Reconstructed and actual weight of stomach contents of Steller sea lions to estimate their food consumption during wintering in Japan

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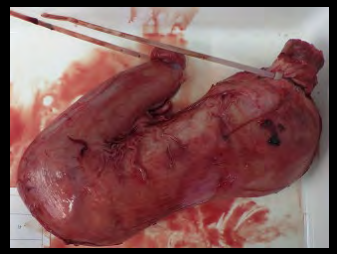
Background

GOAL Food consumption of Steller sea lions

Fundamental data

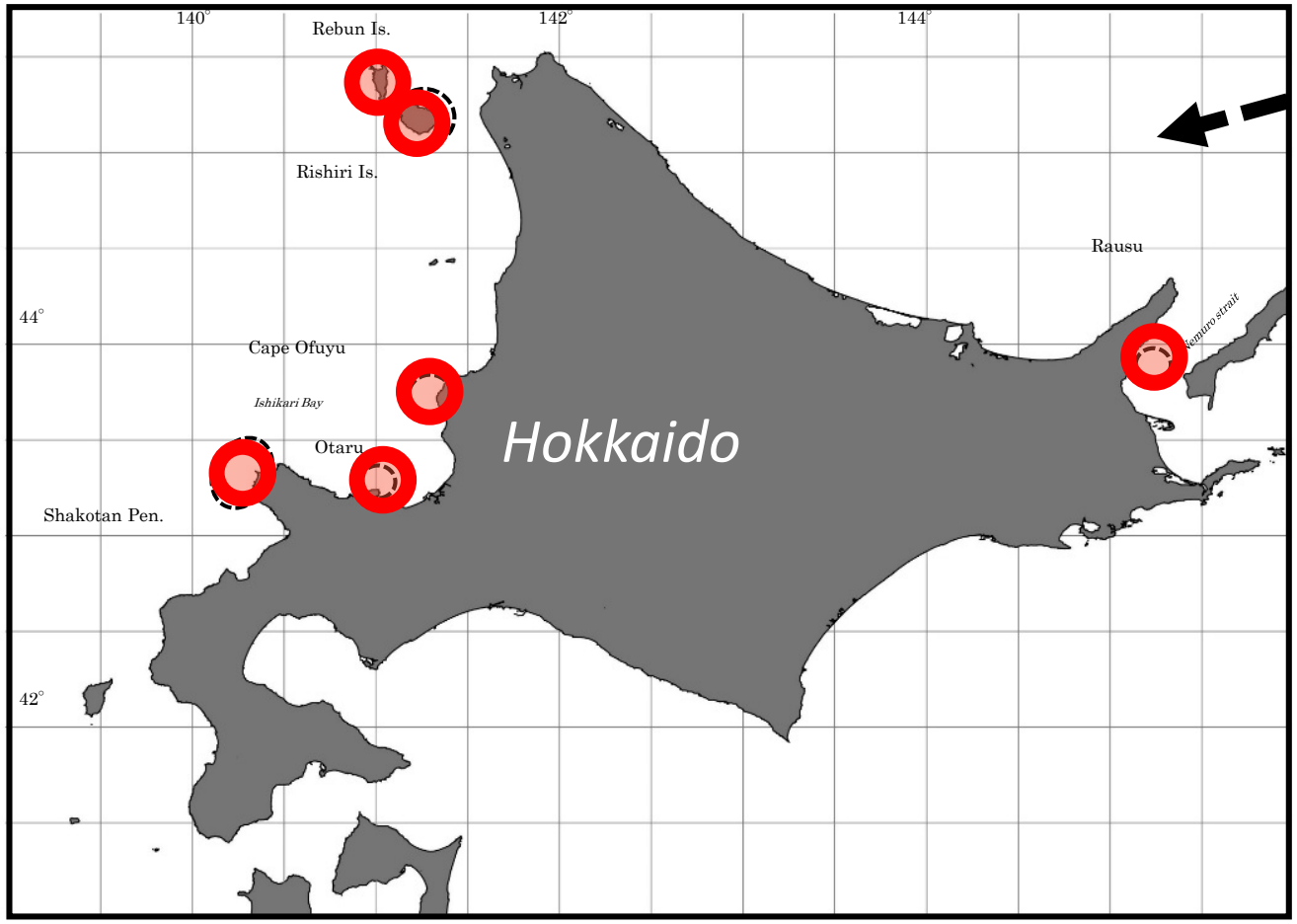
What do they eat?

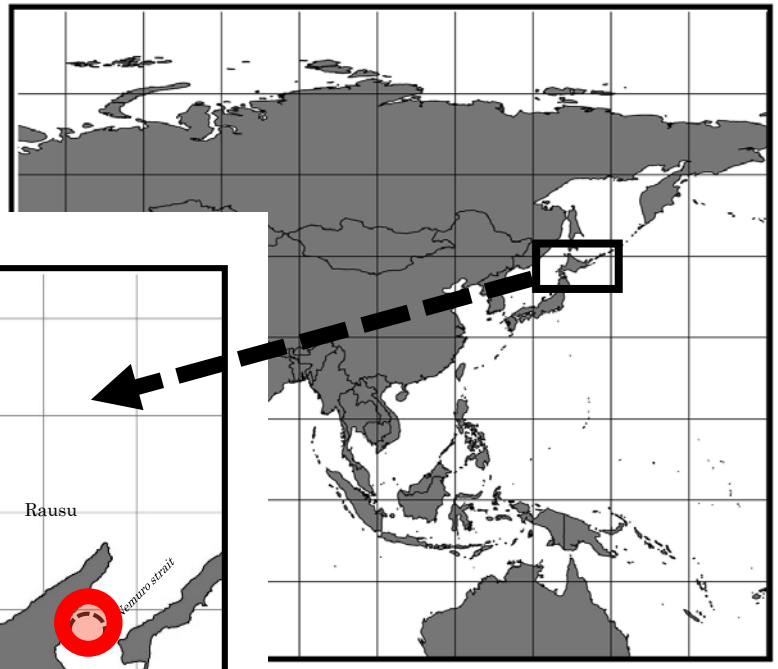
Hokkaido, JAPAN



(samples caught by population culls or entangled in fishing nets)

