



BCBC2019-05

**Occurrence of prey species
identified from remains in
regurgitated pellets from king
shags in 2019 and 2020**

Progress report

Chris Lalas & Rob Schuckard

Bird photos – Rob Schuckard
Fish photos – The fishes of NZ

New Zealand king shag – designated as Nationally Endangered

**Very small distribution:
restricted to Marlborough Sounds**

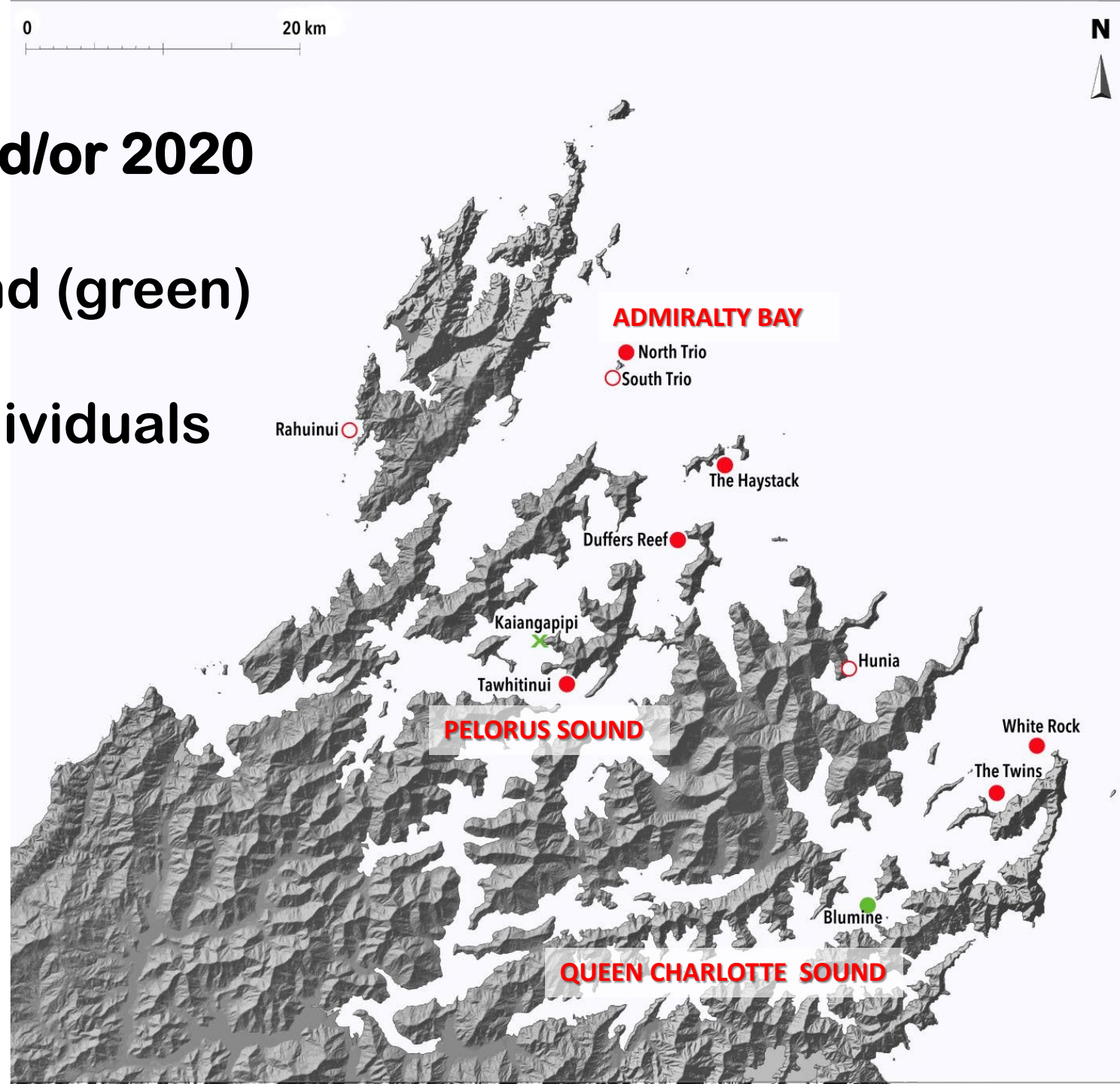
**Very small but fairly stable population size:
estimates from 2020 = 815 individuals and 277 nests**



7 sites sampled in 2019 and/or 2020

(red) 6 of the 9 colonies and (green)

the only roost with ≥ 10 individuals



Foraging behaviour

- **Exclusively marine**
- **Solitary**
- **Typical depths 20 – 60 m**
- **Demersal**
- **Target flatfish**



Source of prey remains: regurgitated pellets

Shags regurgitate one pellet daily

Pellets contain robust/undigestible prey remains

One published king shag diet study:

Comprehensive analysis of 22 pellets

Diet dominated by witch (*Arnoglossus scapha*)

