Preliminary analyses of diet of nine fish species including southern bluefin tuna and ecologically related species

Ministry of Fisheries
New Zealand

Abstract

We conducted a preliminary examination of fish stomach data from around 36,000 fish collected by Ministry of Fisheries observers during 1994 – 2004 in sets that caught Southern Bluefin Tuna (STN). For STN and eight other ecologically related species, we examined the frequency of occurrence empty stomachs and the frequency of occurrence of prey types. Proportions of empty stomachs did not appear to show significant trends through time for any of the nine species, but did vary among species. Observers reported that for most samples, only one prey type was evident in the stomach. Prey-type occurrence appeared to differ between the species. The data were collected opportunistically and we describe the many potential biases that limit the inferences that can be made from analysis of these data.

Introduction

The ecological interactions of fish are considered important in managing the effects of fishing on fish stocks and on associated and dependent species in the marine environment. One of the primary ways to examine interactions between fish species is to examine the diet of fish. Here we present a preliminary analysis of data from fish stomachs collected during fishing for Southern Bluefin Tuna (STN) in New Zealand during 1994 – 2004.

Dietary information can be used to examine whether fish species overlap in their diet, or depend on particular species as a main food source. This requires detailed information about the weight and frequency of occurrence of prey items in the diet. The current study is limited to a cursory examination of prey types found in the stomachs of nine fish species. At this stage methodological limitations with the sampling and analysis preclude conclusions being drawn of the importance of different prey species in the diet of the nine species examined.

Methods

Data collection

Since 1994 Ministry of Fisheries observers aboard tuna longline vessels were instructed to opportunistically record data on stomach contents of fish taken in longline operations. Priority was to be given to tunas and other target species. Because many species are processed at-sea, the collection of this information required relatively little additional sampling effort. The observer instructions are provided in Appendix 1.

Observers characterised the contents of stomachs according to whether they were empty or contained prey items. The prey items were divided into six categories: bait, crustacean (crust), fish, salps, squid and other. The percentage of the stomach contents in each of these groups was noted or the stomach recorded as “empty”. Where fish species or crustacea could be identified, a species code was attributed. Only one fish or crustacean species code was recorded for each stomach. These data were entered and stored in a database.

Data set used for analysis

As the focus of this analysis is on STN and ecologically related species not all records from the database were considered. We have limited our focus to those records taken from STN and other species taken in sets in which STN was caught. We have further refined the data to focus on the nine fish species for which over 100 stomachs had been sampled from 1994-2004. The species included were: albacore tuna *Thunnus alalunga* (ALB), blue shark *Prionace glauca* (BWS), dealfish *Trachipterus trachypterus* (DEA), mako shark *Isurus oxyrinchus* (MAK), moonfish *Lampris gatatus* (MOO), porbeagle shark *Lamna nasus* (POS), Ray’s bream *Brama brama* (RBM), southern bluefin tuna *Thunnus maccoyii* (STN), swordfish *Xiphias gladius* (SWO).

