/2015
	End	3/10/2014	18/12/2014	31/03/2015	16/07/2015
2015/16	Start	17/09/2015	7/12/2015	22/03/2016	13/07/2016
	End	1/10/2015	14/12/2015	3/04/2016	20/07/2016
2016/17	Start	2/10/2016	30/11/2016	24/03/2017	24/07/2017
	End	14/10/2016	10/12/2016	3/04/2017	1/08/2017
2017/18	Start	21/09/2017	3/12/2017	24/03/2018	
	End	7/10/2017	10/12/2017	4/04/2018	

Tasmanian State fishery data

We were able to compile broad information on which Tasmanian managed fisheries were operating within the Shy Albatross foraging area for the study period with assistance from the Institute for Marine and Antarctic Studies. For each Tasmanian managed fishery, we identified if there was a spatial overlap with Shy Albatross (using the overall foraging area), and if so, whether the fishery generated discards of either target, bycatch or bait species. Temporal data on fishing effort, catch amounts and discard species were not available.

Assessing the source of albatross food and potential resource overlaps with fisheries.

This study aims to identify spatial, temporal and dietary overlap between Shy Albatross and fisheries to improve our understanding of the nature and scale of fishery risks on Shy Albatross populations. Throughout this report, the following terminology is used: seabird ‘interaction’ refers to a seabird that has had direct contact with fishing gear or the vessel and potentially resulted in injury or mortality. This study does not quantify rates of seabird-fishery interaction, but rather, identifies the potential for interaction to occur using evidence of ‘engagement’. In this context, seabird ‘engagement’ is when birds attend a vessel, typically consuming discards, offal or target species. We identify engagement where there is spatial and temporal overlap (availability) and dietary overlap between Shy Albatross and fisheries, however the level of interaction is unknown. This study also examines a third mechanism by which albatross and fisheries may affect each other - through ‘shared resources’, i.e. species that are naturally consumed by Shy Albatross and also targeted by a commercial fishery, thus a resource overlap exists.

Source of albatross dietary items

Each fish and cephalopod species detected in the diet was assessed on its natural accessibility to Shy Albatross based on its habitat and depth in the water column (Appendix 4). We identified which of these species were caught by a fishery operating within the albatross foraging area during each stage. Each species detected in the diet was assigned to one of four categories according to the probable source (Table 6).

Table 6: Four categories of likely food *sources* for Shy Albatross according to species accessibility.

<table>
<tr><th rowspan="2" colspan="2"></th><th colspan="2">Species caught by a fishery in foraging area</th></tr>
<tr><th>Yes</th><th>No</th></tr>
<tr><td rowspan="2">Species naturally accessible to albatross</td><td>Yes</td><td>A: Unattributable
The consumed species could have been obtained through the fishery or naturally and therefore the source cannot be attributed.</td><td>B: Natural prey
The consumed species was not caught by the fishery in the albatross foraging area and is naturally accessible to albatross.</td></tr>
<tr><td>No</td><td>C: Fishery discards
The consumed species was caught by the fishery and unlikely to be naturally accessible to albatross due to either the depth or the behaviour (e.g. benthic).</td><td>D: Unknown
There is insufficient information about the fish or cephalopod species behaviour and distribution and it is unknown how they were obtained, potentially through state managed fishery discards, a dead individual or secondary ingestion.</td></tr>
</table>

As an individual animal could obtain food from multiple sources, we used two diet analysis metrics. The relative read abundance (RRA) of sequences was used as a proxy to estimate the proportion of the diet that came from each source/category. Although this value does not represent biomass, it does provide a broad estimate of the contribution of each food source in the diet (Deagle et al 2018). The frequency of occurrence (FOO) enables a calculation of the proportion of individuals that utilised each food source, which is particularly valuable for identifying the proportion of individuals that may be obtaining food from fisheries. FOO can overestimate the importance of minor items and is often problematic on its own, however even if there was only a small amount of a fishery species, it still represents an engagement and is therefore useful in this context. The RRA was calculated as the average proportion of sequences for each food group in each breeding stage using the 18S data, multiplied by the proportion of sequences for the specific species in the diet using the 16S data. For example, if fish contributed 80% of all food sequences (18S) and Redbait was 50% of fish sequences (16S), then Redbait was estimated to be 40% of the prey sequences overall. The RRA of sequences for each food source were averaged across each stage/season.

Assessing likely and potential engagement between albatross and fisheries

From the above categories we used the FOO calculations to estimate the temporal variation in fishery engagement by Shy Albatross. Fishery engagement was defined as either ‘likely engagement’ (Category C - fishery sourced species) where there was opportunity to obtain discards of species that are unlikely to or otherwise available or ‘potential engagement’ (Category A - Unattributed) where there was opportunity to obtain discards, but the food could also have been sourced naturally.

The number of individuals that consumed species likely sourced from fisheries was calculated for each breeding stage as the number of individuals with species from Category C, divided by the total number of samples that contained food DNA (18S or 16S derived food sequences).

We assessed which Commonwealth-managed fisheries and which gear type were operating within the albatross foraging area during the time period (Table 5) that caught the species in Category C (Table 6). From this we could refine which fisheries Shy Albatross at Albatross Island were most likely engaging with.

Identifying shared resources between albatross and fisheries

To identify shared resources between albatross and Commonwealth-managed fisheries operating in SE Australia waters, we identified which species were caught (target and bycatch) by the fisheries in SE Australia bounded by latitudes -35 to -45 and longitudes 135 to 155 (Figure 2), between 2014-2018 (plus March 2013). We extended this spatial extent beyond the foraging range of albatross at Albatross Island to take into consideration potential movement of marine species and to provide an indication of which commercial fishery species in SE Australia are also albatross prey. Each species was allocated into one of four resource categories according to
Table ***7***. Although some of these categories are similar to Table 6, the extended spatial extent meant that there were some changes in species categories. For example, all species from source Category A: Unattributed in Table 6 are “Potential Shared Resources” and all Category C: Fishery Source species are “Fishery Resource”. However, some accessible species that were not caught by a fishery in the albatross foraging area (Category B: Natural) were caught by a fishery in the extended spatial extent and are therefore a “Fishery Resource” (e.g. Redbait).

Table 7: Four categories of likely *resource* overlaps between Shy Albatross and commonwealth fisheries in SE Australia.

		Caught by a fishery in SE Australia	
		Yes	No
Species naturally accessible to albatross	Yes	**Shared resource** Caught by the fishery but also naturally accessible to albatross, therefore potential resource overlap and competition	**Non-fishery resource** No overlap in prey resource between the fishery and albatross.
	No	**Fishery resource** Species caught by the fishery and unlikely to be naturally accessible to albatross due to either the depth or the behaviour (e.g. benthic).	**Unknown** It is unknown how these species were obtained. Potentially through state managed fishery discards, a dead individual or secondary ingestion.

Shy Albatross energy requirements

The approximate volume of food consumed by Shy Albatross on Albatross Island during each breeding stage and annually was calculated for the five main food groups; fish (including chondrichthyes), cephalopods, krill, jellyfish (scyphozoa and hydrozoa) and salps. In addition, the approximate volume of the three main diet species; Redbait, Jack Mackerel and Giant Cuttlefish, and two species of particular interest to AFMA; Blue Grenadier and Ling were estimated, as well as the estimated total volume of species sourced from fisheries. To estimate the volume of food consumed by Shy Albatross, we used metabolic rates, prey assimilation rates and activity patterns from the published literature (Appendix 5).

The energy requirements of adult Shy Albatross were estimated for each breeding stage and extrapolated out to the population based on the equations below modified from Goldsworthy et al (2001). The total energy required *e* in kilojoules per day *k* for an individual albatross *i* was calculated for each breeding stage *s*. Where FMR is the field metabolic rate when active (*a*) and at rest (*r*) and *T* is the proportion of time in either state. *M* is the food assimilation efficiency for prey *j*.

$$e_i^k = \frac{(FMR_a T_a) + (FMR_r T_r)}{M_j}$$

The proportion of time active and at rest for each breeding stage was calculated as the ratio of foraging trip duration to nest shift duration (Hedd and Gales 2005). Although albatross spend a large proportion of their time away from the island sitting on the water (40-50%, Hedd et al. 2001), there is no correlation between energetic expenditure and flying time or distance travelled (Arnould et al. 1996) and taking off and landing may be energetically costly (Shaffer et al. 2004). As such active FMR was used for the entire duration at sea. These energy estimates are based on a number of variables that can vary considerably between individuals. As such, the values produced should be treated as broad estimates and the size of the error range should be taken into account when interpreting the data.

Prey consumption estimates

As different prey types contribute variable amounts of energy, we estimated the volume of prey for each breeding stage at Albatross Island using the following equation:

$$V_{ij}^{k} = e_{i}^{k} \frac{f_{ij}}{\sum_{j=1}^{y} f_{ij} p_{j}}$$

where f_{ij} is the proportion of sequences for species j in the diet of predator i, p is the energy density (kJ/g) of prey species j, and y is total number of prey taxa consumed. From this we can extrapolate the estimated prey volume for each breeding stage based on the number of birds on Albatross Island (b).

$$V_{js} = \sum_{k=1}^{d} \sum_{i=1}^{b} V_{ij}^{k}$$

The proportion of prey sequences was calculated as the average proportion of sequences for each prey group in each breeding stage using the 18S data, multiplied by the proportion of sequences for the specific prey species in the diet using the 16S data (e.g. Redbait; Appendix 6). As with all diet studies, the estimate of prey recorded (from stomach contents, DNA analysis in scats and hard-part analysis) are only an estimate of the prey consumed. Each method has inherent biases that may over or under estimate certain prey groups (Barrett et al. 2007). The RRA of sequences may be biased by amplification biases between prey groups, primer mismatches or DNA quality issues. However, these issues are more likely to affect minor prey items rather than the main prey used in these calculations (Deagle et al. 2019). The RRA of sequences has previously shown to be representative of diet proportions in feeding trials (Deagle et al. 2010, Willerslev et al. 2014) and hard-part studies (Thomas et al. 2017) and is considered to be sufficient for these estimates. The energy content of prey by wet mass was approximated from the literature (Appendix 5).

As the chick metabolic rate was unknown and is likely to vary during the chick-rearing period, we used the approximate chick meal mass to determine prey volume and added this to the total prey volume estimates for adults. The volume of prey j consumed for each chick X during stage s was calculated as the mean daily meal mass m, multiplied by the proportion of prey P for that breeding stage, multiplied by D the number of days in that breeding stage and by the approximate number of chicks in the colony C for each stage (brood and chick-rearing).

$$X_{js} = m\, P_{js} D_{s} C_{s}$$

A total for the year was then calculated as the sum of both adults and chick prey volumes for each breeding stage. Prey volume estimates were based on the mean values in Appendix 5, with the minimum and maximum calculated from the standard deviations in foraging trip durations and mass. As with the estimates of the metabolic rate, these prey/food volumes should be treated as broad estimates only. The likely error range from data derived from such large extrapolations is high and these estimates should be interpreted with caution.

Results

SE Australian diet reference database.

The SE Australian diet reference database contains 1294 records, with 892 identified to species, 127 to genus, 182 to family and 93 to broader group (Order to Phylum). The subset of species that were either consumed by top predators in the region or any species caught by a fishery with a total biomass in any year greater than a tonne, included 209 species (159 Actinopterygii, 27 Chondrichthyes, 21 Cephalopoda). Species were cross-checked with Genbank to identify any gaps in our local sequence library. We were missing sequence data for 43 species that were potential dietary items (28 Actinopterygii, nine Chondrichthyes and six Cephalopoda). Of these, flesh samples or DNA were obtained for 25 species and added to the Genbank library (Appendix 7).

Shy Albatross dietary DNA from scats

DNA was extracted from 1655 scat samples collected from 2013-2018. A total of 41.2 million sequencing reads were obtained for this dataset using the three markers (Table 8).

Table 8: The total number of sequences obtained for each of the three markers (18S_SSU, 16S_Fish and 16S_Ceph) during the study. Also listed is the number of samples included in the study (those which contained >100 sequences) and the proportion of samples collected that were included. As the 18S_SSU marker can also amplify non-food DNA (e.g. parasites) we also included the number of food only sequences for this marker (18S_SSU-Food).

	18S_SSU	18S_SSU-Food	16S_Fish	16S_Ceph
Total Sequences	10,794,148	3,359,226	14,086,484	16,325,272
Number of samples included in the study (>100 sequences per sample)	1572	821	1039	898
Proportion of total samples collected	95.0%	49.6%	62.8%	54.3%

The main food groups detected in the diet of Shy Albatross

Across all seasons and breeding stages, twelve classes of organisms contributed >0.1% of the sequence reads in this dataset (Table 9), with only four classes contributing >1% of sequences (Figure 4). The main prey class was Actinopterygii (bony-fish), with 78% of sequences and present in 93% of samples overall. Cephalopods (squids, octopus and cuttlefish) contributed 16% of sequences and were present in 38 % of samples, Chondrichthyes (sharks, skates and rays) 2.5% of sequences and 7.5% of samples, and Malacostraca (krill, lobsters, crabs, copepods) contributed 2% of sequences and were present in 7.5% of samples. The remaining eight classes combined contributed only 2% of DNA sequences. Overall 0.3% of sequences could not be accurately classified.

Bony-fishes and cephalopods contributed 93% of sequences overall, with little inter-annual variation across the four seasons (range 89-96% of sequences, Table 9). However, there was variation in the proportion of fish and cephalopod sequences between breeding stages, with a higher abundance of cephalopod sequences in the diet during Incubation (late September sampling) than during brood (December), chick-rearing (March) and inter-breeding (July, Figure 4).

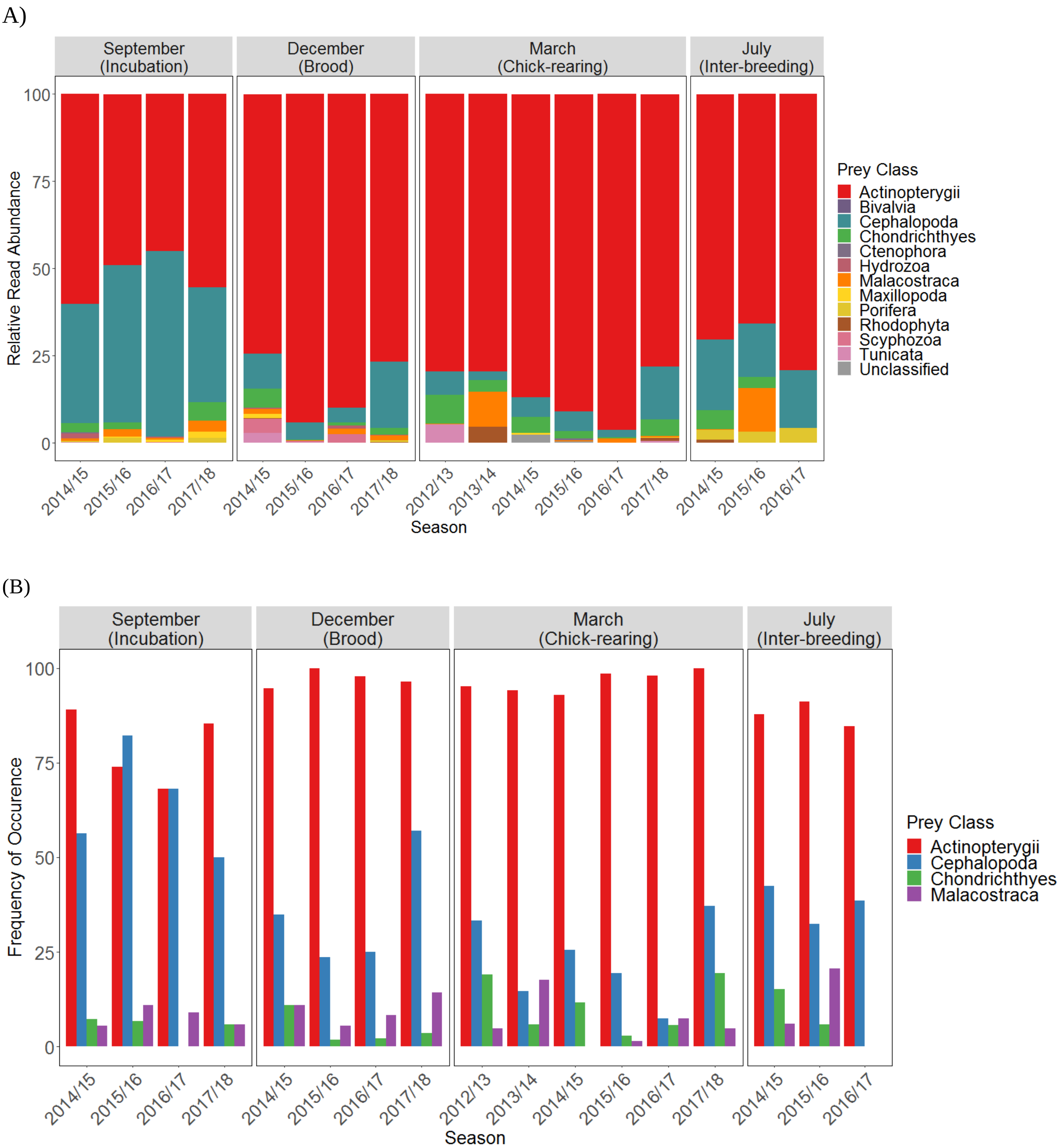


Figure 4: The relative read abundance of prey sequences in the samples across all seasons and breeding stages (A) and frequency of occurrence of the four main prey groups (B). Actinopterygii (Fish), Cephalopoda (squids, octopus, cuttlefish), Chondrichthyes (sharks, skates and rays), Malacostraca (crabs, krill, shrimps).

Table 9: The main prey classes detected in the Shy Albatross from 2012/13 to 2017/18 seasons. Values represent the number of samples containing the prey (n), relative read abundance (RRA) and frequency of occurrence (FOO). Only samples from chick-rearing were collected in 2012/13 and 2013/14 and no samples from inter-breeding 2017/18.

		2012/13 (n=21)			2013/14 (n=34)			2014/15 (n=221)			2015/16 (n=233)			2016/17 (n=184)			2017/18 (n=124)		
Phylum	**Class (bolded) and Order**	n	RRA	FOO	n	RRA	FOO	n	RRA	FOO	n	RRA	FOO	n	RRA	FOO	n	RRA	FOO
Chordata	**Actinopterygii**	**20**	**79.6**	**95.2**	**32**	**79.7**	**94.1**	**205**	**72.6**	**92.8**	**211**	**75**	**90.6**	**173**	**85.8**	**94**	**118**	**71.5**	**95.2**
	Chondrichthyes	**4**	**8.3**	**19.0**	**2**	**3.3**	**5.9**	**24**	**4.6**	**10.9**	**10**	**1.8**	**4.3**	**5**	**0.5**	**2.7**	**15**	**4.3**	**12.1**
	Batoidea	4	8.2	19	1	1.8	2.9	18	3.9	8.1	8	1.5	3.4	3	0.1	1.6	8	3	6.5
	Galeoidea	1	0.1	4.8	1	1.5	2.9	6	0.7	2.7	2	0.3	0.9	1	0.4	0.5	7	1.2	5.6
Mollusca	**Bivalvia:** Pteriomorphia	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**<0.1**	**1.4**	**0**	**<0.1**	**0**	**0**	**<0.1**	**0**	**0**	**<0.1**	**0**
	Cephalopoda	**7**	**6.6**	**33.3**	**5**	**2.4**	**14.7**	**88**	**16.6**	**39.8**	**98**	**19.1**	**42.1**	**48**	**10.2**	**26.1**	**56**	**20.9**	**45.2**
Ctenophora		**0**	**0**	**0**	**0**	**0**	**0**	**2**	**<0.1**	**0.9**	**1**	**<0.1**	**0.4**	**3**	**<0.1**	**1.6**	**0**	**<0.1**	**0**
Cnidaria	**Hydrozoa:** Hydroidolina	**0**	**0**	**0**	**1**	**0.1**	**2.9**	**4**	**<0.1**	**1.8**	**1**	**<0.1**	**0.4**	**12**	**<0.1**	**6.5**	**2**	**<0.1**	**1.6**
	Scyphozoa: Semaeostomeae	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**1.7**	**4.1**	**2**	**0.1**	**0.9**	**13**	**1.4**	**7.1**	**0**	**0**	**0**
Arthropoda	**Malacostraca**	**1**	**0.1**	**4.8**	**6**	**10.0**	**17.6**	**14**	**0.7**	**6.3**	**19**	**2.7**	**8.2**	**14**	**1.2**	**7.6**	**10**	**1.4**	**8.1**
	Amphipoda	0	0	0	2	0.1	5.9	0	0	0	1	0	0.4	0	0	0	0	0	0
	Euphausiacea	0	0	0	0	0	0	0	0	0	10	1.9	4.3	11	1.1	6	6	1.2	4.8
	Isopoda	0	0	0	2	3.1	5.9	0	0	0	0	0	0	0	0	0	1	0	0.8
	Decapoda	1	0.1	4.8	3	6.8	8.8	14	0.7	6.3	8	0.7	3.4	3	0.1	1.6	3	0.2	2.4
	Maxillopoda	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0.2**	**2.3**	**1**	**0**	**0.4**	**1**	**0**	**0.5**	**3**	**0.2**	**2.4**
	Calanoida	0	0	0	0	0	0	3	0.1	1.4	0	0	0	1	0.1	0.5	2	0.1	1.6
	Copepoda	0	0	0	0	0	0	2	0.5	0.9	0	0	0	0	0	0	0	0	0
	Podoplea	0	0	0	0	0	0	0	0	0	1	0.1	0.4	0	0	0	1	0.5	0.8
Porifera	**Unclassified Porifera**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0.5**	**1.4**	**6**	**0.9**	**2.6**	**1**	**0.3**	**0.5**	**3**	**0.5**	**2.4**
Rhodophyta	**Unclassified Rhodophyta**	**0**	**0**	**0**	**6**	**4.5**	**17.6**	**4**	**0.2**	**1.8**	**1**	**0**	**0.4**	**1**	**0**	**0.5**	**2**	**0.4**	**1.6**
Tunicata	**Appendicularia**	**2**	**1.4**	**2.4**	**0**	**0**	**0**	**8**	**0.2**	**3.6**	**1**	**0**	**0.4**	**0**	**0**	**0**	**0**	**0**	**0**
	Ascidiacea	**1**	**3.3**	**4.8**	**0**	**0**	**0**	**5**	**0.2**	**2.3**	**1**	**0**	**0.4**	**0**	**0**	**0**	**1**	**0.2**	**0.8**
	Enterogona	0	0	0	0	0	0	2	0	0.9	0	0	0	0	0	0	0	0	0
	Stolidobranchia	1	3.3	4.8	0	0	0	3	0.2	1.4	1	0	0.4	0	0	0	1	0.2	0.8
	Thaliacea: Salpida	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**0.9**	**3.2**	**4**	**0.1**	**1.7**	**1**	**0**	**0.5**	**2**	**0.2**	**1.6**
Unclassified		**0**	**0**	**0**	**1**	**0.1**	**2.9**	**3**	**0.5**	**1.4**	**1**	**0.1**	**0.4**	**0**	**0**	**0**	**1**	**0**	**0.8**

Fish Species detected in the diet of Shy Albatross

Eighty-four fish species were detected in the Shy Albatross diet across the four years (Appendix 8). The main fish species overall were redbait (*Emmelichthys nitidus*) with 30-46% RRA; Common Jack Mackerel (*Trachurus declivis*) 7-17% RRA, Barracouta *(Thyrsites atun)* 6-22% RRA, Blue Mackerel (*Scomber australasicus)* with 2-16% RRA and Australian Sardine (*Sardinops sagax)* 0-9% RRA, with 1-6% RRA. Five species that contributed lower than 5 % of sequences overall but were present in >5% of samples were Silver Scabbardfish (*Lepidopus caudatus)*, Blue Grenadier *(Macruronus novaezelandiae)*, Bluefin Leatherjacket *(Thamnaconus degeni)*, Bearded Rock Cod *(Pseudophycis barbata)* and Ling *(Genypterus blacodes/tigerinus)*.

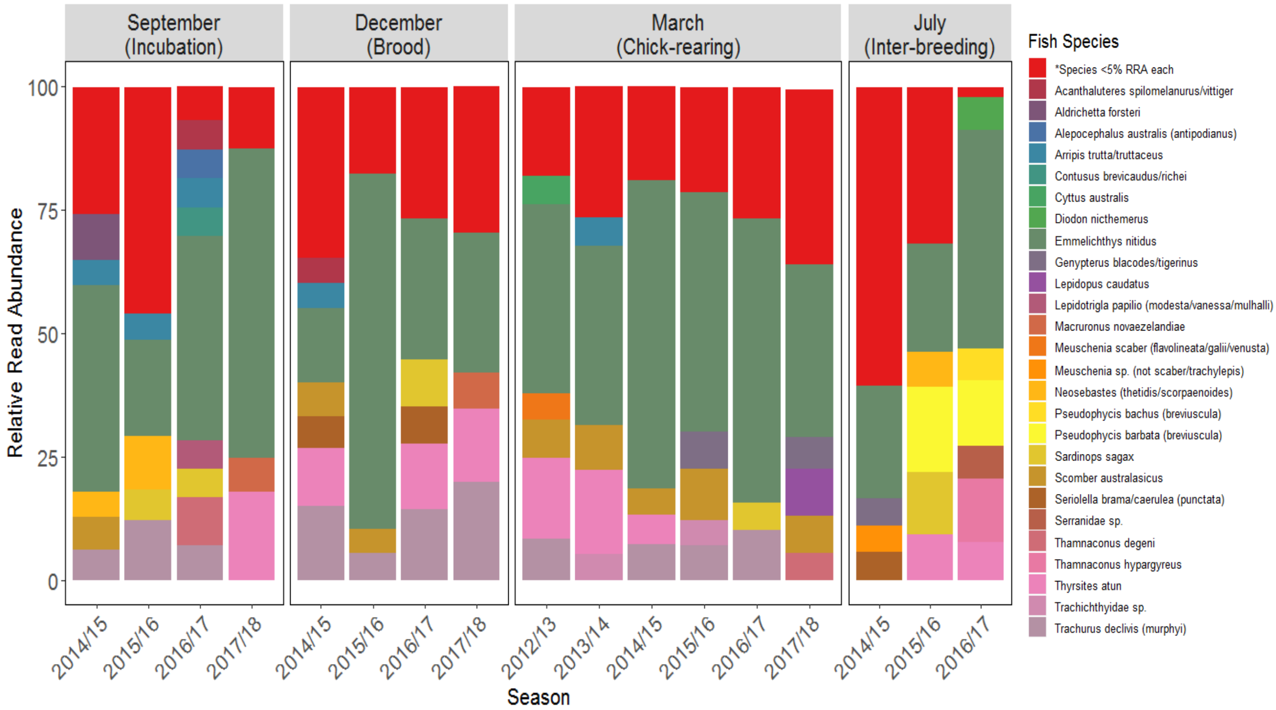
There was intra- inter-annual variability in the fish prey consumed (Figure 5). When comparing between seasons, 34 species contributed >1% of the sequences and were present in >1% of samples and ten species contributed >5% of sequences and samples in any year (Table 10).