2005-2016 study area

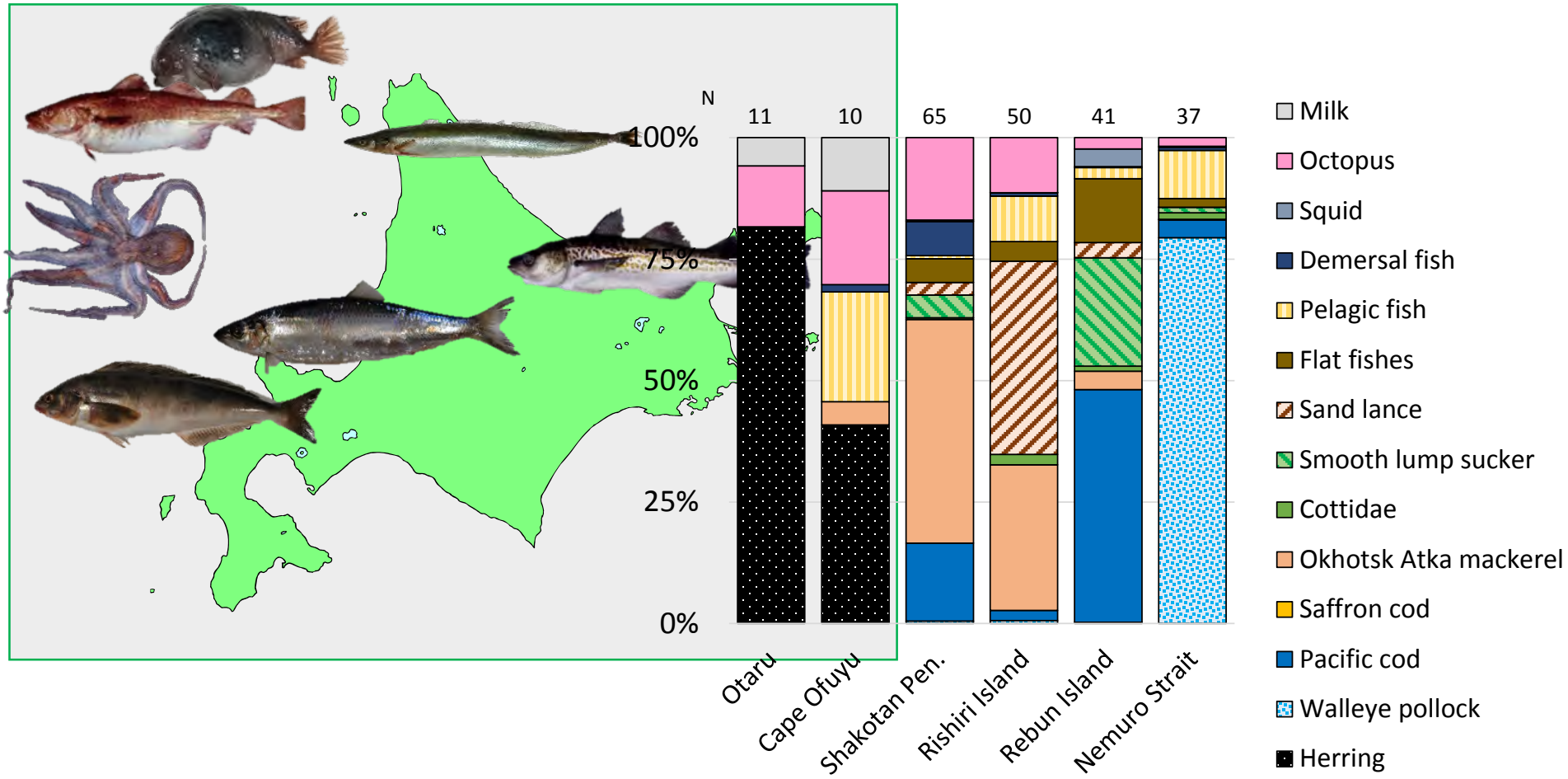




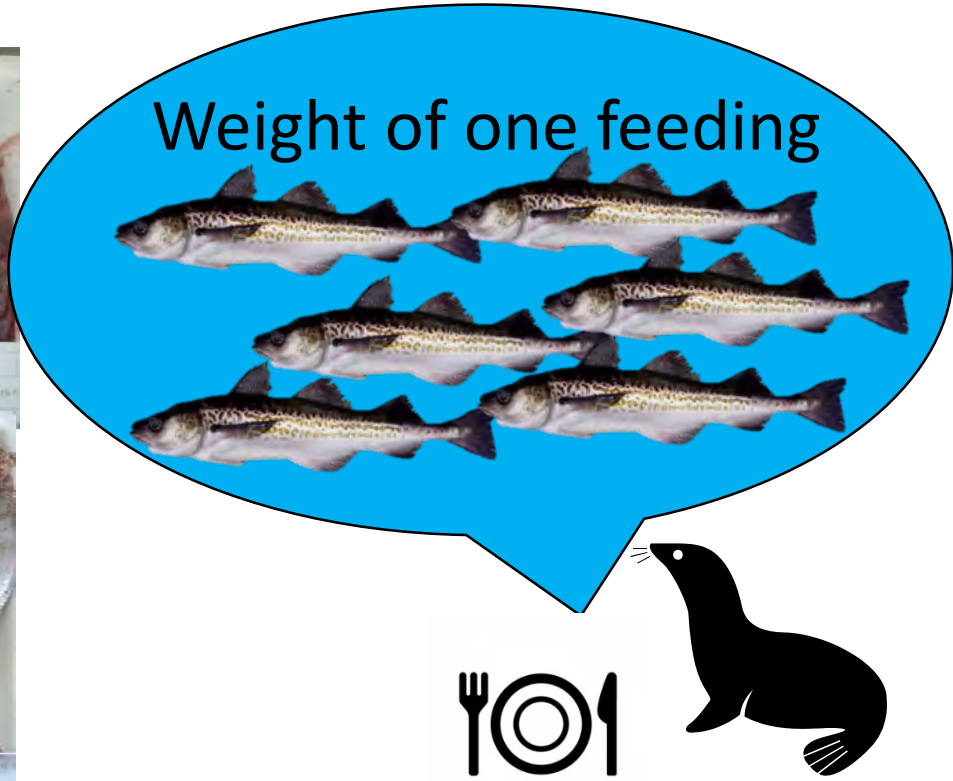
Prey composition of Steller sea lions around Hokkaido, Japan

