

Occurrence of prey species identified from remains in regurgitated  
pellets collected from king shags in 2019 and 2020  
Progress Report



Part of Department of Conservation Project BCBC2019-05

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## ABSTRACT

This report encompasses the first component of a project to deduce diet of king shags from analysis of prey remains from 225 regurgitated pellets collected in Marlborough Sounds during 2019 and 2020. Here we quantified the frequency of occurrence of prey taxa for a future comparison with the outcome of DNA analysis on the same pellets by Andrew Jeffs and Aimee van der Reis (Institute of Marine Science, School of Biological Sciences, University of Auckland). The second component of our project will encompass more thorough analyses of diet that quantify number, mass, length and daily intake of prey species

This study represents the second published investigation of king shag diet from analysis of prey remains in pellets. We increased the biodiversity of prey from the first study in 1991 and 1992 with 10 taxa (two crustaceans and eight fishes) from 22 pellets at one site to this study with 27 taxa (two crustaceans, 2 cephalopods and 23 fishes) from 215 pellets at seven sites. The basic understanding of foraging and diet remains unchanged—king shags target bottom-dwelling fishes and flatfishes, particularly witch (*Arnoglossus scapha*), predominate.

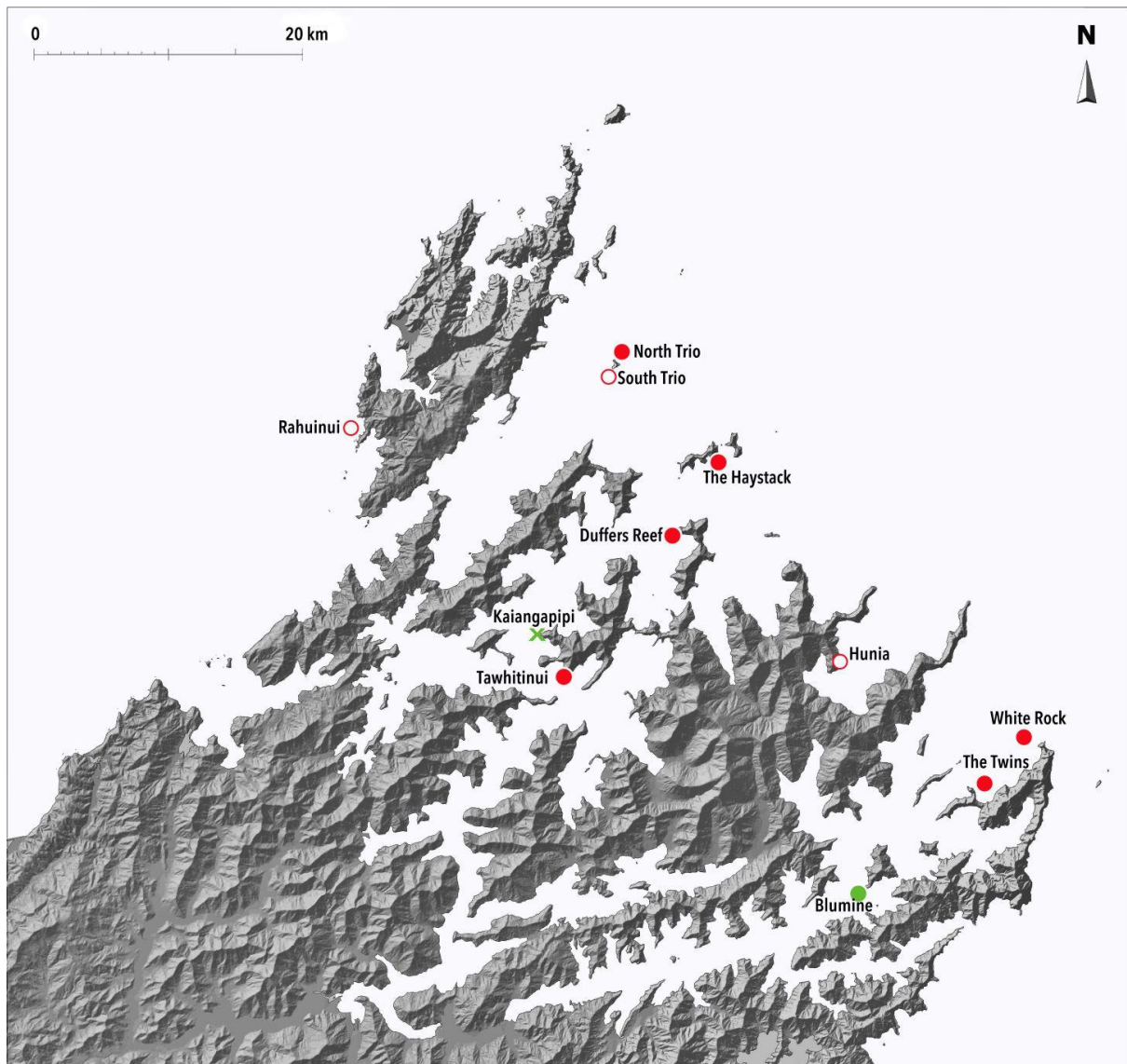
Frequencies of occurrence deduced from prey remains analysis and DNA analysis provide a simple qualitative assessment of king shag diet through the presence/absence of taxa in pellets. Prey remains analysis of pellets can provide a quantitative estimate for daily intake as a total biomass of prey items. The equivalent in DNA analysis is more qualitative: relative read abundance, an assessment of the strength of DNA signatures, generates estimates for proportion of total biomass. Comparisons between results from these two analyses could facilitate calculation of indices to transform relative read abundances into real masses.

The key issue for future projects on king shag diet is to decide on the purpose and desired outcome of research and then select the appropriate methods and analyses before samples are collected.

## INTRODUCTION

New Zealand king shags (king shags, *Leucocarbo carunculatus*) are designated as Nationally Endangered under the New Zealand Threat Classification System (Robertson *et al.* 2017) because they have a small range and very small population. Their distribution is restricted to the sea and small islands bounded within a 55 km by 35 km rectangle within Marlborough Sounds at the northern tip of South Island, New Zealand (Schuckard *et al.* 2018) (Figure 1). This equates to an at least 75% contraction of their more widespread prehistoric distribution that extended to the southern North Island and the northeastern tip of South Island (Rawlence *et al.* 2017). Records stretching back to 1773 indicate that king shags have not been more widespread or more numerous through the historical past and the present population is considered stable (BirdLife International 2020). Monitoring of the species is ongoing with censuses in 2020 producing estimates of 815 individuals in February prior to the breeding season (Bell *et al.* 2020), followed by 277 nests at nine colonies in May (Schuckard & Frost 2020) (Figure 1). King shags are exclusively marine foragers and fly an average of 6–10 km (maximum 24 km) from colonies or roosts (Schuckard 1994, 2006) to forage alone in depths of 20–60 m (Brown 2001).

Shags (Phalacrocoracidae) typically regurgitate daily a pellet containing prey remains that can provide a quantitative assessment of diet composition and daily intake—among the variety of methods to investigate diet, pellets provide the most comprehensive information for the lowest sampling effort and least disturbance (Seefelt & Gillingham 2006, Barrett *et al.* 2007, Oehm *et al.* 2016). However, pellet analysis suffers from biases due to the underestimation of prey that are digested completely and overestimation of prey with resilient remains. These biases potentially can be overcome by analysis of the DNA digested prey, a relatively new technique first applied in 2005 (Barrett *et al.* 2007). However, in common with analysis of prey remains, frequency of occurrence deduced from DNA analysis overestimates the importance of prey species taken frequently but only in small amounts (Deagle *et al.* 2019). This bias is rectified in prey remains analyses by assessing composition of the diet from masses (estimated original masses) of prey species. The equivalent to prey species mass in DNA analysis is relative read abundance, an assessment of the relative strength of species-specific DNA signatures (Deagle *et al.* 2019).



**Figure 1:** Map of Marlborough Sounds showing the nine breeding colonies (red circles) and one major roost site (green circle) of New Zealand king shags in 2019 and 2020. Pellets were collected at six colonies (solid red circles) and the one major roost site. The depicted roost site (Blumine) was the only site to average  $\geq 10$  individuals in a survey on 21 February 2020 by Bell *et al.* (2020) that was not recorded as a breeding colony in 2019 and/or 2020 by Schuckard & Frost (2020). Lalas & Brown (1998) collected pellets at Te Kaiangapipi (green cross), a currently unoccupied roost site.

The purpose of this report is to present frequency of occurrence of remains of prey species in king shag pellets for comparison with DNA analysis of the same pellets. The outcome of this comparison will compare efficacies of these two analyses and highlight similarities, differences and anomalies. Prey remains analysis of pellets can provide a quantitative estimate for daily intake as a total biomass of prey items. The equivalent in DNA analysis is more qualitative: relative read abundance, an assessment of the strength of DNA signatures, generates estimates for proportion of total biomass. Comparisons between results from these two analyses could facilitate calculation of indices to transform relative read abundances into real masses. This outcome is an unexpected bonus that could make a major contribution to the methodology for quantification of DNA analysis. In particular, pellets with only one taxon identified among prey remains could provide the clearest outcomes.

The only previous assessment of the diet of King Shags has been for birds based at Te Kaiangapihi, a roost site within Pelorus Sound (Figure 1). Here prey remains found in 22 pellets collected in 1991 and 1992 contained 10 taxa, all bottom-dwelling species dominated by witch (*Arnoglossus scapha*), a flatfish (Lalas & Brown 1998). Our present study encompasses over 10 times the number of pellets from seven sites and will lead to insight into spatial differences in diet of king shags.

