# FATTY ACID ANALYSIS OF THE DIET OF LEACH'S STORM-PETRELS

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**Fatty acid analysis of the diet of Leach's Storm-Petrels**

by

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A thesis submitted to the

School of Graduate Studies

in partial fulfillment of the

requirements for the degree of

Master's of Science

Cognitive and Behavioural Ecology Program

Memorial University

October, 2007

St. John's Newfoundland

*Your file Votre référence*
*ISBN:* 978-0-494-55275-9
*Our file Notre référence*
*ISBN:* 978-0-494-55275-9

**Abstract**

Leach's Storm-Petrels (*Oceanodroma leucorhoa*) display variation in foraging durations and forage at a wide range of distances from the colony, preying on species in both neritic and pelagic environments. Diet of Leach's Storm-Petrel adults and chicks may contain different proportions of different types of prey due to forging trip lengths and digestion. Fatty acid signature analysis was used to analyze the diets of Leach's Storm-Petrel parents and chicks. Lipids were extracted from stomach regurgitations, bird tissues and prey items. Multivariate techniques were used to examine the differences between groups (i.e. parents and their chicks, males and females, and breeding years) in fatty acid signatures of adipose tissue samples.

Physical properties of Leach's Storm-Petrel regurgitate were found to be significantly different between the incubation and chick-rearing periods. Significant differences in fatty acid signatures of Leach's Storm-Petrels were found between adults and their chicks and breeding years. Fatty acid signatures were then compared to a library of individually discernable fatty acid signatures of potential prey items within a new dietary reconstruction model, and estimates of prey composition were calculated. Fish and crustaceans were dominant prey types depending upon the pre-calculated calibration coefficients that were used in the model. Crustacean species were shown to be more significant to dietary composition than previous stomach content estimates have calculated. Significant differences were observed between prey composition estimates of adults and their offspring, but no significant differences were found between the sexes. Adults tended to consume more pelagic prey and fed a higher proportion of neritic prey to their offspring.

**Acknowledgements**

First off I'd like to thank Bill Montevecchi and Chris Parrish for their long term support and patience with this endeavor. Bill pulled me into Newfoundland with his love of the outdoors, and Chris kept me there with the undying need to keep my samples running in his lab. They provided a roof over my head, food in my stomach and mentorship that has enlightened me of myself and the world of science. My thanks also go out to Sara Iverson for her assistance with modeling and editorial input, Wade Blanchard for his assistance in performing the QFASA modeling simulations and Greg Robertson for his theoretical and statistical input as well.

The Graduate School and Ocean Science Centre at Memorial, and the Newfoundland Department of Tourism Culture and Recreation deserve my thanks for providing finances and facilities for this project.

My thanks go out to the members of the Montevecchi and Parrish laboratories whose support and advice were significant in the completion of my thesis. In particular I'd like to thanks Jonathan Kehoe and Tim Alkanan, whose horse trading in the lab got me through some tough analytical spots.

I'd like to also thank my parents who helped me to get to Newfoundland in the first place and who have supported me constantly on this long and winding trek. You have always be appreciated, even if I don't say it out loud often enough, and I will always be appreciative for everything you do

Second to last I'd like to thank my beautiful wife, Nikki. You came all the way to Newfoundland from warm and sunny Arkansas to let me pursue my dream. I know

you'll never forgive me for that but I know that you made the best of it and I know it will always be a part of our lives that we'll cherish and hold dear.

Finally I'd like to thank the person for whom this thesis was finally finished, my daughter Anna. You'll never know how big a part you played in this whole drama but you were the one who put my nose back to the grindstone, again and again. I will be eternally grateful to you for the lessons in life that you've taught me in the first four years of your existence whether you were inside or outside your mother. You are a blessing, and I will love you forever because of it.