Results and discussion

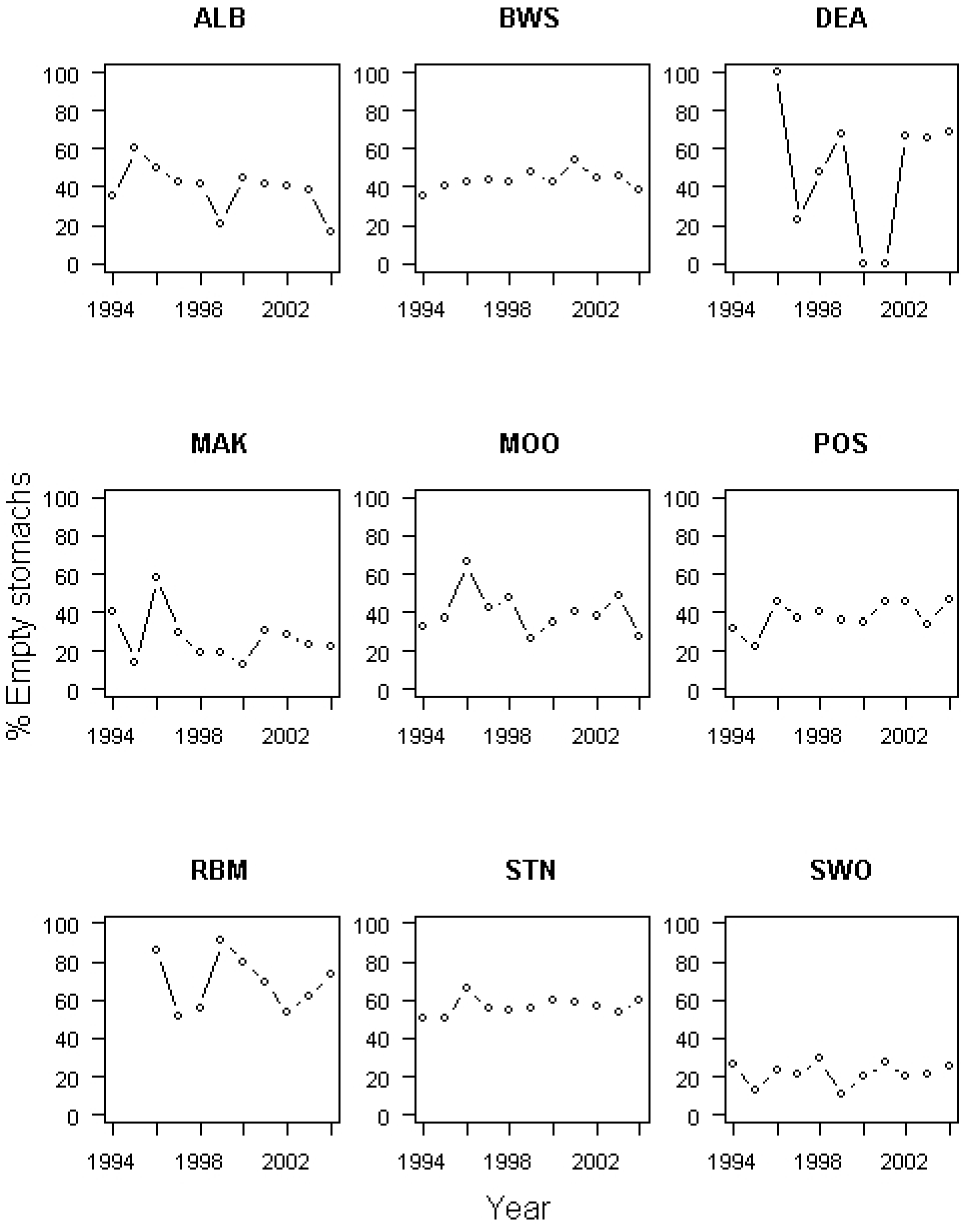
A total of 36633 stomachs were collected for the nine fish species in our study. These were collected during 11 years, with between 5 – 17% of samples being taken in any one year (Table 1).

Table 1. Number of stomachs sampled by year for 9 fish species with totals of stomachs collected for each species and percentage of stomachs collected in each year. The average percentage of empty stomachs for each species is shown on the right.

Fish species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total	Average % empty stomachs
ALB	68	15	289	19	326	62	20	29	15	31	18	892	42
BWS	176	40	1501	472	474	1577	1068	771	556	786	1115	8536	44
DEA	0	0	3	13	135	34	3	4	30	38	38	298	55
MAK	60	21	31	114	106	132	38	26	52	64	59	703	26
MOO	15	51	41	98	475	219	116	83	90	51	43	1282	41
POS	60	41	174	314	458	1175	340	182	121	170	130	3165	38
RBM	0	0	509	68	144	11	5	16	73	493	327	1646	70
STN	2002	1741	212	2250	2267	2639	1610	749	2340	1537	1846	19193	50
SWO	23	8	13	144	169	209	122	59	71	57	43	918	20
Average % of total samples in year for species	7%	5%	8%	10%	12%	17%	9%	5%	9%	9%	10%		

The percentage of empty stomachs for the nine species was examined by year (Figure 1) We noted no consistent trend in the proportions of empty stomachs for any of the species. SWO and MAK had the lowest recorded rates of empty stomachs, while RBM and DEA had the highest rates. There were no obvious trends in the percentage of recorded empty stomach across time. This apparent relationship between the size of fish and the recording of empty stomachs may reflect a real difference among species, or may simply represent a sampling artefact.