## **METHODS**

### ***Source and analyses of pellets***

King shag regurgitated pellets were collected by Mike Bell (Wildlife Management International Ltd) and Dan Palmer (Department of Conservation) from seven sites during monitoring of the species in Marlborough Sounds. Each site was sampled on one or two occasions from March 2019 to March 2020. Pellets were individually coded, stored in alcohol and sent to Andrew Jeffs and Aimee van der Reis (Institute of Marine Science, School of Biological Sciences, University of Auckland) who undertook DNA analyses. Partially sorted pellets stored in alcohol were then forwarded to us (Lalas & Schuckard) with the contents of each pellet subdivided into 2–4 pottles. We sorted and analysed prey remains found in pellets in October 2020.

### ***Identification of prey species from prey remains***

We teased apart pellets in water and retained all diagnostic prey remains identified from a comprehensive reference collection held by Chris Lalas. Diagnostic remains differ among taxa: jaws from polychaete worms; pieces of exoskeleton (especially claws and carapaces; often decalcified) from crustaceans; beaks from cephalopods; tunic (gelatinous tube) from salps; mouthparts from hagfish and lampreys; teeth, body thorns, dorsal spine sheaths and (cartilaginous) vertebrae from sharks and rays; and otoliths (sagittal otoliths), jaws and other dentition, caudal vertebrae and some other species-specific bones for teleost fishes. Otoliths for all the genera and most of the teleosts we encountered are illustrated in Schwarzhans (1984, 1999); Smale *et al.* (1995); or Furlani *et al.* (2007). Jaws and some other fish bones we encountered are illustrated in Leach (1997). For the taxonomy and nomenclature (common and scientific names) of New Zealand fishes we follow Roberts *et al.* (2015), and we list species systematically in tables and text.

### ***Analyses of prey remains in taxa***

We restricted quantified analysis of prey remains in pellets to the occurrence (presence or absence) of each prey taxon. Our precision of presentation of taxon reflected our assessment of reliability in identification of remains: typically to species, but to genus and on occasion family in cases where multiple closely-related species occur at Marlborough Sounds. We quantified frequency of occurrence for each prey taxon as the number (FOO) and proportion (%FOO) of pellets for each site that contained that taxon. We did not attempt to differentiate between primary and secondary prey items.

Here we present results for frequency of occurrence for each site and for totals from all seven sites. Accurate identification of remains required careful inspection of each sample. Consequently, we capitalised on this effort by estimating the minimum number of prey items per taxon. For fishes we typically did this by halving the number of otoliths. These data were entered into spreadsheets and used to indicate occurrence in pellets (Appendix 2).

### *Fate of prey remains*

We dried all diagnostic prey remains and retained them for future further analysis. Each pellet was allocated an A4 ziplock bag containing handwritten details on A4 paper and remains retained in labelled, species-specific, small ziplock bags.

## **RESULTS**

### *Number of pellets analysed*

Analyses were derived from a total of 225 king shag pellets collected from seven colonies during 2019 and 2020 (Table 1). We analysed 215 (96%) of the total 225 pellets. The other 10 pellets were not analysed for a number of reasons and another seven pellets contained anomalies; details about these 17 pellets are presented in Appendix 1. Both types of diet analyses—prey remains and DNA—were performed on 184 (82%) of the total pellets, and represent a large sample size for future comparisons between outcomes of the two methods. These are huge sample sizes relative to the size of the species total population, equivalent to one pellet for every four individuals (where  $215/815 = 26\%$  and  $184/815 = 23\%$ ), and near 10-fold the sample size of 22 pellets in the previous analysis of king shag diet by Lalas & Brown (1998).

### *A problem with alcohol denaturing otoliths*

We encountered two problems attributable to storage of otoliths in alcohol. First, otoliths were dehydrated. Otoliths typically became opaque and lost their internal detail meaning that the internal growth rings and earlier shape of otoliths were often difficult to see. This loss of clarity could compromise the accuracy of species identification, especially for eroded otoliths. Second, otoliths were difficult to clean because grime often adhered to the surface – this could mask the surface and compromise judgements of the degree of erosion of otoliths (important when deriving estimates for prey size) and sometimes species identifications.

**Table 1:** Summary of results for the number of king shag pellets collected from seven sites in 2019 and 2020, and for their contents deduced from analysis of prey remains. Three sites were in Queen Charlotte Sound (Charlotte), three in Pelorus Sound (Pelorus) and one in Admiralty Bay (Admiralty). Sites are depicted in Figure 1. Number of nests are from Schuckard & Frost (2020) and number of individuals from Bell *et al.* (2020).

Criterion	Total	White Rocks	The Twins	Blumine	The Haystack	Duffers Reef	Tawhitiui	North Trio
Features of sites in 2020 (see Figure 1):								
Location	-	Charlotte	Charlotte	Charlotte	Pelorus	Pelorus	Pelorus	Admiralty
Number of nests (% total 277)	213 (77%)	24 (9%)	13 (5%)	0 (0%)	20 (7%)	83 (30%)	29 (10%)	44 (16%)
Number of individuals (% total 815)	564 (69%)	46 (6%)	43 (5%)	55 (7%)	16 (2%)	207 (25%)	78 (10%)	119 (15%)
Number of pellets:								
Collected	225	23	24	28	10	51	42	47
Analysed for prey remains	215	22	22	28	10	46	42	45
Analysed for DNA	189	23	24	28	10	37	33	34
Analysed for DNA & remains	184	22	22	28	10	36	33	33
Mean (range) per pellet:								
Number of prey taxa	3.2 (1-9)	2.8 (1-9)	3.1 (1-7)	2.5 (1-6)	3.4 (1-7)	3.5 (1-7)	3.6 (1-6)	3.0 (1-7)
Minimum number of prey items	19 (2-114)	15 (4-36)	19 (4-64)	15 (4-48)	17 (5-66)	18 (3-69)	25 (2-114)	20 (5-57)
Pellets with particular taxa								
FOO% (proportion of pellets):								
Contain witch ( <i>Arnoglossus scapha</i> )	77%	95%	68%	93%	50%	70%	69%	84%
Contain flatfishes (Pleuronectiformes)	86%	95%	82%	93%	60%	80%	88%	89%
Contain only flatfishes	20%	14%	18%	43%	10%	11%	12%	29%
Do not contain any flatfishes	14%	5%	18%	7%	40%	20%	12%	11%
Pellets with only one taxon								
FOO (number of pellets):								
Witch ( <i>Arnoglossus scapha</i> )	20	3	2	5	0	1	3	6
Leatherjacket ( <i>Meuschenia scaber</i> )	4	0	2	0	1	0	0	1
Red gurnard ( <i>Cheilodichthys kumu</i> )	1	0	0	0	0	0	0	1
Wrasse (Labridae)	1	0	0	0	0	1	0	0
Total with only one taxon	26	3	4	5	1	2	3	8



We need to emphasise that analysis of compromised otoliths had two detrimental impacts on this project. First, the duration required to deduce frequency of occurrence by about a third from an average of about one hour to about 1 h 20 min. Second, the reliability of some species identifications was compromised.

### ***Prey taxa represented in prey remains***

Analysis of prey remains from 215 pellets generated averages of 3.2 (range 1–9) prey taxa and a minimum 19 (range 2–114) prey items per pellet (Table 1). Here we further consider the frequency of occurrence of prey taxa. Minima for number of prey items per taxon are presented in Appendix 2 for each pellet.

Witch, a lefteye flounder (Bothidae), was the most frequently-encountered prey species; recorded in 77% of the total 215 pellets, with a range of 50–95% among the seven sites (Table 1). Following witch in frequency were three genera of southern righteye flounders (Rhombosoleidae): lemon sole (*Pelotretis*), sole (*Peltorhamphus*) and flounder (*Rhombosolea*). The predominance of flatfishes is exemplified by the paucity of pellets that did not contain any flatfishes: no flatfish were found in only 14% of the total 215 pellets, with a range of 5–40% among the seven sites (Table 1). A total of 27 taxa (two crustaceans, 2 cephalopods and 23 fishes) were recorded from the 215 pellets (Table 2). Other than flatfishes, five taxa can be regarded as important prey (recorded in  $\geq 10\%$  of the 215 pellets): jock stewart (*Heliocolenus percoides*), red gurnard (*Chelidonichthys kumu*), opalfish (*Hemerocoetes* cf. *monopterygius*), triplefin (Tripterygiidae) and leatherjacket (*Meuschenia scaber*) (Table 2).

Twenty-six (12%) of the 215 pellets contained only one taxon: 20 with only witch; four with only leatherjacket; and one each with only red gurnard or wrasse (Labridae) (Table 1).

For wrasse, the entry “*Notolabrus & Pseudolabrus* 4 spp” in Table 2 represented 29 fish of which 16 were tentatively identified to species: two spotty (*N. celidotus*), seven girdled wrasse (*N. cinctus*), one banded wrasse (*N. fucicola*) and six scarlet wrasse (*P. miles*).

**Table 2:** Frequency of occurrence of prey taxa deduced from analysis of prey remains found in king shag pellets collected from seven sites in 2019 and 2020. Results for occurrence of each taxon are presented in two formats: first, occurrence as the number (FOO) and proportion (%FOO) of the total 215 pellets; and second, occurrence as the number of sites (1–7) and the range in %FOO among sites.