Prey composition differs between sample sites

*including unpublished data



Aim



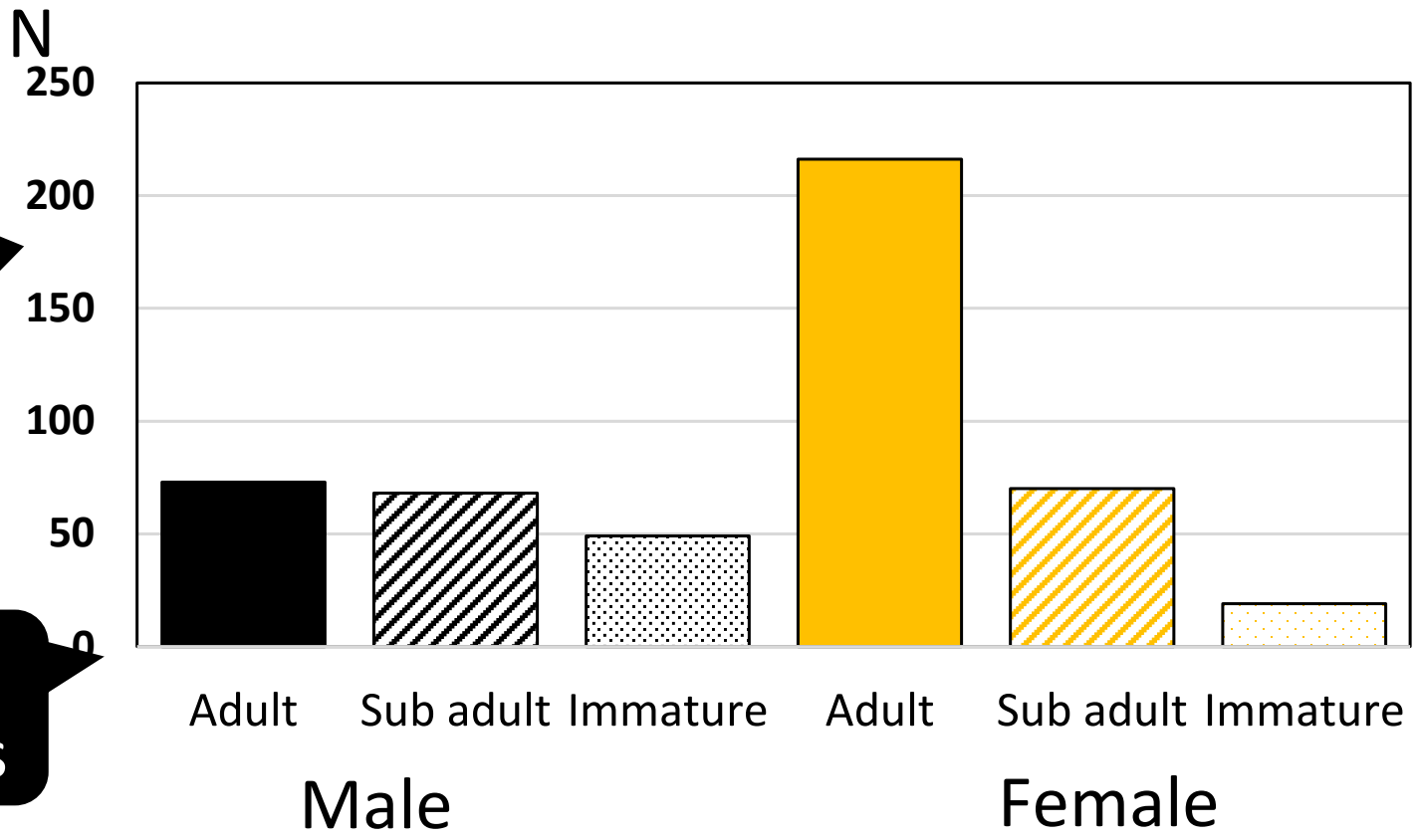
These field data could be useful in comparisons with calculations of feeding rate based on metabolic data.