Figure 1. Average rate occurrence of empty stomachs for 9 fish species by year sampled.



Prey types in the stomachs containing prey

In examining this data set we recognise that the prey types and prey species recorded by observers may be subject to several important limitations and biases in addition to those biases associated with directed scientific diet studies:

- Prey composition by weight was not recorded so the importance of items to the calorific content of the diet cannot be gauged;
- Some species may be more detectable than others; so important dietary components may be unreported;

- Only one fish prey species identity was recorded for each stomach sample, so bias may have occurred in selecting which species to record;
- Items most likely to be recorded were those which were relatively intact and fresh in the stomachs;
- Prey may be common, yet difficult to identify without specialist training, and are therefore likely to be underestimated;
- Bait (either fish or squid) could have been confused with natural prey times in the reporting;
- There is likely to be a different rate of digestion for different prey items - those comprised of soft tissues such as salps will be digested faster so will be under-represented, while those with hard parts especially fish bones will take longer to digest and therefore "fish" and "crustacea" will be recognisable for much longer.

We examined the prey types recorded in the stomachs that contained prey. The numbers of samples for each of our nine fish species is shown in Table 2.

Table 2. Number of stomachs for each of 9 fish species that contained prey items.

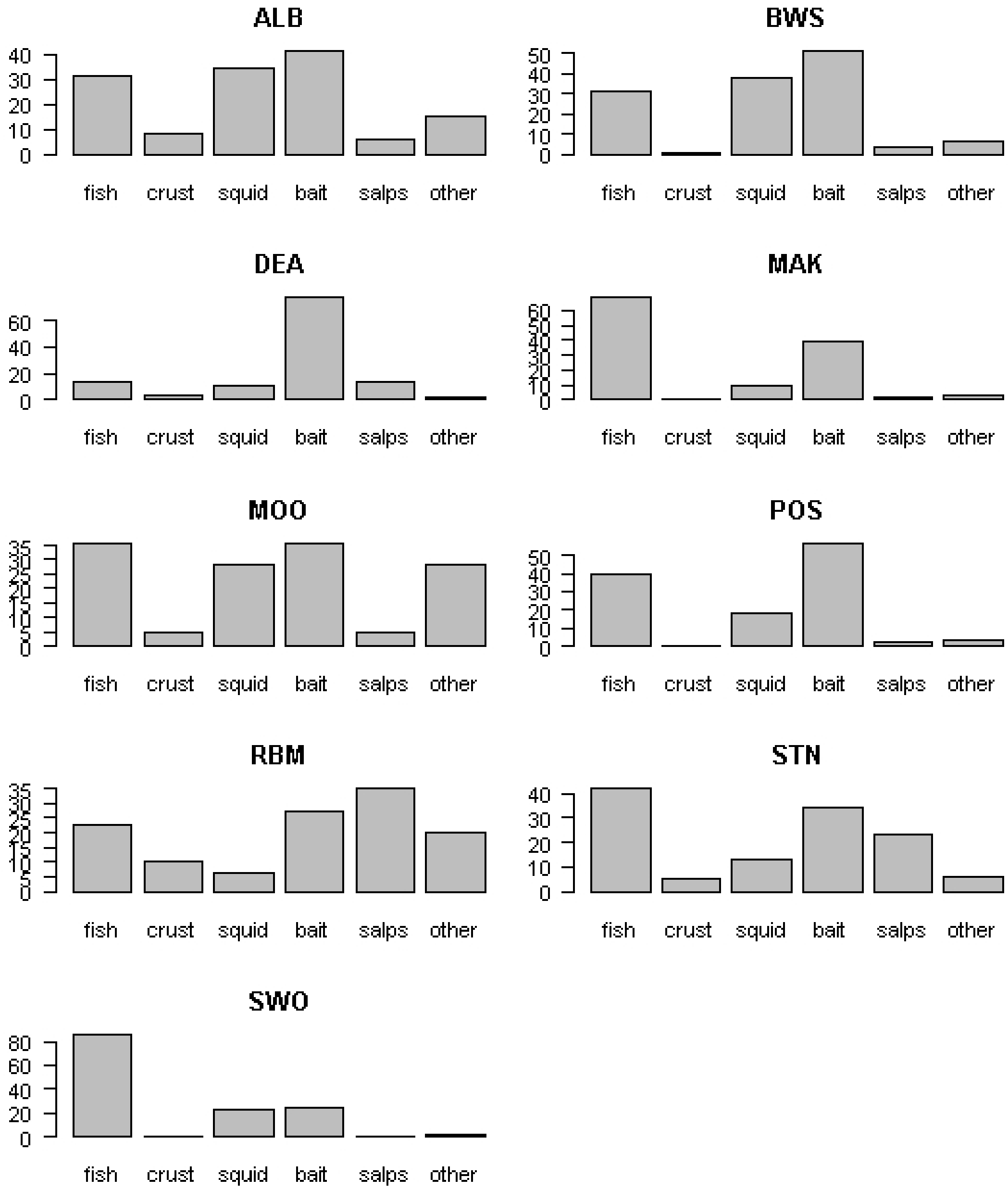
Fish species studied	*ALB*	*BWS*	*DEA*	*MAK*	*MOO*	*POS*	*RBM*	*STN*	*SWO*
Number of stomachs containing prey	517	4755	133	521	761	1953	486	8576	730