Prey taxon recorded from prey remains (taxonomic listing)		Total 7 sites		Range among sites	
		FOO	%FOO	Number	%FOO
Pillbox crab	<i>cf. Halicarcinus sp.</i>	4	1.9%	3	0–5%
Red swimming crab	<i>Nectocarcinus antarcticus</i>	8	3.7%	5	0–10%
Arrow squid	<i>Nototodarus gouldi</i>	1	0.5%	1	0–5%
Midget octopus	<i>Octopus cf. huttoni</i>	12	5.6%	6	0–30%
Silver conger	<i>Gnathophis habenatus</i>	1	0.5%	1	0–4%
Sandfish	<i>Gonorynchus forsteri</i>	3	1.4%	3	0–5%
Ling	<i>Genypterus blacodes</i>	1	0.5%	1	0–2%
cf. Twosaddle rattail	<i>cf. Coelorinchus biclinozonalis</i>	2	0.9%	2	0–5%
Rock cod	<i>Lotella rhacina</i>	1	0.5%	1	0–2%
Dwarf cod	<i>Notophycis marginata</i>	1	0.5%	1	0–2%
cf. Red cod	<i>Pseudophycis 1-3 spp.</i>	12	5.6%	6	0–20%
Common roughy	<i>Paratrachichthys trailli</i>	1	0.5%	1	0–5%
Jock stewart	<i>Helicolenus percooides</i>	47	21.9%	7	7–36%
Red scorpionfish	<i>Scorpaena papillosa</i>	7	3.3%	3	0–40%
Red gurnard	<i>Chelidonichthys kumu</i>	37	17.2%	7	10–32%
Butterfly perch	<i>Caesioperca lepidoptera</i>	8	3.7%	6	0–11%
Greenbone	<i>Odax pullus</i>	1	0.5%	1	0–5%
Wrasse	<i>Notolabrus &amp; Pseudolabrus 4 spp.</i>	20	9.3%	6	0–19%
Blue cod	<i>Parapercis colias</i>	5	2.3%	3	0–10%
Opalfish	<i>Hemerocoetes cf. monopterygius</i>	82	38.1%	7	10–64%
Stargazer	Leptoscopidae sp.	1	0.5%	1	0–2%
Triplefin	Tripterygiidae spp.	55	25.6%	7	5–41%
Witch	<i>Arnoglossus scapha</i>	166	77.2%	7	50–95%
Lemon sole	<i>Pelotretis flavilatus</i>	60	27.9%	6	0–41%
Sole	<i>Peltorhamphus 1-3 spp.</i>	45	20.9%	7	10–28%
Flounder	<i>Rhombosolea 1-3 spp.</i>	47	21.9%	6	0–38%
Leatherjacket	<i>Meuschenia scaber</i>	54	25.1%	6	0–35%

We did not record any gelatinous organisms (salps or jellyfish), polychaete worms or cartilaginous fishes. We did record two non-prey crustacean taxa likely to appear in DNA analyses: parasitic isopods (Cymothoidae, 6 pellets) and hermit crabs (Paguridae, 18 pellets). We also recorded trace remains of molluscs that are unlikely to appear in DNA, gastropod and bivalve shells (typically broken pieces), gastropod opercula; and chiton valves.

### *Fishes underrepresented in prey remains*

Tiny otoliths (< 1 mm) are unlikely to survive digestion and appear as prey remains in pellets. Fish will be underrepresented in pellets if they not only have tiny otoliths but also lack resilient diagnostic bones and teeth. Two families of fishes fulfil these criteria as potential prey of king shags: pipefishes and seahorses (Syngnathidae); and tommyfishes (Creediidae), a close relative of opalfishes (Percophidae). In contrast, another two families have tiny otoliths but resilient diagnostic bones and so are likely to be represented realistically in pellets: bellowsfishes (Macroramphosidae) have a resilient dorsal spine (none recorded in pellets); and leatherjackets (Monacanthidae) have a resilient dorsal spine and resilient enamel teeth (regularly recorded in pellets).

## **DISCUSSION**

This is the second published investigation of king shag diet from analysis of prey remains in pellets. We increased the number of reported prey taxa from 10 (two crustaceans and eight fishes) from 22 pellets (Lalas & Brown 1998) to 27 (two crustaceans, 2 cephalopods and 23 fishes) from 215 pellets.

We confined output to the frequency of occurrence of prey taxa because the allocated time and funding of our contracts were grossly inadequate. For methods we have given the example that the use of alcohol to ensure high quality samples for DNA analysis unfortunately downgraded their quality for analysis of prey remains—this problem could have been resolved at the planning stage of the project. Potential outcomes of prey remain analysis and DNA analysis are compared in Table 3.

**Table 3:** Expected outcomes of king shag diet studies derived from regurgitated pellets: comparison between prey remains analysis and prey DNA analysis.

Outcome	Prey remains analysis	DNA analysis
Definitive differentiation between primary and secondary prey	No	No
Detection of prey species that lack robust remains	Inconsistent	Yes
Number of prey species per pellet	Yes	Yes
Number of prey items per pellet & proportion of diet by number	Yes	No
Lengths of prey items	Yes	No
Biomass of prey items	Yes	No
Proportion of diet by biomass of prey species per pellet	Yes	RRA
Total biomass of all prey per pellet = daily intake	Yes	Not yet

Biomass = original mass of prey

RRA = relative read abundance, an indicator of the relative importance of species.

## RECOMMENDATIONS

### *Recommendations for the remainder of this project*

1. The next step for frequency of occurrence of prey taxa is to compare outcomes between prey remains analysis and DNA analysis for the same 184 pellets. Here our data in Appendix 2 is available as an Excel Workbook.
2. We need to establish expectations and prioritise outcomes that can be accomplished with the second half of our contract.
3. We are particularly keen to fully analyse (following Table 3) the 26 pellets that contained only one prey taxon. This would facilitate calculations to quantify relative read abundances into real masses and broaden the applicability of DNA analysis as a tool to deduce diet.

### ***Recommendations for future diet projects***

1. The key issue for future projects on king shag diet is to decide on the purpose and desired outcome of research and then select the appropriate analyses before samples are collected (Table 3).
2. Statistical advice is critical to deduce the minimum valid number of pellets required to satisfy intended diet analyses; e.g., the extreme range in the present project was for North Trio with 45 pellets (too many pellets) collected on 29 November 2019 and six pellets (too few pellets) collected on 11 March 2020 (Appendix 2).
3. The timing and sites of pellet collections need to be selected to satisfy intentions; e.g., collections must be six months apart for a study to detect seasonal differences from two samples.
4. Any future work involving DNA analysis and prey remains analysis on the same pellets must resolve the problem of degradation of otoliths stored in alcohol.

### **ACKNOWLEDGEMENTS**

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**APPENDIX 1**

Notes for pellets we regarded as anomalous

Pellet code	Colony	Date collected	Fate of pellet (included or excluded)	Notes
WR03	White Rocks	11-Mar-19	excluded	Obviously incomplete: only 1 otolith; but minimum 3 fish ex bones
TT18	The Twins	20-Mar-20	excluded	No pottles. Jeffs note: "No hard parts were separated from the pellet"
TT23	The Twins	20-Mar-20	excluded	Obviously incomplete: only 2 otoliths; fish bones and eye lenses more numerous
DR06	Duffers Reef	26-Nov-19	included but suspect	Jeffs note: "No hard parts were separated from the pellet"
DR08	Duffers Reef	26-Nov-19	excluded	Jeffs note: "Does not exist"
DR15	Duffers Reef	26-Nov-19	included seems OK	Jeffs note: "No hard parts were separated from the pellet"
DR28	Duffers Reef	26-Nov-19	included seems OK	Jeffs note: "No hard parts were separated from the pellet"
Burp ball 3	Duffers Reef	24-Aug-19	excluded	Plant material; no prey remains
Burp ball 5	Duffers Reef	24-Aug-19	excluded	Not a pellet; remains of 1 fish; includes articulated bones & flesh
Burp ball 6	Duffers Reef	24-Aug-19	excluded	Obviously incomplete: 12 eye lenses = min. 6 fish but otoliths = 3 fish
Burp ball 7	Duffers Reef	24-Aug-19	excluded	Plant material; no prey remains
TN02	North Trio	26-Nov-19	included but suspect	No otolith pottle for this sample = none or lost?
TN14	North Trio	26-Nov-19	excluded	Contents of pottles confused = appear mixed with TN15
TN15	North Trio	26-Nov-19	excluded	Contents of pottles confused = appear mixed with TN14
TN19	North Trio	26-Nov-19	included seems OK	Jeffs note: "No hard parts were separated from the pellet"
TN32	North Trio	26-Nov-19	included seems OK	Jeffs note: "Only feathers"
TN45	North Trio	11-Mar-20	included but suspect	No otolith pottle for this sample = none or lost?

## **APPENDIX 2**

Frequency of occurrence and minimum number of prey items per taxon for prey identified from prey remains in king shag pellets collected at seven breeding colonies in 2019 and in 2020.