Materials & Methods

Materials

Total of 495 stomachs collected

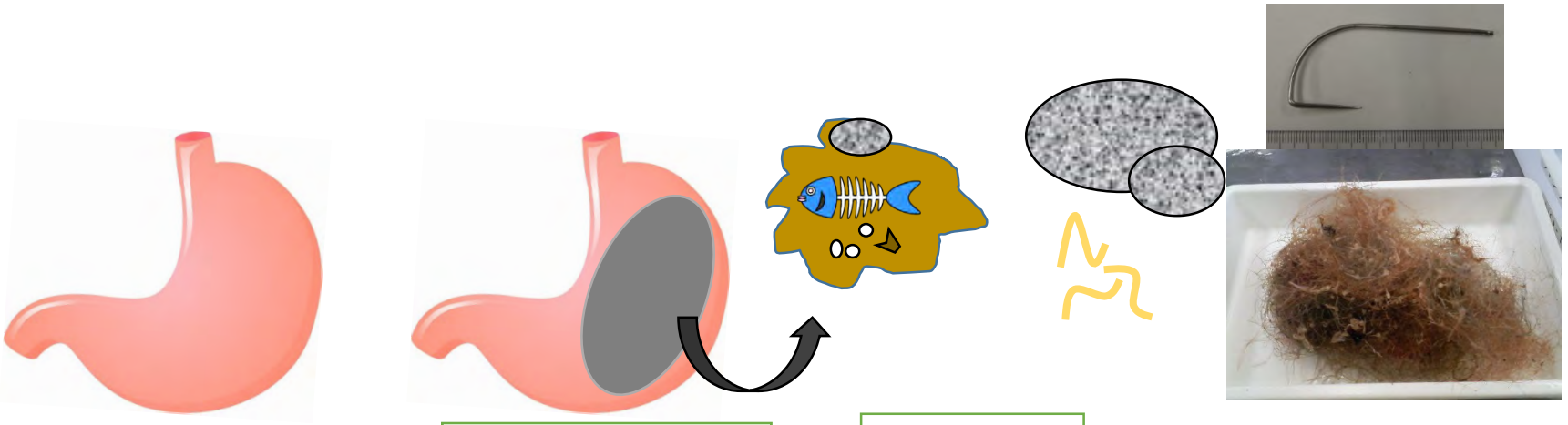
*Including all sampling sites



Materials & Methods

Methods

1. Weight of stomach contents

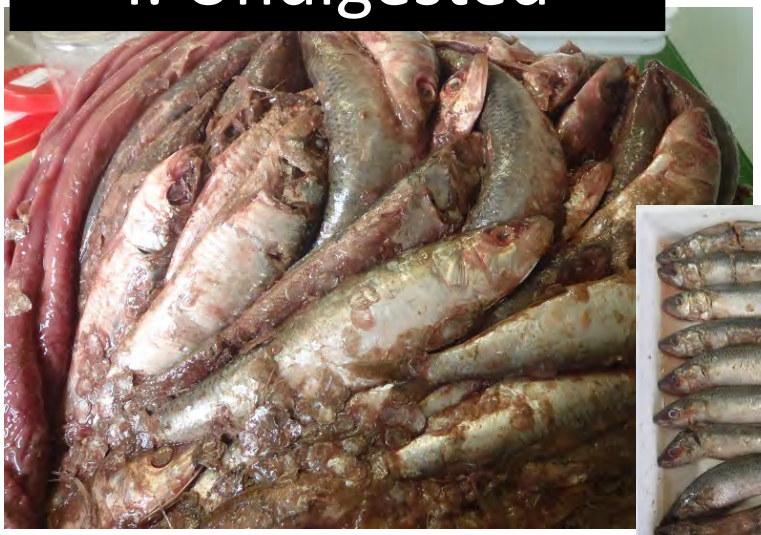


Measure whole stomach with contents **−** Remove contents and measure empty stomach **=** Weight of whole stomach contents **−** Exact weight of non-prey items **=** Real weight of stomach contents

2. Identification of prey species based on shape of undigested fish/cephalopods, bones, otoliths, beaks, etc.

Examples of the Five Digestive Stages

I. Undigested

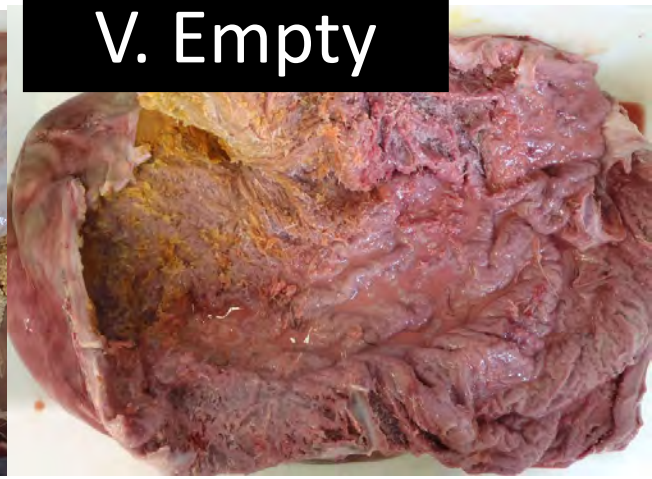


II. Slightly digested

III. Muscle and bone

IV. Traces

V. Empty



Flowchart of method used to reconstruct the weight of prey according to the digestion stage of stomach contents

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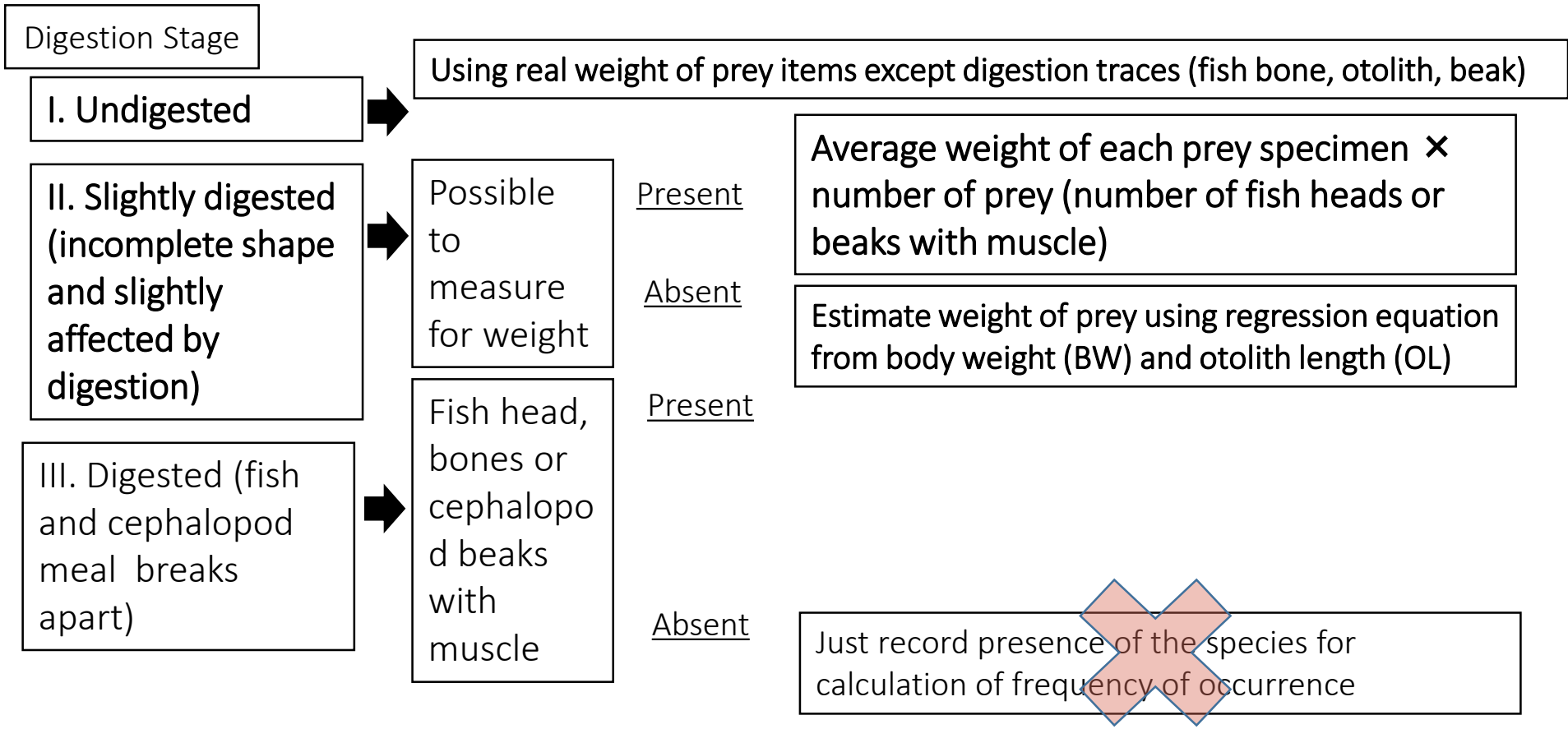
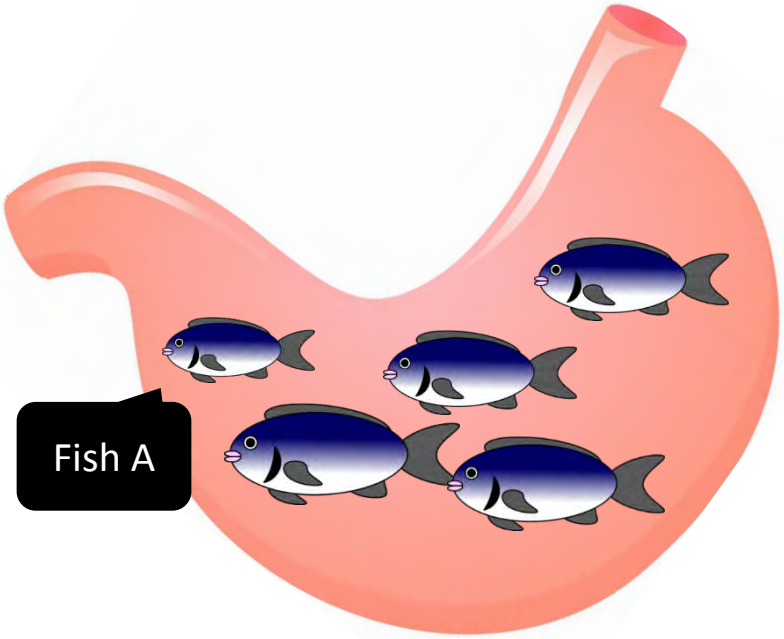
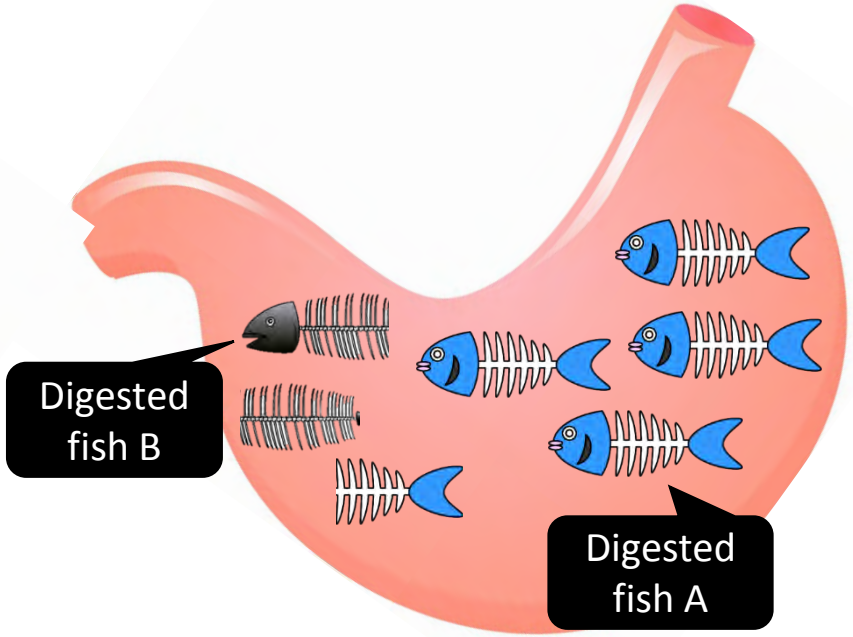