Our present analysis for 215 pellets

Purpose: for comparison with DNA diet analysis

Method: restricted to frequency of occurrence

= presence/absence of species in pellets

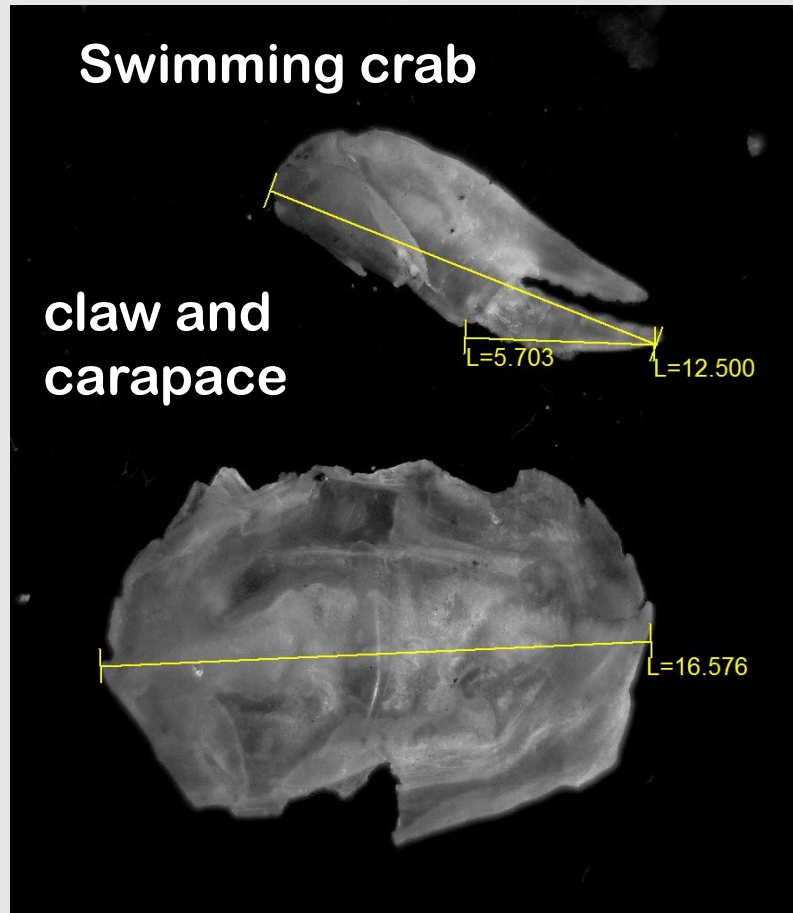
Frequency of occurrence overestimates importance of

- relatively small species
- species taken in relatively small amounts



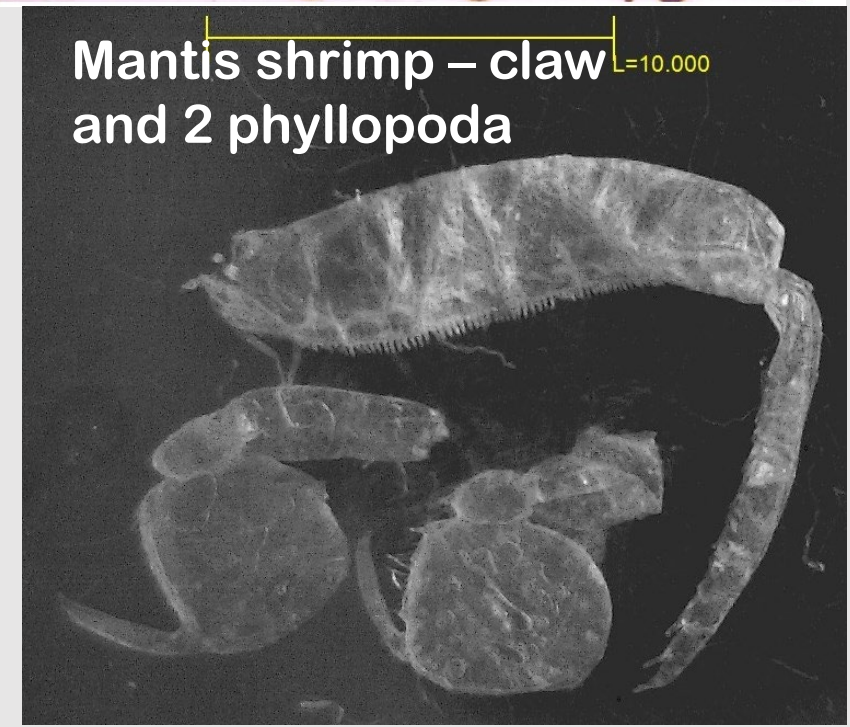
Analysis of prey remains in pellets

‘Prey remains analysis’ =
‘Hard parts analysis’ plus soft bits



Here examples of
decalcified crustacean
exoskeletons

Theme:
broad range in type of
prey remains



Piscium Catalogus

OTOLITHI PISCIUM

2

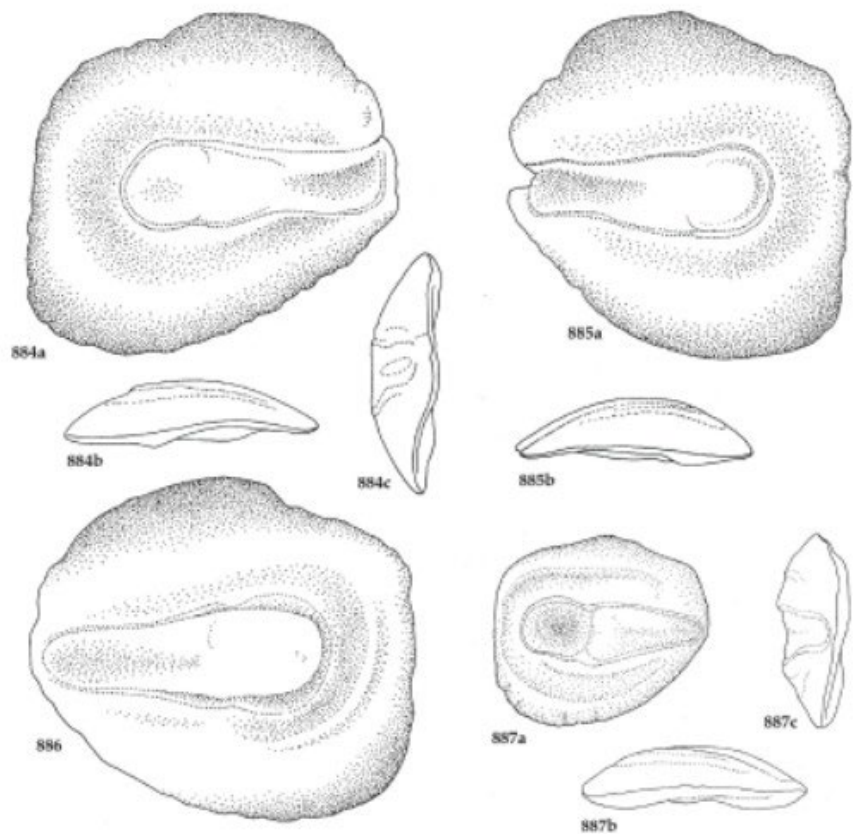
Werner SCHWARZHANS

A comparative morphological treatise
of recent and fossil otoliths
of the order Pleuronectiformes



Edited by
Dr. Friedrich H. PFEIL

336



Figs. 884-886: *Peltorhamphus novaezeelandiae* GÜNTHER 1862 - 15 ×
Fig. 887: *Peltorhamphus latus* JAMES 1972 - 15 ×

Peltorhamphus latus JAMES 1972
Fig. 887

Investigated otoliths: 1 otolith (left side) (paratype) from the Tasman Bay, New Zealand, 41°0'S/173°7'E, BMNH 1970.12.15.3-5.