### Sequence of contents

White Rocks	Appendix pages 3–5
The Twins	Appendix pages 6–8
Blumine	Appendix pages 9–11
The Haystack	Appendix pages 12–13
Duffers Reef	Appendix pages 14–18
Tawhitinui	Appendix pages 19–22
North Trio	Appendix pages 23–27





## King shag pellet analysis 2020 draft report

Lalas and Schuckard

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	WR06 yes	WR07 yes	WR08 yes	WR09 yes	WR10 yes	WR11 yes	WR12 yes	WR13 yes	WR14 yes	WR15 yes	WR16 yes	WR17 yes
WR	VALID prey remains analysis done? Colony	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR
<b>White Rocks</b>	Date pellet collected	11-Mar-19	11-Mar-19	11-Mar-19	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20
	DNA+Remains=yes=2	2	2	2	2	2	2	2	2	2	2	2	2
	Minimum number prey items	36	17	11	17	15	5	15	18	11	14	15	11
	Number prey taxa	3	3	1	5	3	2	4	2	1	2	2	1
	If 1 species enter species code			WIT						WIT			WIT
<b>Not prey species</b>													
Parasitic isopod			4										
Hermit crab								4					
<b>Definite or likely prey species</b>													
Pill-box crab	cf. <i>Halicarcinus</i> sp. or spp.												
Red swimming crab	<i>Nectocarcinus antarcticus</i>												
Arrow squid	<i>Nototodarus gouldi</i>												
Midget octopus	<i>Octopus</i> cf. <i>huttoni</i>												
Silver conger	<i>Gnathophipis habenatus</i>												
Sandfish	<i>Gonorynchus forsteri</i>												
Ling	<i>Genypterus blacodes</i>												
cf. Twosaddle rattail	cf. <i>Coelorrinchus biclinozonalis</i>												
Rock cod	<i>Lotella rhacina</i>												
Dwarf cod	<i>Notophycis marginata</i>												
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.												
Common roughy	<i>Paratrachichthys trailli</i>				3		1						
Jock stewart	<i>Helicolenus percoides</i>							4					
Red scorpionfish	<i>Scorpaena papillosa</i>								3				
Red gurnard	<i>Chelidonichthys kumu</i>				5	13						1	
Butterfly perch	<i>Caesioperca lepidoptera</i>												
Greenbone	<i>Odax pullus</i>												
Wrasse	<i>Notolabrus</i> & <i>Pseudolabrus</i> 4 spp.												
Blue cod	<i>Parapercis colias</i>				1								
Opalfish	<i>Hemerocoetes</i> cf. <i>monopterygius</i>	33	2										
Stargazer	<i>Leptoscopidae</i> sp.												
Triplefin	<i>Tripterygiidae</i> spp.												
Witch	<i>Arnoglossus scapha</i>	2	10	11	7		4	9	15	11	11	14	11
Lemon sole	<i>Pelotretis flavilatus</i>	1						1					
Sole	<i>Peltoirhamphus</i> 1-3 spp.		5		1								
Flounder	<i>Rhombosolea</i> 1-3 spp.												
Leatherjacket	<i>Meuschenia scaber</i>					1							

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	WR18 yes	WR19 yes	WR20 yes	WR21 yes	WR22 yes	WR23 yes
WR	VALID prey remains analysis done? Colony	yes WR	yes WR	yes WR	yes WR	yes WR	yes WR
<b>White Rocks</b>	Date pellet collected	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20
	DNA+Remains=yes=2	2	2	2	2	2	2
	Minimum number prey items	8	6	23	13	15	18
	Number prey taxa	3	3	3	2	3	9
	If 1 species enter species code						1 chiton
<b>Not prey species</b>							
Parasitic isopod							
Hermit crab							
<b>Definite or likely prey species</b>							
Pill-box crab	cf. <i>Halicarinus</i> sp. or spp.						
Red swimming crab	<i>Nectocarcinus antarcticus</i>						
Arrow squid	<i>Nototodarus gouldi</i>						
Midget octopus	<i>Octopus</i> cf. <i>huttoni</i>						
Silver conger	<i>Gnathophis habenatus</i>						
Sandfish	<i>Gonorynchus forsteri</i>						
Ling	<i>Genypterus blacodes</i>						
cf. Twosaddle rattail	cf. <i>Coelorrinchus biclinozonalis</i>		1				
Rock cod	<i>Lotella rhacina</i>						
Dwarf cod	<i>Notophycis marginata</i>						
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.						
Common roughy	<i>Paratrachichthys trailli</i>						
Jock stewart	<i>Helicolenus percoides</i>	4			1	2	2
Red scorpionfish	<i>Scorpaena papillosa</i>						
Red gurnard	<i>Chelidonichthys kumu</i>			2			2
Butterfly perch	<i>Caesioperca lepidoptera</i>						3
Greenbone	<i>Odax pullus</i>						1
Wrasse	<i>Notolabrus</i> & <i>Pseudolabrus</i> 4 spp.						
Blue cod	<i>Paraperca colias</i>						2
Opalfish	<i>Hemerocoetes</i> cf. <i>monopterygius</i>						
Stargazer	<i>Leptoscopidae</i> sp.						
Triplefin	<i>Tripterygiidae</i> spp.						1
Witch	<i>Arnoglossus scapha</i>	2	2	19	12	9	5
Lemon sole	<i>Pelotretis flavilatus</i>						
Sole	<i>Peltorhamphus</i> 1-3 spp.			2		4	1
Flounder	<i>Rhombosolea</i> 1-3 spp.						
Leatherjacket	<i>Meuschenia scaber</i>	2	3				1

**King shag  
Prey number  
and occurrence**

pellet code total = 24  
DNA analysis done total = 24  
Prey remains analysis done total = 22  
DNA & Remains done total = 22

Total minimum number  
of items = 421

Total number of pellets  
analysed = 22

TT	Pellet code	TT01	TT02	TT03	TT04	TT05
	DNA analysis done?	yes	yes	yes	yes	yes
	Jeffs & van der Reis notes					
	Lalas & Schuckard notes					
	VALID prey remains analysis done?	yes	yes	yes	yes	yes
	Colony	TT	TT	TT	TT	TT
	Date pellet collected	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20
	DNA+Remains=yes=2	2	2	2	2	2
	Minimum number prey items	21	24	20	13	26
	Number prey taxa	1	5	4	2	3

Minimum number  
of items per taxon

Occurrence of  
taxon in pellets

Number  
per pellet

% total  
of all pellets

Number  
of pellets

If 1 species enter species code WIT

**Not prey species**

Parasitic isopod

Hermit crab

**Definite or likely prey species**

Pill-box crab cf. *Halicarinus* sp. or spp.

Red swimming crab *Nectocarcinus antarcticus*

Arrow squid *Nototodarus gouldi*

Midget octopus *Octopus cf. huttoni*

Silver conger *Gnathophis habenatus*

Sandfish *Gonorynchus forsteri*

Ling *Genypterus blacodes*

cf. Twosaddle rattail cf. *Coelirinchus biclimozonalis*

Rock cod *Lotella rhacina*

Dwarf cod *Notophycis marginata*

cf. Red cod *Pseudophycis* 1-3 spp.

Common roughy *Paratrachichthys trilli*

Jock steward *Helicolenus percoides*

Red scorpionfish *Scorpaena papillosa*

Red gurnard *Chelidonichthys kumu*

Butterfly perch *Caesioperca lepidoptera*

Greenbone *Odax pullus*

Wrasse *Notolabrus & Pseudolabrus* 4 spp.

Blue cod *Paraperca coltas*

Opalfish *Hemerocoetes cf. monopterygius*

Stargazer *Leptoscopidae* sp.

Triplefin *Tripterygiidae* spp.

Witch *Arnoglossus scapha*

Lemon sole *Pelotretis flavilatus*

Sole *Peltorhamphus* 1-3 spp.

Flounder *Rhombosolea* 1-3 spp.

Leatherjacket *Meuschenia scaber*

0 0%

4 5%

1 0.2%

2 0.5%

0 0.0%

9 2.1%

0 0.0%

1 0.2%

0 0.0%

0 0.0%

0 0.0%

0 0.0%

1 0.2%

0 0.0%

15 3.6%

1 0.2%

20 4.8%

2 0.5%

0 0.0%

2 0.5%

1 0.2%

37 8.8%

0 0.0%

109 25.9%

185 43.9%

14 3.3%

3 0.7%

0 0.0%

18 4.3%

0 0%

4 5%

1 5%

2 9%

0 0%

1 5%

0 0%

1 5%

0 0%

0 0%

0 0%

1 5%

0 0%

4 18%

1 5%

6 27%

1 5%

0 0%

2 9%

1 5%

8 36%

0 0%

9 41%

15 68%

7 32%

3 14%

0 0%

5 23%

0 0%

4 5%

1 5%

2 9%

0 0%

1 5%

0 0%

1 5%

0 0%

0 0%

0 0%

1 5%

0 0%

4 18%

1 5%

6 27%

1 5%

0 0%

2 9%

1 5%

8 36%

0 0%

9 41%

15 68%

7 32%

3 14%

0 0%

5 23%



King shag Prey number and occurrence	Pellet code	TT18	TT19	TT20	TT21	TT22	TT23	TT24
	DNA analysis done? Jeffs & van der Reis notes no hard parts Lalas & Schuckard notes	yes	yes	yes	yes	yes	yes	yes
TT	VALID prey remains analysis done? Colony	no	yes	yes	yes	yes	no	yes
The Twins	Date pellet collected	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20	20-Mar-20
	DNA+Remains=yes=2	1	2	2	2	2	1	2
	Minimum number prey items	14	14	14	8	4	7	7
	Number prey taxa	5	2	2	1	3	1	1