Example of how to determine ‘reconstructed stomach contents weight’

Digestion stage I (undigested)



Digestion stage II, III (slightly digested)



Average weight: ex. 100 g per fish A

100 g × number of heads of fish A (four heads)

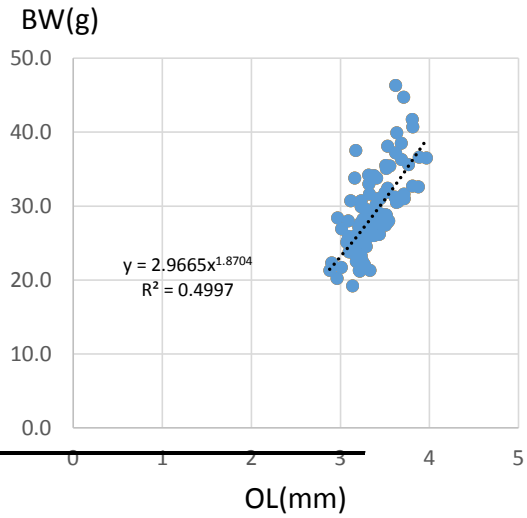
+

Estimated BW of fish B × number of heads of fish B (one head)

*These two stomachs were obtained in the same year.

Equations used in this study to determine the relationship between fish OL and fish BW

Species	Equation	r^2	N	Reference
Pacific herring	$BW = 13.328 (OL)^{1.8779}$	0.862	8	
Japanese anchovy	$BW = 0.0188 (OL)^{5.3122}$	0.744	19	
Pacific cod	FL = 4.51 (OL) - 22.97	0.883	110	Harvey et al. 2000
	$BW = 3E\text{-}06 (\text{Estimated FL})^{3.2331}$	0.916	59	
Walleye pollock	ln BW = 3.72 (OL) - 4.06	0.84	302	Deguchi et al. 2004
Okhotsk atka mackerel	$BW = 6.4238 (OL)^{2.7844}$	0.775	296	
Black edged sculpin	$BW = 0.6403 (OL)^{2.515}$	0.419	24	
Japanese sand lance	$BW = 2.9665 (OL)^{1.8704}$	0.500	100	
Flathead flounder	$BW = 0.1471 (OL)^{4.0606}$	0.849	53	
Pointhead flounder	$BW = 1.1176 (OL)^{2.3764}$	0.554	47	
Dusky sole	$BW = 1.3492 (OL)^{2.8228}$	0.551	20	
Sand flounder	$BW = 27.769 (OL)^{0.8543}$	0.159	12	
Yellow striped flounder (Rausu)	$BW = 1.3461 (OL)^{3.1702}$	0.828	15	
Yellow striped flounder (Japan Se	$BW = 2.8247 (OL)^{2.1631}$	0.613	14	
Cresthead flounder	$BW = 0.6236 (OL)^{3.9857}$	0.827	12	
Blackfin flounder (Rausu)	$BW = 0.8256 (OL)^{2.7406}$	0.529	50	
Blackfin flounder (Japan Sea)	$BW = 1.8323 (OL)^{2.5762}$	0.676	29	