We first examined the distributions of prey categories in the raw data, and found that most frequently, observers recorded that a stomach contained 100% of a particular prey type, with the exception of crustacea. For most of the study fish species, crustacea occurred as minor percentages in a high number of stomachs. For a few fish species, the salps and ‘other’ prey categories were found as a minor percentage of a large number of samples. These data are shown in Appendix 2 for each of the 9 species studied. We consider this finding means that the dataset should be interpreted with caution as there are two possible reasons for this pattern: (1) the fish actually do not mix their food, i.e. they only feed on one prey type at a time, or (2) observers may only record one prey type in a stomach unless there are two prey types which are easily identifiable (e.g. something found in association with crustacea). In particular, data may be skewed to show a higher proportion of contents of some prey types than others, while less detectable or poorly described prey-types and prey species may be under represented.

When we examined the relative frequency of occurrence of different prey types reported by observers for each of the nine species studied, we found that bait was the most common prey type found in stomachs, followed by fish and squid (Figure 2). Fish and squid together were the most common prey categories recorded for albacore, blue shark and moonfish, when bait was excluded. Fish alone was most commonly recorded for Mako and porbeagle sharks, southern bluefin tuna and swordfish after bait was excluded.

These results indicate that there may be important differences between species in the prey types they prefer, but more detailed data are required to quantify these differences.

Figure 2. Prey types recorded by observers in 9 species of fish sampled during fishing for southern bluefin tuna. Prey types are fish, crust = crustacea, squid, bait, salps and other. The bars represent the percentage for each fish species that each prey type comprised.



Fish species reported in stomach contents

Where observers noted fish prey, these were identified to prey species level where possible. Observers only recorded one fish prey species for each stomach. The numbers of stomachs in which fish were reported, and the number of these samples where fish prey was identified are shown in Table 3. Due to the small number of samples for albacore, dealfish and Ray's bream, these three species were excluded from further analysis.

Table 3. The number of samples with fish prey reported by observers and the number of samples where fish prey items were attributed a prey species code.

	ALB	*BWS*	*DEA*	*MAK*	*MOO*	*POS*	*RBM*	*STN*	*SWO*
Number of samples in which fish prey was reported	160	1493	19	359	276	772	113	3563	626
Number of samples in which fish prey was identified to species level	25	727	3	154	55	336	8	1249	168

When we examined which fish species had been recorded by observers, we noted that eight main prey species were reported. These species each made up 10% or greater on average of the items identified by observers in the stomachs. The species were albacore (ALB), dealfish (DEA), hake *Merluccius australis* (HAK), hoki *Macruronus novaezelandiae* (HOK), lantern fish *Myctophus humboldti* (LAN), lancet fish *Alepisaurus ferox* and *A. brevirostris* (LAT), lighthouse fish *Photichthys argentus* (PHO) and Ray's bream (RBM). The frequency of occurrence of each of these prey species in the stomachs of six species of fish studied is shown in Figure 3.