Discussion: Similar to *P. novaezeelandiae* but with very shallow middorsal portion and with clearly separated colliculi. Also the sulcus is rather wide.

Distribution: New Zealand.

Peltorhamphus tenuis JAMES 1972
Figs. 895-899

Investigated otoliths: 1 otolith (left side, fig. 895) (paratype) from Pegasus Bay, New Zealand, 43°27'S/172°7'E, BMNH 1970.12.15.10-11 and 5 fossil specimens (figs. 896-899) from the Pliocene, Wanganui, north island, New Zealand.

**A GUIDE TO THE IDENTIFICATION OF
FISH REMAINS FROM
NEW ZEALAND ARCHAEOLOGICAL SITES**

Foss Leach



The Left Dentary 7

Medial aspect

Lateral aspect



Scorpaena papillosa - Red scorpionfish



Helicolenus barathri - Sea perch



Paraperca colias - Blue cod



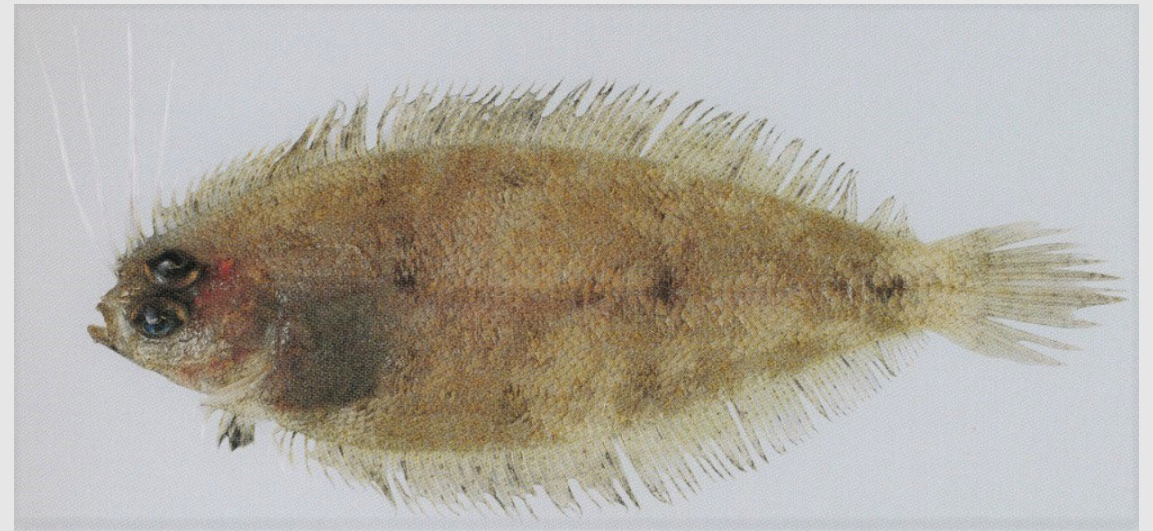
Notothenia angustata - Maori chief

6 families occur in $\geq 20\%$ of 215 pellets

Family	Common name	Occurrence	
		taxon	cumulative
Bothidae	Lefteye flounders	77%	77%



Witch
Arnoglossus scapha



New Zealand crested flounder
Lophonectes mongonuiensis

6 families occur in $\geq 20\%$ of 215 pellets

Family	Common name	Occurrence	
		taxon	cumulative
Bothidae	Lefteye flounders	77%	77%
Rhombosoleidae	Righteye flounders	51%	86%



28%

Lemon sole

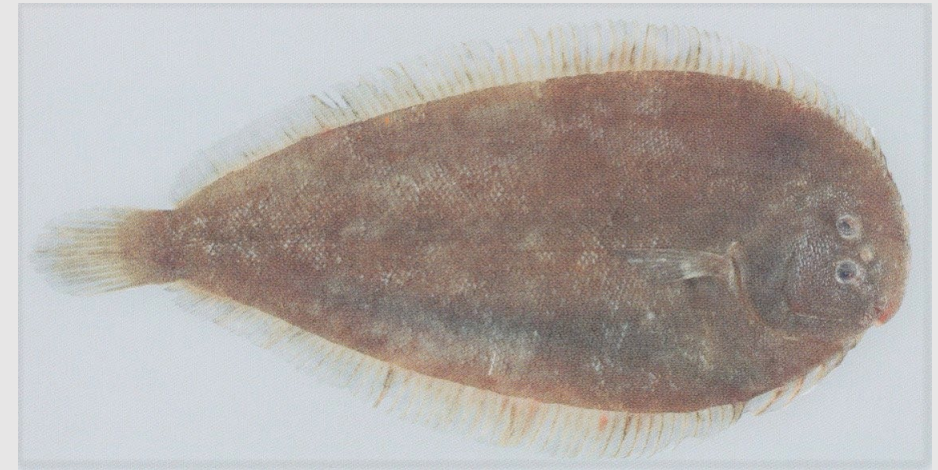
Pelotretis flavilatus



22%

Flounder

Rhombosolea species



21%

Sole

Peltorhamphus species

6 families occur in $\geq 20\%$ of 215 pellets

Family	Common name	Occurrence	
		taxon	cumulative
Bothidae	Lefteye flounders	77%	77%
Rhombosoleidae	Righteye flounders	51%	86%
Percophidae	Opalfish	38%	89%