Table 10: Relative read abundance (RRA) and frequency of occurrence (FOO) of fish species in the diet. Species represent those that contributed >1% RRA and FOO in Shy Albatross samples from 2012/13 to 2017-18. Bolded species are >5% RRA and FOO in any year

			2012/13 (n=46)			2013/14 (n=93)			2014/15 (n=485)			2015/16 (n=379)			2016/17 (n=260)			2017/18 (n=195)		
Family	**Species**	**Common Name**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**
Arripidae	***Arripis trutta/truttaceus***	**Australian Salmon**	**0**	**0**	**0**	**9**	**9.7**	**5.8**	**18**	**3.1**	**3.5**	**8**	**1.8**	**1.5**	**4**	**1.5**	**1.8**	**1**	**0.8**	**1.2**
Berycidae	*Centroberyx lineatus*	Swallowtail	0	0	0	1	1.1	1.3	0	0	0	0	0	0	0	0	0	0	0	0
Carangidae	***Trachurus declivis/murphyi***	**Common Jack Mackerel**	**8**	**17.4**	**8.3**	**6**	**6.5**	**3.5**	**50**	**10.0**	**8.1**	**39**	**9.8**	**7.0**	**39**	**10.2**	**7.9**	**11**	**6.7**	**8.8**
Centrolophidae	*Seriolella brama/ caerulea (punctata)*	Warehou	1	2.2	1.5	2	2.2	0.1	17	3.3	3.1	7	2.2	0.4	12	2.5	1.9	1	0.3	<0.1
Cheilodactylidae	*Cheilodactylus nigripes/ Nemadactylus macropterus*	Magpie Perch/Morwongs	3	6.5	3.7	2	2.2	0.9	6	1.5	0.9	4	1.2	0.1	1	0.3	0.2	5	2.1	0.9
Clupeidae	***Sardinops sagax***	**Australian Sardine**	**1**	**2.2**	**2.7**	**0**	**0**	**0**	**10**	**2.1**	**1.6**	**27**	**7.1**	**5.6**	**35**	**9.5**	**5.3**	**2**	**1.1**	**1.2**
	Sprattus (novaehollandiae)	Australian Spratt	0	0	0	0	0	0	2	0.3	0.4	5	1.3	1.6	0	0	0	3	1.0	0.4
Congridae	*Gnathophis sp.*	Conger	0	0	0	1	1.1	0.1	6	1.7	1.3	3	0.6	0.7	0	0	0	0	0	0
Cyttidae	***Cyttus australis***	**Silver Dory**	**4**	**8.7**	**5.8**	**1**	**1.1**	**0.7**	**2**	**0.5**	**0.5**	**0**	**0**	**0**	**1**	**0.3**	**<0.1**	**2**	**0.7**	**0.1**
Dinolestidae	*Dinolestes lewini*	Longfin Pike	0	0	0	3	3.2	3.1	0	0	0	0	0	0	0	0	0	1	0.3	0.4
Diodontidae	*Diodon nicthemerus*	Globefish/ Slender-spined Porcupine Fish	1	2.2	<0.1	0	0	0	2	0.5	0.8	5	1.0	1.2	1	1.0	1.7	3	1.0	0.9
Emmelichthyidae	***Emmelichthys nitidus***	**Redbait**	**21**	**45.7**	**38.4**	**32**	**34.4**	**36.4**	**142**	**32.6**	**35.5**	**159**	**44.5**	**40.5**	**95**	**34.6**	**42.9**	**64**	**30.7**	**41.9**
Gempylidae	***Thyrsites atun***	**Barracouta**	**10**	**21.7**	**16.5**	**17**	**18.3**	**17**	**40**	**7.8**	**5.0**	**23**	**6.0**	**4.9**	**28**	**8.6**	**5.9**	**16**	**9.4**	**12.0**
Labridae	*Notolabrus tetricus*	Bluethroat Wrasse	0	0	0	1	1.1	<0.1	5	0.9	1.1	0	0	0	0	0	0	0	0	0
Merlucciidae	***Macruronus novaezelandiae***	**Blue Grenadier**	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**2.3**	**2.0**	**11**	**3.3**	**1.7**	**6**	**2.4**	**0.7**	**20**	**9.6**	**5.9**
Monacanthidae	*Acanthaluteres spilomelanurus/vittiger*	Bridled or Toothbrush Leatherjacket	0	0	0	0	0	0	6	0.9	1.3	7	2.1	0.5	6	2.2	2.5	4	1.8	0.5
	Eubalichthys (gunnii/bucephalus)	Leatherjacket	2	4.3	1.3	1	1.1	1.4	3	0.6	0.5	3	0.7	0.5	0	0.0	0.0	1	0.3	<0.1
	Meuschenia scaber (flavolineata/galii/ venusta)	Leatherjacket (velvet)	2	4.3	5.3	2	2.2	1.4	5	1.0	0.3	9	2.1	1.0	7	1.9	0.8	6	2.0	0.3
Monacanthidae	*Meuschenia sp.*	Leatherjacket	0	0	0	1	1.1	<0.1	3	1.0	1.3	0	0	0	0	0	0	0	0	0

			2012/13 (n=46)			2013/14 (n=93)			2014/15 (n=485)			2015/16 (n=379)			2016/17 (n=260)			2017/18 (n=195)		
Family	**Species**	**Common Name**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**
	Thamnaconus degeni	Bluefin Leatherjacket	0	0	0	7	7.5	3.4	14	3.0	2.0	6	1.7	1.1	14	4.8	3.7	12	4.8	3.4
	Thamnaconus hypargyreus	Yellowspotted Leatherjacket	1	2.2	0.3	5	5.4	3.6	16	3.8	1.6	7	1.8	1.0	3	2.2	3.2	3	1.9	1.2
Moridae	*Lotella rhacina*	Large Tooth Beardie/Rock cod	1	2.2	0.1	0	0	0	3	0.5	0.4	9	2.1	1.5	1	0.7	0.1	0	0	0
	Pseudophycis bachus/breviuscula	Red cod	2	4.3	0.4	1	1.1	1.1	8	1.7	1.7	10	2.8	1.9	12	4.8	2.5	5	2.4	3.6
	Pseudophycis barbata	**Bearded Rock Cod**	**1**	**2.2**	**0.2**	**5**	**5.4**	**1.6**	**6**	**1.7**	**0.9**	**20**	**5.7**	**5.2**	**14**	**5.4**	**4.2**	**3**	**1.0**	**0.6**
Mugilidae	*Aldrichetta forsteri*	Yelloweye Mullet	0	0	0	0	0	0	12	1.9	2.5	1	0.3	0	0	0	0	0	0	0
Neosebastidae	*Neosebastes (thetidis/scorpaenoides)*	Gurnard perches	3	6.5	0.7	2	2.2	1.6	10	2.2	2.8	19	4.4	4.9	5	1.2	0.7	3	1.0	0.4
Ophidiidae	*Genypterus blacodes/tigerinus*	Pink Ling or Rock Ling	4	8.7	3.1	0	0	0	15	3.7	2.9	12	3.3	3.5	7	1.7	1.1	9	3.0	2.2
Pempheridae	*Pempheris (multiradiata/compressa)*	Bigscale or smallscale Bullseye	2	4.3	2.8	0	0	0	3	0.9	1.3	1	0.3	0	0	0	0	0	0	0
Scombridae	***Scomber australasicus***	**Blue Mackerel**	**5**	**10.9**	**7.6**	**15**	**16.1**	**9**	**32**	**6.7**	**5.3**	**28**	**7.3**	**5.0**	**8**	**1.7**	**1.1**	**11**	**3.7**	**2.5**
Serranidae	*Caesioperca lepidoptera (rasor)*	Butterfly or Barber Perch	0	0	0	0	0	0	2	0.5	0.0	9	2.3	1.3	7	1.6	0.5	3	1.9	1.6
Serranidae	Serranidae	Seaperch and perches	0	0	0	3	3.2	2.5	10	2.4	1.3	7	2.0	1.1	4	1.6	2.1	2	0.7	0.4
Trachichthyidae	**Trachichthyidae**	**Roughies**	**1**	**2.2**	**0.2**	**6**	**6.5**	**5.3**	**6**	**0.9**	**1.0**	**12**	**3.2**	**1.9**	**4**	**1.4**	**1.4**	**2**	**1.6**	**0.7**
Trichiuridae	*Lepidopus caudatus*	Frostfish	0	0	0	0	0	0	2	0.5	0.1	1	0.3	0.3	4	1.1	0.7	10	3.4	3.2
Triglidae	*Lepidotrigla papilio (modesta/vanessa/ mulhalli)*	Gurnard	1	2.2	0.1	0	0	0	3	0.6	0.4	5	1.3	0.7	6	2.0	2.0	2	0.7	0.6

A)



B)

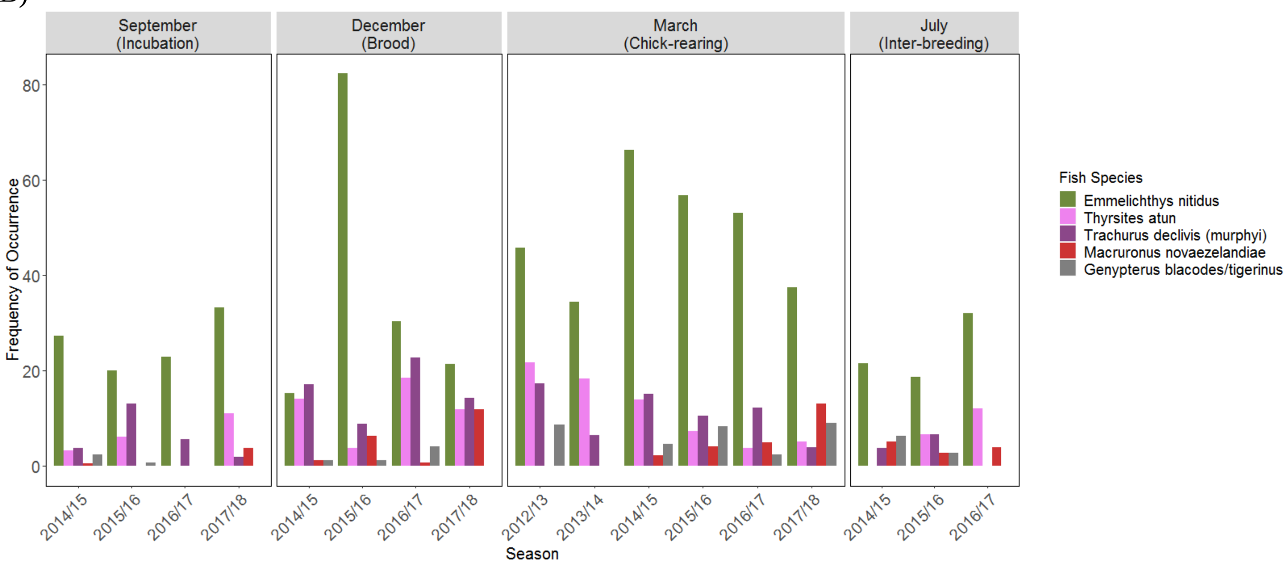


Figure 5: The Relative read abundance of fish species in the diet of Shy Albatross across all breeding stages from 2012-13 to 2017-18 (A) and the Frequency of Occurrence of the main three species, plus two of special interest for AFMA (B). The red bar in figure A represents species that contributed <5% of the RRA and therefore each individual species was a minor component of the diet

Cephalopod species detected in the diet of Shy Albatross

Eleven cephalopod species were detected in the diet of Shy Albatross during the study (Table 11). Of these, six species contributed >1% of the sequences and only four species >5% of the RRA or FOO. There was inter- and intra- annual variation in the species consumed, with cuttlefish dominating the cephalopod component of the diet during incubation and Argonauts and Gould's squid mostly present during brood and chick-rearing (Figure 6). There was one group of sequences that was an exact match to a cuttlefish species not found in Australian waters (*Sepia madokai*) and this could be another similar species for which we do not currently have genetic material. A small number of sequences matched two species found in the Southern Ocean and one in the Tasman Sea.

A)

B)

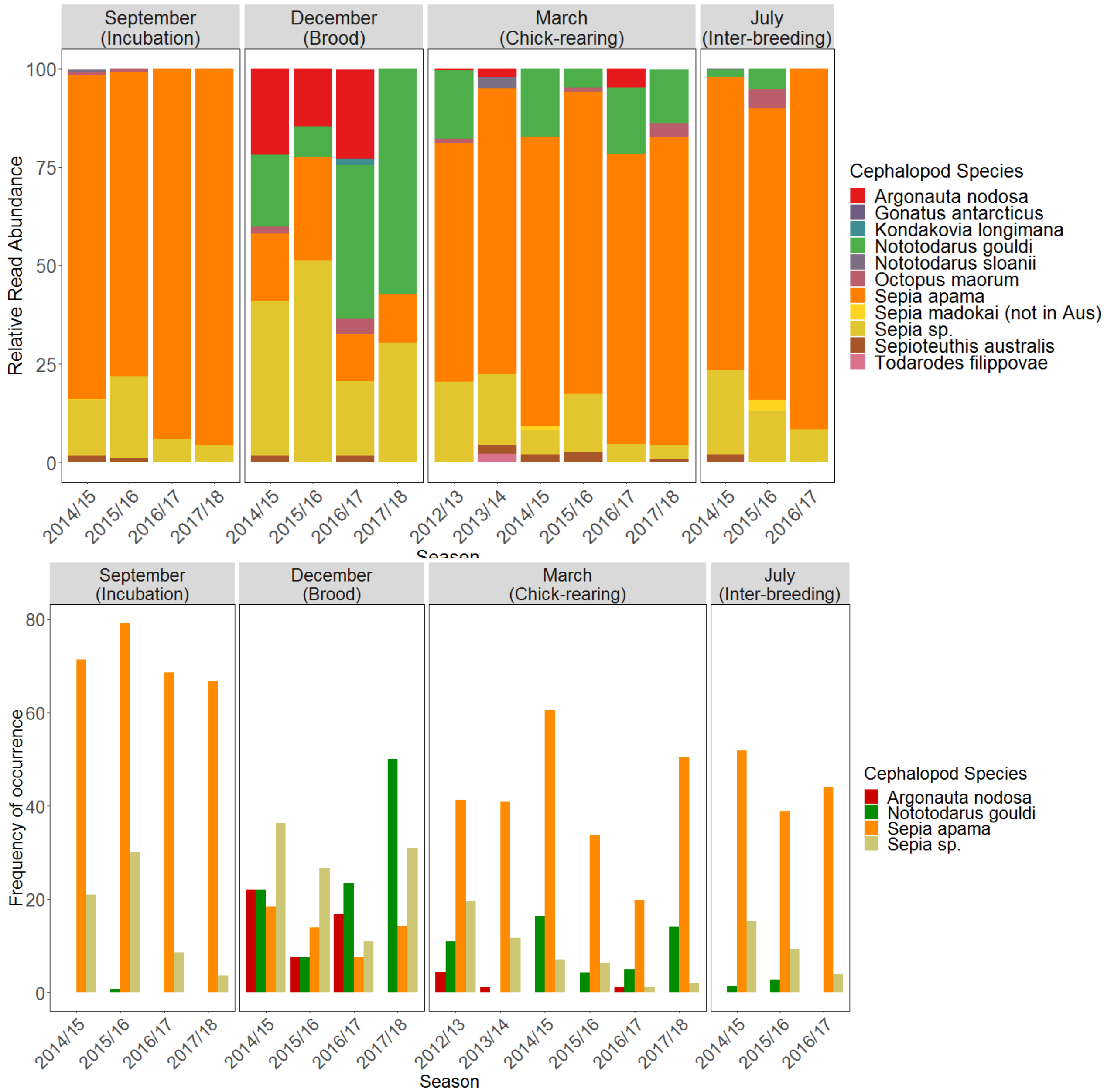


Figure 6: The relative read abundance of cephalopod sequences across all seasons and breeding stages (A) and the frequency of occurrence of the four main species (B).

Table 11: Relative read abundance (RRA) and frequency of occurrence (FOO) of cephalopod species in the diet. Species represent those that contributed >1% RRA and FOO in Shy Albatross samples from 2012/13 to 2017-18. Bolded species are >5% RRA and FOO in any year.

			2012/13 (n=46)			2013/14 (n=93)			2014/15 (n=485)			2015/16 (n=379)			2016/17 (n=260)			2017/18 (n=195)		
Family	**Species**	**Common Name**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**
Argonautidae	***Argonauta nodosa***	**Knobby Argonaut**	**2**	**4.3**	**0.3**	**1**	**1.1**	**2.1**	**36**	**5.5**	**5.5**	**6**	**1.9**	**3.7**	**21**	**4.5**	**6.9**	**0**	**0**	**0**
Loliginidae	*Sepioteuthis australis*	Southern Calamari	0	0	0	2	2.2	2.4	8	1.7	1.8	3	0.7	0.9	1	0.2	0.4	1	0.3	0.2
Octopodidae	*Octopus maorum*	Maori Octopus	2	4.3	1.1	0	0	0	5	0.9	0.6	6	1.5	1.7	4	0.9	1.0	3	1.0	1.2
Ommastrephidae	***Nototodarus gouldi***	**Gould's Squid**	**5**	**10.9**	**17.4**	**0**	**0**	**0**	**51**	**9.9**	**9.4**	**13**	**3.8**	**4.4**	**32**	**7.1**	**14.0**	**35**	**21.4**	**23.7**
Ommastrephidae	*Nototodarus sloanii*	NZ Arrow Squid	0	0	0	2	2.2	2.8	1	0.2	0.2	0	0	0	0	0	0	0	0	0
Ommastrephidae	*Todarodes filippovae*	Antarctic Flying Squid	0	0	0	1	1.1	2.1	0	0	0	0	0	0	0	0	0	0	0	0
Sepiidae	***Sepia apama***	**Giant Cuttlefish**	**19**	**41.3**	**60.7**	**38**	**40.9**	**72.8**	**235**	**50.5**	**61.8**	**175**	**41.4**	**63.6**	**60**	**35.0**	**67.9**	**92**	**43.8**	**62.1**
Sepiidae	***Sepia sp.***	**Cuttlefish sp.**	**9**	**19.6**	**20.4**	**11**	**11.8**	**17.8**	**110**	**19.9**	**20.3**	**73**	**18.1**	**25.0**	**18**	**6.2**	**9.5**	**17**	**12.2**	**12.7**

Spatial overlaps between foraging areas of Shy Albatross from Albatross Island and SE Australian fisheries

During the Shy Albatross breeding season (September-April), the core foraging area of Shy Albatross is restricted to the within 150km of Albatross Island. The home range is also relatively restricted during Incubation and Brood (September to early January) and extends during chick-rearing up to the mainland in the north and south of Macquarie Harbour in the south (Figure 7). During the inter-breeding period (May-August), the core foraging area and home range is much more extended, covering a large proportion of Bass Strait and western Tasmania (Figure 8). The foraging range during Incubation (September/October) which was identified for each year of the study, showed little inter-annual variation, with the core foraging area remaining within close proximity to Albatross Island and the home range extending up along the continental shelf to the west and north to the mainland (Figure 9).

Shy Albatross overlapped spatially with six Commonwealth fisheries during the project duration. There were overlaps during all time periods (Table 5) with the Southern and Eastern Scalefish and Shark Fishery, the Scallop Fishery during all periods except chick-rearing, and the Southern Squid Fishery during chick-rearing (Appendix 10-14) . There was minimal overlap with the Southern Bluefin Tuna, Small Pelagic and High Seas Fisheries, each overlapping during only one breeding stage (Table 12).

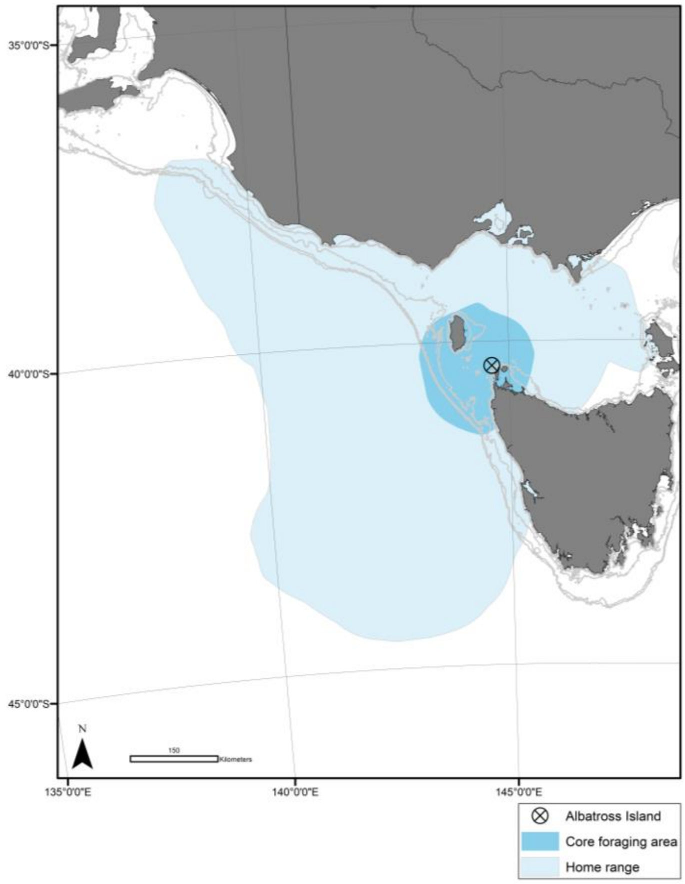


Figure 7: Foraging range of Shy Albatross across all stages and seasons using tracking data derived from GPS, GLS and PTT trackers deployed from 1994-2017.

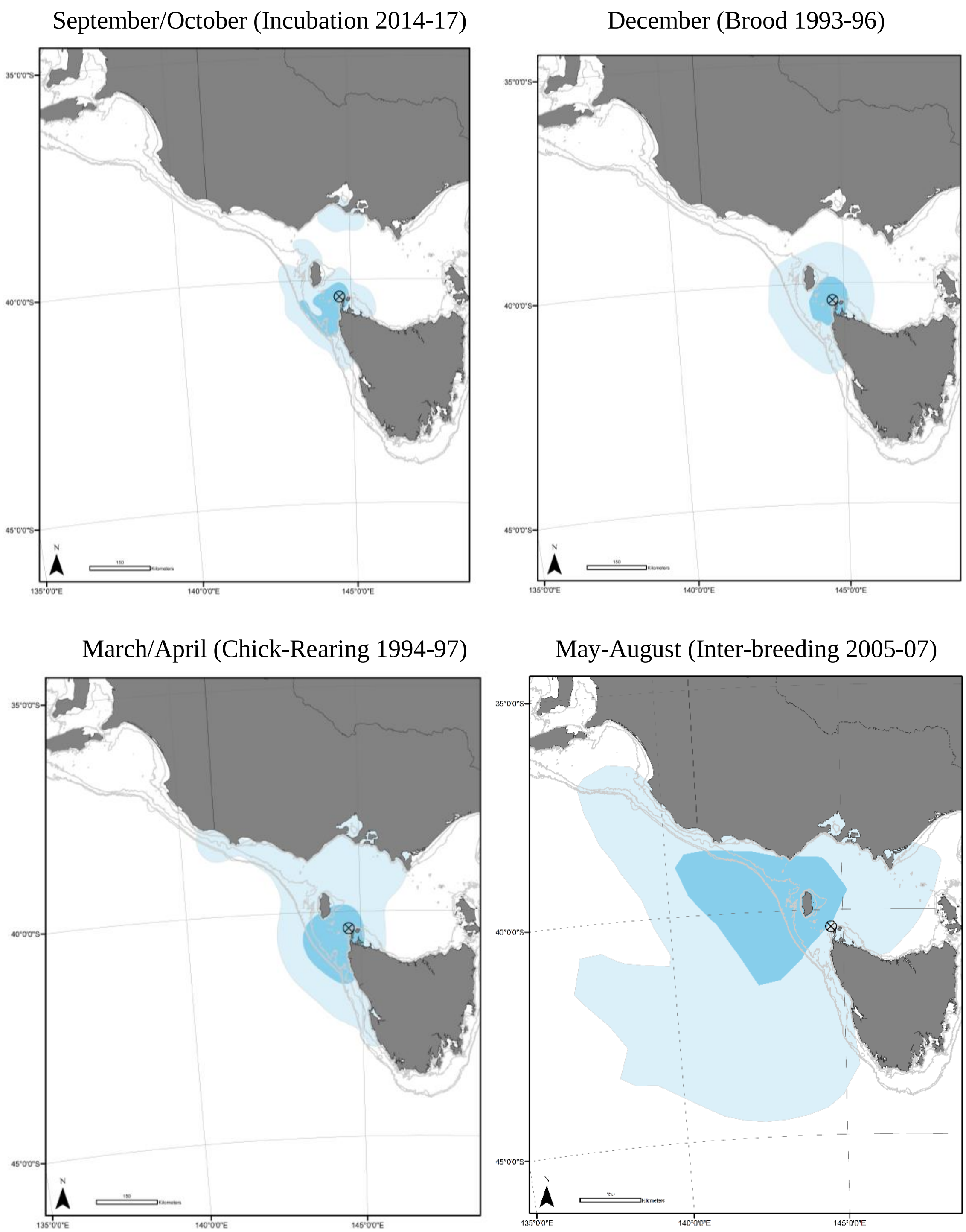
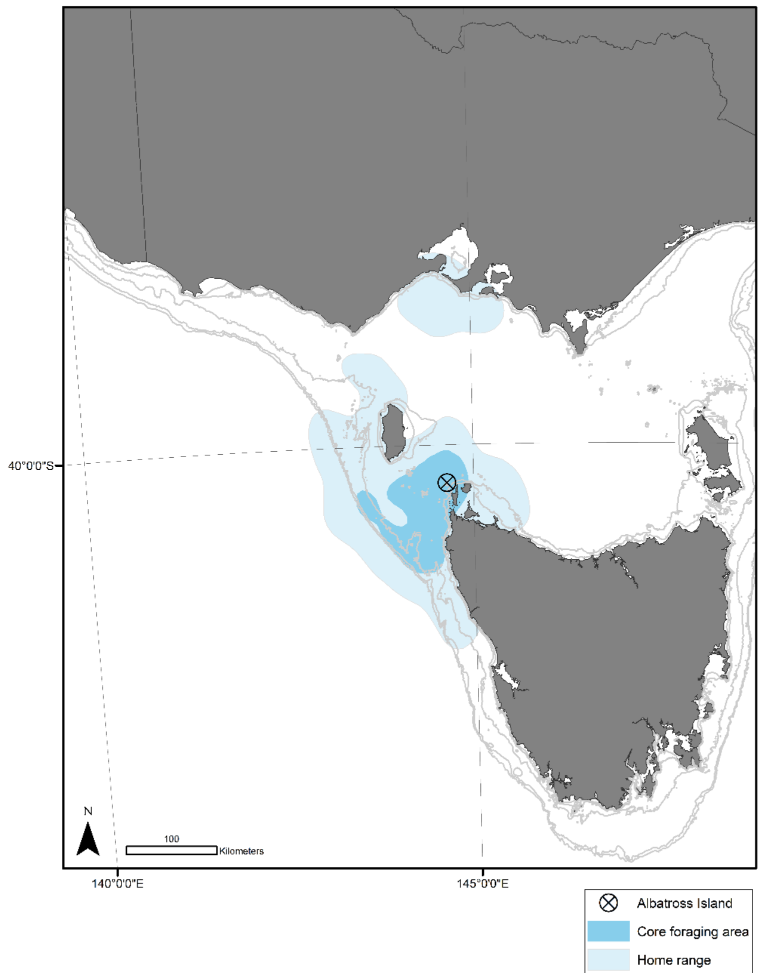


Figure 8: Foraging range of Shy Albatross during each breeding stage. Incubation (September/October) foraging ranges were estimated from 57 GPS trackers deployed from 2014-2017; brood period (December) ranges was estimated using PTT tags deployed on 39 birds between 1993-96; chick-rearing (March) foraging ranges were estimated using PTT tags deployed on seven birds between 1994-97; and Inter-breeding (May-August) foraging ranges were estimated using GLS tags deployed on eight birds during winter 2005-2007.



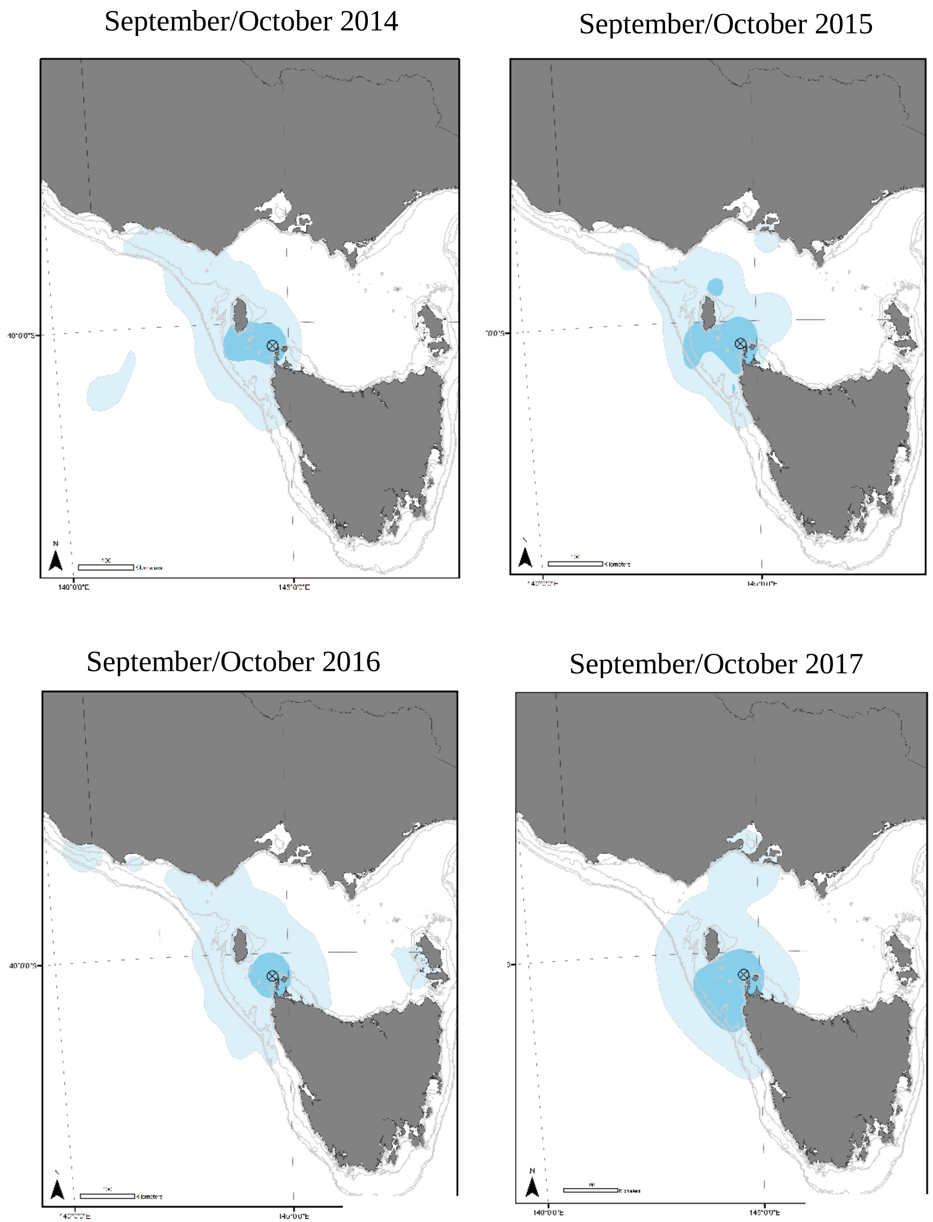


Figure 9: Foraging range of Shy Albatross during incubation derived from PTT tags deployed from 2014-2017. Figures represent all years combined and data from each year individually.

Table 12: Spatial overlaps (X) between Shy Albatross from Albatross Island and Commonwealth managed fisheries during the study.

			SESSF Southern and Eastern Scalefish and Shark Fishery			**HSN** High seas non-trawl	**SBT** Southern Bluefin Tuna	**SCA** Scallop	**SPF** Small Pelagic Fishery	**SQJ** Southern Squid Fishery
SEASON	**MONTH**	**STAGE**	**GHT** Gillnet Hook and Trap	**SET** South East Trawl	**VIT** Victorian Inshore Trawl					
2012/13	March	Chick-rearing	X	X	X					
2013/14	March	Chick-rearing	X	X	X					
2014/15	September	Incubation	X	X				X		
	December	Brood	X	X				X		
	March	Chick-rearing	X	X	X					X
	July	Inter-breeding	X	X				X	X	
2015/16	September	Incubation	X	X	X	X		X		
	December	Brood	X	X				X		
	March	Chick-rearing	X	X	X					X
	July	Inter-breeding	X	X			X			
2016/17	September	Incubation	X	X				X		
	December	Brood	X	X				X		
	March	Chick-rearing	X	X						X
	July	Inter-breeding	X	X				X		
2017/18	September	Incubation	X	X				X		
	December	Brood	X	X				X		
	March	Chick-rearing	X	X						X

Shy Albatross overlapped spatially with six Tasmanian managed fisheries during the project duration: 1) Abalone, 2) Commercial Dive, 3) Octopus, 4) Southern Rock Lobster, 5) Scalefish, and 6) Seaweed (Appendix 14). However, of these fisheries, only the Tasmanian Scalefish and Southern Rock Lobster (SRL) fisheries produced discards, the remaining fisheries selectively hand collect target species. The Tasmanian Scalefish fishery uses twelve different gear types. Of these, six are currently used in the foraging area of Shy Albatross from Albatross Island (drop-line, gill net, hand-line, small mesh net, squid jig and squid vessels with lights), two of these (targeting squid) do not produce discards. The catch amounts are generally considered low for vessels using drop-line, gill nets and small mesh net (<2 tonnes annually overall) and unlikely to produce enough discards to commonly occur in the diet of Shy Albatross. Vessels using hand-lines typically target bluethroat wrasse (*Notolabrus tetricus*) and purple wrasse (*Notolabrus fuciola*). There was no purple wrasse detected in the Shy Albatross diet and bluethroat wrasse was detected in low frequency (six samples, <2% FOO or RRA), all between March 2014 and July 2015. These species are also a common discarded bycatch of the rock lobster fishery and are likely to also be naturally accessible to albatross, therefore the source is unknown. There was a high level of overlap between the bait species discarded in the SRL fishery and food species that commonly occurred in the Shy Albatross diet. The five most common fish species detected in the diet of Shy Albatross are also the baits used in SRL pots (Redbait, Jack Mackerel, Barracouta, Blue Mackerel and Australian Salmon, Rizarri and Gardner, unpublished).