Given that significant biases in the fish species reported may have occurred due to the sampling procedure used, it is not possible to provide an assessment of the importance of the prey species recorded by observers in the stomachs of fish sampled in this study. Prey which observers are unable to identify may be the important species in the diet. The information presented in Figure 3 indicates that there may be important variation or dietary selection between the fishes studied. However, more detailed data, including comprehensive analyses of the dietary components of each stomach, count frequency and wet weight of individual prey items is required to address questions of dietary overlap or competition between species.

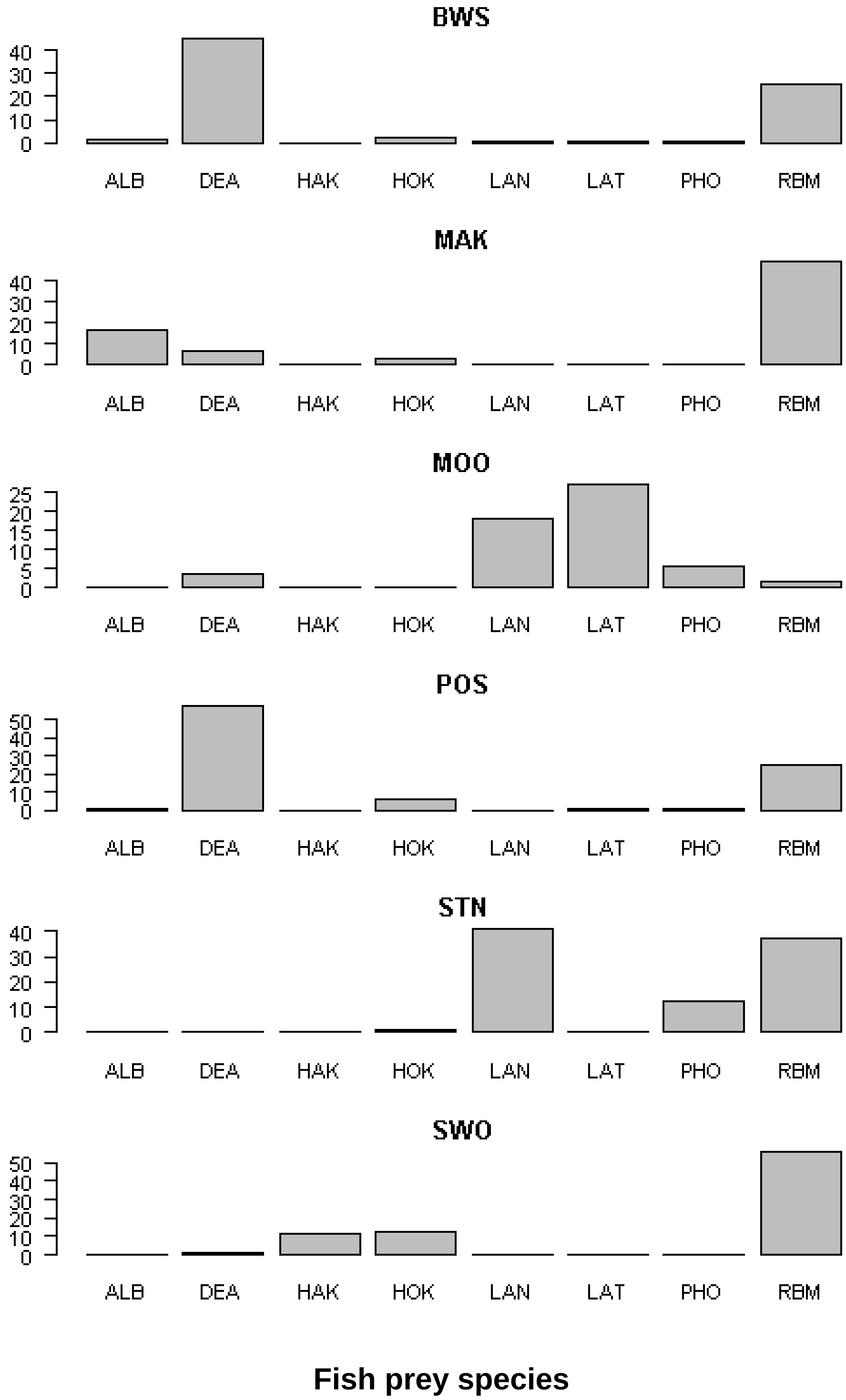
Conclusions

While these data can be collected easily and with minimal cost, there are a number of features of these data and the way in which they are collected and reported that make it difficult to make solid inferences from them. Notwithstanding these difficulties there are some interesting patterns in the data, in particular differences among species, that may be indicative of ecological differences among ecologically related fish species taken in New Zealand STN longline fishery. A more detailed examination of the sampling protocols will now be undertaken to determine the nature and extent of future collection of these data.

Acknowledgements

The Ministry thanks the many observers who have collected these data over the past 11 years.

Figure 3. The percentage of stomachs for which a given fish prey species was recorded by observers (when a fish prey species was identified) in the stomachs of six fish species sampled during fishing for southern bluefin tuna in New Zealand waters.



Appendix 1: Observer instructions for collecting stomach contents data

STOMACH SAMPLES

Purpose of the stomach samples log

This form is used for the recording of fish stomach contents. It is also used for recording instances of fish entangled in plastic.