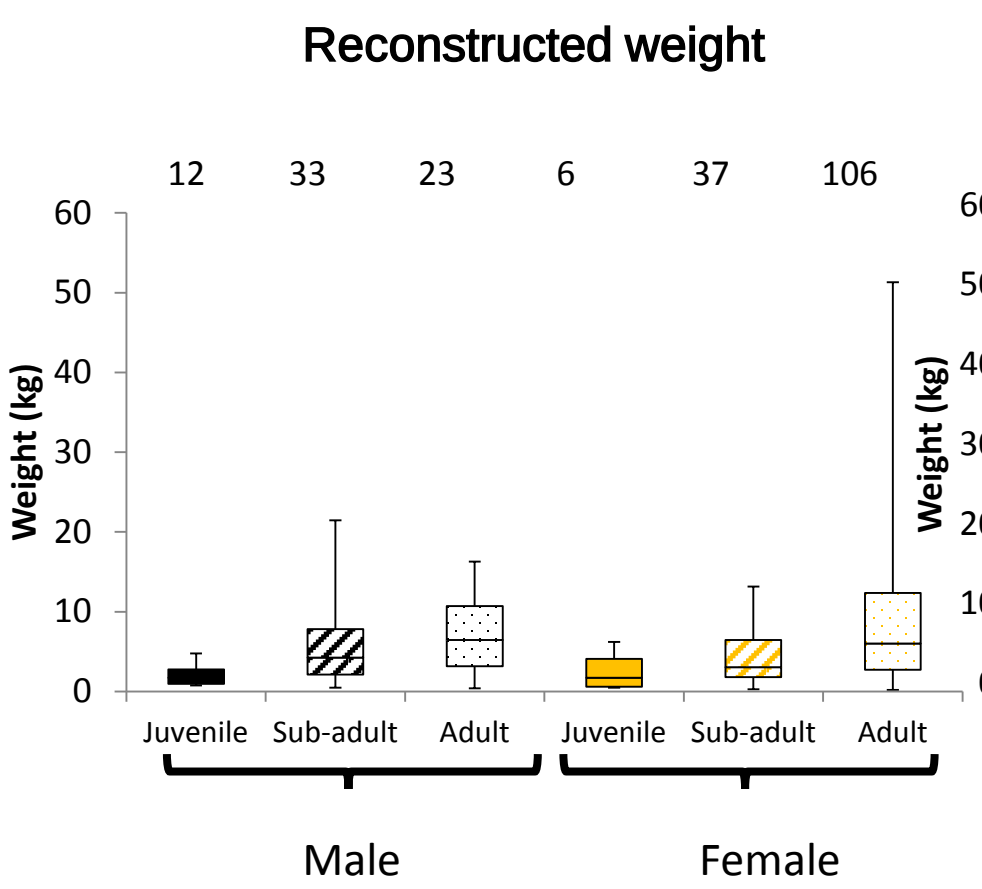
Goto et al. 2017

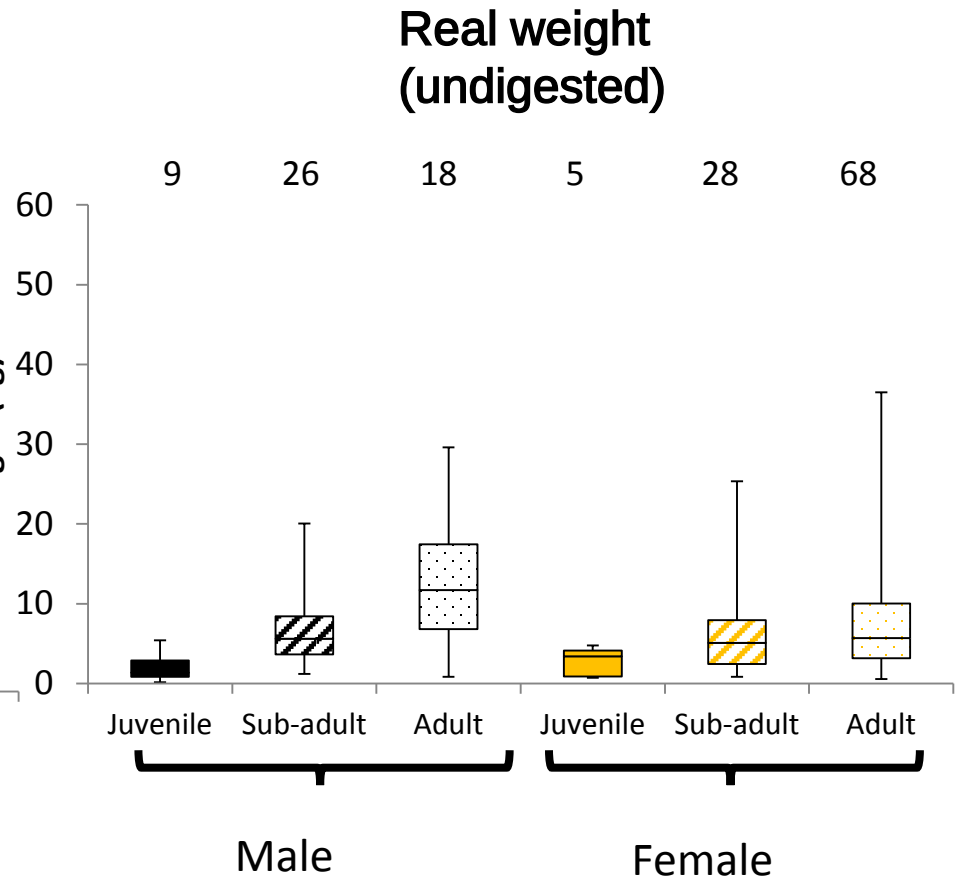
Results

Number of reconstructed stomach contents based on sample weight and undigested/slightly digested samples

	Male			Female			
	Juvenile	Sub-adult	Adult	Juvenile	Sub-adult	Adult	Total
Available to reconstruct	12	33	23	6	37	106	217
Undigested & slightly digested	9	22	15	6	17	12	81