Source of albatross dietary items

The vast majority of Shy Albatross diet was naturally derived. Across all time periods, 57.1% of fish species (n= 48) and 81.8% of cephalopods (n=9) were likely to be sourced by Shy Albatross naturally (60% of fish and cephalopods combined), making up on average 72.5 ± 10.8% of fish sequences and 88.1 ± 16.0% of cephalopod sequences (Table 13). The overall RRA of naturally sourced prey (when corrected for the proportion of fish and cephalopod in the diet) was 77.9 ± 11.4 %. This value assumes that these other food groups (e.g. krill, salps etc) were naturally obtained. If the unattributed species were also sourced naturally this would equate to 64% of fish and all cephalopod species (92 ± 5.5 % of all food sequences). Although there was inter- and intra-seasonal variation, the RRA of cephalopod and fish sequences from naturally sourced prey always exceeded the total RRA of non-natural food sources (Figure 10).

Table 13: The total number of samples and average proportion of samples across all time periods that contained a species that originated from each source type.

			Species caught by a fishery in foraging area	
			Yes	No
Species naturally accessible to albatross	Yes		**A: Unattributable**	**B: Natural**
		Total fish sp.	6 (7.1%)	48 (57.1%)
		Total cephalopod sp.	2 (18.2%)	9 (81.8%)
		Total samples (% FOO)	391 (26.4%)	1231 (83.3%)
		Overall RRA	14.1 ± 9.6%	77.9 ± 11.4 %*
		Fish mean RRA	16.3 ± 9.0%	72.5 ± 10.8%
		Cephalopod mean RRA	11.8 ± 16.0%	88.1 ± 16.0%
	No		**C: Likely fishery source**	**D: Unknown**
		Total fish sp.	22 (26.1%)	8 (9.5%)

	Total cephalopod sp.	0	0
	Total samples (% FOO)	191 (12.7%)	9 (0.7%)
	Overall minimum RRA	7.7 ± 5.7 %	0.2 ± 0.7%
	Fish mean RRA	9.7 ± 7.0 %	0.5 ± 1.4%
	Cephalopod mean RRA	0%	0%

*All non-fish and non-cephalopod species (e.g. krill, salps etc) were assigned to this cateogry for the overall RRA as they were most likley obtained naturally.

Although naturally sourced prey was the primary food source, there was still a reasonable proportion of the diet likely sourced from fisheries. Twenty-three fish species detected in the diet of Shy Albatross were likely sourced from fisheries (27.1% of total fish), with an average RRA of 9.7% overall, but this ranged from 1-28% of sequences. Of these fishery species, 15 species occurred in multiple samples suggesting they were not isolated incidents (Table 15). The three most frequently detected species were Blue Grenadier, Ling and Warehou spp. The source of a further eight species (including two cephalopods) were categorised as 'Unattributed' as they could have been obtained naturally or from a fishery, and eight species were categorised as 'Unknown' as they were not thought to be naturally accessible to albatross, but there was no spatial overlap with a Commonwealth managed fishery that caught these species. These species may have originated from a state based fishery, been an individual dead animal or a species brought to the surface by other predators (Sakamoto et al. 2009).

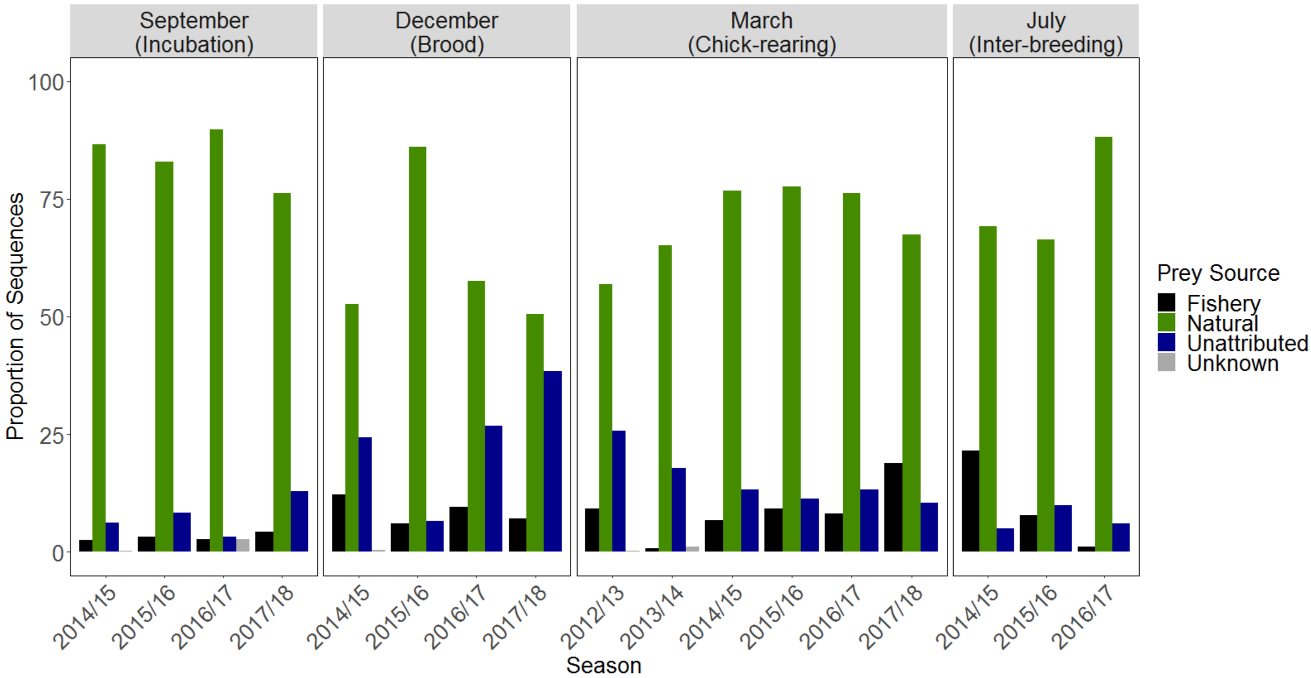


Figure 10: The proportion of food species likely sourced from fisheries and natural sources across each time period. Unattributed species are those where the source could not be determined as prey was accessible to albatross and also caught in a fishery, therefore could have come from either source.

This incidence of likely engagement (Category C: Fishery Source) varied between years and between breeding stages. Across all years, the incubation period (September/October samples) had the lowest proportion of likely fishery engagement 4-6%, whereas the three other breeding stages were higher with an average likely engagement of 12-17% (Figure 11). Engagement during the brood period

(December samples) was consistently between 14-18%, whereas chick-rearing (March samples) and inter-breeding (July samples) were more variable ranging from 4-29%. March 2013 and 2018, and July 2015 had the highest likely engagement (24%, 29% and 24% respectively, Table 14). During these peak periods of likely engagement, the discard species most frequently consumed by albatross were Ling in all three times, plus Silver Dory in March 2013, Frostfish and Blue Grenadier in March 2018 and Blue Grenadier and Conger Eels (July 2015, Table 16). When potential engagement was also included (from Category A: Unattributed Source), engagement remained the lowest during Incubation (10-25%), followed by inter-breeding (16-29%) and then chick-rearing (31-63%) and brood (28-81%, Table 14, Figure 11).

Of the six Commonwealth fisheries that Shy Albatross overlapped with spatially during the study, only the SESSF and HSF caught species that were also in the Shy Albatross diet during that time period (Table 12). The majority of these inaccessible species were caught by the South East Trawl fishery using bottom otter trawl gear and to a lesser extent the Danish seine. However, the Gillnet, Hook and Trap Fishery using the set gillnet and set auto-longline may also have been a source of engagement during the study (Table 17).

Table 14: Proportion of Shy Albatross individuals from Albatross Island that were likely engaging with fisheries during each time period of the study. These individuals consumed food species that were naturally inaccessible and were caught by a Commonwealth managed fishery in the foraging area. The values in brackets include potential engagement (unattributed source - species caught by a fishery but also naturally accessible to albatross).

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	Average
September (Incubation)			4% (10%)	6% (25%)	3% (9%)	4% (17%)	**4% (15%)**
December (Brood)			18 % (58%)	14% (28%)	17% (57%)	14% (71%)	**15% (54%)**
March (Chick-rearing)	24% (63%)	8% (31%)	12% (52%)	15% (34%)	12% (31%)	29% (46%)	**17% (43%)**
July (Inter-breeding)			24% (29%)	9% (21%)	4% (16%)		**12% (22%)**

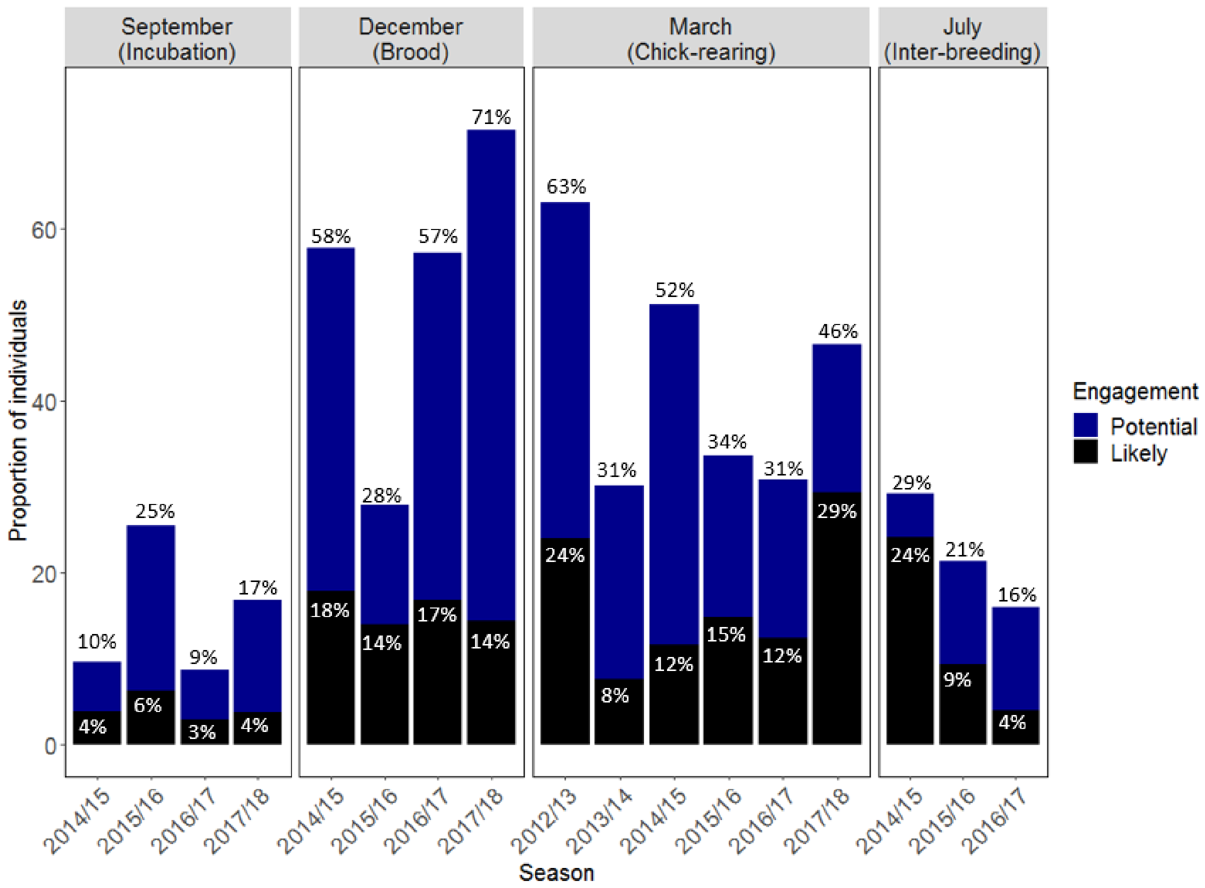


Figure 11: The proportion of Shy Albatross at Albatross Island with likely engagement (black bars) and potential engagement (blue bars) with Commonwealth managed fisheries across each breeding stage and year of the study. These represent the proportion of scat samples that contained species that were naturally inaccessible to albatross and caught by a fishery operating in the albatross foraging area.

Table 15: Fish and cephalopod species that were likely sourced from fisheries as they were unlikely to be naturally accessible to albatross and were caught by a Commonwealth managed fishery operating in the albatross foraging area during the sampling period.

	Common name	**Species**	**Samples (n)**
Inaccessible			
Likely fishery source	Pink Ling or Rock Ling	*Genypterus blacodes/tigerinus*	47
	Blue Grenadier	*Macruronus novaezelandiae*	46
	Warehou	*Seriolella brama/caerulea (punctata)*	40
	Frostfish	*Lepidopus caudatus*	17
	Gurnard	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*	17
	Silver Dory	*Cyttus australis*	10
	Conger	*Gnathophis sp.*	10
	Stingray	*Urolophidae sp.*	5
	Reef Ocean Perch	*Helicolenus (percoides)*	4
	Oreodory	*Oreosoma atlanticum/Allocyttus verrucosus/Neocyttus rhomboidalis*	4
	Tiger Flathead	*Platycephalus richardsoni*	4
	Gurnard	*Pterygotrigla polyommata*	4
	Mirror Dory	*Zenopsis nebulosa*	3
	Common Stargazer	*Kathetostoma laeve*	2
	John Dory	*Zeus faber*	2
	Serrulate Whiptail	*Coryphaenoides serrulatus (fernandezianus/filicauda)*	1
	Skate	*Dipturus sp.*	1
	Common Mora	*Mora moro*	1
	Broadnose Shark	*Notorynchus cepedianus*	1
	Bass Groper/Hapuku	*Polyprion americanus/oxygeneios*	1
	Sleeper sharks, dogfish	*Somniosidae sp.*	1
	Banded stingray	*Urolophus cruciatus*	1
Source unknown	Slickhead	*Alepocephalus australis (antipodianus)*	2
	Sculpin	*(Antipodocottus elegans)*	1
	Swallowtail	*Centroberyx lineatus*	1
	Deepsea Cardinalfish	*Epigonus lenimen (denticulatus/telescopus)*	1
	Southern Hake	*Merluccius australis*	1
	Slender smallmouth	*Microstoma (australis)*	1
	Dragonfish	*Stomiidae sp.*	1
	Squaretail sp.	*Tetragonuridae sp.*	1
Accessible			
Unattributed Source	Common Jack Mackerel	*Trachurus declivis/murphyi*	153
	Gould's squid	*Nototodarus gouldi*	136
	Barracouta	*Thyrsites atun*	134
	Magpie Perch/Morwongs	*Cheilodactylus nigripes/Nemadactylus macropterus*	21
	Longsnout Boarfish	*Pentaceropsis recurvirostris*	4
	Australasian Snapper	*Chrysophrys auratus*	1
	Giant warty squid	*Kondakovia longimana*	1
	Goatfish	*Upeneichthys lineatus/vlamingii*	1

Table 16: Number of individuals eating each fishery species (% in brackets). The total individuals takes into account those that ate multiple fishery species.

Stage	Common Name	Species	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Incubation (September)	Skate	*Dipturus* sp.				1 (1%)		
	Pink ling or rock ling	*Genypterus blacodes/tigerinus*			4 (3%)	1 (1%)		
	Conger	*Gnathophis* sp.				3 (2%)		
	Gurnard	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*			1 (1%)	2 (2%)	1 (3%)	
	Blue grenadier	*Macruronus novaezelandiae*			1 (1%)			2 (4%)
	Gurnard	*Pterygotrigla polyommata*			1 (1%)			
	Stingray	*Urolophidae* sp.			1 (1%)	1 (1%)		
	Mirror dory	*Zenopsis nebulosa*				1 (1%)		
		Total Individuals	**NA**	**NA**	**6 (4%)**	**8 (6%)**	**1 (3%)**	**2 (4%)**
	Common name	**Species**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
Brood (December)	Silver Dory	*Cyttus australis*			1 (1%)			
	Pink Ling or Rock Ling	*Genypterus blacodes/tigerinus*			2 (1%)	1 (1%)	5 (4%)	
	Conger	*Gnathophis* sp.			1 (1%)			
	Reef Ocean Perch	*Helicolenus (percoides)*			1 (1%)			
	Common Stargazer	*Kathetostoma leave*			1 (1%)			
	Frostfish	*Lepidopus caudatus*			1 (1%)	1 (1%)	1 (1%)	
	Gurnard	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*			1 (1%)	1 (1%)	3 (3%)	
	Blue Grenadier	*Macruronus novaezelandiae*			2 (1%)	5 (6%)	1 (1%)	5 (12%)
	Broadnose shark	*Notorynchus cepedianus*			1 (1%)			
	Oreodory	*Oreosoma atlanticum/Allocyttus verrucosus/Neocyttus rhomboidalis*			2 (1%)			
	Tiger Flathead	*Platycephalus richardsoni*					1 (1%)	
	Warehou	*Seriolella brama/caerulea (punctata)*			13 (8%)	6 (8%)	12 (10%)	
	Sleeper sharks and dogfish	Somniosidae sp.			1 (1%)			
	Gurnard	*Pterygotrigla polyommata*			1 (1%)			
	Stingray	Urolophidae sp.			2 (1%)			
	Banded stingray	*Urolophus cruciatus*						1 (2%)
	Mirror Dory	*Zenopsis nebulosa*			2 (1%)			
		Total Individuals	**NA**	**NA**	**29 (18%)**	**11 (14%)**	**20 (17%)**	**6 (14%)**

Stage	Common Name	Species	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Chick-rearing (March)	Serrulate Whiptail	*Coryphaenoides serrulatus (fernandezianus/filicauda)*		1 (1%)				
Chick-rearing (March)	Silver Dory	*Cyttus australis*	4 (9%)	1 (1%)	1 (1%)		1 (1%)	2 (2%)
Chick-rearing (March)	Pink Ling or Rock Ling	*Genypterus blacodes/tigerinus*	4 (9%)		4 (5%)	8 (8%)	2 (2%)	9 (9%)
Chick-rearing (March)	Conger	*Gnathophis* sp.		1 (1%)				
Chick-rearing (March)	Reef Ocean Perch	*Helicolenus (percoides)*						1 (1%)
Chick-rearing (March)	Common Stargazer	*Kathetostoma leave*						1 (1%)
Chick-rearing (March)	Frostfish	*Lepidopus caudatus*			1 (1%)		3 (4%)	10 (10%)
Chick-rearing (March)	Gurnard	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*	1 (2%)			1 (1%)	2 (2%)	2 (2%)
Chick-rearing (March)	Blue Grenadier	*Macruronus novaezelandiae*			2 (2%)	4 (4%)	4 (5%)	13 (13%)
Chick-rearing (March)	Common Mora	*Mora moro*				1 (1%)		
Chick-rearing (March)	Oreodory	*Oreosoma atlanticum/Allocyttus verrucosus/Neocyttus rhomboidalis*		2 (2%)				
Chick-rearing (March)	Tiger Flathead	*Platycephalus richardsoni*			1 (1%)			
Chick-rearing (March)	Bass Groper/Hapuku	*Polyprion americanus/oxygeneios*	1 (2%)					
Chick-rearing (March)	Warehou	*Seriolella brama/caerulea (punctata)*	1 (2%)	2 (2%)	1 (1%)	1 (1%)		1 (1%)
Chick-rearing (March)	Gurnard	Triglidae sp.					1 (1%)	1 (1%)
Chick-rearing (March)	John Dory	*Zeus faber*			1 (1%)			
		Total Individuals	**11 (24%)**	**7 (8%)**	**10 (12%)**	**14 (15%)**	**10 (12%)**	**29 (29%)**
	Common_Name	**Species**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
Inter-breeding (July)	Pink Ling or Rock Ling	*Genypterus blacodes/tigerinus*			5 (6%)	2 (3%)		
Inter-breeding (July)	Conger	*Gnathophis* sp.			5 (6%)			
Inter-breeding (July)	Reef Ocean Perch	*Helicolenus (percoides)*			2 (3%)			
Inter-breeding (July)	Gurnard	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*			1 (1%)	1 (1%)		
Inter-breeding (July)	Blue Grenadier	*Macruronus novaezelandiae*			4 (5%)	2 (3%)	1 (4%)	
Inter-breeding (July)	Tiger Flathead	*Platycephalus richardsoni*			1 (1%)	1 (1%)		
Inter-breeding (July)	Warehou	*Seriolella brama/caerulea (punctata)*			3 (4%)			
Inter-breeding (July)	Stingray	Urolophidae sp.			1 (1%)			
Inter-breeding (July)	John Dory	*Zeus faber*				1 (1%)		
		Total Individuals	**NA**	**NA**	**19 (24%)**	**7 (9%)**	**1 (4%)**	**NA**

Table 17: Fishing gear used where spatial and dietary species overlaps occurred between Shy Albatross and Commonwealth managed fisheries. The X represents when there was a spatial overlap and species overlap between Shy Albatross and the fishery. The XF indicates where the species was naturally inaccessible to albatross and therefore likely a fishery discard (Category C species) and the XN represents species that were also naturally accessible and therefore the source could not be attributed (Category A species) .

		SESSF Southern and Eastern Scalefish and Shark Fishery						High Seas Non-Trawl	Squid Fishery
		GHT		**SET**			**VIT**	**HSN**	**SQJ**
Season	**Stage**	**Set autolongline (demersal longline)**	**Set gillnet (demersal gillnet)**	**Bottom otter trawl**	**Danish seine (trawl fishery)**	**Midwater otter trawl**	**Danish seine (trawl fishery)**	**Set autolongline (demersal longline)**	**Squid jig**
2012/13	Chick-rearing		XF	XF	XF		XF		
2013/14	Chick-rearing	XF	XN	XF	XN		XN		
2014/15	Incubation	XF	XN	XF					
	Brood	XF	XF	XF	XF				
	Chick-rearing	XF	XN	XF	XF		XF		XN
	Inter-breeding		XN	XF					
2015/16	Incubation		XF	XF	XF		XF	XF	
	Brood	XF	XF	XF					
	Chick-rearing	XF	XF	XF	XF		XF		XN
	Inter-breeding		XN	XF	XF	XF			
2016/17	Incubation	XN	XN	XN	XF				
	Brood	XF	XF	XF					
	Chick-rearing		XF	XF	XF				XN
	Inter-breeding		XN	XF	XN				
2017/18	Incubation	XF	XN	XF	XN				
	Brood		XN	XF					
	Chick-rearing		XF	XF	XF				XN

Shared resources between albatross and Commonwealth managed fisheries

There was only a relatively low number of fish species categorised as shared resources (species that are targeted by a fishery in SE Australia and are also naturally available and consumed by Shy Albatross) between Commonwealth Fisheries and Shy Albatross (n=12, 14.3%). However, the relative contribution to the diet was disproportionately high with 51 ± 19% of all food sequences (63.7% fish RRA and 18.2% cephalopod RRA) with on average 57.9% of samples containing these species (Table 18). Four of the fish species categorised as shared resources were very uncommon (in three or less samples), however the other eight species were more common (Table 19). The proportion of shared resources varied between breeding stages (Figure 12). Incubation and inter-breeding had the lowest proportion of shared resource sequences (24-50% and 24-41% respectively) and brood and chick-rearing much higher (45-80% and 46-76% respectively).

Table 18: The total number of samples, average proportion of samples and relative read abundance of sequences (± SD) across all time periods that contained a species that originated from each resource type.

			Species caught by Commonwealth fisheries in SE Australia	
			Yes	**No**
			E: Shared	**F: Non-fishery**
		Total fish sp.	**Resource**	42 (50.0%)
		Total cephalopod sp.	12 (14.3%)	9 (81.8%)
	Yes	Total samples (% FOO)	2 (18.2%)	978 (64.9%)
		Overall RRA	850 (57.9%)	40.8 ± 19.4%*
		Fish mean RRA	51.9 ± 19.0 %	25.2 ± 13.1%
Species naturally accessible to albatross		Cephalopod mean RRA	63.7 ± 15.4%	87.3 ± 15.7%
			12.6 ± 15.7%	
			G: Fishery	**H: Unknown**
		Total fish sp.	**resource**	3 (3.6%)
		Total cephalopod sp.	28 (32.1%)	0
	No	Total samples (% FOO)	0	3 (0.2%)
		Overall RRA	197 (13.2%)	<0.1 %
		Fish mean RRA	7.9 ± 5.5%	<0.1 %
		Cephalopod mean RRA	10.2 ± 6.9%	0%
			0%	

*All non-fish and cephalopod species (e.g. krill, salps etc) were assigned as a non-fishery resource for the overall RRA

Table 19: The common fish and cephalopod species identified as shared resources. These are species that are both a naturally accessible food item for albatross and a commercial fishery species. Values represent the average frequency of occurrence and average proportion of sequences across each breeding stage and season, with the range across sampling periods in brackets.

Common Name	Species	Average occurrence (FOO)	Average Proportion of sequences (RRA)
Redbait	*Emmelichthys nitidus*	37 % (15-82 %)	32 % (10-68 %)
Morwong	*Nemadactylus macropterus*	2 % (0-7 %)	1 % (0-3 %)
Australian Sardine	*Sardinops sagax*	5 % (0-21 %)	2 % (0-9 %)
Blue Mackerel	*Scomber australasicus*	6 % (0-16 %)	3 % (0-10 %)
Barracouta	*Thyrsites atun*	9 % (0-22 %)	6 % (0-14 %)
Common Jack Mackerel	*Trachurus declivis/murphyi*	10 % (0-23 %)	6 % (0-16 %)
Gould's Squid	*Nototodarus gouldi*	9 % (0-50 %)	1 % (0-11 %)
Southern Calamari	*Sepioteuthis australis*	1 % (0-2 %)	0 % (0-1 %)

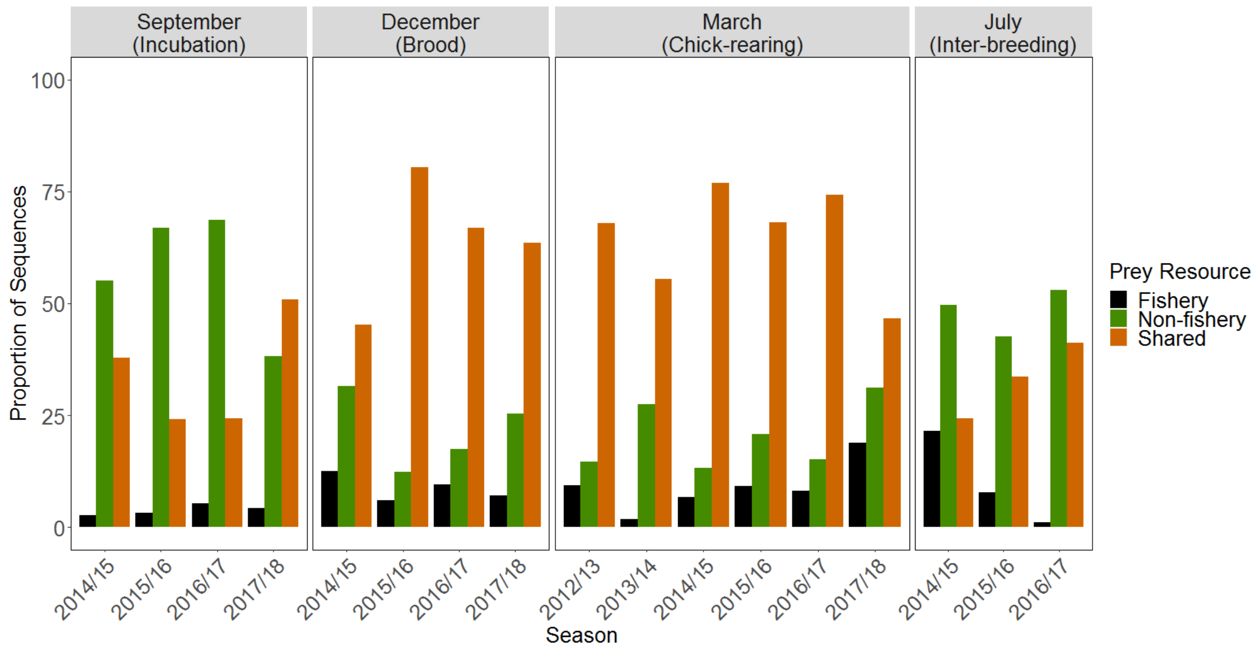


Figure 12: The proportion of dietary sequences that originated from a likely shared, non-fishery and fishery resource.

Shy Albatross energy requirements

The mean estimated energy requirement of Shy Albatross ranged from a low of 2176 ± 295 kj/day in brood to 3581 ± 543 kj/day during chick-rearing (Table 20). The estimated annual volume of food consumed by Shy Albatross was 2306 ± 682 tonnes annually, including an estimated 1846 ± 532 t of fish, 396 ± 125 t of cephalopods, 56 ± 23 t of krill, 6 ± 1 t of jellyfish and 2 ± 1 t of salps (Table 21). However the amount of krill and salps was sporadic, with only two time periods with greater than 11 t of krill consumed (CR 2013/14 and inter-breeding 2015/16) and one time period with a considerable amount of salps (CR 2012/13).The majority of cephalopod consumption was during inter-breeding and incubation.

The annual volume of the main prey species was estimated to be 764 ± 193 t of redbait, 110 ± 23t of Jack Mackerel and 374 ± 118 t of cuttlefish (Table 22). The two main fish species likely to have originated from fishery discards were Blue Grenadier and Ling. The annual volume consumed of these species were estimated to be 38 ± 13 t and 62 ± 18 t respectively, and approximately 195 ± 61 t of likely fishery sourced species overall (see Table 15 for species).