Sample the stomach of all species - a minimum of 10 of each species per vessel trip. There is no limit, so once this minimum has been reached, sample more stomachs as time permits, giving priority to the target species and other tunas.

The following section outlines how to complete this form accurately. It is extremely important that you read this section thoroughly before you begin recording.

Completing The Form

Trip number	Record the **trip number** assigned to your trip at your briefing
Set no.	Record the **set number** (numbers should correspond to set log, haul log and deck log)
Observer name	Record your **name**
Vessel name	Record **vessel** name

For each specimen sampled record the following:

Sample no. — Record the **sample no.** used on the deck log

Stomach contents — Enter the appropriate percentages (1-100%) in the boxes, for food contents in the stomach:

Fish %
Crustaceans % (e.g. prawns, shrimps, krill, crabs)
Squid %
Bait %
Salps %
Other/Unknown %

or place an **E** in the box **Empty**, if there is no food in the stomach.

The category Unknown/Other is to be used for any other type of food in the stomach. This includes unrecognisable partly digested remains, and material that is recognisable but does not fit into one of the other categories (e.g. Nautilus, Octopus). Plastic is also to be included as “Other”.

Plastic type Record any **Plastic** that is either internal (ingested), **I**, or external (tangled around the fish), **E**, in the boxes headed I or E, using the plastics codes shown on the reverse of the stomach log form, and below. Use the letter code corresponding to the appropriate plastic type and record it in the appropriate column. Any **O**ther plastic types should be described (in Comments)

Record any other specimens that are observed with external plastic - such as a free swimming shark or seal with a bait band around its girth. Record anything that is seen but does not come onboard in the diary

Plastics Codes
Code Plastic type S bait **S**trapping G plastic **G**arbage bags W clear plastic bag **W**rap M **M**onofilament line R nylon **R**ope N **N**etting O **O**ther