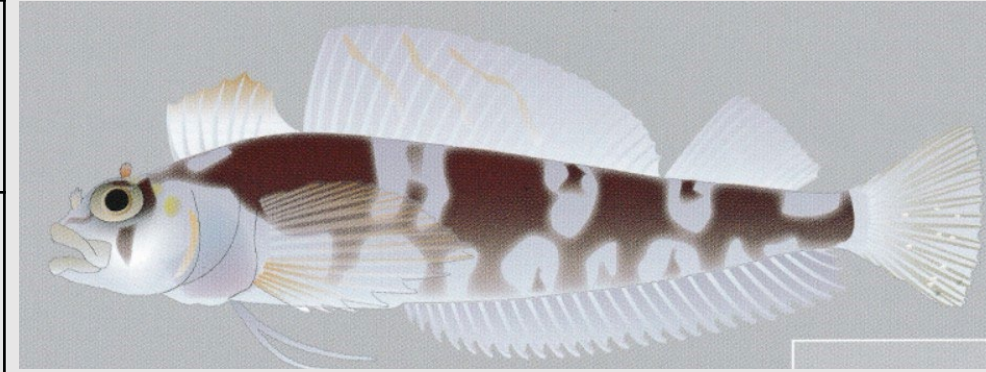


Opalfish

Hemerocoetes monopterygius

6 families occur in $\geq 20\%$ of 215 pellets

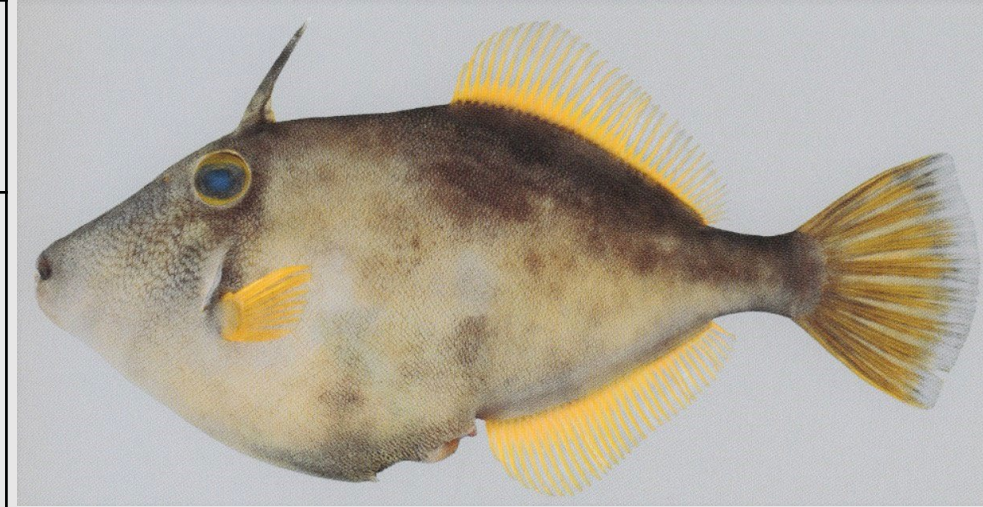
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		taxon	cumulative
Bothidae	Lefteye flounders	77%	77%
Rhombosoleidae	Righteye flounders	51%	86%
Percophidae	Opalfish	38%	89%
Tripterygiidae	Triplefins	26%	89%



Triplefins
 most likely *Forsterygion*
 &/or
Matanui spp.
 especially *M. profundum*

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Monacanthidae	Leatherjacket	25%	97%



Leatherjacket
Meuschenia scaber

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Tripterygiidae	Triplefins	26%	89%
Monacanthidae	Leatherjacket	25%	97%
Sebastidae	Jock stewart	22%	99%



Jock stewart
Helicolenus percooides

King shag prey: Fish species distribution maps across the broader Marlborough Sounds

Prepared for Ministry of Primary Industries

September 2017



1 Introduction

The National Institute of Water and Atmospheric Research (NIWA) was contracted by the Ministry for Primary Industries (MPI) to provide fish density and distribution maps for five prey species (Witch, Opalfish, Lemon Sole, NZ Sole and Triplefins) of the New Zealand King Shag, including three size classes for four of these prey species (Witch, Opalfish, Lemon sole, NZ sole) for the broader Marlborough Sounds Region.

Figure 2: Examples of juvenile and small fishes collected in NIWA's little beam-trawl net used to sample benthic fishes across the Marlborough Sounds. Fish shown here include witch, opalfish, lemon sole, triplefins and sole (see maps below), as well as blue cod and tarakihi – the two primary target species of this survey.

Comparison of scope of outcomes between prey remains analysis and DNA analysis	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

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

Determining the diet of New Zealand king shag using DNA metabarcoding



Aimee van der Reis and Andrew Jeffs

What is DNA metabarcoding?



AGTACGATATATT

AGTAAAAGGGTT

•GGCCTATATATAG



Witch – *Arnoglossus scapha*

Southern lemon sole - *Pelotretis flavilatus*

Smooth leatherjacket - *Meuschenia scaber* •

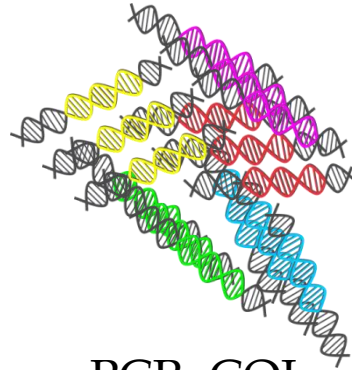
DNA metabarcoding



Pellet content



DNA



PCR: COI

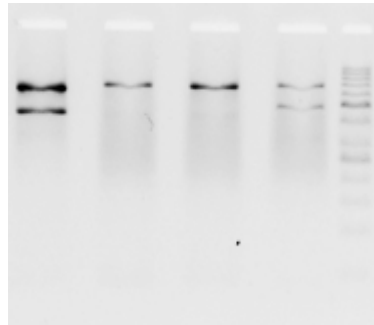


Results

Sex ID

- Host DNA from gut content used
- Single band for males (600 bp)
- Double band for females (450 bp and 600 bp)

F M M F



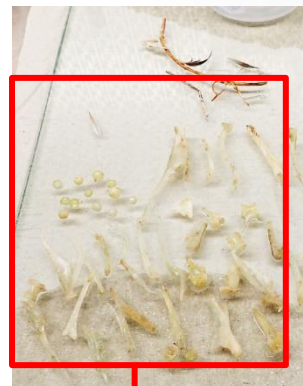


Potential parasite?

Fish...



Crab spp.