Table 20: Estimated daily energy requirement of Shy Albatross based on the proportion of time active for each breeding stage

	Estimated total daily energy requirement of Shy Albatross (kj/day)	**Estimated proportion of time active**
Incubation	2276 ± 464	53% ± 6%
Brood	2176 ± 295	50% ± 3%
Chick-rearing	3581 ± 543	90% ± 3%
Inter-breeding	3151 ± 750	78% ± 28%

Table 21: Estimated total volume (tonnes) of food groups consumed by Shy Albatross at Albatross Island during each breeding stage and annually. These values are based on the estimated energy requirements of Shy Albatross and RRA of each food group in the scat samples and have been extrapolated across the total numbers of birds on Albatross Island. Seasonal food volumes are the sum of food volumes for that breeding season plus the following inter-breeding period (i.e. September-August)

Year	Breeding stage	Fish and chondrichthyes	Cephalopods	Malacostracta (Krill)	Scyphozoa and hydrozoa	Tunicates (Salps)
2012/13	Chick-rearing	711 ± 112	50 ± 8	0 ± 0	0 ± 0	54 ± 9
2013/14	Chick-rearing	673 ± 106	16 ± 3	81 ± 13	1 ± 1	0 ± 0
2014/15	Incubation	225 ± 46	123 ± 25	2 ± 1	5 ± 1	0 ± 0
	Brood	115 ± 16	14 ± 2	2 ± 1	6 ± 1	4 ± 1
	Chick-rearing	717 ± 113	45 ± 7	0 ± 0	0 ± 0	1 ± 0
	Inter-breeding	813 ± 367	219 ± 99	2 ± 1	0 ± 0	1 ± 1
2015/16	Incubation	188 ± 38	167 ± 34	8 ± 2	0 ± 0	0 ± 0
	Brood	124 ± 17	7 ± 1	0 ± 0	0 ± 0	0 ± 0
	Chick-rearing	721 ± 114	44 ± 7	3 ± 1	0 ± 0	0 ± 0
	Inter-breeding	755 ± 341	168 ± 76	138 ± 62	0 ± 0	1 ± 1
2016/17	Incubation	169 ± 35	199 ± 41	2 ± 1	2 ± 1	0 ± 0
	Brood	123 ± 17	6 ± 1	2 ± 0	5 ± 1	0 ± 0
	Chick-rearing	740 ± 117	16 ± 3	9 ± 2	0 ± 0	0 ± 0
	Inter-breeding	844 ± 381	178 ± 80	0 ± 0	0 ± 0	0 ± 0
2017/18	Incubation	220 ± 45	119 ± 25	11 ± 2	0 ± 0	0 ± 0
	Brood	107 ± 15	26 ± 4	2 ± 0	0 ± 0	0 ± 0
	Chick-rearing	660 ± 104	121 ± 19	3 ± 1	0 ± 0	5 ± 1
Seasonal	**volume (September-August)**					
2014/15		1871 ± 540	402 ± 132.5	6 ± 2	11 ± 2	6 ± 1
2015/16		1790 ± 509	386 ± 117.5	149 ± 64	0 ± 0	1 ± 0.5
2016/17		1877 ± 549	399 ± 124	13 ± 2	7 ± 1	0 ± 0
Overall		**1846 ± 532**	**396 ± 125**	**56 ± 23**	**6 ± 1**	**2 ± 1**

Table 22: Estimated total volume (tonnes) of the main species consumed by Shy Albatross at Albatross Island during each breeding stage and annually.

Redbait	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**Average**
1_Incubation			95 ± 20	37 ± 8	70 ± 14	137 ± 28	**85 ± 17**
2_Brood			17 ± 3	90 ± 13	36 ± 5	31 ± 4	**44 ± 6**
3_Chick-rearing	273 ± 43	245 ± 39	447 ± 70	350 ± 55	426 ± 67	230 ± 36	**329 ± 52**
4_Inter-breeding			185 ± 83	165 ± 75	373 ± 169		**241 ± 109**
Seasonal Total			**744 ± 175**	**642 ± 150**	**905 ± 254**		**764 ± 193**

Jack mackerel	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**Average**
1_Incubation			14 ± 3	23 ± 5	12 ± 3	7 ± 2	**14 ± 3**
2_Brood			17 ± 3	7 ± 1	18 ± 3	22 ± 3	**16 ± 3**
3_Chick-rearing	59 ± 10	24 ± 4	52 ± 8	50 ± 8	75 ± 12	21 ± 3	**44 ± 8**
4_Inter-breeding			33 ± 15	28 ± 13	0 ± 0		**20 ± 9**
Seasonal Total			**116 ± 28**	**108 ± 26**	**105 ± 17**		**110 ± 23**

Cuttlefish	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**Average**
1_Incubation			119 ± 24	164 ± 34	199 ± 41	119 ± 25	**150 ± 31**
2_Brood			9 ± 1	5 ± 1	2 ± 0	13 ± 2	**7 ± 1**
3_Chick-rearing	41 ± 7	15 ± 3	37 ± 6	40 ± 6	13 ± 2	101 ± 16	**41 ± 6**
4_Inter-breeding			209 ± 95	146 ± 66	178 ± 80		**178 ± 80**
Seasonal Total			**374 ± 125**	**355 ± 107**	**392 ± 123**		**374 ± 118**

Blue Grenadier	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**Average**
1_Incubation			0 ± 0	0 ± 0	0 ± 0	15 ± 3	**4 ± 1**
2_Brood			0 ± 0	3 ± 1	0 ± 0	8 ± 1	**3 ± 1**
3_Chick-rearing	0 ± 0	0 ± 0	19 ± 3	12 ± 2	9 ± 2	22 ± 4	**10 ± 2**
4_Inter-breeding			39 ± 18	20 ± 10	12 ± 6		**24 ± 11**
Seasonal Total			**58 ± 20**	**35 ± 12**	**21 ± 7**		**38 ± 13**

Ling	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**Average**
1_Incubation			6 ± 1	1 ± 0	0 ± 0	0 ± 0	**2 ± 0**
2_Brood			1 ± 0	2 ± 1	2 ± 1	0 ± 0	**1 ± 0**
3_Chick-rearing	77 ± 4	0 ± 0	17 ± 3	55 ± 9	22 ± 4	43 ± 7	**36 ± 5**
4_Inter-breeding			46 ± 21	35 ± 16	0 ± 0		**27 ± 13**
Seasonal Total			**70 ± 25**	**93 ± 25**	**24 ± 4**		**62 ± 18**

Fishery	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**Average**
1_Incubation			9 ± 2	12 ± 3	10 ± 2	15 ± 3	**12 ± 3**
2_Brood			18 ± 2	8 ± 1	13 ± 1	10 ± 1	**12 ± 1**
3_Chick-rearing	77 ± 10	7 ± 1	53 ± 7	71 ± 11	63 ± 8	152 ± 18	**71 ± 9**
4_Inter-breeding			231 ± 104	85 ± 39	12 ± 6		**109 ± 49**
Seasonal Total			**311 ± 114**	**176 ± 53**	**98 ± 16**		**195 ± 61**

Discussion

This project provides the first synthesis of Shy Albatross diet data for over twenty years, and the first quantification of the level of engagement between Shy Albatross and Commonwealth Fisheries operating in the foraging region adjacent to Albatross Island. Previously, diet data have only been accessible when chicks are present at the colony, however, by analysing scat samples we were able to investigate the diet during all breeding stages.

South-east Australian dietary reference database

We created the south-east Australian dietary reference database to identify sequence data gaps in Genbank of possible albatross prey species in SE Australia. Additional missing species sequences were identified once we had the final Shy Albatross dietary sequence data, and where possible flesh and DNA were sourced to fill these gaps. However, not all species could be obtained during the project timeframe. Throughout the report we have ensured that any species that were genetically inconclusive were highlighted in the tables and figures to show: 1) where multiple species were genetically identical in the 16S gene region (e.g. *Seriolella*), and 2) where we were missing species information (using parentheses). By reporting this way, species confirmation can be assigned retrospectively for the latter group once sequences are available. This database will continue to be added to over the coming years for the Bass Strait region to provide a robust and comprehensive reference for future studies.

The range of food species consumed by Shy Albatross

Giant cuttlefish and Redbait were the main species detected in the diet of Shy Albatross. Other common fish species were Jack Mackerel, Blue mackerel and Barracouta. These prominent small pelagic fish species were also common in previous Shy Albatross dietary studies (Hedd and Gales 2001) and other predators in the region such as fur seals (Kirkwood et al. 2008, Deagle et al. 2009). Giant cuttlefish have previously been detected in the Shy Albatross diet, however, they occurred more commonly in this study. This is likely due to the high prevalence of cuttlefish in September (incubation) when diet data were previously not obtained due to sampling of chicks only.

There was a greater variation in diet throughout the year than between years, with the exception of 2015/16, which had a much higher occurrence of Redbait during December than other years (82% of samples compared to 15-30%). Overall, the occurrence of Redbait in this study was higher than that of Jack Mackerel, which is the opposite trend to Shy Albatross dietary data obtained between 1996-98. These fluctuations in Redbait prevalence are not uncommon in Western Bass Strait (Kirkwood et al. 2008) and the ratio of Jack Mackerel and Redbait has also shifted in other regions of Tasmania (McLeod et al. 2012). This may reflect cyclical changes in water temperature influenced by fluctuations of inflow from subantarctic surface waters in the region (Kirkwood et al. 2008), or changes in fish prey availability. Although Jack Mackerel and Redbait school together, they have different prey, and changes in ocean temperatures can affect these food resources differently (McLeod et al. 2012).

It is possible that some of the minor food items may represent secondary ingestion (the prey of fish). By highlighting the species that contributed <1% of food sequences for that group in any time period, we can identify those that are minor components of the diet and treat these with caution when interpreting the results. However, even if dietary items detected are the food of a prey species, these interactions and trophic links show the value of the species in SE Australian food webs.

The extent to which Shy Albatross potentially engage with fisheries

The majority of fish and cephalopod species consumed were likely to be obtained naturally (60%) and this study provides evidence that Shy Albatross source most of their food independently of fishing operations (78% of food sequences). This high prevalence of natural prey in the diet highlights that Shy Albatross are unlikely to be reliant on fishing discards for survival or to raise chicks. However, there was still a reasonably high proportion of the Shy Albatross population (up to 28% at times) likely to be engaging with Commonwealth based fisheries, based on the prevalence of fishery species in the albatross diet that are naturally inaccessible to albatross. These species are caught by fisheries operating in the foraging range of the albatross and were likely obtained through discards. The majority of the discards detected in the diet were from three species, Blue Grenadier, Ling and Warehou.

The occurrence of Blue Grenadier in the diet and the estimated volume consumed is understandable. Blue Grenadier has one of the highest discard weights of any target species in the SESSF fishery (ranging 302-742t between 2012-2017, Castillo-Jordán et al. 2018), providing an easily accessible supplementary food source for albatross. This was particularly the case during December and March sampling and is likely the case throughout the summer when resources near the island are reduced.

The relatively high occurrence of Ling in the Shy Albatross diet is more difficult to explain. Discard volumes of Ling are relatively low compared to Blue Grenadier (21-27t annually, Figure 13) and the estimated volume of Ling consumed by albatross (~62t annually) far exceeds the availability of discarded whole fish. As Ling is a high value species, they are gutted at sea by both trawl and long-line vessels, with guts discarded overboard. It is possible that birds were obtaining this species through offal discards from animals processed on-board rather than undersized whole fish. AFMA observers have noted "*Ling have quite a lot of guts with large livers which is what the albatross actively choose to prey upon. A lot of the time even when a whole fish is floating on the surface if it has come off a line, the Albatross will peck through the stomach cavity so they can access the liver, eat that then leave the rest of the fish*". As the majority of fat in a white fish is stored in the liver, this is likely to provide high energy for the birds (Gruger et al. 1964). However, the total allowable catch of Ling is relatively low across the entire fishery (1150t per year) and therefore the catch amount in such a small area of Bass Strait where birds are foraging is also likely to be low. The methods used to calculate the estimated food volumes consumed by albatross have large error ranges and may have caused an overestimation of food volumes. The volume of food consumed is based on the estimated metabolic rates of albatross, the average meal masses returned to chicks and utilises prey proportions based on a small sampling period (Typically <1 week). The extrapolation of these data across extended time periods and to the population level may exacerbate any errors. This would particularly be the case when extrapolated time periods are longest (chick-rearing and inter-breeding) which was when Ling was most common. However, irrespective of the calculated prey volumes, Ling did occur in up to 9% of samples, was present in 70% of sampling periods and contributed up to 7% of the sequence reads. More work is needed to understand how Shy Albatross are obtaining Ling and potentially increase the sampling of albatross during chick-rearing to assess whether Ling is consistently in the diet across extended time periods.

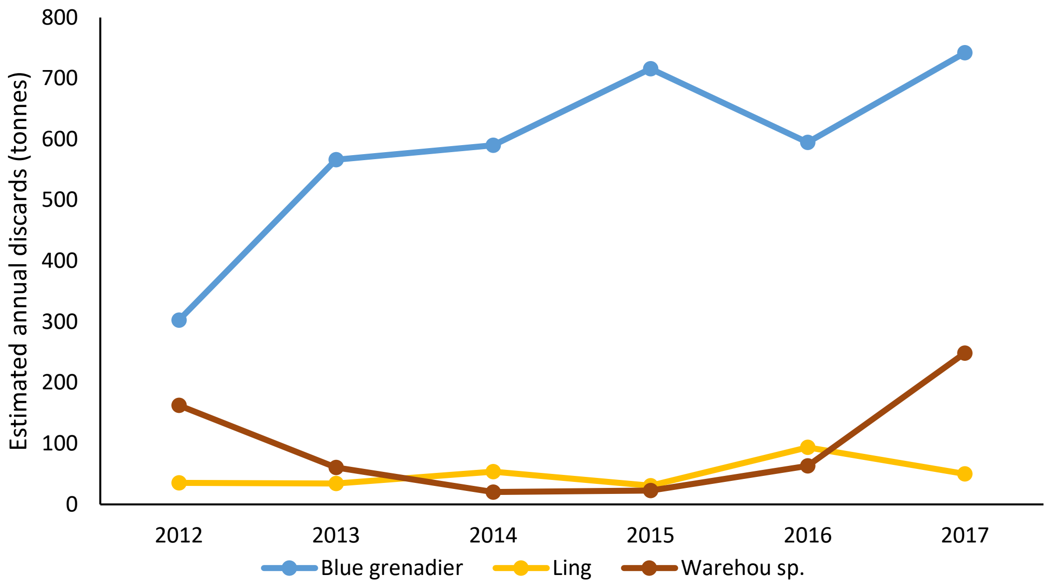


Figure 13: Estimated annual discards of blue grenadier and ling in the SESSF from observer records (Castillo-Jordán et al. 2018).

Warehou (*Seriolella sp.*) was the third most common discard species, though it is possible this could have also been sourced naturally, as juvenile fish can be found in surface waters (Roberts et al. 2015). However, there were no incidences where Warehou were consumed without also being caught by the fishery and multiple cases where they co-occurred in the diet with other discarded species, suggesting that it was likely obtained from the fishery. The main time period that Warehou occurred in the diet was during December (brood). If this species was indeed obtained naturally, the level of likely engagement would be closer to 8-14% for brood instead of 14-18%, however the overall patterns of engagement would not change considerably (Figure 14).

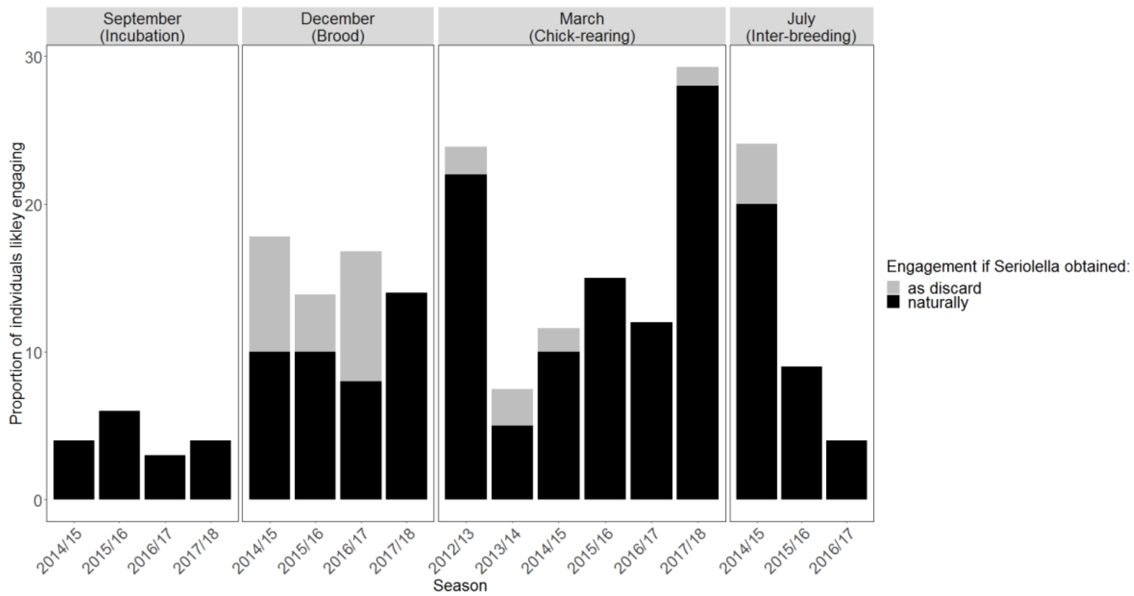


Figure 14: The proportion of individuals likely engaging with fisheries if *Seriolella* obtained as a natural prey source (Category B) or a fishery discard (Category C).

There were a small number of inaccessible species detected in the diet that were not reported as discards in the foraging area of the albatross, and therefore were not included in estimations of engagement. These species may still have been obtained as discards if individuals were foraging outside the main foraging range estimated from the subset of birds we tracked. The spatial movements of albatross during brood and chick-rearing (December to March) were based on old tracking data (20+ years). Birds during these periods are difficult to track as disturbance can increase the risk of nest abandonment (Brothers et al. 1998), making it difficult to justify intensive tracking studies to capture inter-annual variation during these time periods. As tracking technology and batteries improve, there will be more scope to leave devices on the birds for longer and still obtain fine scale tracking data that are not available from current tags with a longer battery life (e.g. GLS).

Spatial and temporal variability in Shy Albatross diet and fishery catch

Shy Albatross overlapped spatially with all Commonwealth managed fisheries operating in Bass Strait, however, this was only consistently occurring with the Southern and Eastern Scalefish and Shark Fishery (SESSF), which overlapped in all sampling periods, and the Squid Fishery during chick rearing. These spatial overlaps do not represent interaction or engagement, but do mean that there is the opportunity for engagement to occur.

Shy Albatross have a fairly constrained foraging area, with the core foraging range restricted to Western Bass Strait. Although we only had annual spatial data for September (Incubation), there was minimal inter-annual variation in foraging range during that period. There was some intra-annual variation though, with the foraging range during December (brood) the most constrained as birds do short trips to feed young. During chick-rearing this range may increase due to resource depletion in close proximity to the island. This is a typical pattern for seabirds where prey in close proximity to the colony declines as the food demands of the chicks increase, causing parents to forage further from the colony as the season progresses (Ashmole 1963, Gaston et al. 2007). Conversely, during winter, seabirds are less constrained by foraging location and prey, allowing them to move further from the colony and consume a more diverse diet (Baird 1991, Ludynia et al. 2005), which was particularly evident for Shy Albatross during 2014/15.

Even though there was opportunity to access discards during all sampling periods through the SESSF fishery, the level of engagement also varied throughout the season. The level of likely and potential engagement was highest in December and March, which would correspond to the period when birds are raising young and energy demands are at their highest. Although the incidence of engagement in March (chick-rearing) fluctuated between years, compared to September and December that were relatively consistent (consistently low and higher, respectively). Engagement did not appear to coincide with a low prevalence of natural prey, although further work is required to investigate this in greater depth.

There have been changes in the mitigation measures used by SE Australian fisheries during the timeframe of the project. These included: specified sink rates of longline hooks (0.3m/sec to a depth of 15m, September 2014); the use of 600mm diameter Pinkie buoy ‘warp deflectors’ on all trawl vessels during the day (November 2014, this was a change from *either* a 400mm warp deflector or warp scarer); and the use of bird bafflers on all SE and Great Australian Bight trawlers (May 2017). However, no obvious decrease in the proportion of birds engaging with vessels was recorded and changes in mitigation measures cannot explain the patterns observed in the data. This is likely due to the fact that the availability of discards has not changed during the project. Any reduction in seabird interaction with fishing gear would not be detected using this dataset.

Shy Albatross*Shy Albatross*During December and March we saw the highest level of likely engagement with fisheries, which also coincided with the highest level of shared resources in the diet. Shy Albatross naturally consume similar species to those targeted by the Small Pelagic Fishery (SPF), predominantly Redbait and Jack Mackerel. There is currently no spatial overlap between the SPF and Shy Albatross and therefore no competition for resources. However, understanding the requirements of these birds and the role they play in Bass Strait is important to understand if fisheries in the region expand in the future.

Although there were eight state managed fisheries in Tasmania with 19 fishery-gear combinations (Appendix 14), only the Tasmanian Scalefish fishery using hand-lines and the Southern Rock-lobster fishery produced discards in the foraging area of Shy Albatross from Albatross Island. The amount of discards available from the Tasmanian Scalefish fishery are likely to be very low and there was little species overlap. The SRL fishery, however, had an extensive overlap in the frequency of occurrence of bait species in the diet of Shy Albatross. Approximately 50-100 tonnes of bait is discarded each year from the SRL fishery compared with approximately less than one tonne of discards from the Tasmanian Scalefish fishery in the foraging area (C. Gardner pers comms), making the SRL fishery a larger potential food resource for seabirds. The majority of these fish species are naturally accessible to albatross, therefore it is difficult to determine how the birds are sourcing these resources. Barracouta is the main species that is less likely to be naturally accessible. We have conservatively classified barracouta as accessible during this study as there are periods when they are near the surface, however, they are commonly found at depths over 40m and are typically benthopelagic. Therefore there is a greater likelihood that this species may be obtained through fishery discards, however, the data needed to confirm this was not available during this study. To assess if and when engagements are occurring between this fishery and albatross, data on the spatial and temporal rate of discards in the SRL fishery and which bait species are used in a specific location is required.

Conclusion

This project identified that the majority of the Shy Albatross food was sourced naturally (i.e. the proportion of prey species, number of albatross and proportion of DNA sequences) suggesting birds are not reliant on discards. However, at least 10% of the population overall is sourcing food from fisheries. There are spatial overlaps between Shy Albatross and six Commonwealth managed fisheries operating in South-East Australia and two Tasmanian managed fisheries, with engagement likely occurring with the Commonwealth Southern and Eastern Scalefish and Shark Fishery and Tasmanian Southern Rock Lobster Fishery. There was considerable intra-annual variation in the level of engagement with the Commonwealth fishery, but little inter-annual variability. Blue Grenadier, Ling and Warehou sp. were the main Commonwealth managed fishery discard species consumed by Shy Albatross at Albatross Island. Temporal and spatial data on bait discards in the Tasmanian Southern Rocklobster Fishery are not currently collected and therefore the level of engagement cannot be estimated.

Although we have a greater understanding of when engagement is occurring, we do not yet understand what the drivers of these engagements are. This could be an increase in discard availability or factors directly effecting the birds or their prey, such as poor breeding success or fluctuations in availability of natural prey.

Implications

This project is the first to generate a longitudinal dietary data set for Shy Albatross at Albatross Island using accurate and of high taxonomic resolution dietary methods. This novel dietary data, in conjunction with existing complimentary albatross foraging distribution and fisheries catch data, further informs our understanding of spatial, temporal and dietary overlap between Shy Albatross and fisheries. The analyses and products of this work provide a range of end-users with data and supporting information for a variety of management and conservation applications, including sustainable fisheries management, Ecological Risk Assessments and to ensure continued conservation and management of Shy Albatross populations. Key stakeholders have provided summaries of the direct implications of this project for their areas, below[1].

"AFMA is keen to work with the relevant industry to minimise and avoid seabird interactions in our fisheries. The research is invaluable to assist in identifying temporal and spatial interactions between the various fisheries and Shy Albatross. This information will improve the quality of management decisions and the accuracy of management responses to interactions in the fishery". AFMA

"This in-depth study of Shy Albatross will be useful in several ways to our research at CSIRO with these authors and other collaborators. First, based on Objective 1, these data will be useful for conditioning an Ecopath ecosystem model for the south-east of Australia, led by Cathy Bulman, and potentially the SE Atlantis model (Beth Fulton and team). While the data are just for a single predator, they will reduce the uncertainty across a range of tropically linked groups and reduce overall model uncertainty. Second, these data will generally inform understanding about demand for prey species across the range of the species, an issue that has been contentious in fisheries in recent years. Finally, the managers of marine parks should also be informed about these results, as they provide a potential monitoring approach, for sampling the prey that are available in and around protected areas. As the authors identify, these baseline data will also be important as a reference to anticipated change in the south-east marine region as a result of climate change." CSIRO

"This study is especially of interest for the southern rock lobster fishery which operates almost year-round in the foraging area. There are no other commercial state fisheries in the foraging area that have catches of more than a few tonnes so any interactions with these will be trivial. Scale fish catch in the NW of Tasmania is dominated by recreational fishers although still very small as a potential source of food relative to the rock lobster fishery. Many bycatch species from the lobster fishery were observed in the albatross diets although it was unclear if these could be naturally foraged. Greatest interaction is likely to be through discarded bait with species like Redbait and mackerel – these are common bait and occurred frequently in the albatross diet samples. Understanding interactions of the

[1] Information on implications provided by R. Murphy and M. Gerner (AFMA), A. Hobday (CSIRO), C. Gardner (IMAS), J. Barington (AAD), W. Misiak (ACAP).

lobster fishery through bait usage and bycatch is increasingly of interest as we seek to understand the broader ecosystem role. Given that rock lobster fishers are likely to be interacting with Shy Albatross through discarded bait, it may be helpful to guide fishers on how to manage this interaction." IMAS

"These data contribute to actions under the 'National Recovery Plan for threatened albatrosses and petrels', particularly action C 8.2 concerning the scale and nature of interactions between albatrosses and trawl (and longline) fisheries, and C 9.1 concerning quantifying the scale and nature of dietary requirements of albatrosses, and total dietary requirements. The data also contribute to fisheries assessments and the development of improved management strategies. This research further provides a timely update to our understanding of the diet of Shy Albatross. The research highlights a range of important questions that will form the basis of future studies, and the benefit of future studies resolving the extent of engagement of Shy Albatross with State fisheries. Future research using the methods outlined in this report may help to distinguish the engagement of albatross and petrel species with coastal State fisheries from that with high seas fisheries." AAD

"The methods and results are an important contribution to the work of ACAP. This research provides baseline information about the engagement of a seabird species with fisheries that contributes to discussions about ensuring the sustainability of marine living resources that provide food for albatrosses. The methods will assist individual ACAP Parties to better understand seabird engagement with fisheries, and the degree of dependence of individual species on fisheries as a source of food. "
ACAP

Recommendations

There are a number of key recommendations from this project that will enhance the use of the current dataset. These recommendations will improve the sustainability of fisheries and the conservation status of Shy Albatross and other threatened species.

Albatross Recovery Plan

- **The Department of Environment to consider the inclusion of project information in the revision of the Albatross and Giant Petrel Recovery Plan 2011-2016.** This project provided a baseline of spatial and dietary data which will address key actions listed under the Albatross and Giant Petrel Recovery Plan. We recommend the Department of Environment consider the inclusion of data and key findings from this report when revising and compiling information for the next recovery plan. Specifically this report provides data relevant to:
    - Action A 2.1: At sea data for albatross and giant petrel populations breeding within Australian jurisdiction are evaluated with respect to overlap with fisheries and consequent risk.
    - Action C 8.3: All longline and trawl fisheries, both Commonwealth and State managed, are and continue to be assessed for the risk of albatross and giant petrel interactions.
    - Action C 9.1: Encourage research to quantify the scale and nature of dietary requirements of albatrosses and giant petrels, with priority for populations breeding in Australian jurisdiction. Provide these data to AFMA and other agencies managing fisheries that overlap with albatross and giant petrel species. Promote the incorporation of total dietary requirements of albatross and giant petrel populations into fisheries assessments and the development of improved management strategies.

Fishery recommendations

- **AFMA to consider inclusion of project data and key findings in future management plans and ecological risk assessments.** This report provides information about spatial and temporal overlap of foraging area with commercial fishing operations and will assist AFMA in undertaking ecological risk assessments for the fisheries operating in the South East of Australia. The composition of the diet also provides a better understanding of seabird dependence on commercial fishing discards and the potential impact of changes to fishing and discarding practices over time.
- **Discourage fishers in the Southern Rock-Lobster fishery from feeding baits and bycatch to Shy Albatross.** There was a considerable overlap between Shy Albatross prey and the baits used by the Southern Rock Lobster Fishery. Feeding of albatross can lead to habituation and encourage birds to approach vessels. Although engagement with the SRL fishery may not be a direct threat to Shy Albatross, it will change the behaviour of birds and increase ship following behaviour leading to increased interactions with vessels that do pose a bycatch risk. As a considerable amount of bait is sourced from New Zealand, there is also a biosecurity concern.

Data Dissemination

- **Provision of project data to end users for incorporation into ecosystem models, risk assessments and species distribution databases where applicable.** This project generated a considerable amount of data that either has been made available or will be available after project completion. The table below provides a list of data and potential end users to increase the visibility and accessibility of the data.

Data set	Data type	Future Location	Status at project completion
Shy albatross dietary data	Summary tables and figures	This report, scientific publications	Report available through FRDC website, publications in prep.
	Raw data	DPIPWE, ACAP Albatross dietary database	Dietary database currently being developed for ACAP
Prey reference sequence data	Merged genomic prey sequence data from collections	Genbank	Uploaded, ascension numbers included in report appendix
Shy albatross resource requirements	Summary tables	This report, scientific publications	Available through FRDC website, publications in prep
	Raw data	DPIPWE, CSIRO	Available through DPIPWE.
Shy albatross spatial data	Summary maps	This report, scientific publications	Available through FRDC website, publications in prep
	Raw tracks	DPIPWE, Birdlife Procellariiformes tracking database, scientific publications	Data still being used for publications and will be provided to Birdlife.
Prey distribution data	Prey species lists and approximate distributions	This report, DPIPWE, Atlas of Living Australia, Global Biodiversity Information Facility, Ocean Biogeographic Information System.	End users contacted and data provision underway.