obviously incomplete

If 1 species enter species code

LEA

### Not prey species

Parasitic isopod								
Hermit crab								
<b>Definite or likely prey species</b>								
Pill-box crab	cf. <i>Halicarinus</i> sp. or spp.	1						
Red swimming crab	<i>Nectocarcinus antarcticus</i>	1						
Arrow squid	<i>Nototodarus gouldi</i>							
Midget octopus	<i>Octopus cf. huttoni</i>							
Silver conger	<i>Gnathophis habenatus</i>							
Sandfish	<i>Gonorynchus forsteri</i>							
Ling	<i>Genypterus blacodes</i>							
cf. Twosaddle rattail	cf. <i>Coelorinchus biclinozonalis</i>							
Rock cod	<i>Lotella thacina</i>							
Dwarf cod	<i>Notophycis marginata</i>							
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.							
Common roughy	<i>Paratrachichthys trailli</i>							
Jock stewart	<i>Helicolenus percoides</i>	6						7
Red scorpionfish	<i>Scorpaena papillosa</i>							
Red gurnard	<i>Chelidonichthys kumu</i>							
Butterfly perch	<i>Caesioperca lepidoptera</i>					2		
Greenbone	<i>Odax pullus</i>							
Wrasse	<i>Notolabrus &amp; Pseudolabrus</i> 4 spp.					1		
Blue cod	<i>Paraperis colias</i>							
Opalfish	<i>Hemerocoetes cf. monopterygius</i>	2						
Stargazer	<i>Leptoscopidae</i> sp.							
Triplefin	<i>Tripterygiidae</i> spp.		1					
Witch	<i>Arnoglossus scapha</i>	4		13				
Lemon sole	<i>Pelotretis flavilatus</i>							
Sole	<i>Peltothamphus</i> 1-3 spp.							
Flounder	<i>Rhombosolea</i> 1-3 spp.							
Leatherjacket	<i>Meuschenia scaber</i>				8			1

**King shag**  
**Prey number**  
**and occurrence**

pellet code total = 28  
DNA analysis done total = 28  
Prey remains analysis done total = 28  
DNA & Remains done total = 28

Blu	Blu01	Blu02	Blu03	Blu04	Blu05
<b>Blumine</b>	yes	yes	yes	yes	yes

Pellet code	DNA analysis done?	Jeffs & van der Reis notes	Lalas & Schuckard notes
20-Mar-20	2	2	2
20-Mar-20	15	15	15
20-Mar-20	2	1	2

Minimum number of items per taxon	Occurrence of taxon in pellets
Number	% total
of all prey	of all pellets

Minimum number of items per prey	Number prey taxa
2	2
4	4

Total minimum number of items = 424  
Total number of pellets analysed = 28

**Not prey species**

Species	Blu01	Blu02	Blu03	Blu04	Blu05
Parasitic isopod	yes	yes	yes	yes	yes
Hermit crab	yes	yes	yes	yes	yes
<b>Definite or likely prey species</b>					
Pill-box crab	yes	yes	yes	yes	yes
Red swimming crab	yes	yes	yes	yes	yes
Arrow squid	yes	yes	yes	yes	yes
Midget octopus	yes	yes	yes	yes	yes
Silver conger	yes	yes	yes	yes	yes
Sandfish	yes	yes	yes	yes	yes
Ling	yes	yes	yes	yes	yes
cf. Twosaddle rattail	yes	yes	yes	yes	yes
Rock cod	yes	yes	yes	yes	yes
Dwarf cod	yes	yes	yes	yes	yes
cf. Red cod	yes	yes	yes	yes	yes
Common roughy	yes	yes	yes	yes	yes
Jock stewart	yes	yes	yes	yes	yes
Red scorpionfish	yes	yes	yes	yes	yes
Red gurnard	yes	yes	yes	yes	yes
Butterfly perch	yes	yes	yes	yes	yes
Greenbone	yes	yes	yes	yes	yes
Wrasse	yes	yes	yes	yes	yes
Blue cod	yes	yes	yes	yes	yes
Opalfish	yes	yes	yes	yes	yes
Stargazer	yes	yes	yes	yes	yes
Tripletfin	yes	yes	yes	yes	yes
Witch	yes	yes	yes	yes	yes
Lemon sole	yes	yes	yes	yes	yes
Sole	yes	yes	yes	yes	yes
Flounder	yes	yes	yes	yes	yes
Leatherjacket	yes	yes	yes	yes	yes

WIT

WIT

WIT

If 1 species enter species code





King shag pellet analysis 2020 draft report

Lalas and Schuckard

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	Blu18	Blu19	Blu20	Blu21	Blu22	Blu23	Blu24	Blu25	Blu26	Blu27	Blu28
Blu	VALID prey remains analysis done? Colony	yes Blu	yes Blu	yes Blu	yes Blu	yes Blu	yes Blu	yes Blu	yes Blu	yes Blu	yes Blu	yes Blu
Blumine	Date pellet collected DNA+Remains=yes=2 Minimum number prey items Number prey taxa	20-Mar-20 2 19 4	20-Mar-20 2 15 2	20-Mar-20 2 16 2	20-Mar-20 2 11 2	20-Mar-20 2 20 2	20-Mar-20 2 12 2	20-Mar-20 2 16 2	20-Mar-20 2 10 1	20-Mar-20 2 8 3	20-Mar-20 2 7 2	20-Mar-20 2 4 2

If 1 species enter species code

WIT

**Not prey species**

Parasitic isopod												
Hermit crab												
<b>Definite or likely prey species</b>												
Pill-box crab	cf. <i>Halicarcinus</i> sp. or spp.											
Red swimming crab	<i>Nectocarcinus antarcticus</i>											
Arrow squid	<i>Nototodarus gouldi</i>											
Midget octopus	<i>Octopus cf. huttoni</i>											
Silver conger	<i>Gnathophis habenatus</i>											
Sandfish	<i>Gonorynchus forsteri</i>											
Ling	<i>Genypterus blacodes</i>											
cf. Twosaddle rattail	cf. <i>Coelorinchus biclinozonalis</i>											
Rock cod	<i>Lotella rhacina</i>											
Dwarf cod	<i>Notophycis marginata</i>											
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.											1
Common roughy	<i>Paratrachichthys trailli</i>											
Jock stewart	<i>Helicolenus percoides</i>											
Red scorpionfish	<i>Scorpaena papillosa</i>											
Red gurnard	<i>Chelidonichthys kumu</i>											
Butterfly perch	<i>Caesioperca lepidoptera</i>											
Greenbone	<i>Odax pullus</i>											
Wrasse	<i>Notolabrus &amp; Pseudolabrus</i> 4 spp.											
Blue cod	<i>Paraperca coltas</i>											
Opalfish	<i>Hemerocoetes cf. monopterygius</i>	3			3	1						
Stargazer	<i>Leptoscopidae</i> sp.											
Tripletfin	<i>Tripterygiidae</i> spp.	5										
Witch	<i>Arnoglossus scapha</i>	10	14	15	8	19	9	15	10	6	6	
Lemon sole	<i>Pelotretis flavilatus</i>											
Sole	<i>Peltorhamphus</i> 1-3 spp.	1										
Flounder	<i>Rhombosolea</i> 1-3 spp.											
Leatherjacket	<i>Meuschenia scaber</i>		1	1				1		1		

**King shag  
Prey number  
and occurrence**

pellet code total = 10  
DNA analysis done total = 10  
Prey remains analysis done total = 10  
DNA & Remains done total = 10

Total minimum number  
of items = 168  
Total number of pellets  
analysed = 10

Minimum number  
of items per taxon

Number % total Occurrence of  
of pellets of all pellets taxon in pellets  
per pellet of all prey of all pellets of pellets

**Not prey species**

Parasitic isopod  
Hermit crab

**Definite or likely prey species**

Species	Minimum number of items per taxon	Number per pellet	% total of all prey	Occurrence of taxon in pellets	% total of all pellets	Number of pellets
Pill-box crab	0	0	0.0%	0	0%	0
Red swimming crab	1	1	0.6%	10%	10%	1
Arrow squid	0	0	0.0%	0%	0%	0
Midget octopus	3	3	1.8%	30%	30%	3
Silver conger	0	0	0.0%	0%	0%	0
Sandfish	0	0	0.0%	0%	0%	0
Ling	0	0	0.0%	0%	0%	0
cf. Twosaddle rattail	0	0	0.0%	0%	0%	0
Rock cod	0	0	0.0%	0%	0%	0
Dwarf cod	0	0	0.0%	0%	0%	0
cf. Red cod	7	7	4.2%	20%	20%	2
Common roughy	0	0	0.0%	0%	0%	0
Jock stewart	3	3	1.8%	20%	20%	2
Red scorpionfish	9	9	5.4%	40%	40%	4
Red gurnard	4	4	2.4%	10%	10%	1
Butterfly perch	1	1	0.6%	10%	10%	1
Greenbone	0	0	0.0%	0%	0%	0
Wrasse	0	0	0.0%	0%	0%	0
Blue cod	1	1	0.6%	10%	10%	1
Opalfish	40	40	23.8%	10%	10%	1
Stargazer	0	0	0.0%	0%	0%	0
Tripletfin	29	29	17.3%	30%	30%	3
Witch	39	39	23.2%	50%	50%	5
Lemon sole	4	4	2.4%	40%	40%	4
Sole	1	1	0.6%	10%	10%	1
Flounder	2	2	1.2%	20%	20%	2
Leatherjacket	24	24	14.3%	30%	30%	3