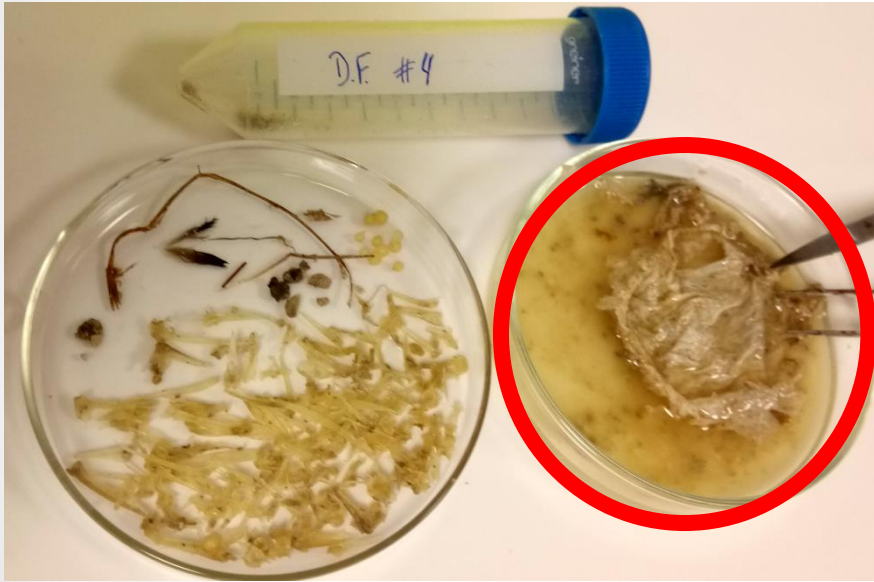
A lot of fish bones



Otoliths

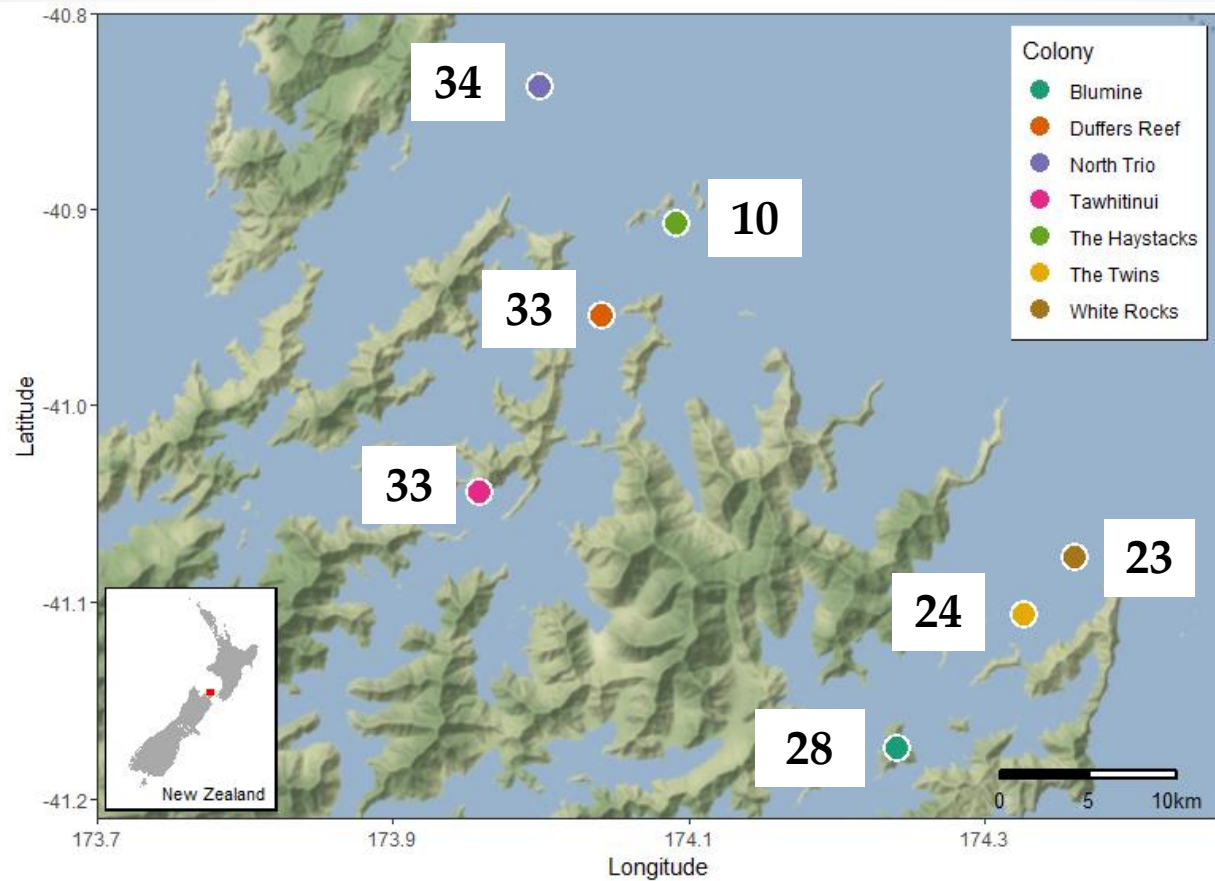
Identification of hard parts highly reliant on:

- Sufficient morphological structure
- Taxonomic expertise



DNA metabarcoding:

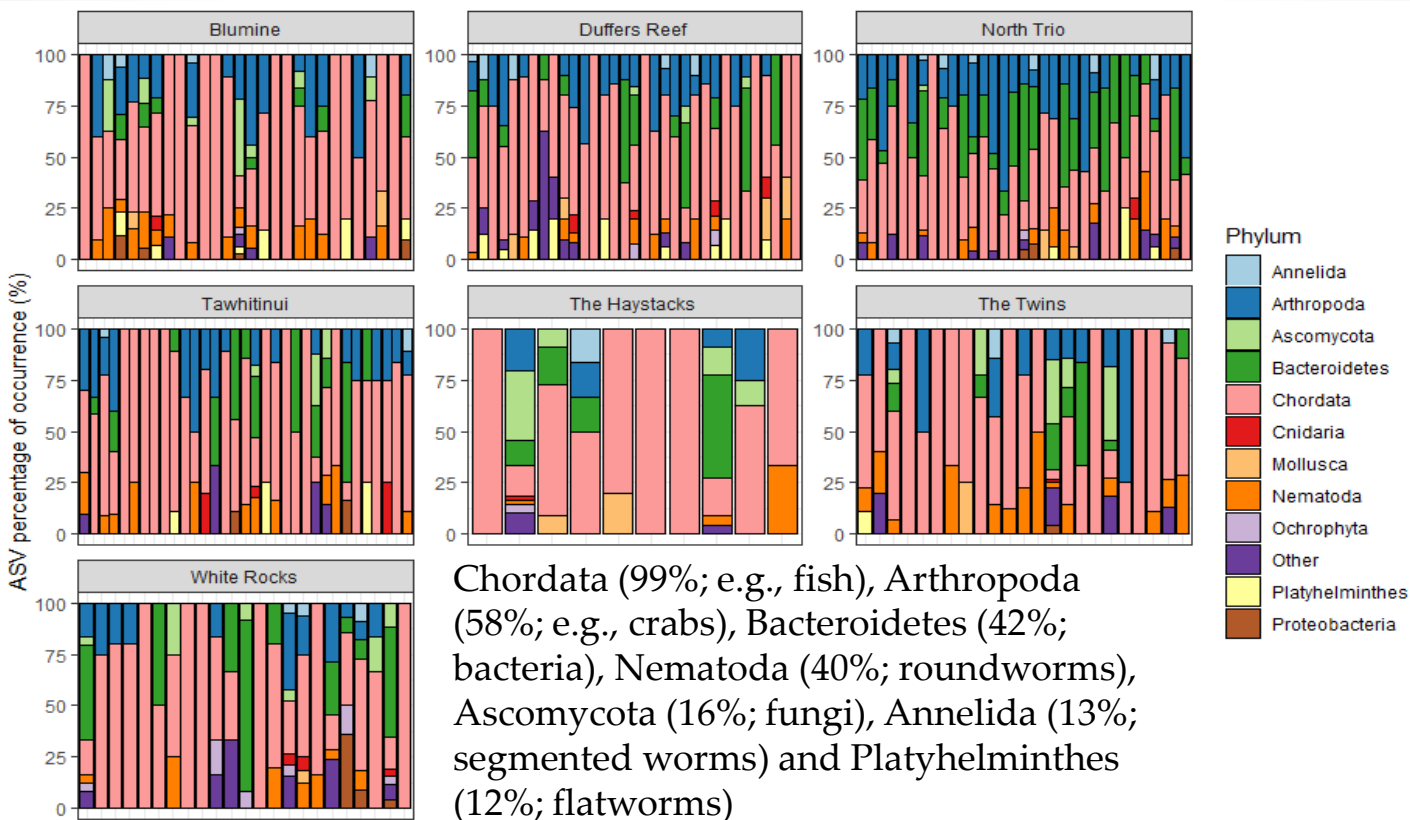
- No taxonomic expertise
- No morphological structure
- Species level ID