Filling Information gaps

- **Investigate what factors contribute to the inter- and intra-annual variability in engagements between Shy Albatross and Commonwealth fisheries.** This project provides information on when fishery engagements occur and with which fisheries, however, it does not explain why engagement fluctuates throughout the year. By understanding what drives engagement, we can begin to predict when engagement might occur and also target those time periods to reduce the level of risk for Shy Albatross and other threatened species. To answer this question, the occurrence of engagement could be tested against the following variables: fishing effort, discard availability (catch and discard amounts), albatross age and sex, bird behaviour e.g. same or different individuals, prey availability and oceanographic variables e.g, SST, Chlorophyll A.
- **Expand the scope of the work to incorporate southern Shy Albatross populations.** This project focused on one population within the species range. Different populations are subject to different foraging distributions, stressors and consequently varying levels of risk. Ideally future work should seek to understand the level of fisheries engagement across both Albatross Island and the Mewstone, the latter being home to 60% of the breeding population.
- **Continue to collect DNA sequence data from potential prey samples to populate the SE Australian DNA database.** Through collaborations with the National Fish Collection, fishers and researchers, continue to identify gaps and populate the sequence database to facilitate ongoing and broader (both spatially and different species) dietary studies in SE Australia.
- **Re-evaluate the potential for genetic methods to distinguish between shy and white-capped albatross**. These two species are difficult to distinguish visually and genetically. With the improvement of sequencing technology, the genetic differences between these species should be re-evaluated. If sufficient genetic diversity exists, feather samples could be collected from birds behind fishing vessels and satellite trackers attached to investigate colony origin. These data will provide greater information of the relative risk of fisheries to each species.
- **Obtain high accuracy Shy Albatross foraging data throughout the breeding season when resources allow.** Recent spatial data is currently only available for the incubation period due to disturbance issues (see methods for details). With the improvement of tracking technology and increased battery life of devices, future research may focus on gaps in key breeding stages when engagement with fisheries is highest (e.g. brood and chick-rearing), while minimising disturbance to breeding birds.

Extension and Adoption

- The project was guided by a Steering Committee composed of members from industry (SETFIA, AFMA, FRDC), science (DPIPWE, CSIRO, IMAS) and conservation management (ACAP, DPIPWE).
- A stakeholders workshop will be held in 2019 for AFMA and the SETFIA Seabird Bycatch group to discuss results of the project, recommendations and feedback on how we can improve this dietary technique to apply to other TEP species and/or regions. We will specifically incorporate a feedback element into the stakeholder workshop to evaluate extent of reach and adoption and any identified barriers.
- Working papers will be submitted to ACAP on the methods and results of the research.
- Trophic data will be included in the Albatross Diet Database held by ACAP and will be incorporated into the SCAR Southern Ocean Diet and Energetics Database (SOED). The Albatross Diet Database and SOED are being developed to provide a synthesis of the diet of marine predators across a broad spatial and temporal scale.
- This innovative approach to informing risk assessments and managing TEP species will be reported on as part of country submissions to international fora, including the submission of a working paper to the ACAP Advisory Committee meeting, ACAP Bycatch Working Group and other RFMOs
- Engagement occurrence results and trophic data will be provided to AMFA for use in future risk assessments.
- All DNA sequences will be uploaded onto Genbank which is the globally accessible database for DNA sequencing data. This database will facilitate the application of this technique to other TEP species and significant marine predators in the south east.
- Managers, industry and scientists will be engaged through publication of results in high-impact scientific journals
- In the longer term, data and findings will be seen to be incorporated in future drafts of the Threat Abatement Plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations, National Recovery Plan for threatened albatrosses and giant petrels, IPOA-Seabirds and associated NPOA.

Project coverage

- An article on the project was included in the:
  - June 2018 SETFIA Newsletter to provide background on scope and aims of the project.
  - June 2019 addition of the FRDC magazine Fish to disseminate the results and project success.

Glossary

Term	Definition
Interaction	When a seabird directly interacts with the fishing gear. This is typically when incidental mortalities and injuries can occur.
Engagement	When birds are in the vicinity of a vessel consuming discards and offal or taking food from nets, but the level of interaction is unknown.
Shared resource	Species that are naturally consumed by albatross and also caught by a fishery.
Fishery source/resource	Species that albatross are likely to have obtained from a fishery as they are not naturally accessible to albatross and were caught by the fishery in the foraging area
Natural source	Species that are naturally accessible to albatross.
Relative read abundance	The proportion of sequence reads for a food group or species divided by the total sequences of all food or all fish/cephalopod species.
Frequency of occurrence	The proportion of samples that contain a particular food group or species.

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Appendices

Appendix 1: Intellectual Property

No intellectual property is identified as arising from the project.

The dataset generated from this project is being housed at the Department of Primary Industries, Parks, Water and Environment Marine Conservation Branch.

Appendix 2: List of researchers and project staff.

The following table lists researchers involved in the project

Name	Organisation
Dr Rachael Alderman	DPIPWE
Dr Julie McInnes	DPIPWE
Dr Geoff Tuck	CSIRO
Ms Claire Mason	IMAS
Dr Bruce Deagle	AAD
Ms Andrea Polanowski	AAD
Dr Kris Carlyon	DPIPWE
Dr Natalie Bool	IMAS

DPIPWE: Tasmanian Department of Primary Industries, Parks, Water and Environment
CSIRO: The Commonwealth Scientific and Industrial Research Organisation
IMAS: Institute for Marine and Antarctic Studies, University of Tasmania
AAD: Australian Antarctic Division

Appendix 3: Data collected during the project.

All dietary data was analysed as part of this FRDC project, however some samples were collected prior to project commencement.

Diet data

Breeding site	Breeding Stage	Month	Temporal coverage (years)	Number of scat samples
Samples collected during study				
Albatross Island	Incubation	September/October	2017	55
Albatross Island	Brood	December	2017	43
Albatross Island	Chick-Rearing	March	2018	104
Albatross Island	Inter-breeding	May-August	2017	40
Samples collected separate to study				
Albatross Island	Incubation	September/October	2014-16	367
Albatross Island	Brood	December	2014-16	377
Albatross Island	Chick-Rearing	March	2013-17	460
Albatross Island	Inter-breeding	May-August	2015-16	209

Spatial data

Breeding Stage	Month	Tracking device	Temporal coverage (years)	Number of individuals tracked	Temporal overlap with diet samples
Data collected during study					
Incubation	September/October	GPS	2017	13	Yes
Data collected separate to study					
Incubation	September/October	GPS	2014-16	44	Yes
Brood	December	PTT	1993-96	39	No
Chick-Rearing	March	PTT	1994-97	7	No
Inter-breeding	May-August	GLS	2005-07	8	No

Appendix 4: Categories of fish and cephalopod species based on behaviour and depth. Species were categorised as either 1) Likely Fishery sourced, 2) Natural, or 3) Shared Resource.

	Family	Species	Common name	n samples	Min depth (m)	Habitat
Fish						
Likely fishery sourced- multiple samples	Cyttidae	*Cyttus australis*	Silver Dory	9	20	Continental shelf, near bottom
	Ophidiidae	*Genypterus blacodes/tigerinus*	Pink Ling or Rock Ling	47	10 (usually 300)	bathydemersal
	Congridae	*Gnathophis sp.*	Conger	9	0	Benthic
	Centrolophidae	*Seriolella brama/caerulea (punctata)*	Warehou	35	3	Pelagic, benthopelagic
	Sebastidae	*Helicolenus (percoides)*	Reef Ocean Perch	3	10	Reef associated/sandy areas
	Uranoscopidae	*Kathetostoma laeve*	Common Stargazer	2	0	Benthic
	Trichiuridae	*Lepidopus caudatus*	Frostfish	16	50	Benthopelagic/mesopelagic
	Triglidae	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*	Gurnard	13	2 (some 30m)	Shelly and sandy bottoms
	Merlucciidae	*Macruronus novaezelandiae*	Blue Grenadier	44	2 (usually 450)	Benthopelagic
	Oreosomatidae	*Oreosoma atlanticum/Allocyttus verrucosus/Neocyttus rhomboidalis*	Oreodory	4	450	Benthopelagic
	Platycephalidae	*Platycephalus richardsoni*	Tiger flathead	4	20	Sandy & silty bottoms
	Triglidae	*Pterygotrigla polyommata*	Gurnard	4	10	Benthic
	Urolophidae	*Urolophidae sp.*	Stingray	4	0	Muddy & sandy bottoms, typically benthic
	Zeidae	*Zenopsis nebulosa*	Mirror Dory	2	30	Benthopelagic
Likely fishery sourced- single sample	Rajidae	*Dipturus sp.*	Skate	1	15	Demersal
	Merlucciidae	*Merluccius australis*	Southern Hake	1	28	Benthopelagic
	Hexanchidae	*Notorynchus cepedianus*	Broadnose Shark	1	1	Demersal

	Family	Species	Common name	n samples	Min depth (m)	Habitat
	Polyprionidae	*Polyprion americanus/oxygeneios*	Bass Groper/Hapuku	1	100	Deep rocky reefs
	Somniosidae	*Somniosidae sp.*	Sleeper Sharks and Dogfish	1	250	Benthopelagic
	Urolophidae	*Urolophus cruciatus*	Banded Stingray	1	0	Muddy & sandy bottoms, typically benthic
	Zeidae	Zeus faber	John Dory	1	Variable	Reef associated
Source unknown-single sample	Cottidae	*(Antipodocottus elegans)*	Sculpin	1	150	Benthic
	Alepocephalidae	*Alepocephalus australis (antipodianus)*	Slickhead	1	690	Bathydemersal
	Microstomatidae	*Microstoma (australis)*	Slender Smallmouth	1	50	epipelagic - demersal
	Berycidae	*Centroberyx lineatus*	Swallowtail	1	12	Reef associated
Shared resource	Cheilodactylidae	*Cheilodactylus nigripes/ Nemadactylus macropterus*	Magpie Perch/Morwongs	21	0	Reef associated
	Emmelichthyidae	*Emmelichthys nitidus*	Redbait	513	0	Pelagic offshore
	Pentacerotidae	*Pentaceropsis recurvirostris*	Longsnout Boarfish	3	3	Reef associated
	Clupeidae	*Sardinops sagax*	Australian Sardine	74	0	Pelagic, coastal waters
	Scombridae	*Scomber australasicus*	Blue Mackerel	99	1	Pelagic, oceanodromous
	Gempylidae	*Thyrsites atun*	Barracouta	134	0 (commonly 40-500m)	Pelagic benthopelagic
	Carangidae	*Trachurus declivis/murphyi*	Common Jack mackerel	153	0	Pelagic
	Trachipteridae	*Trachipterus (arawatae)*	Southern ribbonfish	3	0	Mesopelagic, epipelagic, oceanic
	Sparidae	*Chrysophrys auratus*	Australiasian Snapper	1	1	Reef associated
	Scombridae	*Katsuwonus pelamis*	Skipjack Tuna	1	0	Pelagic
	Carangidae	*Seriola lalandi*	Yellowtail kingfish	1	0	Pelagic around reefs, dropoffs

	Family	**Species**	**Common name**	**n samples**	**Min depth (m)**	**Habitat**
Likely natural prey species- Multiple samples	Monacanthidae	*Acanthaluteres spilomelanurus/vittiger*	Bridled or Toothbrush Leatherjacket	21	1	Shallow bays, seagrass beds
	Mugilidae	*Aldrichetta forsteri*	Yelloweye Mullet	12	0	Coastal marine, entering freshwater
	Aracanidae	*Aracana ornata/aurita*	Cowfish	2	0	Seagrass beds
	Arripidae	*Arripis trutta/truttaceus*	Australian Salmon	40	0	Pelagic inshore
	Serranidae	*Caesioperca lepidoptera (rasor)*	Butterfly or Barber Perch	17	4	Rocky reefs, outcrops & drop-offs
	Tetraodonidae	*Contusus brevicaudus/richei*	Toadfish	5	1	Weedy, sandy areas
	Dinolestidae	*Dinolestes lewini*	Longfin Pike	4	Variable	Benthopelagic, coastal
	Diodontidae	*Diodon nicthemerus*	Globefish/ Slender-Spined Porcupine Fish	11	0	Reef associated
	Monacanthidae	*Eubalichthys (gunnii/bucephalus)*	Leatherjacket	8	4	Reef associated
	Gnathanacanthidae	*Gnathanacanthus goetzeei*	Red Velvetfish	3	1	Reef associated, kelp beds
	Hemiramphidae	*Hyporhamphus melanochir*	Southern Garfish	2	0	Epipelagic, inshore
	Moridae	*Lotella rhacina*	Large Tooth Beardie/Rock cod	11	10	Rocky reefs, in caves & crevices
	Monacanthidae	*Meuschenia scaber (flavolineata/galii/venusta)*	Leatherjacket (velvet)	30	5	Reef associated
	Monacanthidae	*Meuschenia sp. (*not *scaber/trachylepis)*	Leatherjacket	3	0	Reef associated
	Neosebastidae	*Neosebastes (thetidis/scorpaenoides)*	Gurnard Perches	41	2/45	Demersal
	Labridae	*Notolabrus tetricus*	Bluethroat Wrasse	5	1	
	Gerreidae	*Parequula melbournensis*	Silverbelly	10	Variable	Sandy, silty, seagrass areas
	Pempheridae	*Pempheris (multiradiata/compressa)*	Bigscale or Smallscale Bullseye	5	2	Reef associated
	Labridae	*Pictilabrus laticlavius*	Senator Wrasse	2	3	Reef associated

	Family	Species	Common name	n samples	Min depth (m)	Habitat
	Platycephalidae	*Platycephalus bassensis*	Southern Sand Flathead	3	1	Sandy, muddy bottom
	Moridae	*Pseudophycis bachus/breviuscula*	Red cod	38	2	Reef associated
	Moridae	*Pseudophycis barbata*	Bearded Rock Cod	47	1	Reef associated
	Kyphosidae	*Scorpis lineolata/aequipinnis*	Silver/sea Sweep	2	1	Reef associated
	Serranidae	*Serranidae sp.*	Seaperch and Perches	26	0	Reef associated
	Clupeidae	*Sprattus (novaehollandiae)*	Australian Spratt	10	0	Pelagic-neritic
	Tetragonuridae	*Tetragonurus cuvieri*	Smalleye Squaretail	3	1	bathypelagic
	Monacanthidae	*Thamnaconus degeni*	Bluefin Leatherjacket	53	4 (usually 30)	Reef associated
	Monacanthidae	*Thamnaconus hypargyreus* (98% match)	Yellowspotted Leatherjacket	33	1	Rocky reeds and seagrass
	Trachichthyidae	*Trachichthyidae sp.*	Roughies	30	Variable	Variable
	Apogonidae	*Vincentia conspersa (novaehollandiae/punctata/ macrocauda)*	Cardinalfish	2	3	Reef associated
Natural prey - single sample	Rhombosoleidae	*Ammotretis rostratus (lituratus/macrolepis)*	Flounder	1	1	Sandy areas, bottom dweller
	Anguilliformes	*Anguilliformes sp.*	Eel	1	0	Benthic
	Scyliorhinidae	*Asymbolus vincenti*	Gulf Catshark	1	2	Reef associated
	Monacanthidae	*Monacanthus chinensis* (98% match)	Leatherjacket	1	0	Reef associated
	Myctophidae	*Myctophidae sp.*	Myctophid	1	0	Mesopelagic
	Priacanthidae	*Priacanthus macracanthus 97%*	Bigeyes	1	15	If this species then unlikely- but sp unknown
	Salmonidae	*Salmo salar*	Atlantic Salmon	1	0	Freshwater & marine
	Sillaginidae	*Sillaginodes punctatus*	King George Whiting	1	0	Seagrass, sandy areas
	Syngnathidae	*Solegnathus spinosissimus*	Spiny Pipehorse	1	Variable	Reef associated

	Family	Species	Common name	n samples	Min depth (m)	Habitat
Cephalopods						
Shared resource	Ommastrephidae	*Nototodarus gouldi*	Gould's squid	135	66	0
	Loliginidae	*Sepioteuthis australis*	Southern calamari	15	3	0
Likely natural prey	Argonautidae	*Argonauta nodosa*	Knobby Argonaut	66	19	0
	Ommastrephidae	*Nototodarus sloanii*	NZ Arrow Squid	3	623	0
	Octopodidae	*Octopus maorum*	Maori octopus	19	3	0 (usually <20)
	Sepiidae	*Sepia apama*	Giant Cuttlefish	623	238	Variable
	Sepiidae	*Sepia madokai (not in Aus)*	Madokai's Cuttlefish	3	1	0
	Sepiidae	*Sepia sp.*	Cuttlefish sp.	238	1	0
	Ommastrephidae	*Todarodes filippovae*	Antarctic Flying Squid	1	66	0
	Onychoteuthidae	*Kondakovia longimana*	Giant Warty Squid	1	3	0

Appendix 5: Parameters used in prey consumption estimates.

Parameter	Value	Source
Adult mass average end incubation shift	4kg	DPIPWE, unpublished data
Adult mass average start incubation shift	4.6kg	DPIPWE, unpublished data
Adult field metabolic rate - active	670 kj/kg	(Green and Brothers 1995)
Adult field metabolic rate - resting	290 kj/kg	(Green and Brothers 1995)
Albatross Island breeding population (adults)	10,400	(Alderman et al. 2011)
Number of chicks - brood stage	2,730 ± 354	DPIPWE, unpublished data
Number of chicks - chick-rearing	1,775 ±212	DPIPWE, unpublished data
Incubation period	73 days	(Hedd and Gales 2005)
Brood period	28 days	(Hedd et al. 2002)
Chick rearing period	100 days	(Hedd et al. 2002)
Non-breeding period - April-May	164 days	
Foraging trip duration (days) - incubation	2.8 ± 0.7 days	(Hedd and Gales 2005)
Foraging trip duration (days) - brood	1.0 ± 0.1 days	(Hedd and Gales 2005)
Foraging trip duration - chick-rearing	1.8 ± 0.62 days	(Hedd and Gales 2005)
Nest shift duration - incubation	2.5 ± 0.2 days	(Hedd and Gales 2005)
Nest shift duration - brood	1.0 ± 0.3 days	(Hedd and Gales 2005)
Nest shift duration - chick-rearing	Minimal	
Proportion of time in colony - inter-breeding	22 ± 17%	(Hedd and Gales 2005)
Mean meal mass - chick-rearing	392 ± 36 g/day	(Hedd et al. 2002)
Mean meal mass - brood	156 g/day	(Hedd et al. 2002)
Energy content - fish kj/g	5.4 kj/g	(Nurnadia et al. 2011, Owen et al. 2017)
Energy content - cephalopods kj/g	4.0 kj/g	(Nurnadia et al. 2011)
Energy content - krill kj/g	3.9 kj/g	(Owen et al. 2017)
Energy content - scyphozoa kj/g	0.13 kj/g	(Doyle et al. 2007)
Energy content - salps kj/g	0.43 kj/g	(Cardona et al. 2012)
Fish assimilation efficiency	0.69	(Jackson 1986)
Squid assimilation efficiency	0.68	(Jackson 1986)

Appendix 6: The relative read abundance of each prey group and species in the diet during each breeding stage and season and values used to calculate prey volumes.

		Proportion of 18S sequences						Proportion of 16S fish sequences					Proportion of 16S cephalopod sequences
		Fish and chondrichthyes	**Cephalopoda**	**Krill**	**Scyphozoa and Hydrozoa**	**Cuttlefish**	**Other**	**Redbait**	**Jack mackerel**	**Blue grenadier**	**Ling**	**All fishery sp.**	**Cuttlefish**
2012/13	**Chick-rearing**	0.87	0.06	0.00	0.00	0.20	0.01	0.38	0.08	0.00	0.03	0.11	0.20
2013/14	**Chick-rearing**	0.83	0.02	0.10	0.00	0.91	0.05	0.35	0.03	0.00	0.01	0.02	0.91
2014/15	**Incubation**	0.63	0.34	0.01	0.02	0.97	0.01	0.40	0.07	0.00	0.02	0.04	0.97
	Brood	0.80	0.10	0.01	0.04	0.59	0.02	0.15	0.14	0.00	0.01	0.16	0.59
	Chick-rearing	0.91	0.06	0.00	0.00	0.82	0.03	0.62	0.07	0.02	0.04	0.07	0.82
	Inter-breeding	0.76	0.20	0.00	0.00	0.95	0.04	0.20	0.04	0.04	0.05	0.28	0.95
2015/16	**Incubation**	0.51	0.45	0.02	0.00	0.98	0.02	0.19	0.12	0.00	0.02	0.07	0.98
	Brood	0.94	0.05	0.00	0.00	0.83	0.00	0.72	0.05	0.02	0.01	0.06	0.83
	Chick-rearing	0.93	0.06	0.00	0.00	0.91	0.01	0.47	0.07	0.02	0.07	0.10	0.91
	Inter-breeding	0.69	0.15	0.13	0.00	0.87	0.03	0.18	0.05	0.02	0.05	0.11	0.87
2016/17	**Incubation**	0.45	0.53	0.00	0.00	1.00	0.01	0.39	0.07	0.00	0.00	0.12	1.00
	Brood	0.91	0.04	0.01	0.03	0.33	0.00	0.28	0.14	0.00	0.01	0.11	0.33
	Chick-rearing	0.97	0.02	0.01	0.00	0.78	0.00	0.54	0.09	0.04	0.04	0.09	0.78
	Inter-breeding	0.79	0.17	0.00	0.00	1.00	0.04	0.41	0.00	0.01	0.00	0.01	1.00
2017/18	**Incubation**	0.61	0.33	0.03	0.00	1.00	0.03	0.56	0.03	0.06	0.00	0.07	1.00
	Brood	0.79	0.19	0.01	0.00	0.41	0.01	0.26	0.21	0.10	0.00	0.09	0.41
	Chick-rearing	0.83	0.15	0.00	0.00	0.82	0.01	0.35	0.03	0.04	0.06	0.23	0.82

Appendix 7: Flesh samples sourced during the study by SETFIA fishery observers or provided by IMAS, and DNA provided by the Australian Fish Collection. These samples were sequenced with the 16S_long primers (Table 3) and sequences uploaded to Genbank online genetic reference database.

Class	**Order**	**Family**	***Species***	**Common name**	**Accession number**
Actinopterygii	Beryciformes	Berycidae	*Centroberyx gerrardi*	Bight Redfish	MN147851
		Trachichthyidae	*Paratrachichthys sp*	Sandpaper Fish?	MN147858
	Gadiformes	Macrouridae	*Coelorinchus australis*	Southern Whiptail	MN147842
			Lepidorhynchus denticulatus	Toothed whiptail	MN147856
		Moridae	Pseudophycis breviuscula	Bastard Rod cod	MN147845
	Myctophiformes	Myctophidae	*Lampanyctus australis*	Austral lanternfish	MN147855
	Perciformes	Carangidae	*Trachurus murphyi*	Jack mackerel	MN147844
		Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong	MN147846
			Cheilodactylus spectabilis	Banded morwong	MN147847
		Epigonidae	*Epigonus lenimen*	Bigeye Deepsea Cardinalfish	MN147852
		Serranidae	*Lepidoperca pulchella*	Eastern Orange Perch	MN147837
	Rajiformes	Rajidae	*Dipturus canutus*	Grey Skate	MN147841
	Salmoniformes	Argentinidae	*Argentina australiae*	Silverside	MN147850
	Scorpaeniformes	Scorpaenidae	*Helicolenus barathri*	Bigeye Ocean Perch	MN147853
			Helicolenus percoides	Reef ocean perch	MN147854
			Neosebastes thetidis	Thetis Fish	MN147840
		Triglidae	*Lepidotrigla modesta*	Cocky gurnard	MN147838
			Pterygotrigla polyommata	Cocky gurnard	MN147859
Chondrichthyes	Squaliformes	Squalidae	*Squalus chloroculus*	Greeneye Spurdog	MN147839
	Zeiformes	Cyttidae	*Cyttus traversi*	King Dory	MN147843
	Zeiformes	Oreosomatidae	*Oreosoma atlanticum*	Oxeye Oreodory	MN147857

Appendix 8: The relative read abundance and frequency of occurrence of all fish and cephalopod species detected in Shy Albatross samples across each season of the study.

			2012/13 (n=46)			2013/14 (n=93)			2014/15 (n=485)			2015/16 (n=379)			2016/17 (n=260)			2017/18 (n=195)		
Family	**Species**	**Common Name**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**
Fish																				
Alepocephalidae	*Alepocephalus australis (antipodianus)*	Slickhead	0	0	0	0	0	0	0	0	0	1	0.3	0	1	0.7	1.5	0	0	0
Anguilliformes	*Anguilliformes sp.*	Eel	0	0	0	0	0	0	0	0	0	1	0.3	0.2	0	0	0	0	0	0
Apogonidae	*Vincentia conspersa (novaehollandiae/punctata/ macrocauda)*	Cardinalfish	0	0	0	0	0	0	2	0.6	1.0	0	0	0	0	0	0	0	0	0
Aracanidae	*Aracana ornata/aurita*	Cowfish	0	0	0	0	0	0	1	0.2	0.1	0	0	0	1	0.2	0.1	0	0	0
Arripidae	*Arripis trutta/truttaceus*	Australian Salmon	0	0	0	9	9.7	5.8	18	3.1	3.5	8	1.8	1.5	4	1.5	1.8	1	0.8	1.2
Berycidae	*Centroberyx lineatus*	Swallowtail	0	0	0	1	1.1	1.3	0	0	0	0	0	0	0	0	0	0	0	0
Carangidae	*Seriola lalandi*	Yellowtail Kingfish	0	0	0	0	0	0	1	0.2	0.2	0	0	0	0	0	0	0	0	0
Carangidae	*Trachurus declivis/murphyi*	Common Jack Mackerel	8	17.4	8.3	6	6.5	3.5	50	10.0	8.1	39	9.8	7.0	39	10.2	7.9	11	6.7	8.8
Centrolophidae	*Seriolella brama/caerulea (punctata)*	Warehou	1	2.2	1.5	2	2.2	0.1	17	3.3	3.1	7	2.2	0.4	12	2.5	1.9	1	0.3	<0.1
Cheilodactylidae	*Cheilodactylus nigripes/Nemadactylus macropterus*	Magpie Perch/Morwongs	3	6.5	3.7	2	2.2	0.9	6	1.5	0.9	4	1.2	0.1	1	0.3	0.2	5	2.1	0.9
Clupeidae	*Sardinops sagax*	Australian Sardine	1	2.2	2.7	0	0	0	10	2.1	1.6	27	7.1	5.6	35	9.5	5.3	2	1.1	1.2
Clupeidae	*Sprattus (novaehollandiae)*	Australian Spratt	0	0	0	0	0	0	2	0.3	0.4	5	1.3	1.6	0	0	0	3	1.0	0.4
Congridae	*(Conger verreauxi)*	Southern Coger	1	2.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Congridae	*Gnathophis sp.*	Conger	0	0	0	1	1.1	0.1	6	1.7	1.3	3	0.6	0.7	0	0	0	0	0	0
Cottidae	*(Antipodocottus elegans)*	Sculpin	0	0	0	0	0	0	1	0.2	0.1	0.0	0	0	0	0	0	0	0	0
Cyttidae	*Cyttus australis*	Silver Dory	4	8.7	5.8	1	1.1	0.7	2	0.5	0.5	0	0	0	1	0.3	<0.1	2	0.7	0.1
Dinolestidae	*Dinolestes lewini*	Longfin Pike	0	0	0	3	3.2	3.1	0	0	0	0	0	0	0	0	0	1	0.3	0.4
Diodontidae	*Diodon nicthemerus*	Globefish/ Slender-Spined Porcupine Fish	1	2.2	<0.1	0	0	0	2	0.5	0.8	5	1.0	1.2	1	1.0	1.7	3	1.0	0.9
Emmelichthyidae	*Emmelichthys nitidus*	Redbait	21	45.7	38.4	32	34.4	36.4	142	32.6	35.5	159	44.5	40.5	95	34.6	42.9	64	30.7	41.9
Epigonidae	*Epigonus lenimen (denticulatus/ telescopus)*	Deepsea Cardinalfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.3	0.0
Gadiformes	*Coryphaenoides serrulatus (fernandezianus/filicauda)*	Serrulate Whiptail	0	0	0	1	1.1	<0.1	0	0	0	0	0	0	0	0	0	0	0	0
Gempylidae	*Thyrsites atun*	Barracouta	10	21.7	16.5	17	18.3	17	40	7.8	5.0	23	6.0	4.9	28	8.6	5.9	16	9.4	12.0
Gerreidae	*Parequula melbournensis*	Silverbelly	0	0	0	0	0	0	3	0.9	0.6	3	0.7	0.2	4	0.9	0.6	0	0	0
Gnathanacanthidae	*Gnathanacanthus goetzeei*	Red Velvetfish	0	0	0	0	0	0	3	0.5	0.5	0	0	0	0	0	0	0	0	0
Hemiramphidae	*Hyporhamphus melanochir*	Southern Garfish	0	0	0	0	0	0	0	0	0	0	0	0	2	0.6	0.1	0	0	0
Hexanchidae	*Notorynchus cepedianus*	Broadnose Shark	0	0	0	0	0	0	1	0.2	0.1	0	0	0	0	0	0	0	0	0