HS Pellet code HS01 HS02 HS03 HS04 HS05  
yes yes yes yes yes yes  
DNA analysis done? yes yes yes yes  
Jeffs & van der Reis notes yes yes  
Lalas & Schuckard notes yes yes  
VALID prey remains analysis done? yes yes  
Colony HS HS HS HS  
Date pellet collected 11-Mar-19 11-Mar-19 11-Mar-19 11-Mar-19 11-Mar-19  
DNA+Remains=yes=2 2 2 2 2 2  
Minimum number prey items 12 66 6 27 8  
Number prey taxa 5 5 2 7 2  
1 chiton

If 1 species enter species code

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	HS06 yes	HS07 yes	HS08 yes	HS09 yes	HS10 yes
HS	VALID prey remains analysis done? Colony	yes HS	yes HS	yes HS	yes HS	yes HS
<b>The Haystack</b>	Date pellet collected	11-Mar-19	11-Mar-19	11-Mar-19	11-Mar-19	11-Mar-19
	DNA+Remains=yes=2	2	2	2	2	2
	Minimum number prey items	12	8	12	12	5
	Number prey taxa	1	3	2	2	5

If 1 species enter species code LEA

#### Not prey species

Parasitic isopod						
Hermit crab						6
<b>Definite or likely prey species</b>						
Pill-box crab	cf. <i>Halicarinus</i> sp. or spp.					1
Red swimming crab	<i>Nectocarcinus antarcticus</i>					
Arrow squid	<i>Nototodarus gouldi</i>					
Midget octopus	<i>Octopus</i> cf. <i>huttoni</i>					
Silver conger	<i>Gnathophis habenatus</i>					
Sandfish	<i>Gonorynchus forsteri</i>					
Ling	<i>Genypterus blacodes</i>					
cf. Twosaddle rattail	cf. <i>Coelorrinchus biclinozonalis</i>					
Rock cod	<i>Lotella thacina</i>					
Dwarf cod	<i>Notophycis marginata</i>					1
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.					
Common roughy	<i>Paratrachichthys trailli</i>					1
Jock stewart	<i>Heliocolenus percooides</i>					1
Red scorpionfish	<i>Scorpaena papillosa</i>					
Red gurnard	<i>Chelidonichthys kumu</i>					4
Butterfly perch	<i>Caesioperca lepidoptera</i>					
Greenbone	<i>Odax pullus</i>					
Wrasse	<i>Notolabrus</i> & <i>Pseudolabrus</i> 4 spp.					
Blue cod	<i>Parapercis coltas</i>					
Opalfish	<i>Hemerocoetes</i> cf. <i>monopterygius</i>					
Stargazer	<i>Leptoscopidae</i> sp.					1
Tripletfin	<i>Tripterygiidae</i> spp.					11
Witch	<i>Arnoglossus scapha</i>					1
Lemon sole	<i>Pelotretis flavilatus</i>					1
Sole	<i>Peltothamphus</i> 1-3 spp.					
Flounder	<i>Rhombosolea</i> 1-3 spp.					
Leatherjacket	<i>Meuschenia scaber</i>					12

**King shag  
Prey number  
and occurrence**

pellet code total = 51  
DNA analysis done total = 37  
Prey remains analysis done total = 46  
DNA & Remains done total = 36

**also 7 pellets entered in "Burp ball" series 24-Aug-19**

Total minimum number of items = 839  
Total number of pellets analysed = 46

DNA analysis done?  
Pellet code  
DNA analysis done?  
Jeffs & van der Reis notes  
Lalas & Schuckard notes  
VALID prey remains analysis done?  
Date pellet collected  
DNA+Remains=yes=2  
Minimum number prey items  
Number prey taxa

DF01 DF02 DF03 DF04 DF05  
yes yes no yes yes  
26-Nov-19 26-Nov-19 26-Nov-19 26-Nov-19 26-Nov-19  
2 2 1 2 2  
16 4 24 7 36  
2 2 4 2 3

Occurrence of  
taxon in pellets  
% total Number  
of all pellets of pellets

Minimum number  
of items per taxon  
Number % total  
per pellet of all prey

If 1 species enter species code

**Not prey species**

Parasitic isopod  
Hermit crab

**Definite or likely prey species**

Pill-box crab	cf. <i>Hallicarcinus</i> sp. or spp.	1	0.1%	1	0%	0	0
Red swimming crab	<i>Nectocarcinus antarcticus</i>	2	0.2%	2	43%	6	4
Arrow squid	<i>Nototodarus gouldi</i>	0	0.0%	0	2%	1	
Midget octopus	<i>Octopus cf. huttoni</i>	7	0.8%	5	4%	2	
Silver conger	<i>Gnathophis habenatus</i>	0	0.0%	0	0%	0	
Sandfish	<i>Gonorynchus forsteri</i>	0	0.0%	0	0%	0	
Ling	<i>Genypterus blacodes</i>	0	0.0%	0	0%	0	
cf. Twosaddle rattail	<i>Coelrinchus biclinozonalis</i>	1	0.1%	1	11%	5	
Rock cod	<i>Lotella rhacina</i>	1	0.1%	1	0%	0	
Dwarf cod	<i>Notophycis marginata</i>	0	0.0%	0	0%	0	
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.	4	0.5%	3	2%	1	
Common roughy	<i>Paratrachichthys trailii</i>	0	0.0%	0	7%	3	1
Jock Stewart	<i>Helicolenus percoides</i>	29	3.5%	12	0%	0	
Red scorpionfish	<i>Scorpaena papillosa</i>	2	0.2%	2	26%	12	1
Red gurnard	<i>Chelidonichthys kumu</i>	10	1.2%	5	4%	2	
Butterfly perch	<i>Caesioperca lepidoptera</i>	1	0.1%	1	11%	5	
Greenbone	<i>Odax pullus</i>	0	0.0%	0	2%	1	
Wrasse	<i>Notolabrus &amp; Pseudolabrus</i> 4 spp.	12	1.4%	5	0%	0	3
Blue cod	<i>Parapercis colias</i>	0	0.0%	0	0%	0	
Opalfish	<i>Hemerocoetes cf. monopterygius</i>	215	25.6%	24	52%	24	
Stargazer	<i>Leptoscopidae</i> sp.	2	0.2%	1	2%	1	
Triplefin	<i>Tripterygiidae</i> spp.	62	7.4%	13	28%	13	1
Witch	<i>Arnoglossus scapha</i>	371	44.2%	32	70%	32	32
Lemon sole	<i>Pelotretis flavilatus</i>	25	3.0%	19	41%	19	
Sole	<i>Peltothamphus</i> 1-3 spp.	30	3.6%	13	28%	13	
Flounder	<i>Rhombosolea</i> 1-3 spp.	13	1.5%	6	13%	6	
Leatherjacket	<i>Meuschenia scaber</i>	51	6.1%	16	35%	16	1

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	DF06 no hard parts	DF07 yes	DF08 no Does not exist	DF09 yes	DF10 yes	DF11 yes	DF12 no	DF13 yes	DF14 yes	DF15 no no hard parts	DF16 no	DF17 yes
DR	VALID prey remains analysis done? Colony	no	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
<b>Duffers Reef</b>	Date pellet collected	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19
	DNA+Remains=yes=2	0	2	0	2	2	2	1	2	2	1	1	2
	Minimum number prey items	10	46		12	9	12	8	31	11	69	19	15
	Number prey taxa	4	5		3	4	5	4	5	4	3	5	3
	If 1 species enter species code												
<b>Not prey species</b>													
Parasitic isopod													
Hermit crab													
<b>Definite or likely prey species</b>													
Pill-box crab	cf. <i>Halicarinus</i> sp. or spp.												
Red swimming crab	<i>Nectocarcinus antarcticus</i>												
Arrow squid	<i>Nototodarus gouldi</i>												
Midget octopus	<i>Octopus cf. huttoni</i>	1	1										
Silver conger	<i>Gnathophis habenatus</i>												
Sandfish	<i>Gonorynchus forsteri</i>												
Ling	<i>Genypterus blacodes</i>												
cf. Twosaddle rattail	cf. <i>Coelorinchus biclinozonalis</i>												
Rock cod	<i>Lotella rhacina</i>												
Dwarf cod	<i>Notophycis marginata</i>												
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.												
Common roughy	<i>Paratrachichthys trailii</i>												
Jock steward	<i>Helicolenus percoides</i>				2		4						
Red scorpionfish	<i>Scorpaena papillosa</i>												
Red gurnard	<i>Chelidonichthys kumu</i>												
Butterfly perch	<i>Caesioperca lepidoptera</i>												
Greenbone	<i>Odax pullus</i>												
Wrasse	<i>Notolabrus &amp; Pseudolabrus</i> 4 spp.												
Blue cod	<i>Paraperca colias</i>												
Opalfish	<i>Hemerocoetes cf. monopterygius</i>	2			5			1	2	3	64	2	
Stargazer	<i>Leptoscopidae</i> sp.												
Triplefin	<i>Tripterygiidae</i> spp.	1	7		2		3				3		
Witch	<i>Arnoglossus scapha</i>	6	28		9		3	5	21		2	13	12
Lemon sole	<i>Pelotretis flavilatus</i>				1		1	1	3	3		1	1
Sole	<i>Peltorhamphus</i> 1-3 spp.		8			1		1	2	2			2
Flounder	<i>Rhombosolea</i> 1-3 spp.												
Leatherjacket	<i>Meuschenia scaber</i>					1			3	3		1	