## Table of Contents

## List of Tables

## List of Figures

## List of Abbreviations

ALC – alcohol

AMPL – acetone mobile polar lipid

BAME – bacterial acid methyl ester

FA – fatty acid

FAME – fatty acid methyl ester

FASA – fatty acid signature analysis

FFA – free fatty acid

FID – flame ionization detection

GC – gas chromatograph

GPS – global positioning system

HC – hydrocarbon

KET – ketone

MANOVA – multiple analysis of variance

PCA – principal components analysis

PL – polar lipid

PUFA1 – polyunsaturated methyl ester #1

PUFA3 – polyunsaturated methyl ester #3

QFASA – quantitative fatty acid signature analysis

SE – steryl ester

ST – sterol

TG – triaclyglycerol

TLC – thin layer chromatography

WE – wax ester

## List of Appendices

# Chapter 1 - Thesis Introduction

## 1.1 General life history of Leach's Storm-Petrels

Leach's Storm-Petrels (*Oceanodroma leucorhoa*) are small (~45-50 g), pelagic seabirds that spend most of their lives foraging in deep water along the continental shelf (Huntington *et al.*, 1996). They are the smallest and most abundant seabird breeding in the northwest Atlantic (Montevecchi *et al.*, 1992), and more than half of the world's population (~ 8 million breeding pairs) nest on islands on the coast of Newfoundland from June to September (Huntington *et al.*, 1996). Pairs dig burrows approximately half a meter deep, preferably in soft, well drained peaty soil (Stenhouse & Montevecchi, 2000) which provides protection from avian predators and likely good insulation from temperature fluctuation.

The female lays a single egg which is about 20% of her body mass (Montevecchi *et al.*, 1980) and both parents alternate incubation with foraging every 2-3 days. During incubation, parents subsist on concentrated oil (i.e. stomach oil), stored in the proventriculus that is digested selectively from prey items caught on the previous foraging bout (reviewed by Warham, 1977; Place *et al.*, 1989). Once chicks hatch and attain homeothermy, parents assume continuous foraging bouts and return to the colony at night with a partially digested slurry of prey and stomach oil. Stomach oil has been shown to be an excellent source of calories that also produces high amounts of heat and water (Warham *et al.*, 1976; Warham, 1977; Clarke & Prince, 1980). Most chicks (86%) are fed by at least one parent each night, but the duration of a parent's foraging trip can range between 1 and 5 days (Ricklefs *et al.* 1985).

This rate of chick provisioning of lipid loaded meals causes rapid weight gain in chicks (Warham, 1977; Roby, 1991; Schultz & Klomp, 2000; Hamer *et al.*, 2000; Quillfeldt & Peter, 2000; Reid *et al.*, 2000). Lipid rich food loads, rapid weight gain and extended post-natal development (Warham, 1977; Quillfeldt & Peter, 2000; Mauck & Ricklefs, 2005) are characteristic adaptations of the Order Procellariiformes. The only exception to this is the Family *Pelecanoididae* which do not produce stomach oil (Roby, 1991; Roby *et al.* 1997). Stomach oil provides a substantial portion of chick diets (Klages *et al.*, 1990; Obst & Nagy, 1993; Roby *et al.* 1997) and when not supplied to the chick can be detrimental to chick growth (Roby *et al.* 1997). Leach's Storm-Petrel chicks accumulate lipid reserves at a rate of 0.4 g/day and, over a breeding season, have been recorded to accumulate 35 g of lipid or more since some chicks have been found to weigh over 100 g (Ricklefs *et al.* 1980a). Excess adipose tissue is usually lost in the final weeks before fledging, which occurs in mid to late September (Ricklefs *et al.* 1980b).