Comments

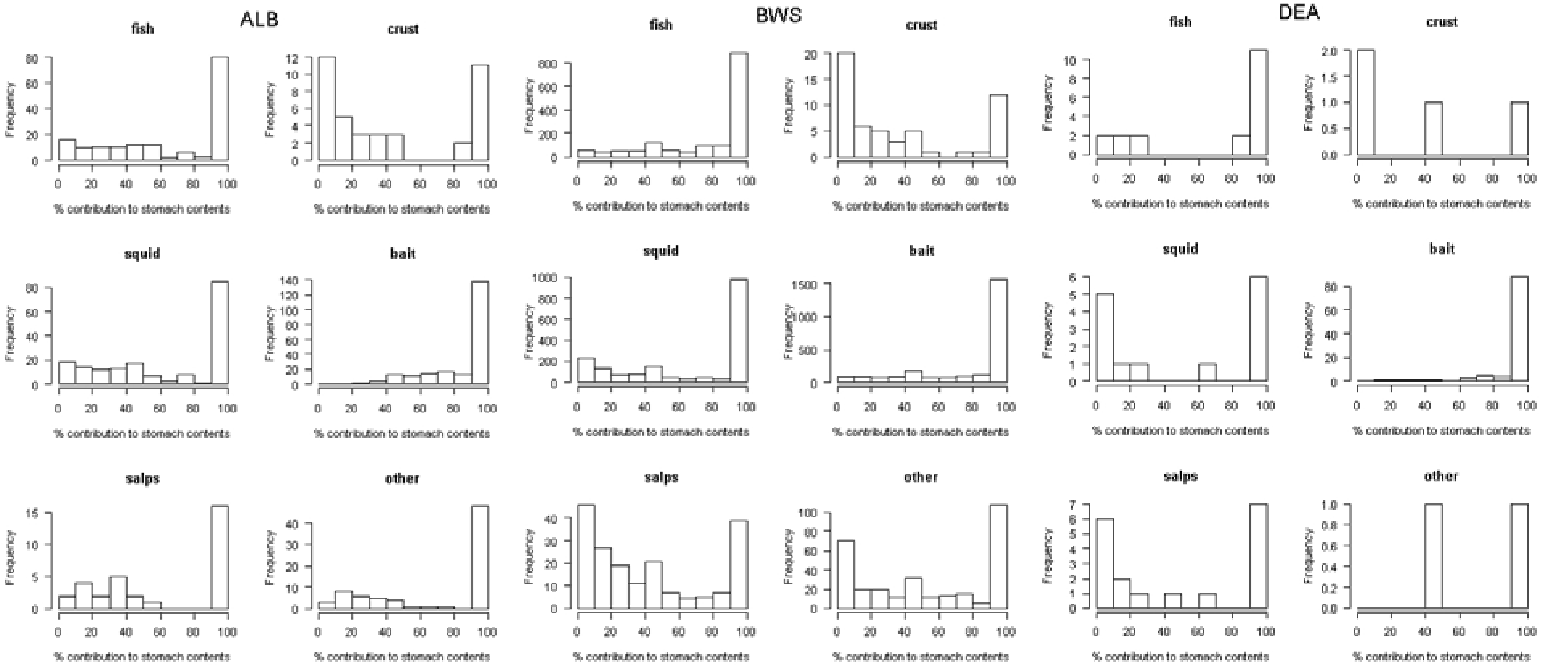
Record any notes as appropriate. Please record:

- The bait type (e.g. squid) where Bait % was recorded
- The species of fish where recognisable
- Type of crustacean where recognisable (e.g., "prawn", species identification is not expected)
- Recognisable food types included under Unknown %