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	DF18 yes	DF19 yes	DF20 yes	DF21 yes	DF22 no	DF23 yes	DF24 no	DF25 no	DF26 yes	DF27 yes	DF28 yes	DF29 yes
DR	VALID pre remains analysis done? Colony	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
<b>Duffers Reef</b>	Date pellet collected	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19
	DNA+Remains=yes=2	2	2	2	2	1	2	1	1	2	2	2	2
	Minimum number prey items	4	21	15	29	13	21	19	45	3	18	13	23
	Number prey taxa	2	7	5	5	3	4	5	2	3	1	3	3
	If 1 species enter species code										WWT		
<b>Not prey species</b>													
Parasitic isopod						4	4						
Hermit crab													4
<b>Definite or likely prey species</b>													
Pill-box crab	cf. <i>Halicarcinus</i> sp. or spp.												
Red swimming crab	<i>Nectocarcinus antarcticus</i>						1						
Arrow squid	<i>Nototodarus gouldi</i>												
Midget octopus	<i>Octopus</i> cf. <i>huttoni</i>		1	1									
Silver conger	<i>Gnathophis habenatus</i>												
Sandfish	<i>Gonorynchus forsteri</i>												
Ling	<i>Genypterus blacodes</i>												
cf. Twosaddle rattail	cf. <i>Coelorinchus biclinozonalis</i>		1										
Rock cod	<i>Lotella thacina</i>												
Dwarf cod	<i>Notophycis marginata</i>												
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.												
Common roughy	<i>Paratrachichthys trailii</i>												
Jock stewart	<i>Heliocolenus percoides</i>					5			1				
Red scorpionfish	<i>Scorpaena papillosa</i>												
Red gurnard	<i>Chelidonichthys kumu</i>				2		1						
Butterfly perch	<i>Caesioperca lepidoptera</i>												
Greenbone	<i>Odax pullus</i>												
Wrasse	<i>Notolabrus</i> & <i>Pseudolabrus</i> 4 spp.									1			
Blue cod	<i>Paraperca colias</i>											1	1
Opalfish	<i>Hemerocoetes</i> cf. <i>monopterygius</i>		8	3	7		2	1	37				
Stargazer	Leptoscopidae sp.												
Tripletfin	Tripterygiidae spp.												
Witch	<i>Arnoglossus scapha</i>		3	2	16	7	17	15	8	1	18	11	18
Lemon sole	<i>Pelotretis flavilatus</i>		1	1	1			1				1	
Sole	<i>Peltothamphus</i> 1-3 spp.		2		3								
Flounder	<i>Rhombosolea</i> 1-3 spp.												
Leatherjacket	<i>Meuschenia scaber</i>		2	5		1				1			4

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	DF30	DF31	DF32	DF33	DF34	DF35	DF36	DF37	DF38	DF39	DF40	DF41
DR	VALID prey remains analysis done? Colony	yes	yes	yes	yes	no	yes	yes	yes	no	yes	yes	yes
<b>Duffers Reef</b>	Date pellet collected	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19
	DNA+Remains=yes=2	2	2	2	2	1	2	2	2	1	2	2	2
	Minimum number prey items	15	32	6	13	29	14	16	13	28	41	33	4
	Number prey taxa	3	3	2	2	4	3	3	4	7	7	3	3
	If 1 species enter species code												
<b>Not prey species</b>													
Parasitic isopod													
Hermit crab													
<b>Definite or likely prey species</b>													
Pill-box crab	cf. <i>Halicarcinus</i> sp. or spp.												
Red swimming crab	<i>Nectocarcinus antarcticus</i>												
Arrow squid	<i>Nototodarus gouldi</i>												
Midget octopus	<i>Octopus</i> cf. <i>huttoni</i>												
Silver conger	<i>Gnathophis habenatus</i>												
Sandfish	<i>Gonorynchus forsteri</i>												
Ling	<i>Genypterus blacodes</i>												
cf. Twosaddle rattail	cf. <i>Coelorhynchus biclinozonalis</i>												
Rock cod	<i>Lotella rhacina</i>												1
Dwarf cod	<i>Notophycis marginata</i>												
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.									1			
Common roughy	<i>Paratrachichthys trailli</i>												
Jock stewart	<i>Helicolenus percoides</i>	2				2							
Red scorpionfish	<i>Scorpaena papillosa</i>								1				
Red gurnard	<i>Chelidonichthys kumu</i>												2
Butterfly perch	<i>Caesioperca lepidoptera</i>												
Greenbone	<i>Odax pullus</i>												
Wrasse	<i>Notolabrus</i> & <i>Pseudolabrus</i> 4 spp.		3							1			
Blue cod	<i>Paraperca colias</i>												
Opalfish	<i>Hemerocoetes</i> cf. <i>monopterygius</i>		26	3			11	1	4	18	7	5	1
Stargazer	Leptoscopidae sp.												
Triplefin	Tripterygiidae spp.		3										26
Witch	<i>Arnoglossus scapha</i>	3			12	22	1	14		1	3	27	1
Lemon sole	<i>Pelofretis flavilatus</i>				1	3					1		1
Sole	<i>Peltothamphus</i> 1-3 spp.					2		1	1	4			
Flounder	<i>Rhombosolea</i> 1-3 spp.												
Leatherjacket	<i>Meuschenia scaber</i>	10		3			2		7				2











King shag pellet analysis 2020 draft report

Lalas and Schuckard

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes VALID prey remains analysis done?	Taw31 yes Taw 11-Mar-19	Taw32 yes Taw 11-Mar-19	Taw33 yes Taw 11-Mar-19	Taw34 yes Taw 11-Mar-19	Taw35 yes Taw 11-Mar-19	Taw36 yes Taw 11-Mar-19	Taw37 yes Taw 11-Mar-19	Taw38 yes Taw 11-Mar-19	Taw39 yes Taw 11-Mar-19	Taw40 yes Taw 11-Mar-19	Taw41 yes Taw 11-Mar-19	Taw42 yes Taw 11-Mar-19
<b>Tawhitinui</b>	Colony Date pellet collected DNA+Remains=yes=2 Minimum number prey items Number prey taxa	2 63 5	2 9 2	2 54 5	2 5 4	2 8 5	2 2 2	2 36 6	2 5 4	2 32 4	2 2 2	2 17 4	2 5 2
If 1 species enter species code													
<b>Not prey species</b>													
Parasitic isopod							1						
Hermit crab													
<b>Definite or likely prey species</b>													
Pill-box crab	cf. <i>Hallicarcinus</i> sp. or spp.												
Red swimming crab	<i>Nectocarcinus antarcticus</i>												
Arrow squid	<i>Nototodarus gouldi</i>												
Midget octopus	<i>Octopus cf. huttoni</i>												
Silver conger	<i>Gnathophis habenatus</i>												
Sandfish	<i>Gonorynchus forsteri</i>							1					
Ling	<i>Genypterus blacodes</i>												
cf. Twosaddle rattail	cf. <i>Coelorinchus biclinozonalis</i>												
Rock cod	<i>Lotella rhacina</i>												
Dwarf cod	<i>Notophycis marginata</i>												
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.				1								
Common roughy	<i>Paratrachichthys trailli</i>				1								
Jock steward	<i>Helicolenus percoides</i>						1						
Red scorpionfish	<i>Scorpaena papillosa</i>												
Red gurnard	<i>Chelidonichthys kumu</i>												
Butterfly perch	<i>Caesioperca lepidoptera</i>												
Greenbone	<i>Odax pullus</i>												
Wrasse	<i>Notolabrus &amp; Pseudolabrus</i> 4 spp.						1						
Blue cod	<i>Paraperis colias</i>												
Opalfish	<i>Hemerocoetes cf. monopterygius</i>			10									
Stargazer	Leptoscopidae sp.												
Triplefin	Tripterygiidae spp.			3									
Witch	<i>Arnoglossus scapha</i>			4	2	2							
Lemon sole	<i>Pelotretis flavilatus</i>			1									2
Sole	<i>Peltorhamphus</i> 1-3 spp.			31									
Flounder	<i>Rhombosolea</i> 1-3 spp.			2									
Leatherjacket	<i>Meuschenia scaber</i>				1	2	1					4	3

**King shag  
Prey number  
and occurrence**

pellet code total = 47  
DNA analysis done total = 34  
Prey remains analysis done total = 45  
DNA & Remains done total = 33

Total minimum number  
of items = 902

Total number of pellets  
analysed = 45

Minimum number  
of items per taxon

Occurrence of  
taxon in pellets

Number % total  
per pellet of all prey

Number  
of pellets of pellets

**Not prey species**

Parasitic isopod

Hermit crab

**Definite or likely prey species**

Pill-box crab cf. *Hallicarcinus* sp. or spp.

Red swimming crab *Nectocarcinus antarcticus*

Arrow squid *Nototodarus gouldi*

Midget octopus *Octopus cf. huttoni*

Silver conger *Gnathophis habenatus*

Sandfish *Gonorynchus forsteri*

Ling *Genypterus blacodes*

cf. Twosaddle rattail cf. *Coelrinchus biclinozonalis*

Rock cod *Loteila rhacina*

Dwarf cod *Notophycis marginata*

cf. Red cod *Pseudophycis* 1-3 spp.

Common roughy *Paratrachichthys trailli*

Jock stewart *Helicolenus percoides*

Red scorpionfish *Scorpaena papillosa*

Red gurnard *Chelidonichthys kumu*

Butterfly perch *Caesioperca lepidoptera*

Greenbone *Odax pullus*

Wrasse *Notolabrus & Pseudolabrus* 4 spp.