Results of reconstructed weight of stomach contents



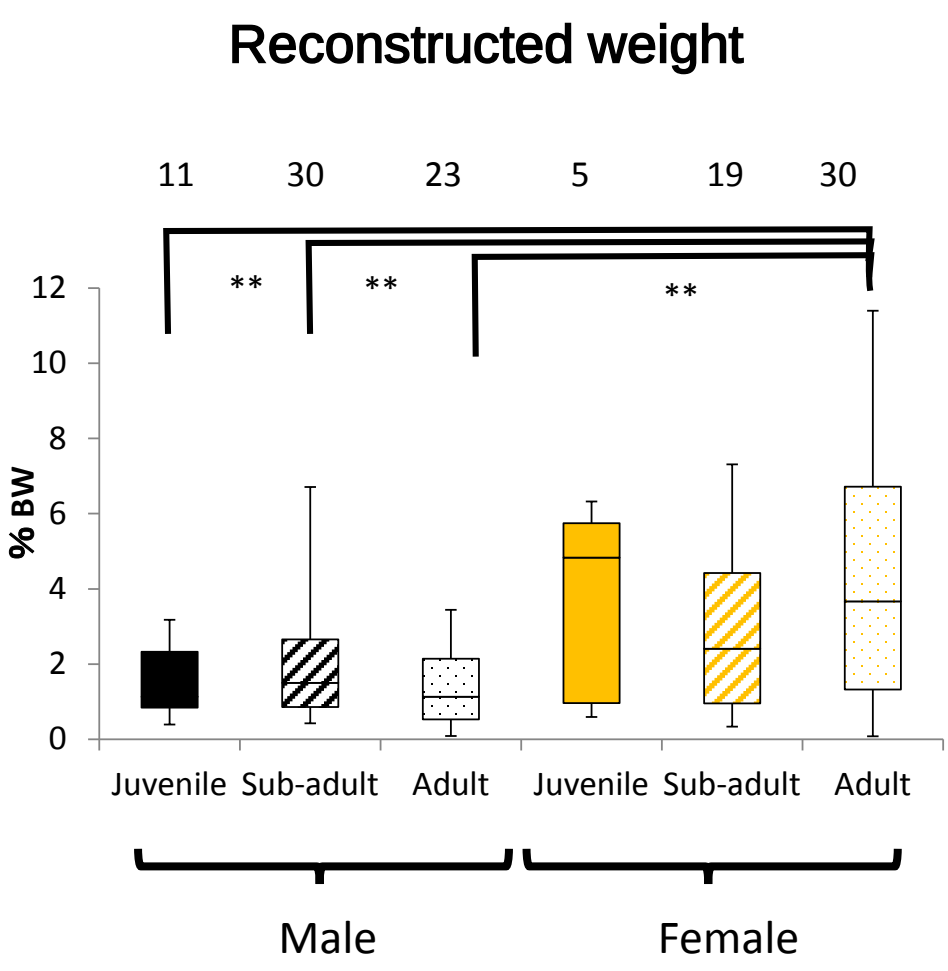


Mean ± SD of reconstructed stomach contents weight (kg) and weight of undigested and slightly digested stomach contents (kg)

	Male			Female		
	Juvenile	Sub-adult	Adult	Juvenile	Sub-adult	Adult
Reconstructed	1.94±1.18	5.19±4.24	7.01±4.94	2.36±2.22	4.13±3.29	9.02±9.30
Real	1.92±1.69	6.74±4.74	12.31±7.11	2.67±1.74	6.30±5.32	7.88±7.33

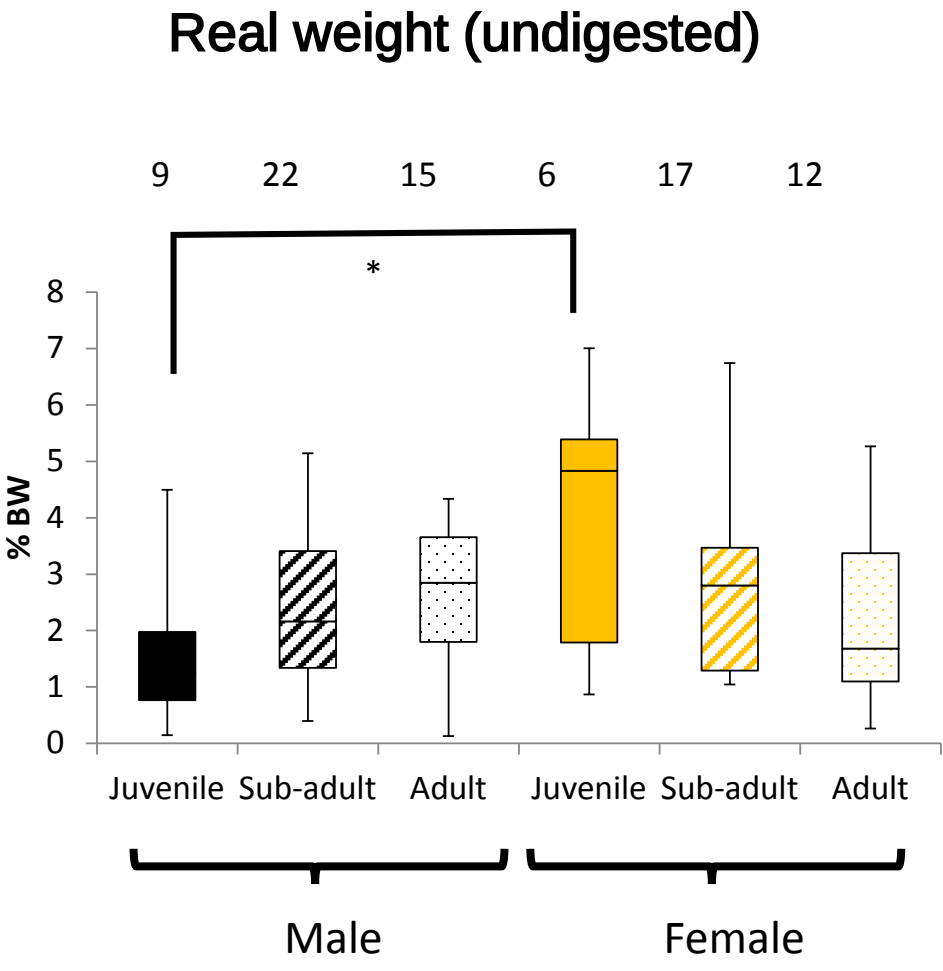
There were no significant differences between reconstructed weight and real weight by sex or growth stage.