### 1.2 Foraging behaviour of Leach's Storm-Petrels and other Procellariiformes

Leach's Storm-Petrels, like many Procellariiformes, vary the length of post-natal foraging trips (1-5 nights; Ricklefs *et al.* 1985) and are seen sporadically foraging 100-300 km (shelf edge) offshore (personal observations). A primary reason for the great distance from shore where they forage may be to avoid avian predators such as Great Black-backed (*Larus marinus*) and Herring Gulls (*L. argentatus*) that have been observed foraging up to 30 km from shore (personal observations). Estimated travel time for a direct flight of 300 km, would take 8.1-11.4 h at 7.3-10.4 m/s (estimated flight speed for Wilson's Storm-Petrel *Oceanites oceanicus*: Pennycuick, 1997) and therefore it would

not be energetically efficient to travel on a single day foraging trip. Different lengths of trips are considered to correspond to different foraging areas in some species of Procellariiformes (Weimerskirch *et al.* 1993, 1994; Sagar & Weimerskirch, 1996; Booth *et al.* 2000), and possibly to differences in prey collected (Chaurand & Weimerskirch 1994). Satellite tracking has shown that Wandering (*Diomedea exulans*; Weimerskirch *et al.* 1993) and Southern Buller's Albatross (*D. bulleri bulleri*; Sagar & Weimerskirch, 1996) use long trips to forage in waters over the shelf break and continental slope (pelagic environment), and short trips to forage in waters over the continental shelf (neritic environment). Long trips have been shown to be associated with lipid rich prey used for both self-provisioning and offspring provisioning while short trips are used primarily for chick provisioning (Little Shearwaters *Puffinus assimilis*: Booth *et al.* 2000; Wandering Albatross: Weimerskirch *et al.*, 1994, 1997). Wandering Albatrosses in the Crozet Islands feed more neritic prey (squid; 72%) to their chicks than pelagic prey (fish, 24%) as a result of this divergence in trip length (Weimerskirch *et al.* 1997). Although adult prey consumption was not determined in that study, adults did gain more mass on long trips than on short ones. If this pattern were to hold in Leach's storm-petrel, then the chick would receive more neritic than pelagic prey and the reverse would be true for the adult.

Male and female Wandering Albatrosses tend to forage in different areas (Weimerskirch *et al.* 1993, 1997) with different trip lengths (Weimerskirch 1995) and provide different amounts of food for the chick (Berrow & Croxall, 2001). This difference in resource allocation between males and females is considered to be dependent upon differences in life history (i.e. sexual dimorphism), body condition, and

long-term chick investment. Leach's Storm-Petrels show little sexual dimorphism compared to other species of Procellariiformes (Shaffer *et al.*, 2001) that exhibit sex differences in prey selection and foraging locations. Differences in foraging locations could also lead to differences in dietary intake between males and females. However, since there are no means of determining locations of foraging trips (Leach's Storm-Petrels are too small to carry goepositioning devices) and because of threats from gull predators at nesting colonies (Bryant, 1993; Stenhouse *et al.*, 2000), individual trip times do not necessarily reflect foraging activity. Hence, dietary studies can shed light on these aspects of the foraging ecology of Leach's Storm-Petrels.

### 1.3 Prey of Leach's Storm-Petrel and fatty acid signature analysis

Leach's Storm-Petrels are pelagic planktivores/piscivores that feed at the surface in both the neritic and pelagic environment. This foraging pattern allows for a wide breadth of potential prey that vary throughout their breeding range in the northwestern Atlantic (Linton, 1978). Linton (1978) described differences in predation on amphipods and euphausiids moving between a colony in the middle of Leach's Storm-Petrels' breeding range (Middle Lawn Island, NL, Canada) and one near its southern extremity (Pearl Island, NS, Canada). These differences were considered to be due to prey availability rather than prey selection (Linton, 1978).