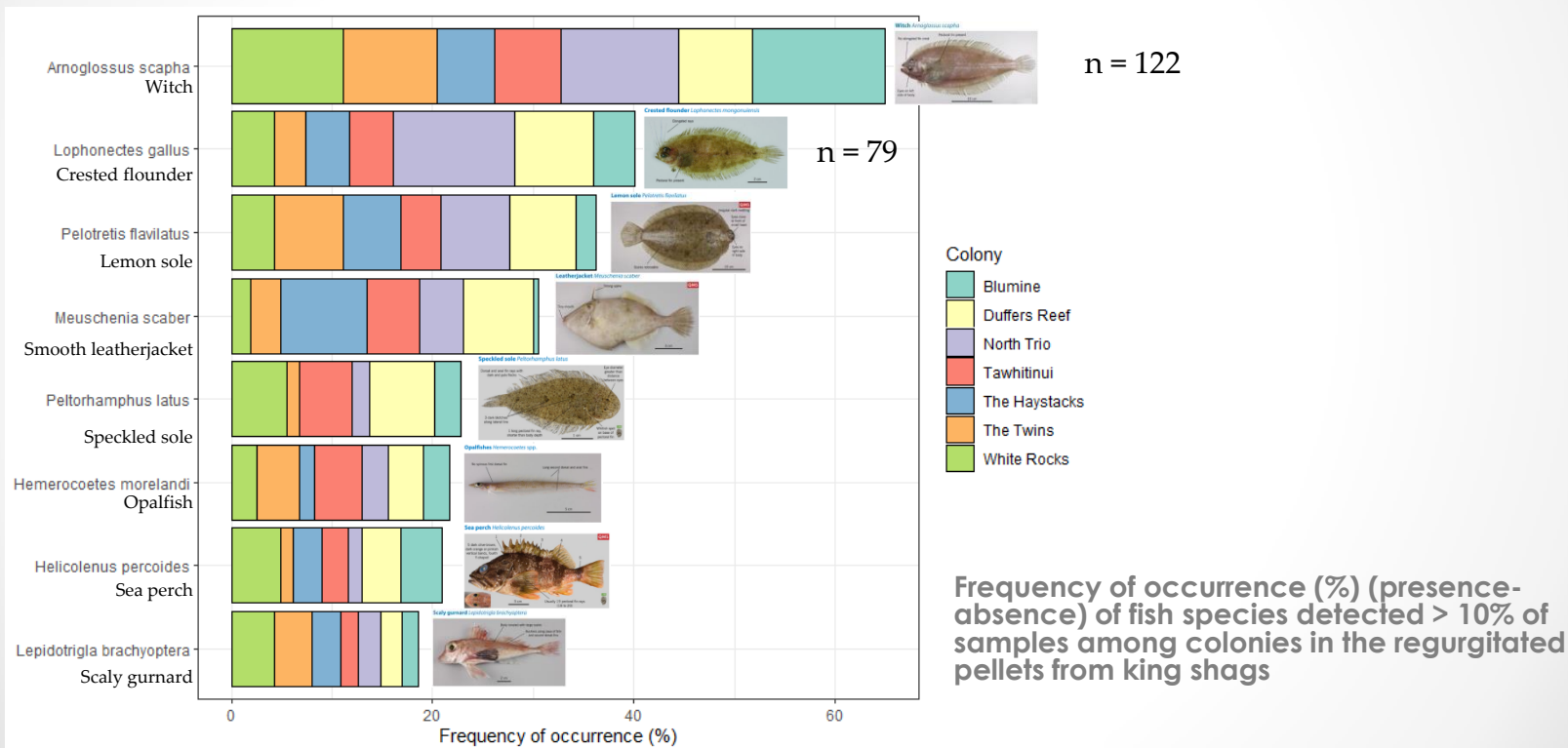
n = 185

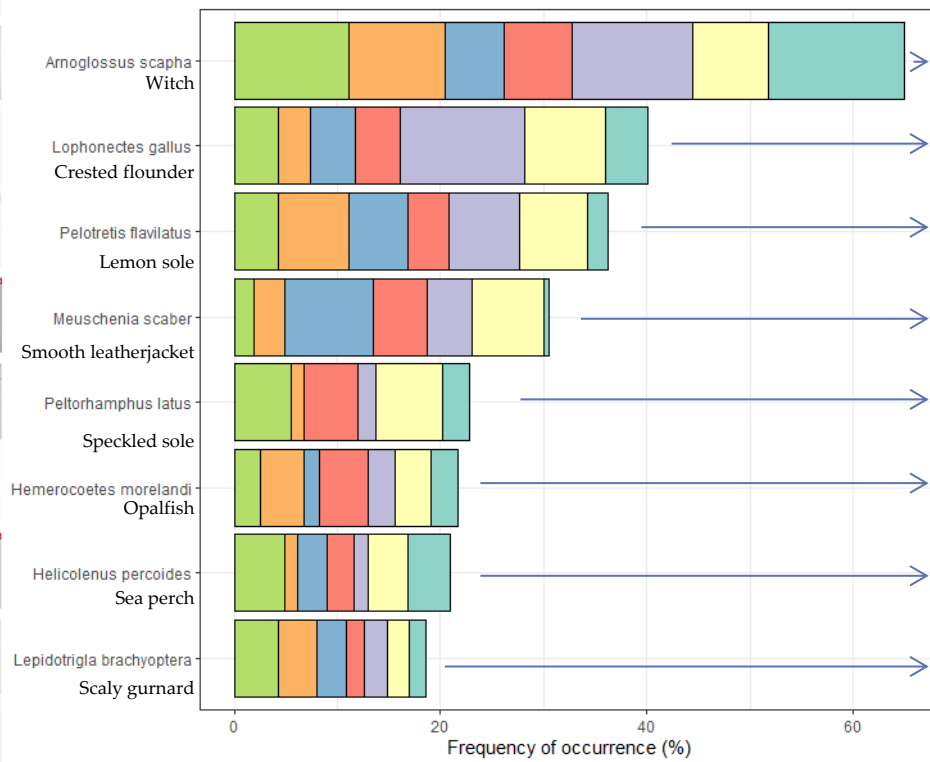
69 females, 109 males and 7 unidentified

Pellet content results



Pellet content results





Frequency of occurrence (n = 183)	Frequency of occurrence (%)
122	66.67
79	43.17
66	36.07
53	28.96
47	25.68
42	22.95
38	20.77
32	17.49

Pellet content results

Dietary:

Shrimps



Crabs

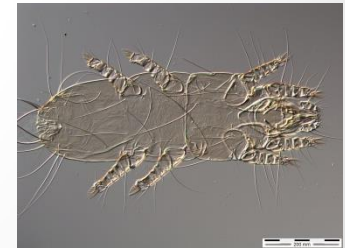


Non-dietary:

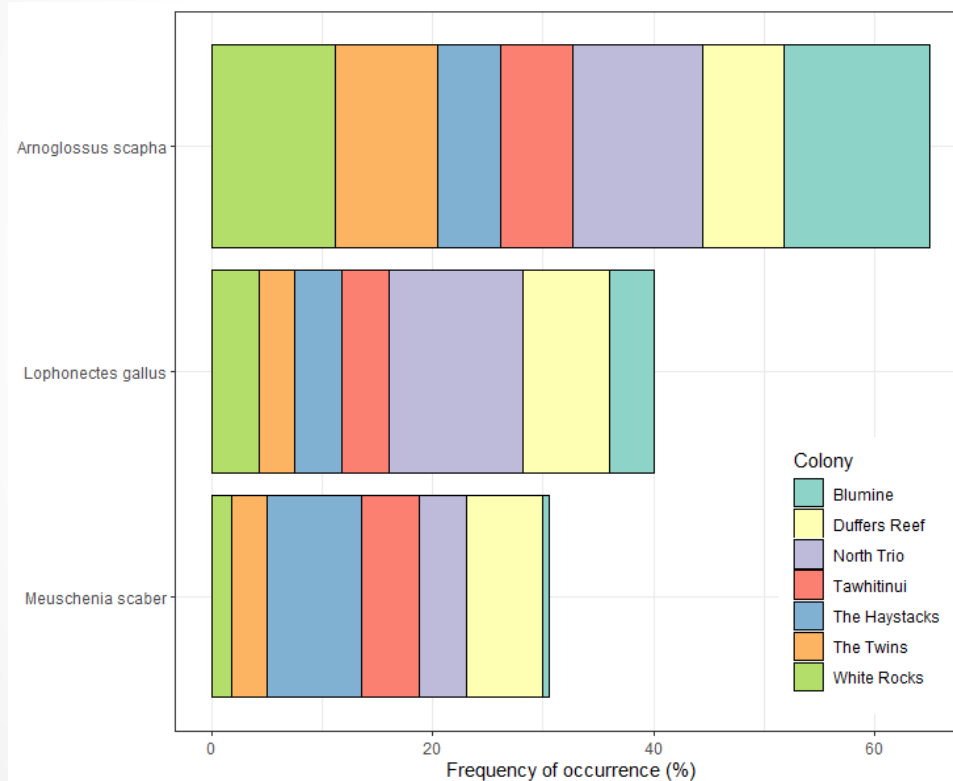
Parasites



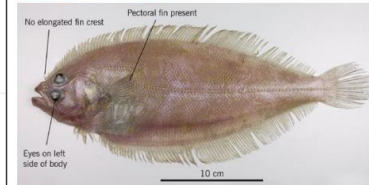
Feather mites



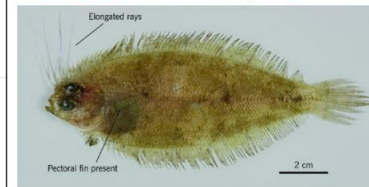
Significant difference - Area



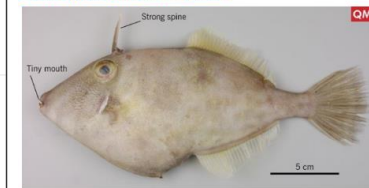
Witch *Arnoglossus scapha*



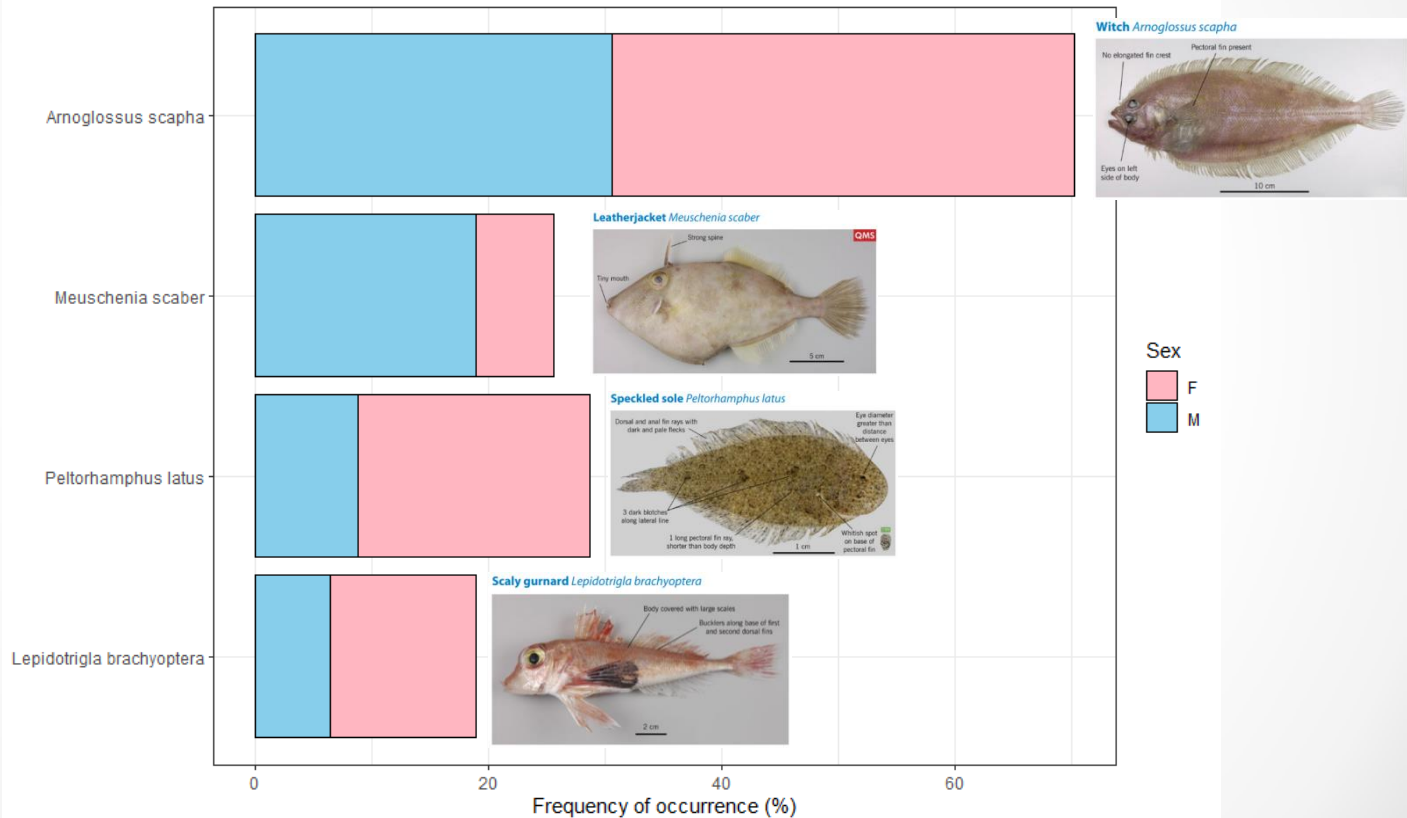
Crested flounder *Lophonectes mongonuiensis*



Leatherjacket *Meuschenia scaber*



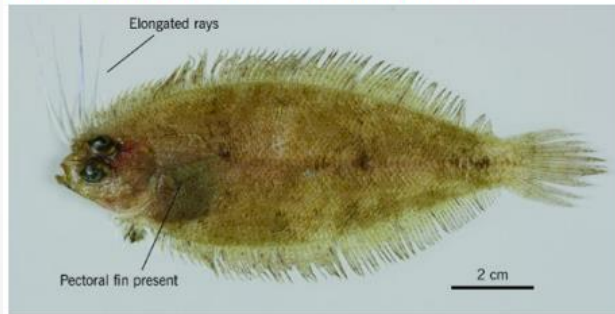
Significant difference - Sex



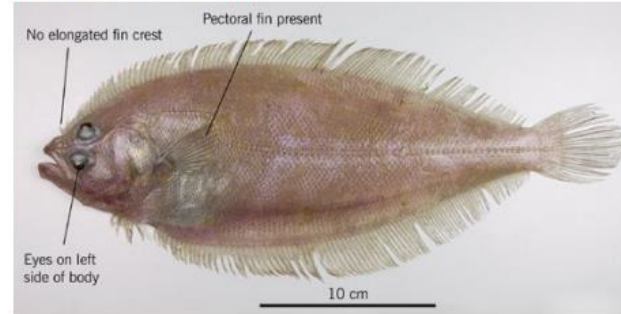
New record using DNA

- Crested flounder – 43% samples
- Easily mistaken for that of small witch
- DNA sequences for these two species vary by ~15%
 - These two species of fish are reliably distinguished using DNA.

Crested flounder *Lophonectes mongonuiensis*



Witch *Arnoglossus scapha*



Summary

- Detect dietary and non-dietary items
 - New records: Crested flounder, John Dory and the big-belly seahorse
- The frequency of occurrence dietary species detected is comparable to the microscopic study
- Sex ID the birds that regurgitated the pellet
- Potential to genetically identify individuals too