Blue cod *Paraperca colias*

Opalfish *Hemerocoetes cf. monopterygius*

Stargazer *Leptoscopidae* sp.

Triplefin *Tripterygiidae* spp.

Witch *Arnoglossus scapha*

Lemon sole *Pelotretis flavilatus*

Sole *Peltorhamphus* 1-3 spp.

Flounder *Rhombosolea* 1-3 spp.

Leatherjacket *Meuschenia scaber*

TN	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes VALID prey remains analysis done?	TN01 yes TN	TN02 no TN	TN03 no TN	TN04 yes TN	TN05 no TN	Pellet code	
							Colony	Date pellet collected
		2	1	1	2	1	26-Nov-19	26-Nov-19
	DNA+Remains=yes=2	18	6	14	15	14	26-Nov-19	26-Nov-19
	Minimum number prey items	3	3	5	3	3		
	Number prey taxa	opercula		opercula				
		opercula		opercula				
		opercula		opercula				

If 1 species enter species code

King shag pellet analysis 2020 draft report

Lalas and Schuckard

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	TN06 yes	TN07 yes	TN08 yes	TN09 yes	TN10 no	TN11 yes	TN12 yes	TN13 no	TN14 yes	TN15 no	TN16 yes	TN17 yes
TN	VALID prey remains analysis done? Colony	yes TN	yes TN	yes TN	yes TN	yes TN	yes TN	yes TN	yes TN	yes TN	no TN	yes TN	yes TN
<b>North Trio</b>	Date pellet collected	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19	26-Nov-19
	DNA+Remains=yes=2	2	2	2	2	1	2	2	1	1	0	2	2
	Minimum number prey items	31	11	22	38	8	17	31	18	1	0	18	5
	Number prey taxa	6	4	3	3	2	4	3	4	1	0	3	2

mix +TN15 mix +TN14

If 1 species enter species code

**Not prey species**

Parasitic isopod													
Hermit crab				2		4							
<b>Definite or likely prey species</b>													
Pill-box crab	cf. <i>Halicarinus</i> sp. or spp.												
Red swimming crab	<i>Nectocarcinus antarcticus</i>												
Arrow squid	<i>Nototodarus gouldi</i>												
Midget octopus	<i>Octopus cf. huttoni</i>												
Silver conger	<i>Gnathophis habenatus</i>												
Sandfish	<i>Gonorynchus forsteri</i>												
Ling	<i>Genypterus blacodes</i>						1						
cf. Twosaddle rattail	cf. <i>Coelorinchus biclinozonalis</i>												
Rock cod	<i>Lotella thacina</i>												
Dwarf cod	<i>Notophycis marginata</i>												
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.												
Common roughy	<i>Paratrachichthys trilli</i>												
Jock stewart	<i>Helicolenus percoides</i>												
Red scorpionfish	<i>Scorpaena papillosa</i>												
Red gurnard	<i>Chelidonichthys kumu</i>							1					
Butterfly perch	<i>Caesioperca lepidoptera</i>												
Greenbone	<i>Odax pullus</i>												
Wrasse	<i>Notolabrus &amp; Pseudolabrus</i> 4 spp.												
Blue cod	<i>Parapercis coltas</i>			5									
Opalfish	<i>Hemerocoetes cf. monopterygius</i>		3										
Stargazer	<i>Leptoscopidae</i> sp.												
Tripletfin	<i>Tripterygiidae</i> spp.	3		2					6				
Witch	<i>Arnoglossus scapha</i>	22	6	15		7	14	28	9			14	
Lemon sole	<i>Pelotretis flavilatus</i>	2	1			1	1		1				1
Sole	<i>Peltothamphus</i> 1-3 spp.	1			32								
Flounder	<i>Rhombosolea</i> 1-3 spp.	1			1			2				2	
Leatherjacket	<i>Meuschenia scaber</i>		1						2				4

King shag pellet analysis 2020 draft report

Lalas and Schuckard

King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	TN18	TN19	TN20	TN21	TN22	TN23	TN24	TN25	TN26	TN27	TN28	TN29
TN	VALID prey remains analysis done? Colony	yes TN	no TN	no TN	no TN	no TN	yes TN	yes TN	yes TN	yes TN	yes TN	yes TN	no TN
North Trio	Date pellet collected DNA+Remains=yes=2	26-Nov-19 20	26-Nov-19 9	26-Nov-19 23	26-Nov-19 22	26-Nov-19 23	26-Nov-19 27	26-Nov-19 15	26-Nov-19 17	26-Nov-19 5	26-Nov-19 22	26-Nov-19 22	26-Nov-19 9
	Minimum number prey items	20	9	23	22	23	27	15	17	5	22	22	9
	Number prey taxa	4	1	3	4	7	1	4	3	4	1	4	2
		GUR			operculum			operculum			WIT		
		GUR			operculum			operculum			WIT		
<b>Not prey species</b>													
Parasitic isopod													
Hermit crab													
<b>Definite or likely prey species</b>													
Pill-box crab	cf. <i>Halicarcinus</i> sp. or spp.									1			
Red swimming crab	<i>Nectocarcinus antarcticus</i>												
Arrow squid	<i>Nototodarus gouldi</i>												
Midget octopus	<i>Octopus</i> cf. <i>huttoni</i>												
Silver conger	<i>Gnathophis habenatus</i>												
Sandfish	<i>Gonorynchus forsteri</i>												
Ling	<i>Genypterus blacodes</i>												
cf. Twosaddle rattail	cf. <i>Coelorinchus biclinozonalis</i>												
Rock cod	<i>Lotella thacina</i>												
Dwarf cod	<i>Notophycis marginata</i>												
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.				1								
Common roughy	<i>Paratrachichthys trilli</i>												
Jock stewart	<i>Heliocolenus percoides</i>												
Red scorpionfish	<i>Scorpaena papillosa</i>												
Red gurnard	<i>Chelidonichthys kumu</i>											1	
Butterfly perch	<i>Caesioperca lepidoptera</i>												
Greenbone	<i>Odax pullus</i>												
Wrasse	<i>Notolabrus</i> & <i>Pseudolabrus</i> 4 spp.												
Blue cod	<i>Paraperca colias</i>												
Opalfish	<i>Hemerocoetes</i> cf. <i>monopterygius</i>	2						1					
Stargazer	<i>Leptoscopidae</i> sp.												
Tripletfin	<i>Tripterygiidae</i> spp.		7										
Witch	<i>Arnoglossus scapha</i>	13		20		4	27	12	14		22	15	8
Lemon sole	<i>Pelotretis flavilatus</i>	3				1			2				
Sole	<i>Peltorhamphus</i> 1-3 spp.												1
Flounder	<i>Rhombosolea</i> 1-3 spp.	2		2		2		1				2	
Leatherjacket	<i>Meuschenia scaber</i>			1	1			1	1				





King shag Prey number and occurrence	Pellet code DNA analysis done? Jeffs & van der Reis notes Lalas & Schuckard notes	TN42 yes	TN43 yes	TN44 yes	TN45 yes	TN46 yes	TN47 yes
TN	VALID prey remains analysis done? Colony	yes TN	yes TN	yes TN	yes TN	yes TN	yes TN
North Trio	Date pellet collected DNA+Remains=yes=2	11-Mar-20 2	11-Mar-20 2	11-Mar-20 2	11-Mar-20 2	11-Mar-20 2	11-Mar-20 2
	Minimum number prey items	9	10	18	5	19	16
	Number prey taxa	3	2	2	1	3	2
	operculum						
	If 1 species enter species code				LEA		
<b>Not prey species</b>							
Parasitic isopod							
Hermit crab							
<b>Definite or likely prey species</b>							
Pill-box crab	cf. <i>Hallicarcinus</i> sp. or spp.						
Red swimming crab	<i>Nectocarcinus antarcticus</i>						
Arrow squid	<i>Nototodarus gouldi</i>						
Midget octopus	<i>Octopus</i> cf. <i>huttoni</i>						
Silver conger	<i>Gnathophis habenatus</i>						
Sandfish	<i>Gonorynchus forsteri</i>						
Ling	<i>Genypterus blacodes</i>						
cf. Twosaddle rattail	cf. <i>Coelorrinchus biclinozonalis</i>						
Rock cod	<i>Lotella rhacina</i>						
Dwarf cod	<i>Notophycis marginata</i>						
cf. Red cod	<i>Pseudophycis</i> 1-3 spp.						
Common roughy	<i>Paratrachichthys trailli</i>						
Jock stewart	<i>Helicolenus percoides</i>						
Red scorpionfish	<i>Scorpaena papillosa</i>						
Red gurnard	<i>Chelidonichthys kumu</i>						
Butterfly perch	<i>Caesioperca lepidoptera</i>						
Greenbone	<i>Odax pullus</i>						
Wrasse	<i>Notolabrus</i> & <i>Pseudolabrus</i> 4 spp.	1					
Blue cod	<i>Paraperca colias</i>						
Opalfish	<i>Hemerocoetes</i> cf. <i>monopterygius</i>	2					
Stargazer	<i>Leptoscopidae</i> sp.						
Triplefin	<i>Tripterygiidae</i> spp.	2					
Witch	<i>Arnoglossus scapha</i>		8	17		15	8
Lemon sole	<i>Pelotretis flavilatus</i>					3	
Sole	<i>Peltorhamphus</i> 1-3 spp.						
Flounder	<i>Rhombosolea</i> 1-3 spp.			1		1	8
Leatherjacket	<i>Meuschenia scaber</i>	6					5