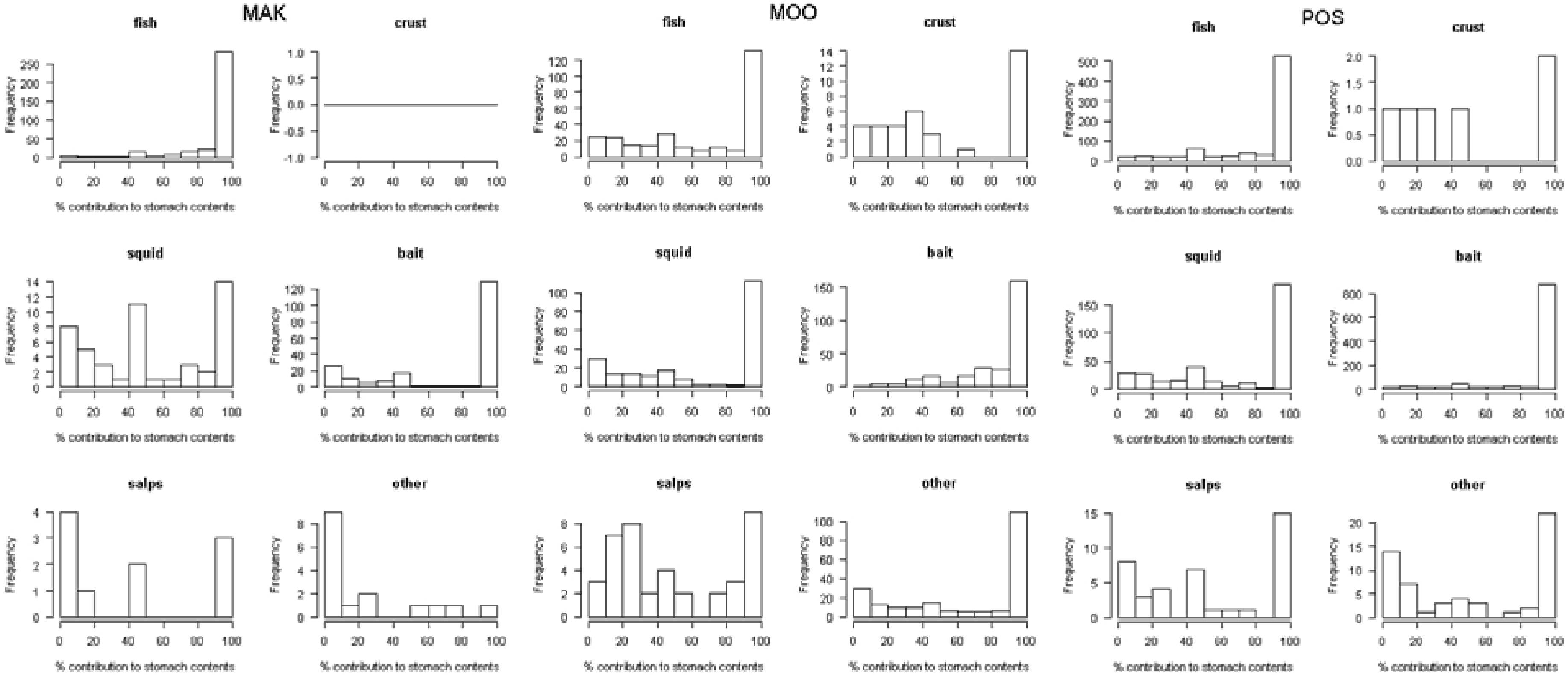
Note: Remember to complete ***page ___ of ___*** *at the top of the page*

NOTE: • *sample code* ***5*** *refers to checking the stomach contents and recording the information on the stomach log* • *sample code* ***21*** *is to be used where stomach contents are kept. Stomach contents may be kept for further identification, or if something rare or of particular interest (e.g., Plastic) is encountered in a stomach*

Appendix 2. The distributions of different percentages of six prey types (fish, crust = crustacea, squid, bait, salps and other) in the stomachs of albacore (ALB) (left hand columns), blue shark (BWS) (central columns) and dealfish (DEA) (right hand columns) sampled during fishing for southern bluefin tuna. The frequency distribution of the percentage contribution of each prey type to the stomach contents for individual samples is shown. Zero percent bars are omitted.



Appendix 2 continued. The distributions of different percentages of six prey types (fish, crust = crustacea, squid, bait, salps and other) in the stomachs of mako shark (MAK) (left hand columns), moonfish (MOO) (central columns) and porbeagle shark (POS)(right hand columns) sampled during fishing for southern bluefin tuna. The frequency distribution of the percentage contribution of each prey type to the stomach contents for individual samples is shown. Zero percent bars are omitted.



Appendix 2 continued. The distributions of different percentages of six prey types (fish, crust = crustacea, squid, bait, salps and other) in the stomachs of Ray's bream (RBM) (left hand columns), southern bluefin tuna (STN) (central columns) and swordfish (SWO) (right hand columns) sampled during fishing for southern bluefin tuna. The frequency distribution of the percentage contribution of each prey type to the stomach contents for individual samples is shown. Zero percent bars are omitted.