			2012/13 (n=46)			2013/14 (n=93)			2014/15 (n=485)			2015/16 (n=379)			2016/17 (n=260)			2017/18 (n=195)		
Family	**Species**	**Common Name**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**
Kyphosidae	*Scorpis lineolata/aequipinnis*	Silver/Sea Sweep	0	0	0	0	0	0	0	0	0	2	0.6	0.2	0	0	0	0	0	0
Labridae	*Notolabrus tetricus*	Bluethroat Wrasse	0	0	0	1	1.1	<0.1	5	0.9	1.1	0	0	0	0	0	0	0	0	0
Labridae	*Pictilabrus laticlavius*	Senator Wrasse	0	0	0	0	0	0	1	0.3	0.3	1	0.3	0.4	0	0	0	0	0	0
Merlucciidae	*Macruronus novaezelandiae*	Blue Grenadier	0	0	0	0	0	0	9	2.3	2.0	11	3.3	1.7	6	2.4	0.7	20	9.6	5.9
Merlucciidae	*Merluccius australis*	Southern Hake	0	0	0	0	0	0	1	0.2	0.1	0	0	0	0	0	0	0	0	0
Microstomatidae	*Microstoma (australis)*	Slender smallmouth	1	2.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monacanthidae	*Acanthaluteres spilomelanurus/vittiger*	Bridled or Toothbrush Leatherjacket	0	0	0	0	0	0	6	0.9	1.3	7	2.1	0.5	6	2.2	2.5	4	1.8	0.5
Monacanthidae	*Eubalichthys (gunnii/bucephalus)*	Leatherjacket	2	4.3	1.3	1	1.1	1.4	3	0.6	0.5	3	0.7	0.5	0	0.0	0.0	1	0.3	<0.1
Monacanthidae	*Meuschenia scaber (flavolineata/galii/venusta)*	Leather jacket (velvet)	2	4.3	5.3	2	2.2	1.4	5	1.0	0.3	9	2.1	1.0	7	1.9	0.8	6	2.0	0.3
Monacanthidae	*Meuschenia sp.*	Leatherjacket	0	0	0	1	1.1	<0.1	3	1.0	1.3	0	0	0	0	0	0	0	0	0
Monacanthidae	*Monacanthus chinensis*	Leatherjacket	0	0	0	0	0	0	0	0	0	0	0	0	1	0.3	0.4	0	0	0
Monacanthidae	*Thamnaconus degeni*	Bluefin Leatherjacket	0	0	0	7	7.5	3.4	14	3.0	2.0	6	1.7	1.1	14	4.8	3.7	12	4.8	3.4
Monacanthidae	*Thamnaconus hypargyreus*	Yellowspotted Leatherjacket	1	2.2	0.3	5	5.4	3.6	16	3.8	1.6	7	1.8	1.0	3	2.2	3.2	3	1.9	1.2
Moridae	*Lotella rhacina*	Large Tooth Beardie/Rock cod	1	2.2	0.1	0	0	0	3	0.5	0.4	9	2.1	1.5	1	0.7	0.1	0	0	0
Moridae	*Mora moro*	Common Mora	0	0	0	0	0	0	0	0	0	1	0.3	0	0	0	0	0	0	0
Moridae	*Pseudophycis bachus/breviuscula*	Red Cod	2	4.3	0.4	1	1.1	1.1	8	1.7	1.7	10	2.8	1.9	12	4.8	2.5	5	2.4	3.6
Moridae	*Pseudophycis barbata*	Bearded Rock Cod	1	2.2	0.2	5	5.4	1.6	6	1.7	0.9	20	5.7	5.2	14	5.4	4.2	3	1.0	0.6
Mugilidae	*Aldrichetta forsteri*	Yelloweye Mullet	0	0	0	0	0	0	12	1.9	2.5	1	0.3	0	0	0	0	0	0	0
Mullidae	*Upeneichthys lineatus/vlamingii*	Goatfish	0	0	0	0	0	0	0	0	0	1	0.2	0	0	0	0	0	0	0
Myctophidae	*Lampanyctodes hectori*	Hector's Lanternfish	0	0	0	0	0	0	0	0	0	0	0.0	0	1	0.3	0	1	0.8	0
Myctophidae		Myctophid	0	0	0	0	0	0	0	0	0	1	0.3	0	0	0	0	0	0	0
Neosebastidae	*Neosebastes (thetidis/scorpaenoides)*	Gurnard Perches	3	6.5	0.7	2	2.2	1.6	10	2.2	2.8	19	4.4	4.9	5	1.2	0.7	3	1.0	0.4
Ophidiidae	*Genypterus blacodes/tigerinus*	Pink Ling or Rock Ling	4	8.7	3.1	0	0	0	15	3.7	2.9	12	3.3	3.5	7	1.7	1.1	9	3.0	2.2
Oreosomatidae		Oreodory	0	0	0	2	2.2	0.2	2	0.3	0.2	0	0	0	0	0	0	0	0	0
Pempheridae	*Pempheris (multiradiata/compressa)*	Bigscale or Smallscale Bullseye	2	4.3	2.8	0	0	0	3	0.9	1.3	1	0.3	0	0	0	0	0	0	0
Pentacerotidae	*Pentaceropsis recurvirostris*	Longsnout Boarfish	0	0	0	0	0	0	2	0.3	0.4	0	0	0	1	0.2	0	1	0.8	0.1
Platycephalidae	*Platycephalus bassensis*	Southern Sand Flathead	0	0	0	0	0	0	1	0.2	0.1	0	0	0	1	0.2	0.1	1	0.8	0.6
Platycephalidae	*Platycephalus richardsoni*	Tiger Flathead	0	0	0	0	0	0	2	0.6	0.5	1	0.3	0.4	1	0.2	0.2	0	0	0

			2012/13 (n=46)			2013/14 (n=93)			2014/15 (n=485)			2015/16 (n=379)			2016/17 (n=260)			2017/18 (n=195)		
Family	**Species**	**Common Name**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**
Polyprionidae	*Polyprion americanus/oxygeneios*	Bass Groper/Hapuku	1	2.2	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Priacanthidae	*Priacanthus macracanthus* (97% match)	Bigeyes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.6	1.2
Rajidae	*Dipturus sp.*	Skate	0	0	0	0	0	0	0	0	0	1	0.2	0.2	0	0	0	0	0	0
Rhombosoleidae	*Ammotretis rostratus (lituratus/macrolepis)*	Flounder	0	0	0	0	0	0	1	0.2	0.3	0	0	0	0	0	0	0	0	0
Salmonidae	*Salmo salar*	Atlantic Salmon	0	0	0	0	0	0	1	0.2	0.3	0	0	0	0	0	0	0	0	0
Scombridae	*Gasterochisma melampus*	Butterfly Mackerel	0	0	0	0	0	0	1	0.3	0.0	0	0	0	0	0	0	0	0	0
Scombridae	*Katsuwonus pelamis*	Skipjack Tuna	0	0	0	0	0	0	0	0.0	0.0	0	0	0	0	0	0	1	0.3	0.4
Scombridae	*Scomber australasicus*	Blue Mackerel	5	10.9	7.6	15	16.1	9	32	6.7	5.3	28	7.3	5.0	8	1.7	1.1	11	3.7	2.5
Scyliorhinidae	*Asymbolus vincenti*	Gulf Catshark	0	0	0	0	0	0	0	0.0	0.0	0	0	0	1	0.2	0.1	0	0	0
Sebastidae	*Helicolenus (percoides)*	Reef Ocean Perch	0	0	0	0	0	0	3	0.8	1.2	0	0	0	0	0	0	1	0.3	0
Serranidae	*Caesioperca lepidoptera (rasor)*	Butterfly or Barber Perch	0	0	0	0	0	0	2	0.5	0.0	9	2.3	1.3	7	1.6	0.5	3	1.9	1.6
Serranidae		Seaperch and Perches	0	0	0	3	3.2	2.5	10	2.4	1.3	7	2.0	1.1	4	1.6	2.1	2	0.7	0.4
Sillaginidae	*Sillaginodes punctatus*	King George Whiting	0	0	0	0	0	0	0	0	0	1	0.2	0.2	0	0	0	0	0	0
Somniosidae		Sleeper Sharks and Dogfish	0	0	0	0	0	0	1	0.2	0.2	0	0	0	0	0	0	0	0.0	0.0
Sparidae	*Chrysophrys auratus*	Australasian Snapper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.3	0.3
Stomiidae		Dragonfish	0	0	0	0	0	0	0	0	0	0	0	0	1	0.2	0	0	0	0
Syngnathidae	*Solegnathus spinosissimus*	Spiny Pipehorse	0	0	0	0	0	0	1	0.2	0.1	0	0	0	0	0	0	0	0	0
Tetragonuridae	*Tetragonuridae sp.*	Smalleye Squaretail	0	0	0	0	0	0	1	0.2	0.0	0	0	0	0	0	0	0	0	0
Tetragonuridae	*Tetragonurus cuvieri*	Smalleye Squaretail	0	0	0	0	0	0	3	0.5	0.6	0	0	0	0	0	0	0	0	0
Tetraodonidae	*Contusus brevicaudus/richei*	Toadfish	0	0	0	0	0	0	1	0.3	0.1	3	0.7	0.2	1	0.7	1.5	2	0.7	0.0
Trachichthyidae		Roughies	1	2.2	0.2	6	6.5	5.3	6	0.9	1.0	12	3.2	1.9	4	1.4	1.4	2	1.6	0.7
Trachipteridae	*Trachipterus (arawatae)*	Southern Ribbonfish	0	0	0	0	0	0	0	0	0	0	0	0	3	0.6	0.4	0	0	0
Trichiuridae	*Lepidopus caudatus*	Frostfish	0	0	0	0	0	0	2	0.5	0.1	1	0.3	0.3	4	1.1	0.7	10	3.4	3.2
Triglidae	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*	Gurnard	1	2.2	0.1	0	0	0	3	0.6	0.4	5	1.3	0.7	6	2.0	2.0	2	0.7	0.6
Triglidae	*Pterygotrigla polyommata*	Gurnard	0	0	0	0	0	0	2	0.3	0.5	0	0	0	1	0.3	0.2	1	0.3	0.1
Uranoscopidae	*Kathetostoma laeve*	Common Stargazer	0	0	0	0	0	0	1	0.2	0.1	0	0	0	0	0	0.0	1	0.3	0.4
Urolophidae		Stingray	0	0	0	0	0	0	4	0.8	0.6	1	0.2	0.1	0	0	0	0	0	0
Urolophidae	*Urolophus cruciatus*	Banded Stingray	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.8	0.5
Zeidae	*Zenopsis nebulosa*	Mirror Dory	0	0	0	0	0	0	2	0.3	0.3	1	0.2	0	0	0	0	0	0	0
Zeidae	*Zeus faber*	John Dory	0	0	0	0	0	0	1	0.3	0	1	0.3	0.6	0	0	0	0	0	0
		Unmatched	1	2.2	0.1	1	1.1	<0.1	14	3.2	0.6	19	4.8	0.8	14	4.4	0.5	8	3.9	1.0

			2012/13 (n=46)			2013/14 (n=93)			2014/15 (n=485)			2015/16 (n=379)			2016/17 (n=260)			2017/18 (n=195)		
Family	**Species**	**Common Name**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**	**n**	**RRA**	**FOO**
Cephalopoda																				
Argonautidae	*Argonauta nodosa*	Knobby Argonaut	2	4.3	0.3	1	1.1	2.1	36	5.5	5.5	6	1.9	3.7	21	4.5	6.9	0	0	0
Gonatidae	*Gonatus antarcticus*	Gonatus Squid	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Onychoteuthidae	*Kondakovia longimana*	Giant Warty Squid	0	0	0	0	0	0	0	0	0	0	0	0	1	0.2	0.4	0	0	0
Ommastrephidae	*Nototodarus gouldi*	Gould's Squid	5	10.9	17.4	0	0	0	51	9.9	9.4	13	3.8	4.4	32	7.1	14.0	35	21.4	23.7
Ommastrephidae	*Nototodarus sloanii*	NZ Arrow Squid	0	0	0	2	2.2	2.8	1	0.2	0.2	0	0	0	0	0	0	0	0	0
Octopodidae	*Octopus maorum*	Maori Octopus	2	4.3	1.1	0	0	0	5	0.9	0.6	6	1.5	1.7	4	0.9	1.0	3	1.0	1.2
Sepiidae	*Sepia apama*	Giant Cuttlefish	19	41.3	60.7	38	40.9	72.8	235	50.5	61.8	175	41.4	63.6	60	35.0	67.9	92	43.8	62.1
Sepiidae	*Sepia madokai* (not in Aus)	Madokai's Cuttlefish	0	0	0	0	0	0	2	0.5	0.3	1	0.3	0.7	0	0.0	0.0	0	0.0	0.0
Sepiidae	*Sepia* sp.	Cuttlefish sp.	9	19.6	20.4	11	11.8	17.8	110	19.9	20.3	73	18.1	25.0	18	6.2	9.5	17	12.2	12.7
Loliginidae	*Sepioteuthis australis*	Southern Calamari	0	0	0	2	2.2	2.4	8	1.7	1.8	3	0.7	0.9	1	0.2	0.4	1	0.3	0.2
Ommastrephidae	*Todarodes filippovae*	Antarctic Flying Squid	0	0	0	1	1.1	2.1	0	0	0	0	0	0	0	0	0	0	0	0
		Unmatched	0	0	0	0	0	0	2	0.3	0	0	0	0	0	0	0	2	0.7	0

Appendix 9: The number of breeding stages that each fish and cephalopod species were observed and whether it was caught by a fishery in the foraging area. Accessibility was categorised as 'accessible' to albatross, 'unlikely' to be accessible based on prey depth and behaviour, or 'unknown' when species details were lacking. The source was allocated according to spatial overlaps and catch data: 'Natural' (accessible and not caught by fishery), 'Fishery' (inaccessible and caught by fishery), 'Unconfirmed' (where they may have been obtained from a fishery or naturally) or 'Unknown' (unlikely to be accessible but not caught in fishery). The resource was based on species caught in a fishery in SE Australia. Species were 'Non-fishery', 'Fishery' or 'Shared' resource (where they are caught by a fishery and naturally accessible to albatross).

		Caught by fishery in foraging area for each stage						
Class	**Species**	**No**	**Perhaps**	**Yes**	**Total breeding stages**	**Accessibility**	**Source**	**Resource**
Cephalopod	*Argonauta nodosa*	6			6	Accessible	Natural	Non-fishery
Cephalopod	*Kondakovia longimana*		1		1	Accessible	Unattributed	Non-fishery
Cephalopod	*Nototodarus gouldi*	2	1	9	12	Accessible	Unattributed	Shared
Cephalopod	*Nototodarus sloanii*	2			2	Accessible	Natural	Non-fishery
Cephalopod	*Octopus maorum*	3	6		9	Accessible	Natural	Non-fishery
Cephalopod	*Sepia apama*	10	12		22	Accessible	Natural	Non-fishery
Cephalopod	*Sepia madokai* (not in Aus)	2	1		3	Accessible	Natural	Non-fishery
Cephalopod	*Sepia* sp.	8	9		17	Accessible	Natural	Non-fishery
Cephalopod	*Sepioteuthis australis*	6	2	1	9	Accessible	Natural	Shared
Cephalopod	*Todarodes filippovae*	1			1	Accessible	Natural	Non-fishery
Fish	*(Antipodocottus elegans)*	1			1	Unlikely	Unknown	Fishery
Fish	*(Conger verreauxi)*	1			1	Accessible	Natural	Non-fishery
Fish	*Acanthaluteres spilomelanurus/vittiger*	8			8	Accessible	Natural	Non-fishery
Fish	*Aldrichetta forsteri*	3			3	Accessible	Natural	Non-fishery
Fish	*Alepocephalus australis (antipodianus)*	2			2	Unlikely	Unknown	Fishery
Fish	*Ammotretis rostratus (lituratus/macrolepis)*	1			1	Accessible	Natural	Non-fishery
Fish	*Anguilliformes* sp.	1			1	Unknown	Natural	Non-fishery
Fish	*Aracana ornata/aurita*	2			2	Accessible	Natural	Non-fishery
Fish	*Arripis trutta/truttaceus*	10			10	Accessible	Natural	Non-fishery
Fish	*Asymbolus vincenti*	1			1	Accessible	Natural	Non-fishery
Fish	*Caesioperca lepidoptera (rasor)*	9			9	Accessible	Natural	Non-fishery
Fish	*Centroberyx lineatus*	1			1	Unlikely	Unknown	Fishery

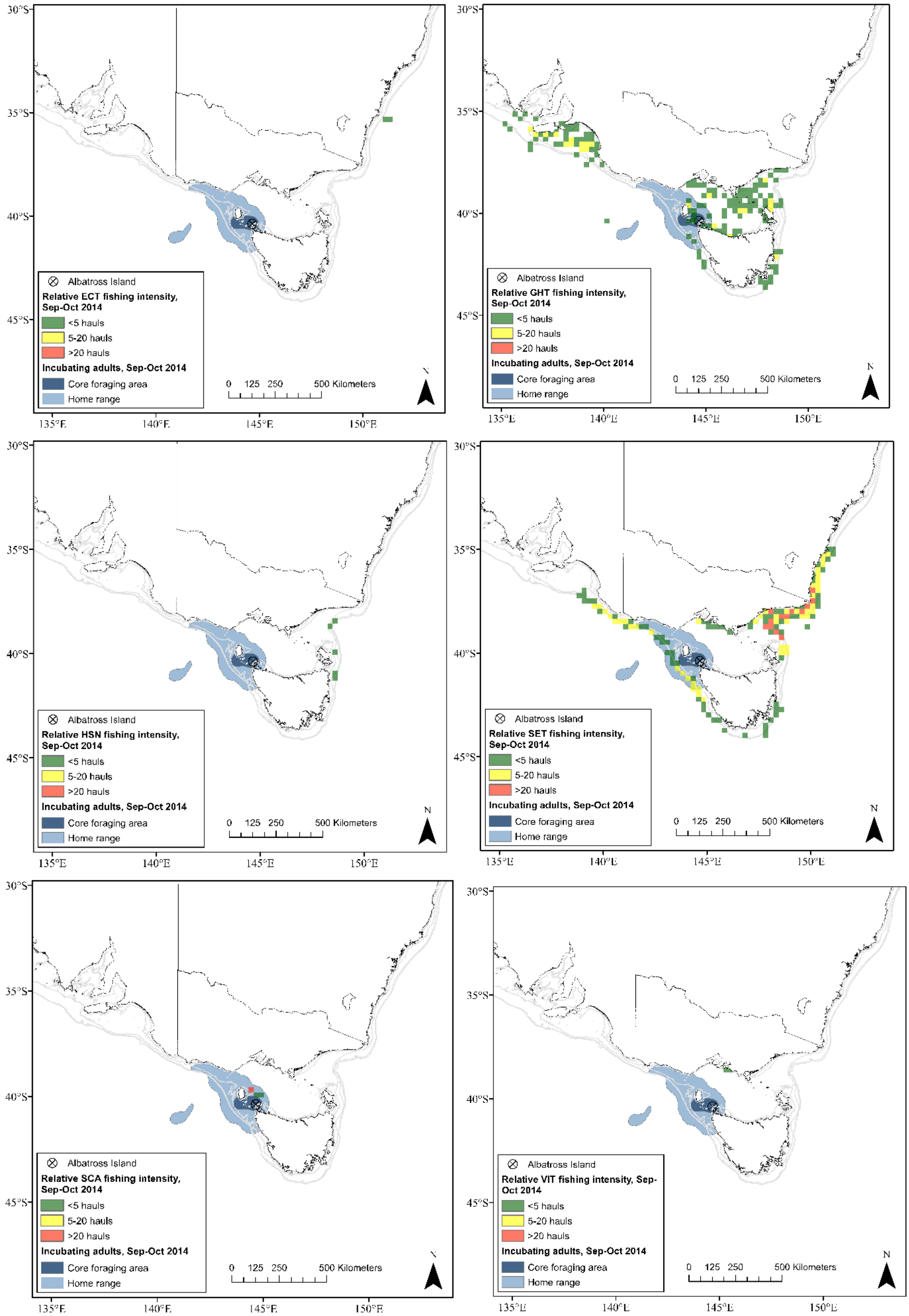
Class	Species	Caught by fishery in foraging area for each stage			Total breeding stages	Accessibility	Source	Resource
		No	Perhaps	Yes				
Fish	*Cheilodactylus nigripes/Nemadactylus macropterus*	1		9	10	Accessible	Unattributed	Shared
Fish	*Chrysophrys auratus*			1	1	Accessible	Unattributed	Shared
Fish	*Contusus brevicaudus/richei*	5			5	Accessible	Natural	Non-fishery
Fish	*Coryphaenoides serrulatus (fernandezianus/filicauda)*		1		1	Unlikely	Fishery	Fishery
Fish	*Cyttus australis*	2		4	6	Unlikely	Fishery	Fishery
Fish	*Dinolestes lewini*	2			2	Accessible	Natural	Non-fishery
Fish	*Diodon nicthemerus*	6			6	Accessible	Natural	Non-fishery
Fish	*Dipturus* sp.		1		1	Unlikely	Fishery	Fishery
Fish	*Emmelichthys nitidus*	16		1	17	Accessible	Natural	Shared
Fish	*Epigonus lenimen (denticulatus/telescopus)*	1			1	Unlikely	Unknown	Unknown
Fish	*Eubalichthys (gunnii/bucephalus)*	7			7	Accessible	Natural	Non-fishery
Fish	*Gasterochisma melampus*	1			1	Accessible	Natural	Non-fishery
Fish	*Genypterus blacodes/tigerinus*			12	12	Unlikely	Fishery	Fishery
Fish	*Gnathanacanthus goetzeei*	1			1	Accessible	Natural	Non-fishery
Fish	*Gnathophis* sp.	1	2	1	4	Unlikely	Fishery	Fishery
Fish	*Helicolenus (percoides)*			3	3	Unlikely	Fishery	Fishery
Fish	*Hyporhamphus melanochir*	1			1	Accessible	Natural	Non-fishery
Fish	*Kathetostoma laeve*		2		2	Unlikely	Fishery	Fishery
Fish	*Katsuwonus pelamis*	1			1	Accessible	Natural	Shared
Fish	*Lampanyctodes hectori*	2			2	Accessible	Natural	Non-fishery
Fish	*Lepidopus caudatus*	2		4	6	Unlikely	Fishery	Fishery
Fish	*Lepidotrigla papilio (modesta/vanessa/mulhalli)*	2		10	12	Unlikely	Fishery	Fishery
Fish	*Lotella rhacina*	7	1		8	Possible	Natural	Non-fishery
Fish	*Macruronus novaezelandiae*			13	13	Unlikely	Fishery	Fishery
Fish	*Merluccius australis*	1			1	Unlikely	Unknown	Fishery
Fish	*Meuschenia scaber (flavolineata/galii/venusta)*	9	1		10	Accessible	Natural	Non-fishery
Fish	*Meuschenia* sp. *(not scaber/trachylepis)*	2			2	Accessible	Natural	Non-fishery
Fish	*Microstoma (australis)*	1			1	Unlikely	Unknown	Fishery

Class	Species	Caught by fishery in foraging area for each stage			Total breeding stages	Accessibility	Source	Resource
		No	Perhaps	Yes				
Fish	*Monacanthus chinensis* (98% match)	1			1	Unknown	Natural	Non-fishery
Fish	*Mora moro*			1	1	Unlikely	Fishery	Fishery
Fish	Myctophidae sp.	1			1	Unknown	Natural	Non-fishery
Fish	*Neosebastes (thetidis/scorpaenoides)*	11		2	13	Accessible/Unlikely	Natural	Non-fishery
Fish	*Notolabrus tetricus*	4			4	Accessible	Natural	Non-fishery
Fish	*Notorynchus cepedianus*			1	1	Unlikely	Fishery	Fishery
Fish	Oreosomatidae sp.1			2	2	Unlikely	Fishery	Fishery
Fish	Oreosomatidae sp.2			1	1	Unlikely	Fishery	Fishery
Fish	*Parequula melbournensis*	6			6	Accessible	Natural	Non-fishery
Fish	*Pempheris (multiradiata/compressa)*	4			4	Accessible	Natural	Non-fishery
Fish	*Pentaceropsis recurvirostris*		3	1	4	Accessible	Unattributed	Shared
Fish	*Pictilabrus laticlavius*	2			2	Accessible	Natural	Non-fishery
Fish	*Platycephalus bassensis*	3			3	Accessible	Natural	Non-fishery
Fish	*Platycephalus richardsoni*			4	4	Unlikely	Fishery	Fishery
Fish	*Polyprion americanus/oxygeneios*			1	1	Unlikely	Fishery	Fishery
Fish	*Priacanthus macracanthus* (97% match)	1			1	Unknown	Natural	Non-fishery
Fish	*Pseudophycis bachus/breviuscula*	13	2	1	16	Accessible	Natural	Non-fishery
Fish	*Pseudophycis barbata*	10	3	1	14	Accessible	Natural	Non-fishery
Fish	*Salmo salar*	1			1	Accessible	Natural	Non-fishery
Fish	*Sardinops sagax*	14			14	Accessible	Natural	Shared
Fish	*Scomber australasicus*	8	3		11	Accessible	Natural	Shared
Fish	*Scorpis lineolata/aequipinnis*	2			2	Accessible	Natural	Non-fishery
Fish	*Seriola lalandi*	1			1	Accessible	Natural	Shared
Fish	*Seriolella brama/caerulea (punctata)*			9	9	Unlikely	Fishery	Fishery
Fish	*Serranidae* sp.	12			12	Accessible	Natural	Non-fishery
Fish	*Sillaginodes punctatus*	1			1	Accessible	Natural	Non-fishery
Fish	*Solegnathus spinosissimus*	1			1	Accessible	Natural	Non-fishery
Fish	*Somniosidae* sp.		1		1	Unlikely	Fishery	Fishery

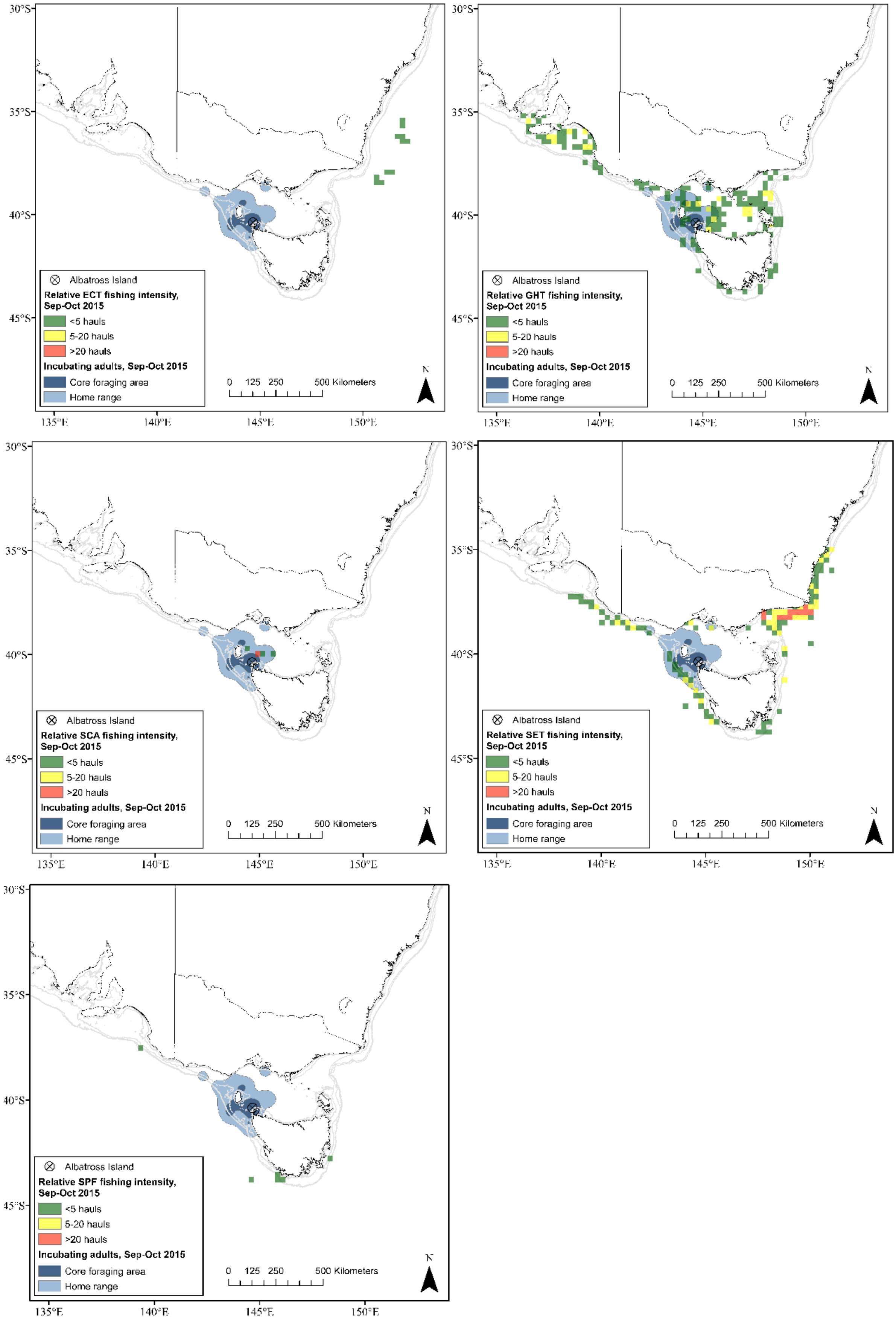
Class	Species	Caught by fishery in foraging area for each stage			Total breeding stages	Accessibility	Source	Resource
		No	Perhaps	Yes				
Fish	*Sprattus (novaehollandiae)*	5			5	Accessible	Natural	Non-fishery
Fish	*Stomiidae* sp.	1			1	Unlikely	Unknown	Unknown
Fish	*Tetragonuridae* sp.	1			1	Unlikely	Unknown	Unknown
Fish	*Tetragonurus cuvieri*	1			1	Accessible	Natural	Non-fishery
Fish	*Thamnaconus degeni*	14			14	Possible	Natural	Non-fishery
Fish	*Thamnaconus hypargyreus* (98% match)	13			13	Unknown	Natural	Non-fishery
Fish	*Thyrsites atun*	7		8	15	Accessible	Unattributed	Shared
Fish	*Trachichthyidae* sp.	10			10	Possible	Natural	Non-fishery
Fish	*Trachipterus (arawatae)*	1			1	Accessible	Natural	Shared
Fish	*Trachurus declivis/murphyi*	10		6	16	Accessible	Unattributed	Shared
Fish	*Pterygotrigla polyommata*		4		4	Unlikely	Fishery	Fishery
Fish	*Upeneichthys lineatus/vlamingii*			1	1	Accessible	Unattributed	Shared
Fish	*Urolophidae sp.*	2	3		5	Unlikely	Fishery	Fishery
Fish	*Urolophus cruciatus*		1		1	Unlikely	Fishery	Fishery
Fish	*Vincentia conspersa (novaehollandiae/punctata/macrocauda)*	1			1	Accessible	Natural	Non-fishery
Fish	*Zenopsis nebulosa*			2	2	Unlikely	Fishery	Fishery
Fish	*Zeus faber*	1		2	3	Unlikely	Fishery	Fishery

Appendix 10: Spatial overlap between shy albatross at Albatross Island and Commonwealth fisheries during Incubation (October-September) 2014-2017. Fishing intensity squares represent ¼ degree cells.