Results of reconstructed stomach content weight against BW (%)



P<0.01 ANOVA

** Bonferroni's multiple comparison test



P>0.01 ANOVA

n.s. Bonferroni's multiple comparison test

Percentage of mean ±SD of reconstructed stomach contents weight against Stellar sea lion BW and weight of undigested and slightly digested stomach contents against Stellar sea lion BW

	Male			Female		
	Juvenile	Sub-adult	Adult	Juvenile	Sub-adult	Adult
Reconstructed	1.51±0.93	1.82±1.32	1.34±0.95	3.65±2.53	2.99±2.17	4.18±3.21
Real	1.56±1.27	2.36±1.37	2.57±1.20	4.08±2.22	2.64±1.46	2.26±1.58

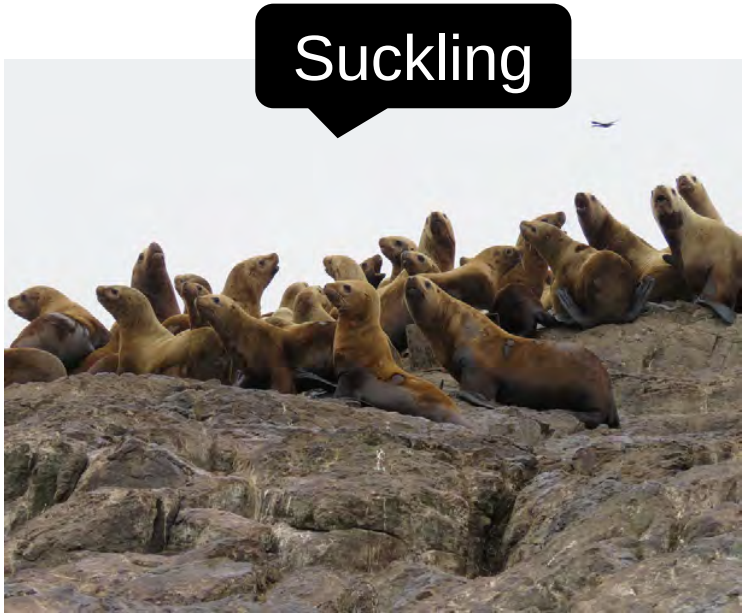
There were no significant difference between reconstructed weight and real weight by sex or growth stage.

Summary

Wintering on the Hokkaido coast

1.5-4.0%

Future study

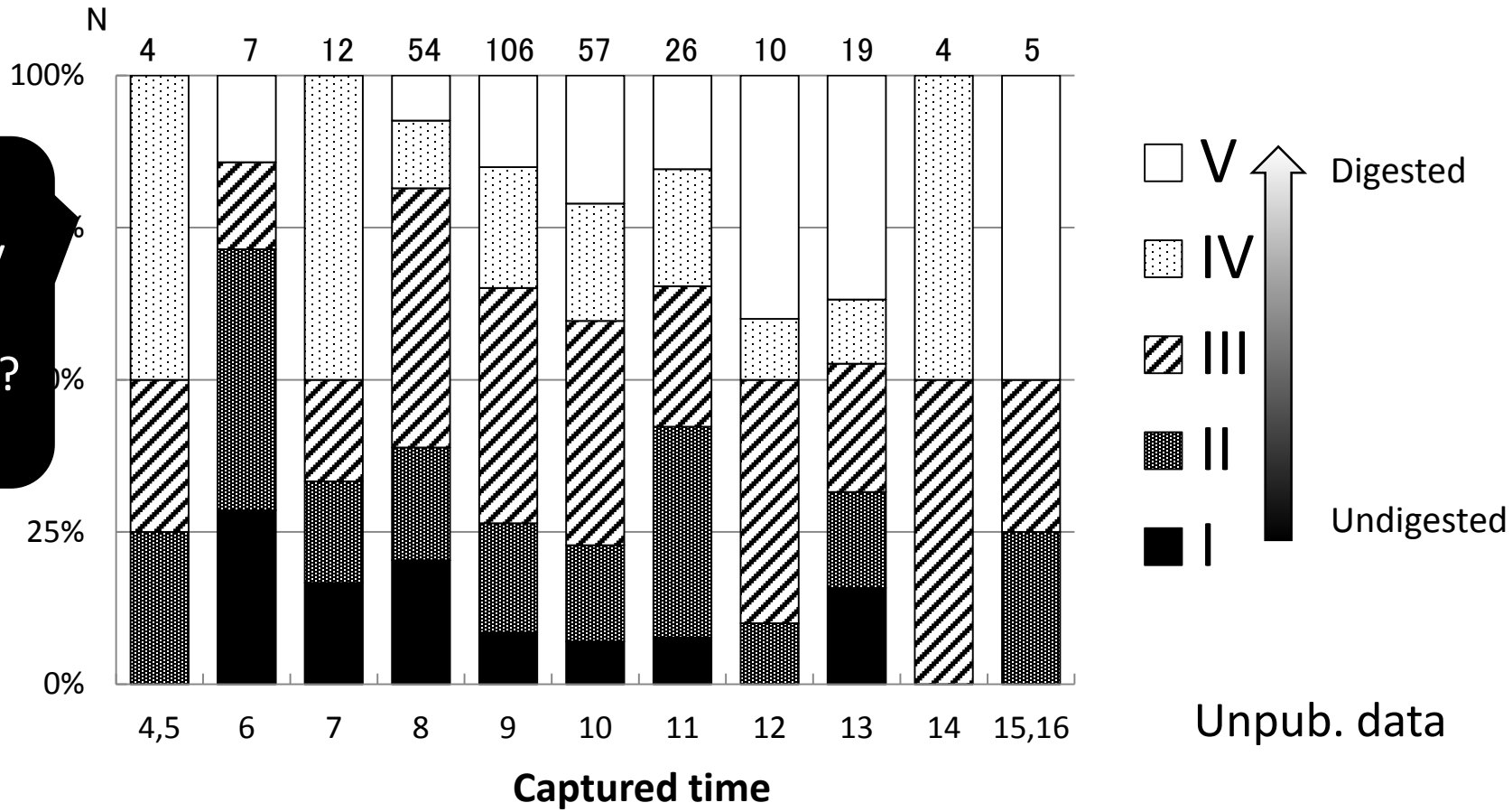


Do they have similar daily energy requirements?

Future study

How many times a day do they feed?

Do they feed anytime?



Unpub. data

Future study …?

Why do they ingest so many stones?

Do we need consider the weight of these stones?

All of these stones were found in a single stomach!

For now,

- In a future study, we will try to collect more data to determine the caloric density of prey.

Thank you!