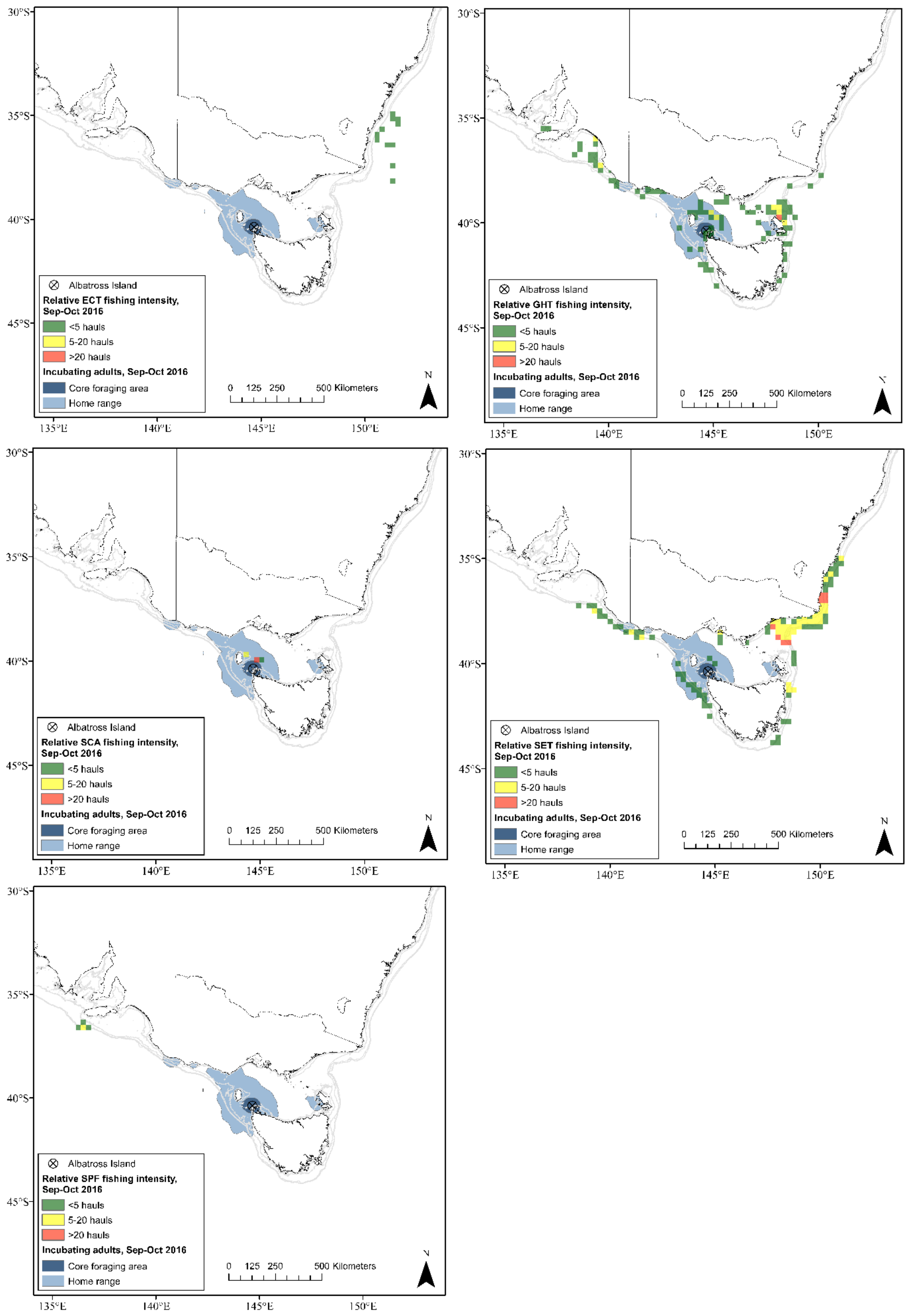
10A) Incubation 2014 (September-October).



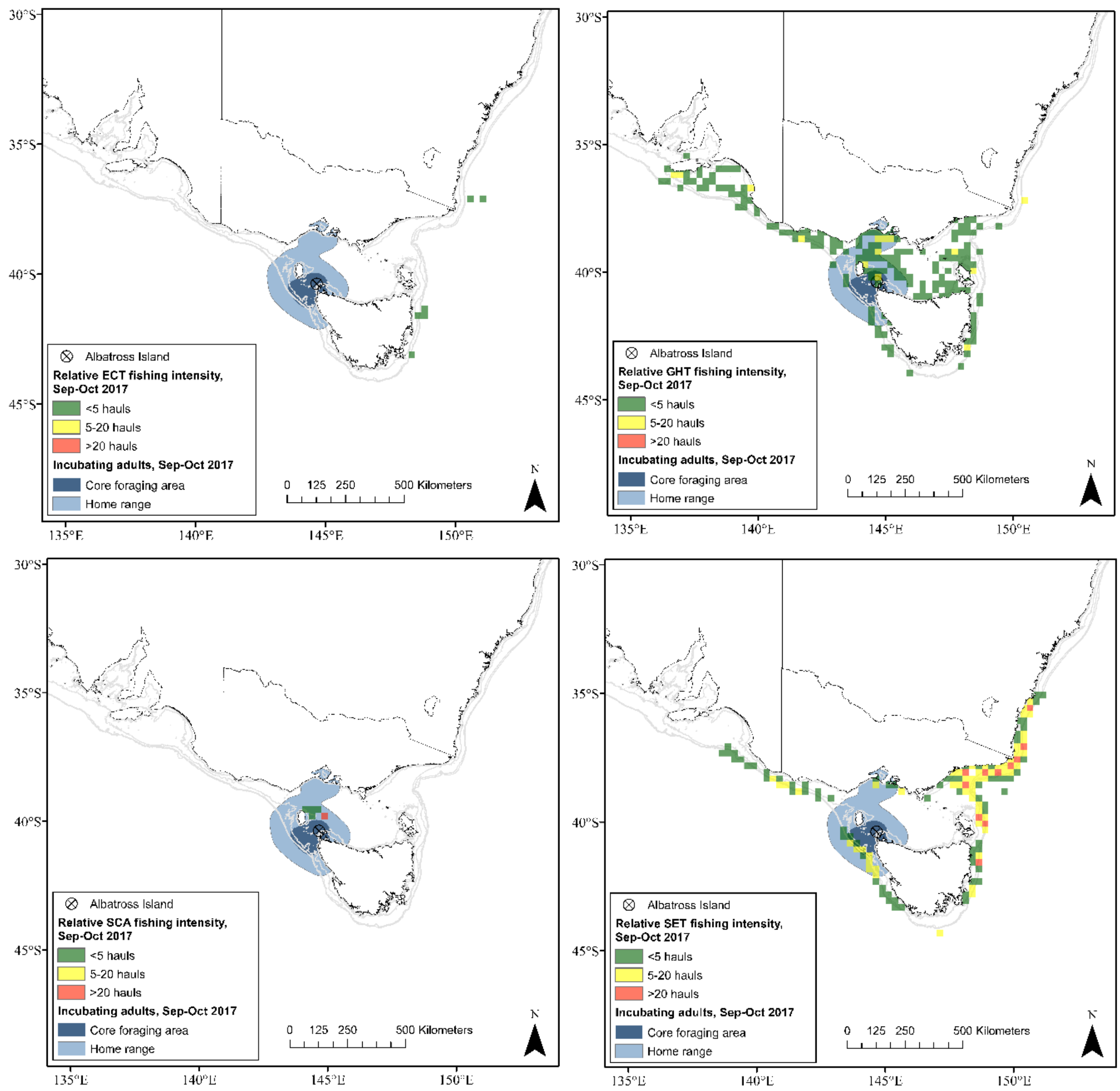
10B) Incubation 2015 (September-October).



10C) Incubation 2016 (September-October).

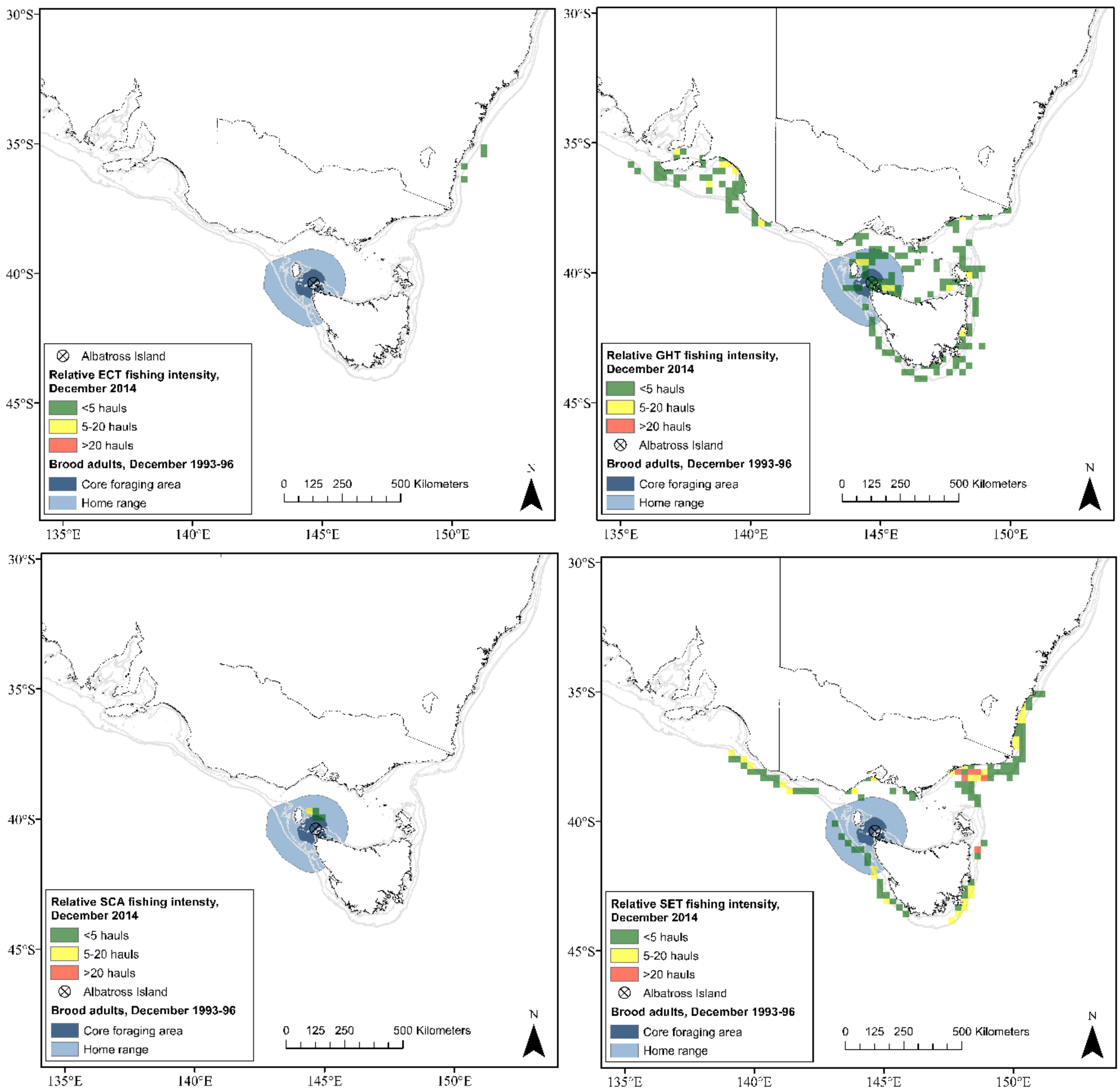


10D) Incubation 2017 (September-October).

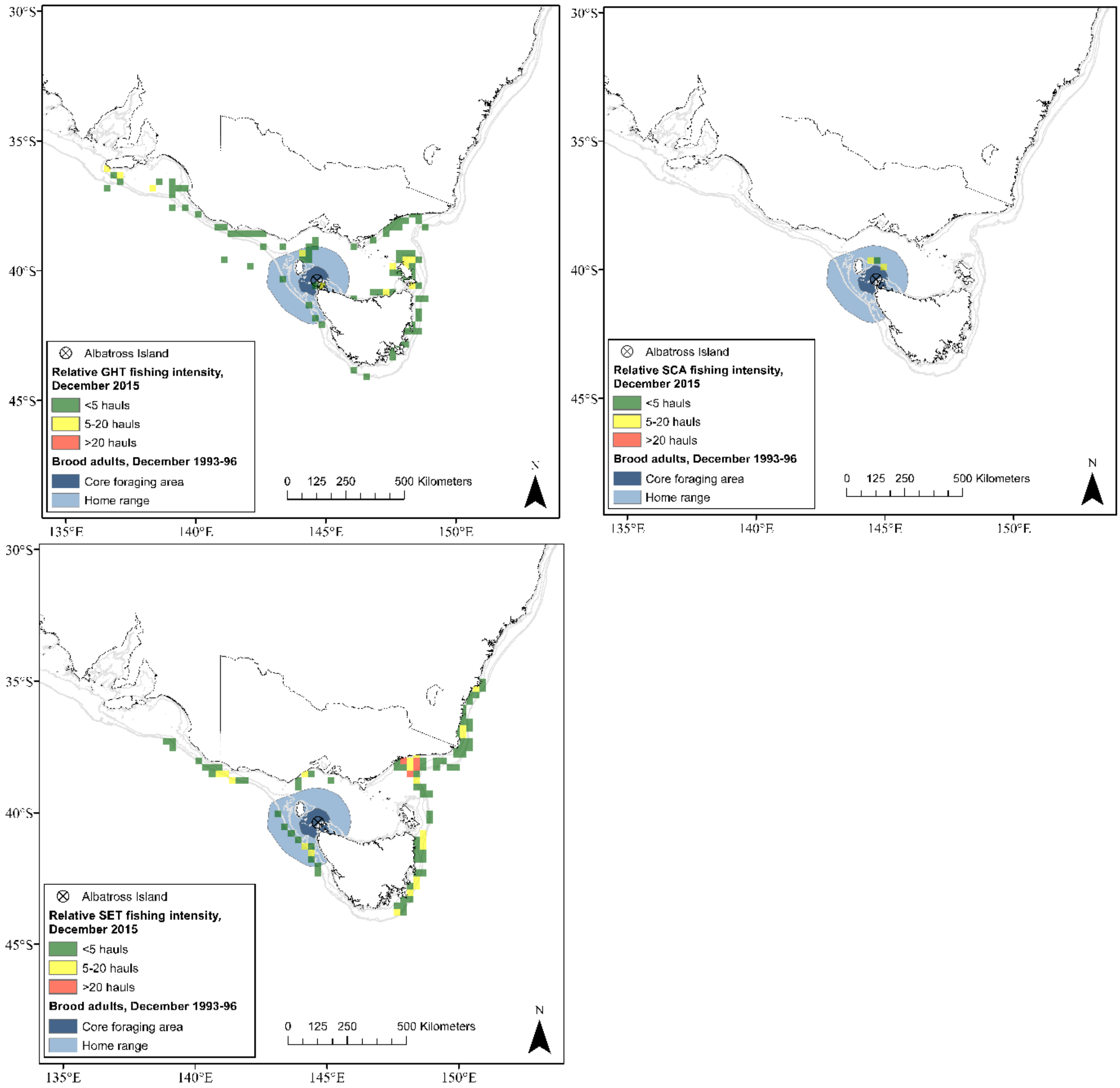


Appendix 11: Spatial overlap between shy albatross at Albatross Island and Commonwealth fisheries during Brood (December) 2014-2017. Fishing intensity squares represent ¼ degree cells.

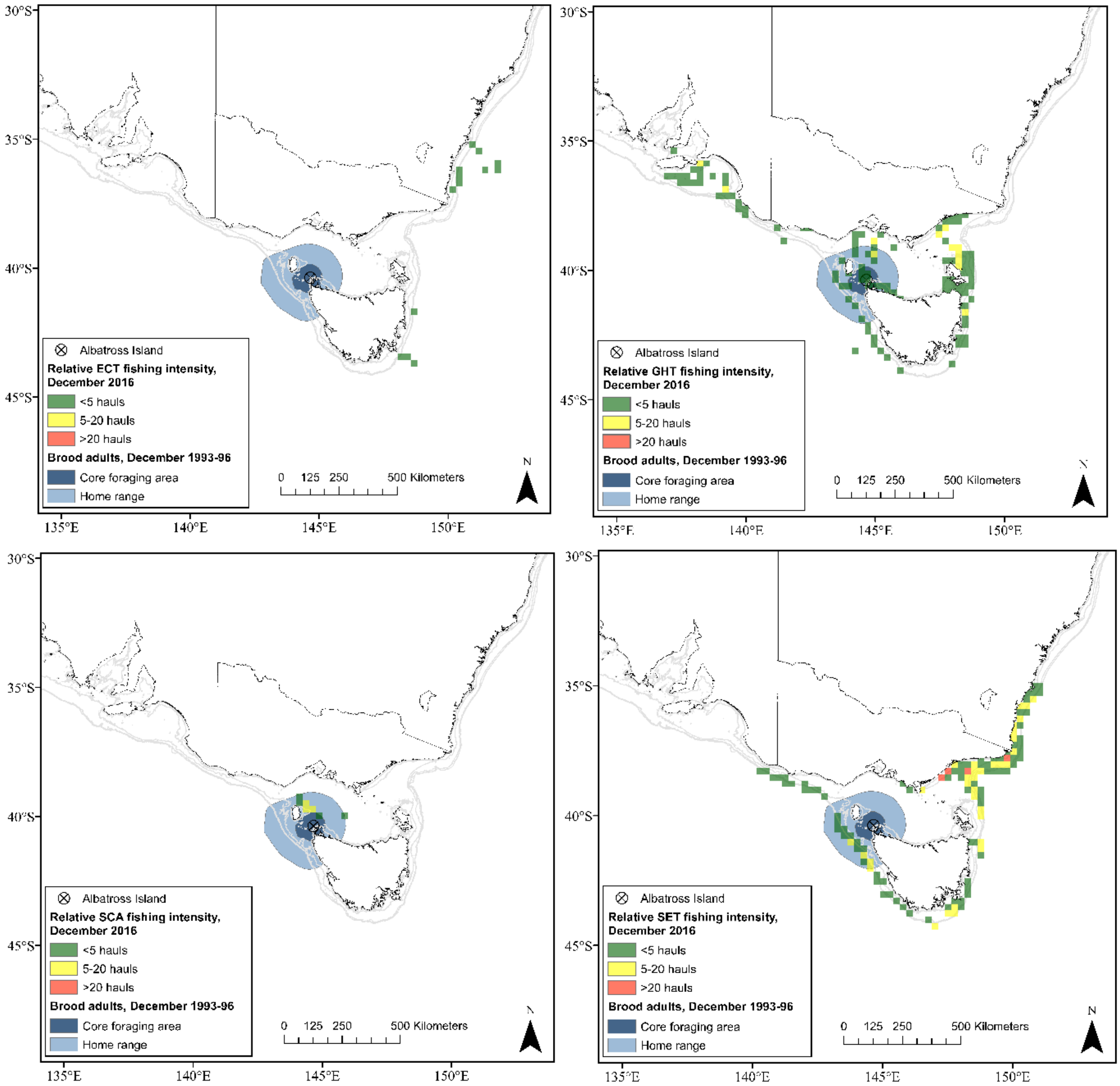
11A) Brood 2014 (December)



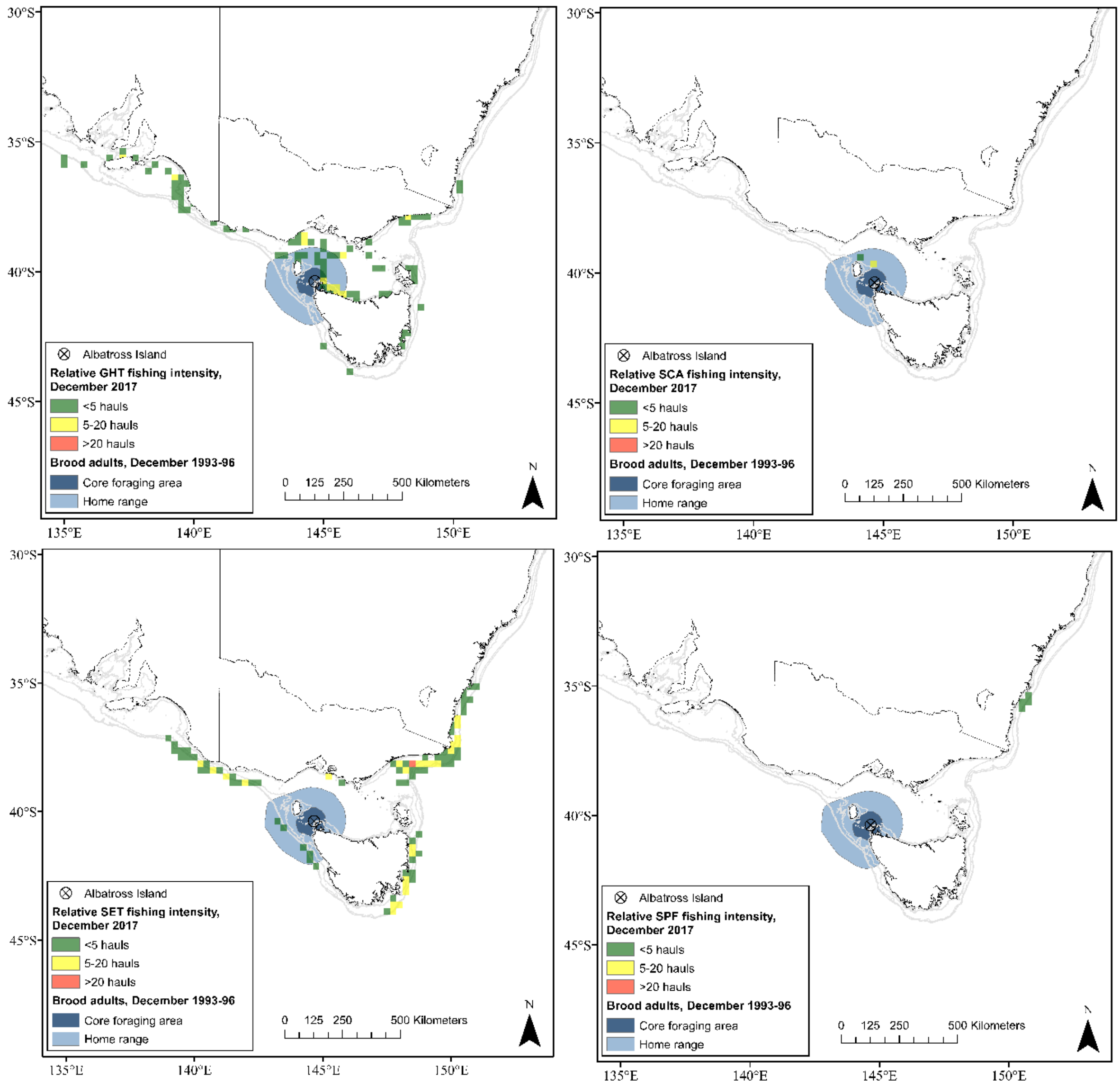
11B) Brood 2015 (December)



11C) Brood 2016 (December)

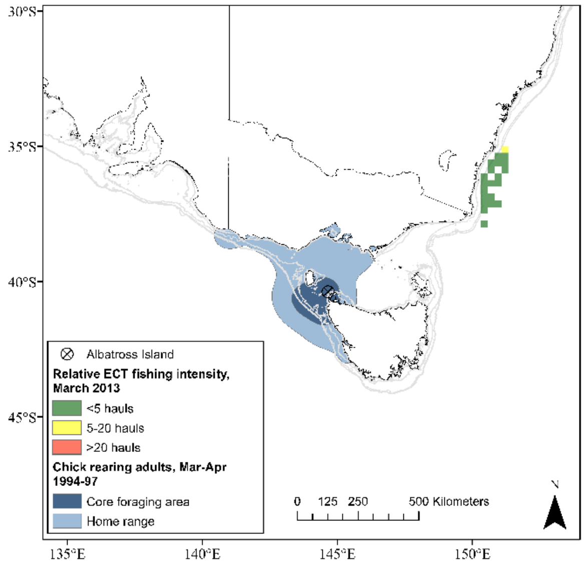


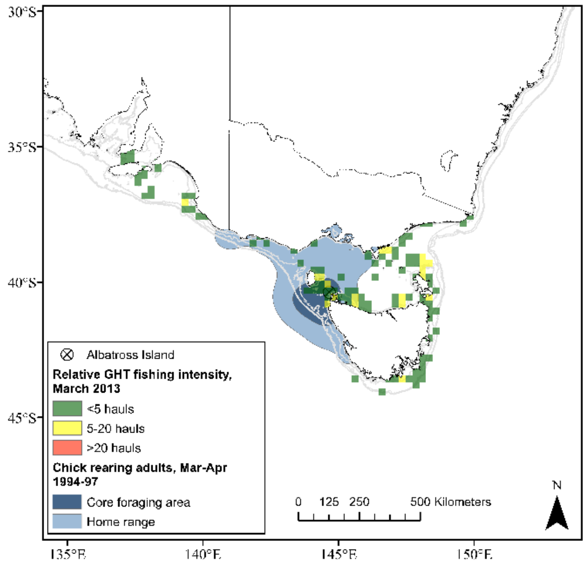
11D) Brood 2017 (December)

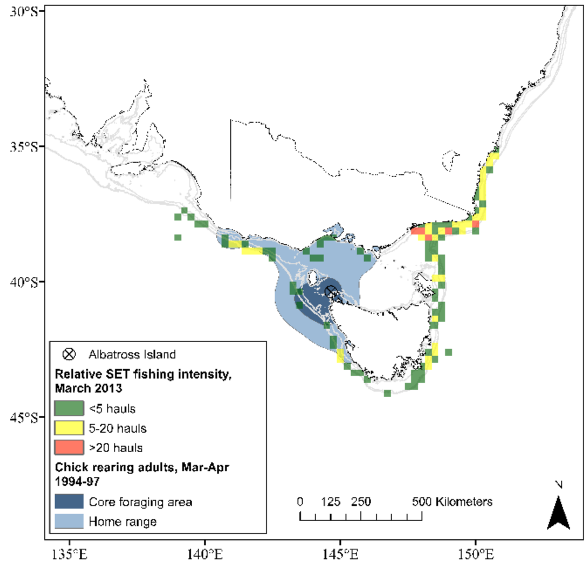


Appendix 12: Spatial overlap between shy albatross at Albatross Island and Commonwealth fisheries during Chick-rearing (March) 2013-2018. Fishing intensity squares represent ¼ degree cells.

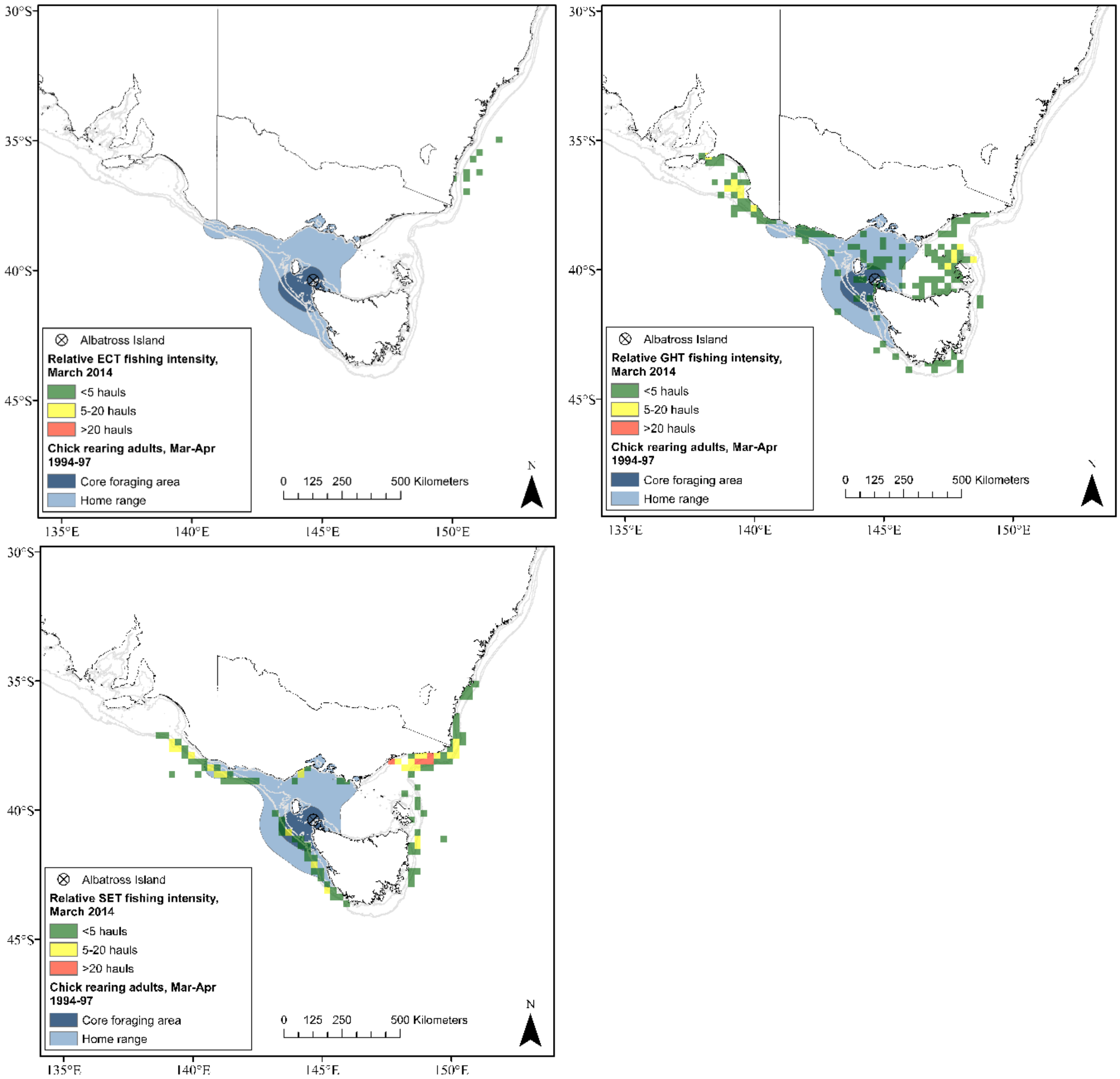
12A) Chick-rearing 2013 (March)



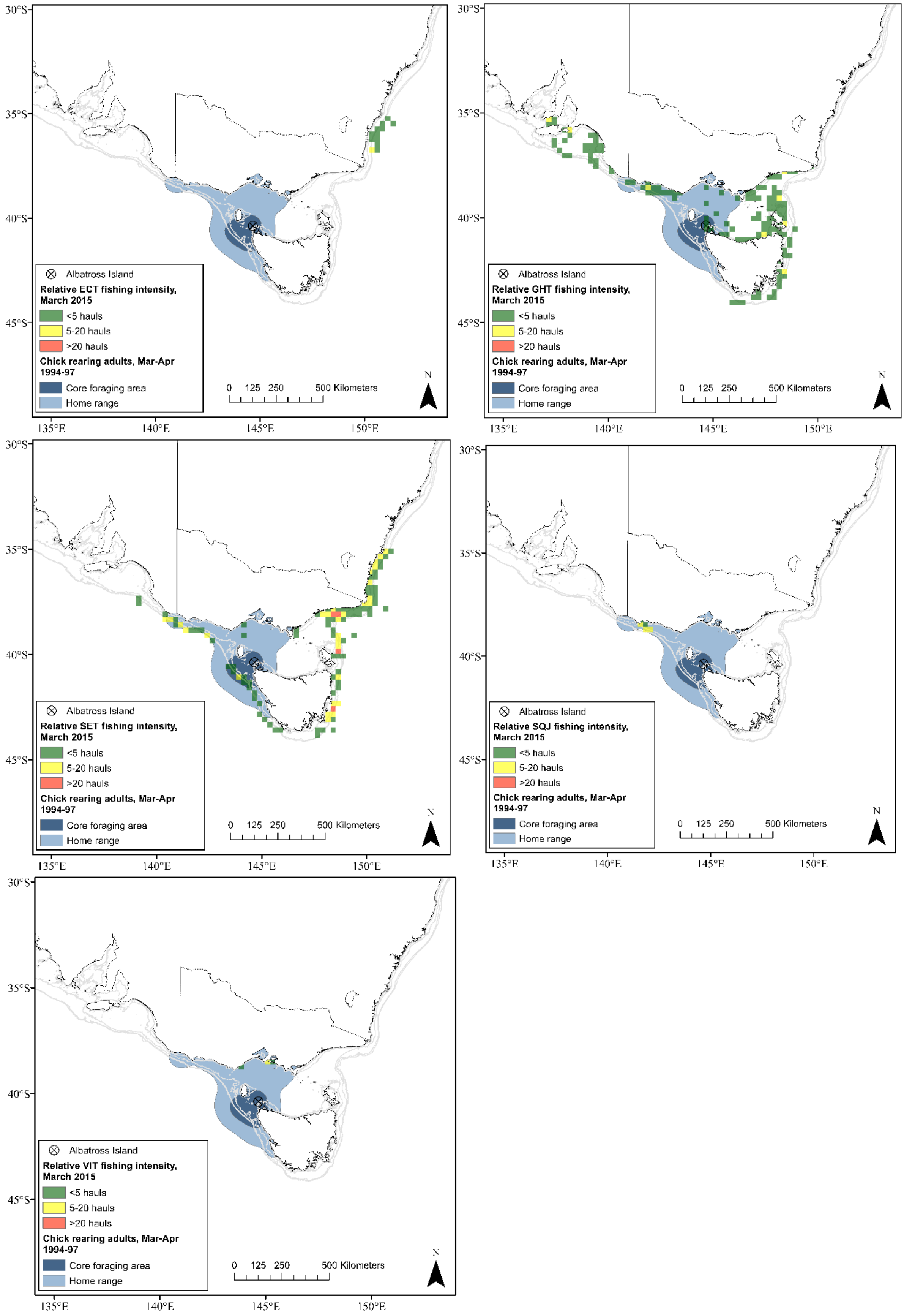




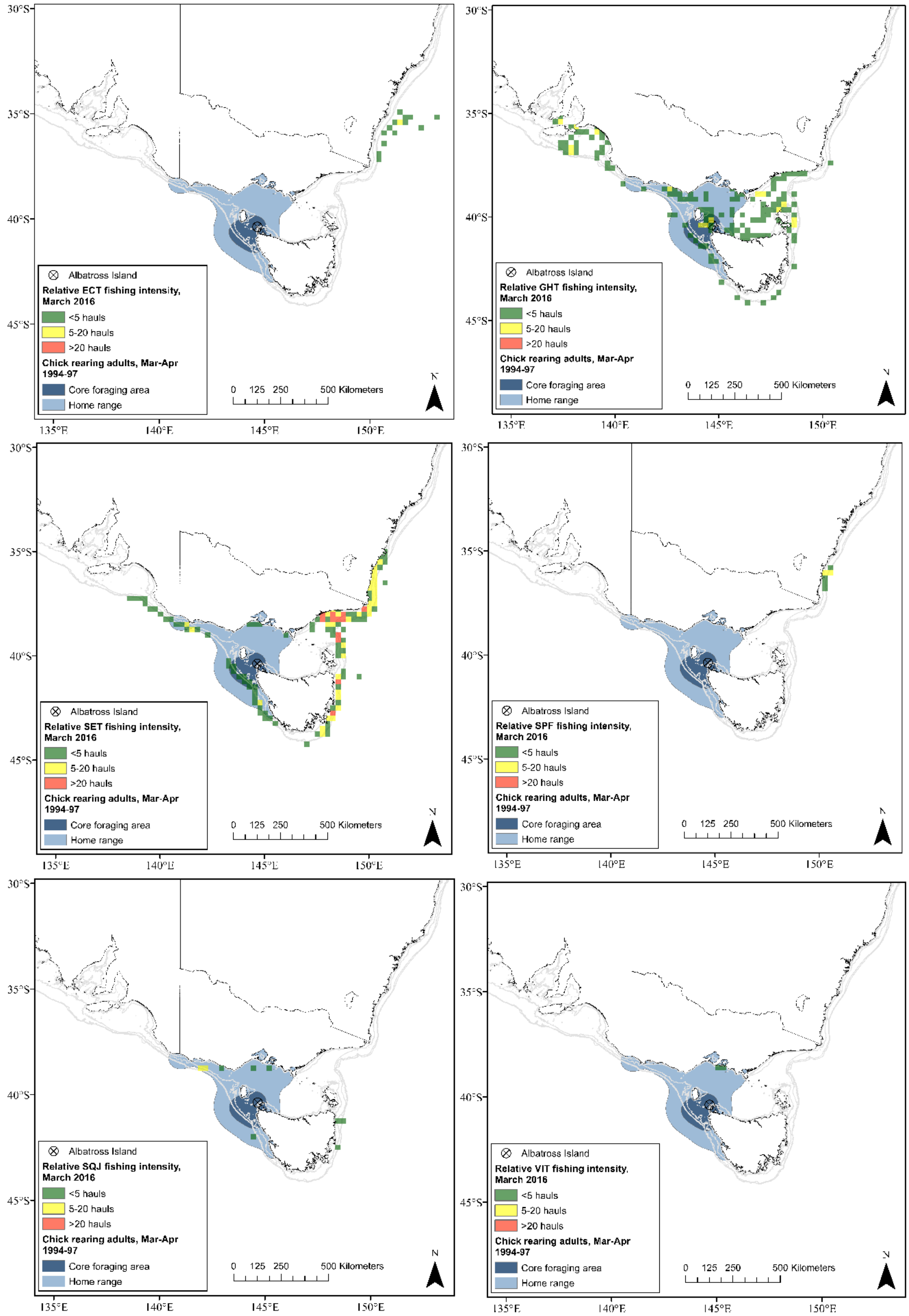
12B) Chick-rearing 2014 (March)



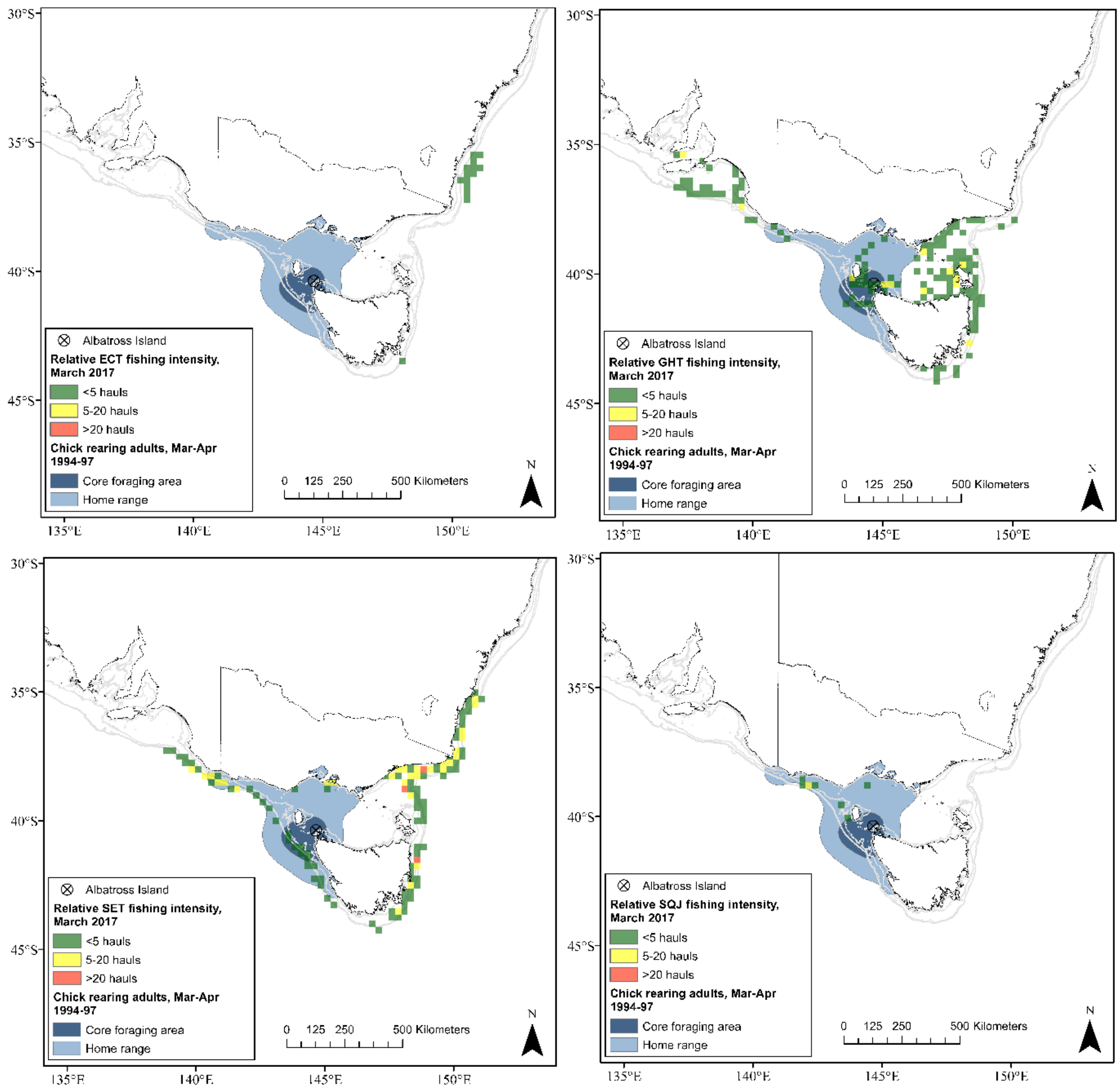
12C) Chick-rearing 2015 (March)



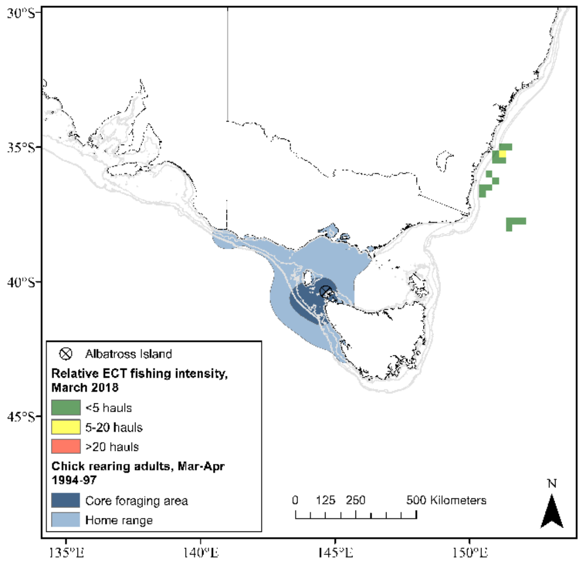
12D) Chick-rearing 2016 (March)

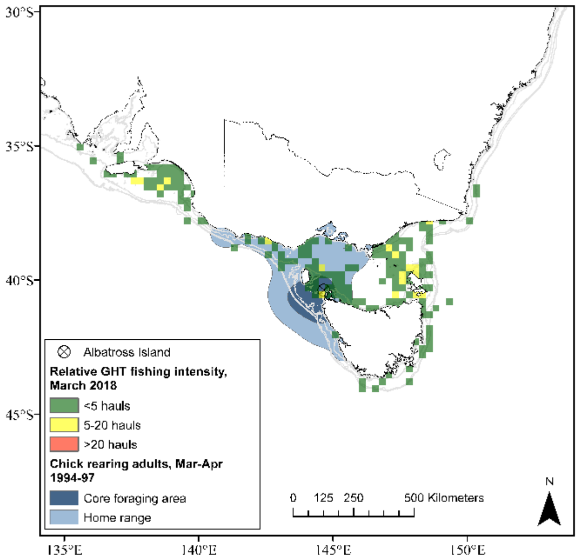


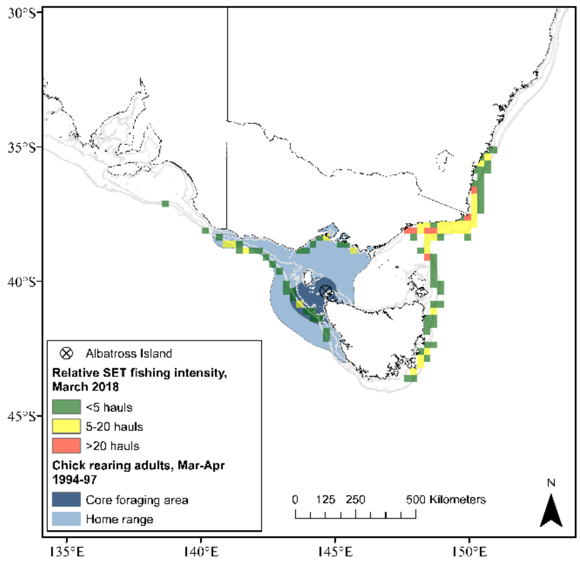
12E) Chick-rearing 2017 (March)

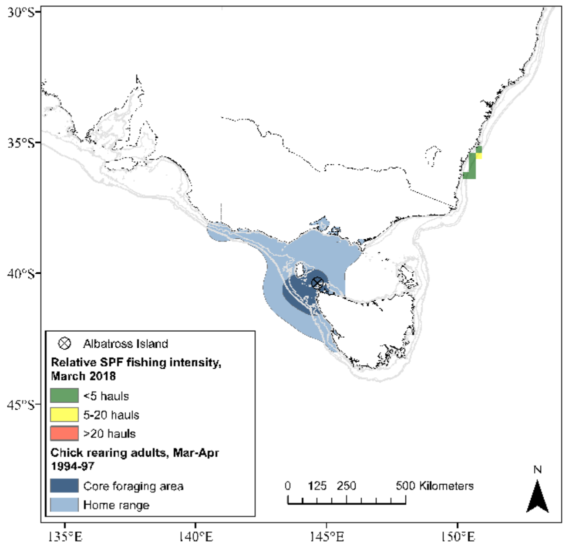


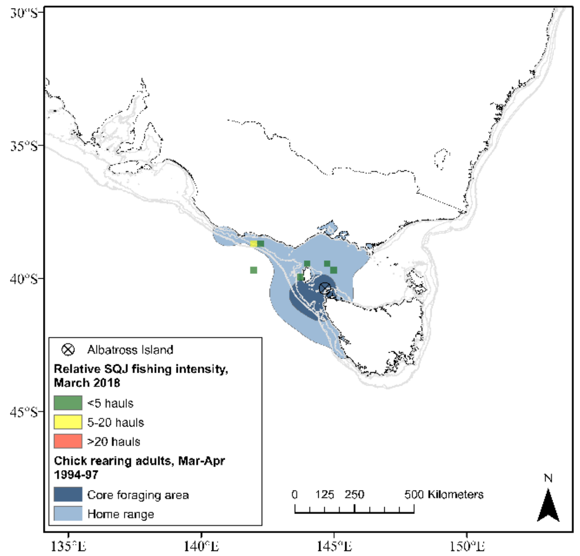
12F) Chick-rearing 2018 (March)





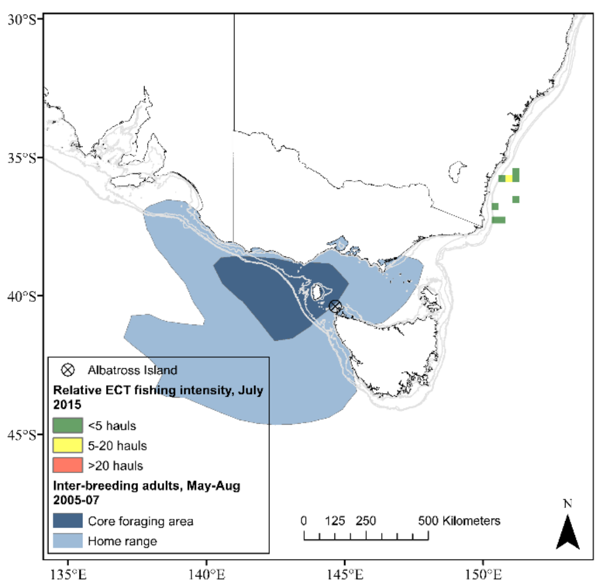


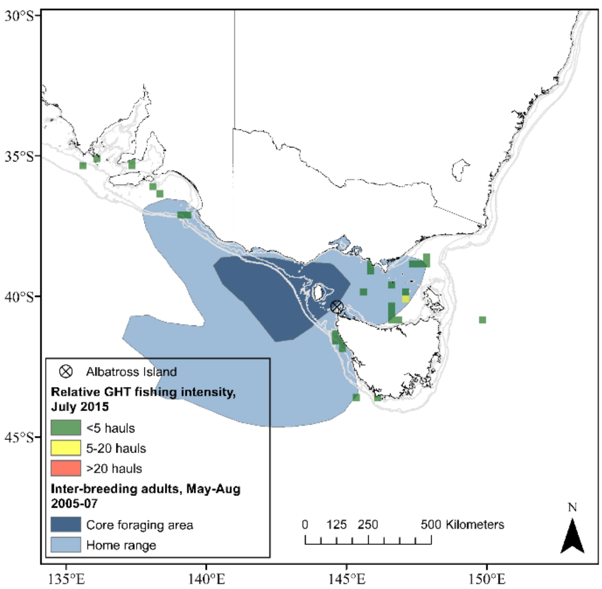


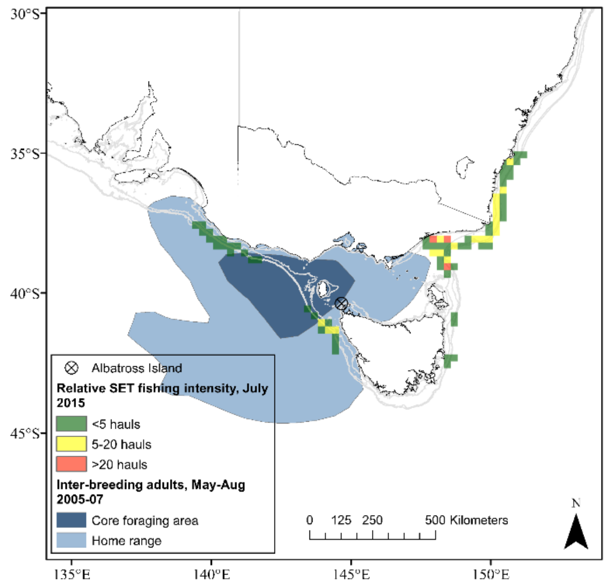


Appendix 13: Spatial overlap between shy albatross at Albatross Island and Commonwealth fisheries during Inter-breeding (July) 2015-2017. Fishing intensity squares represent ¼ degree cells.

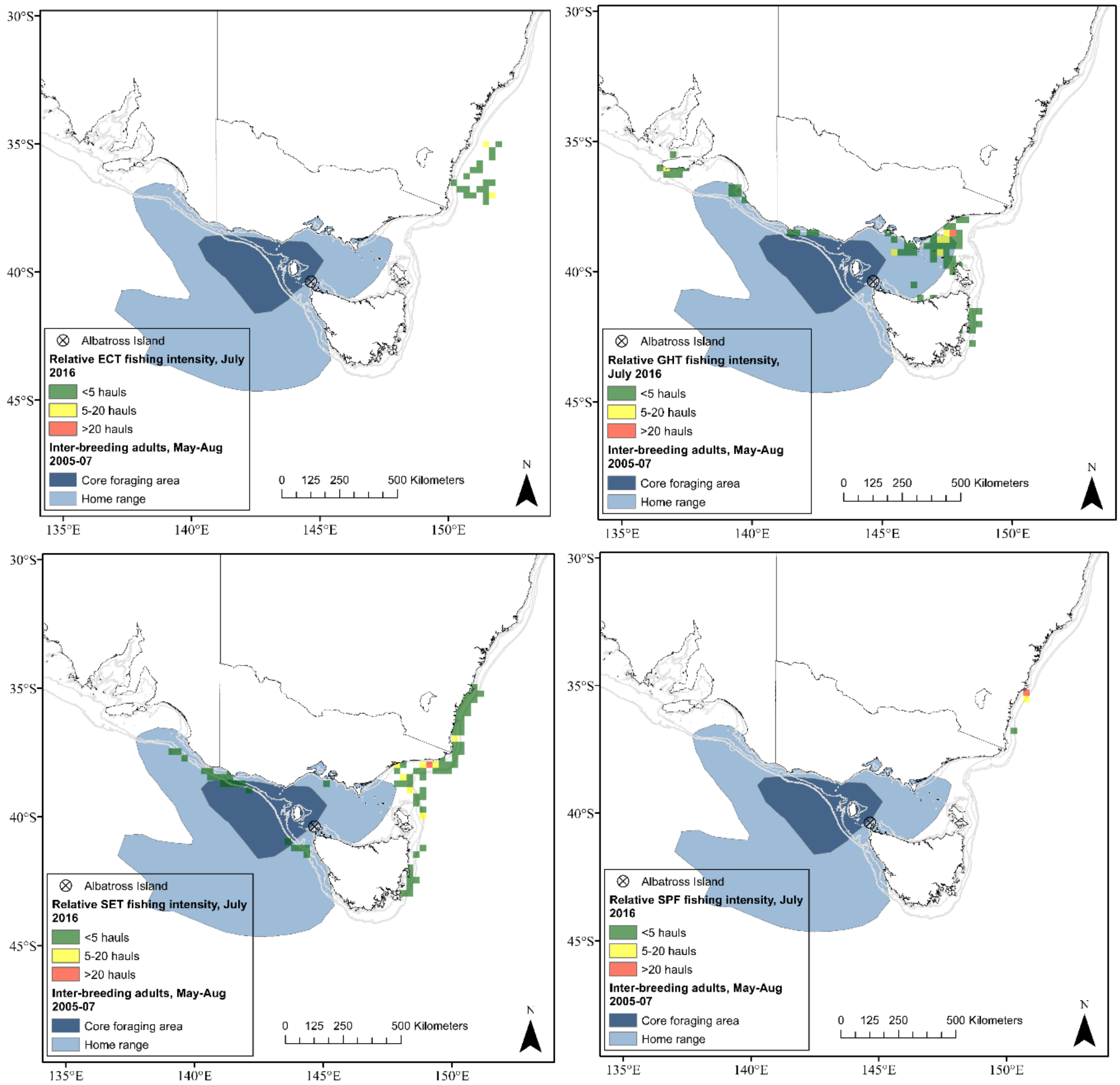
13A) Inter-breeding 2015 (July)



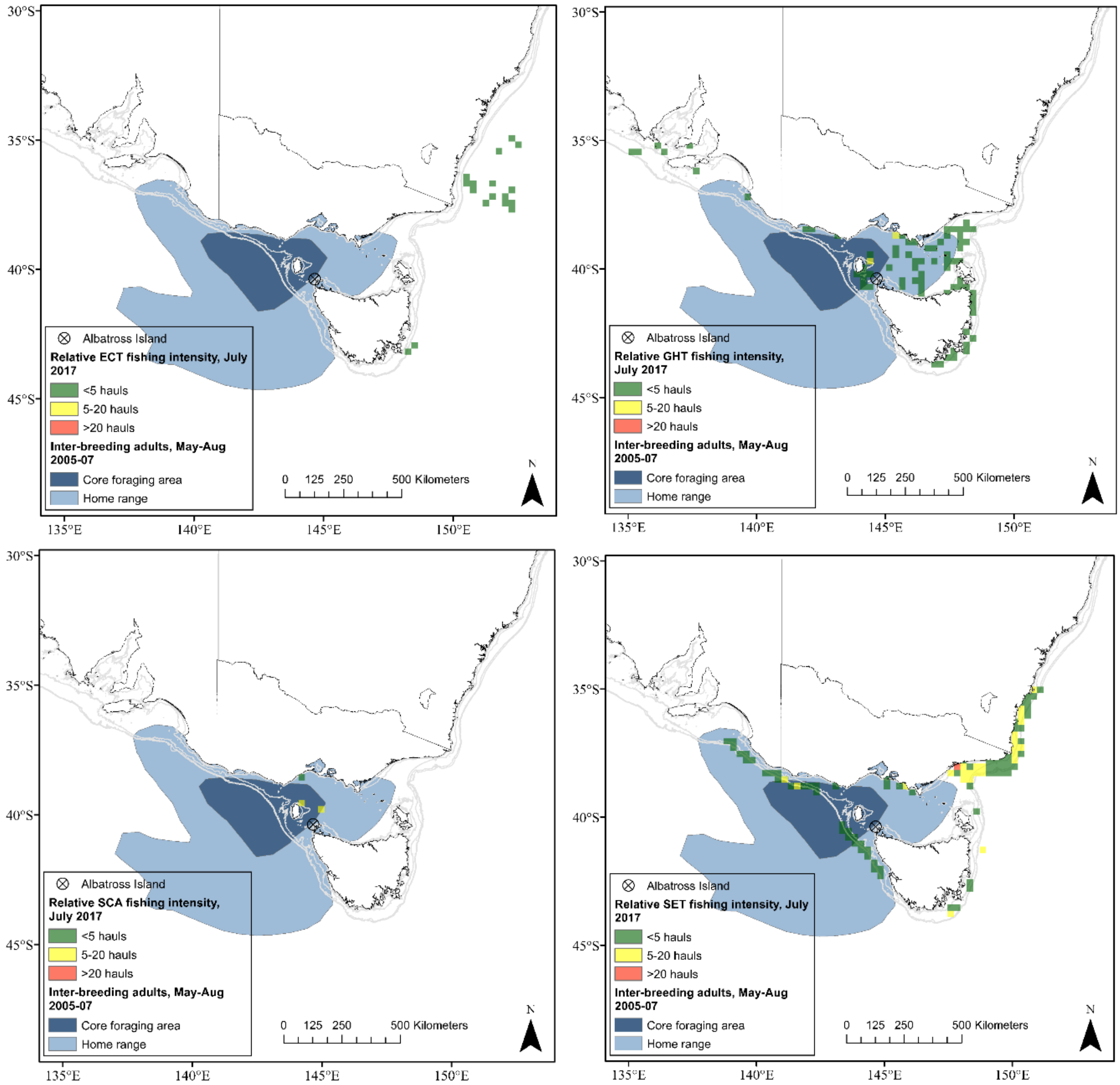




13B) Inter-breeding 2016 (July)



13C) Inter-breeding 2017 (July)



Appendix 14: Tasmanian State-managed fisheries operating in the albatross foraging area during the study and those where discards available. The grey bars are those fisheries where spatial overlap occurs with the albatross foraging area and discards are available to albatross.

Fishery	**Fishing method/gear**	**Target species**	**Fishing in albatross foraging area**	**Bycatch or discard availability**	**Bycatch species**	**Bait species**
Abalone	Hand collection (lever/knife)	Black-Lip Abalone *(Haliotis rubra)* and Greenlip Abalone *(H. laevigata)*	Yes	No		
Commercial dive	Hand collection (hand or hook)	sea urchins (*Heliocidaris erythrogramma, Centrostephanus rodgersii)* and Periwinkle (*Littorina* sp.)	Yes	No		
Octopus	Unbaited pots (habitat)	Pale Octopus *(Octopus pallidus)*	Yes	No		
Rock lobster	Pots	Southern Rock Lobster *(Jasus edwardsii)*	Yes	Yes	many includng Barber perch (*Caesioperca rasor*), Purple Wrasse (*Notolabrus fuciola*), Blue Throat Wrasse (Notolabrus tetricus), Hermit Crab (Paguroidea sp.), Draughtboard shark (*Cephaloscyllium laticeps*), Conger eel (Congridae), Maori octopus (*Octopus maorum*)	Barracouta (*Thyrsites atun*), Australian Salmon (*Arripis Sp.*), Jack Mackerel (*Trachurus sp.*), Blue Mackerel (*Scomber australasicus*), Redbait (*Emmelichthys nitidus*)
Scalefish	Danish seine	Flathead (*Platycephalus sp.*), School Whiting (*Sillago flindersi*)	No			
	Dip-net	garfish (*Hyporhamphus melanochir)*	Minimal	No		
	Drop-line	Striped Trumpeter (*Latris lineata*)	Yes	Minimal	Bearded rock cod (*Pseudophycis barbata*), gurnard species(Triglidae)	Octopus
	Fish trap	Bluethroat Wrasse (*Notolabrus tetricus*), Purple Wrasse *(Notolabrus fuciola)*	No	No	leatherjackets (Monocanthidae)	
	Gill net	Banded Morwong (*Cheilodactylus spectabilis*), Jackass Morwong (*Nemadactylus macropterus*), Bastard Trumpeter (*Latridopsis forsteri*), Blue	Yes (Jackass morwong, leatherjacket) No (banded	Minimal		

Fishery	Fishing method/gear	Target species	Fishing in albatross foraging area	Bycatch or discard availability	Bycatch species	Bait species
		Warehou (*Seriolella brama*), Bluethroat Wrasse (*Notolabrus tetricus*), Purple Wrasse (*Notolabrus fuciola*)	morwong, bastard trumpeter)			
	Hand line	bluethroat wrasse (*Notolabrus tetricus*), purple wrasse (*Notolabrus fuciola*)	Yes	Minimal	leather jacket, gurnard	
	Hand spear	flounder (Pleuronectidae family)	No	No		
	Purse seine	Australian salmon (*Arripis trutta*)	Yes – beaches theefore unlikely for albatross to forage	No		
	Small mesh net	various species	Yes	Minimal		
	Squid jig (hand line)	Southern calamari (*Sepioteuthis australis*)	Yes	No		
	Squid vessel (lights+ jig machine)	Gould's squid (*Nototodarus gouldi*)	Yes	No		
	Trolling	Longfin Pike (*Dinolestes lewini,* Dinolestidae), Snook or Shortfin Pike (*Sphyraena novaehollandiae,* Sphyraenidae), Barracouta (*Thyrsites atun),* Australian Salmon (Arripis trutta)	No			
Scallop	Dredge	commercial Scallops (*Pecten fumatus*)	Occasionally although not in the study period	Minimal		
Seaweed	Beach collection	Bull Kelp (*Durvillea Pototorum*)	Yes	No		
Small bivalve	Hand collection	Venus Clams (*Venerupis largillierti*) and Flat Oysters (*Ostrea angasi*)	No			