Estimates of fish composition, primarily myctophids (*Benthosema glaciale*) and a smaller proportion of several species of Gadid larvae, in Leach's Storm-Petrel diets range from 55% of the diet by wet mass (Montevecchi *et al.*, 1992) to 70% by volume (Linton, 1978) and to 92% by wet mass (Hedd *et al.*, 2006). The remainder of diet is estimated to

comprise amphipods (primarily *Hyperia* spp. and *Parathemisto* spp.), and euphausiids (primarily *Meganyctiphanes norvegica*), as well as minor proportions of squid, Cnidarians and other planktonic crustaceans (Linton, 1978; Montevecchi *et al.*, 1992; Hedd *et al.*, 2006). Of the prey identified, only myctophids and some species of euphausiids are restricted to the pelagic environment (McKelvie, 1985) where they occur at depth diurnally and vertically migrate nocturnally (Watanabe *et al.*, 1999) in search of vertically migrating prey (Moku *et al.*, 2000). Wilson's (*Oceanites oceanicus*) and Fork-tailed Storm-Petrels (*Oceanodroma furcata*), and other populations of Leach's Storm-Petrels prey on myctophids, amphipods and euphausiids in both the southern and northern oceans (Linton, 1978; Croxall *et al.*, 1988; Croxall & North, 1988; Vermeer & Devito, 1988; Montevecchi *et al.*, 1992; Cherel *et al.*, 2002; Hedd *et al.*, 2006).

In the case of Leach's Storm-Petrels, and most other Procellariiformes, the analysis of diets by stomach contents cannot provide information about the prey composition of the stomach oil, which can be a substantial component by mass and especially in terms of caloric value. Many studies of diet in Procellariiformes have removed this portion of the stomach contents and focused only on hard parts (Croxall *et al.*, 1988; Vermeer & Devito, 1988; Hedd & Gales, 2001) or the oil is simply measured as another component of the stomach contents (Croxall & North, 1988; Cherel *et al.*, 2002). Analysis of stomach contents from regurgitate can provide useful information about dietary intake in marine predators, but can be biased due to differential rates of digestion (Jobling and Brieby, 1986; Bowen *et al.*, 1993) and provides information about the last meal only.

Stable isotope ratio analysis can also offer information about the diet of individuals on a trophic level scale (Hedd & Montevecchi, 2006) primarily by analyzing the ratios of isotopes of carbon and nitrogen. Changes in the ratios of these two elements can be used to estimate the number of trophic steps that a particular organism is away from the primary producer in its food web. Differences can be determined between groups of animals that are ecologically significant and can expose limitations that traditional dietary studies exhibit, such as the importance of certain forage species in a predator's diet (Hobson *et al.*, 1994). In seabirds however, this can be confounded in species that forage in several different environments (i.e. neteric vs. pelagic), trophic levels (Forero *et al.*, 2005) or latitudes (Forero *et al.*, 2005; Quillfeldt *et al.*, 2005). In addition, rarely can stable isotopes provide information about the species composition of predator diets.

Fatty acid analysis provides an alternative or complementary tool in the investigation of diet and one that examines a longer-term integration of dietary intake than stomach contents and more specific predator prey linkages than stable isotope analysis. Fatty acids are organic acids with an unbranched hydrocarbon chain, of which there are approximately 80 commonly identified from nature, especially in marine ecosystems (Ackman, 1986); however, there may be more than 1000 fatty acids, when all possible lengths and functional groups are considered (Christie, 2003). They are defined by the carboxylic acid terminus at one end, linked to a carbon chain and terminating at the other end with a methyl group. Each fatty acid is distinguished by the length of the chain (which varies from 4 carbons to over 30) and number and placement of double bonds along the chain. Biologically derived fatty acids must have at least 8 carbons in

their chain but most commonly have a chain length between 14 and 22 carbons long (Iverson, 1993). The notation format for each is A: Bn- (or n-) C: (Gurr and James, 1980 p. 3) where A is the number of carbons, B is the number of double bonds in the chain and C is the placement of the double bond closest to the methyl terminus of the carbon chain. For example, 18:1n-3 has 18 carbons in its chain and one double bond positioned three carbons from the methyl terminus of the molecule.

Fatty acids with no double bonds are called saturated because all of the available sights for a hydrogen molecule to bond to the chain are occupied (it is saturated with hydrogen). If any two of the sites for hydrogen are unoccupied on adjacent carbon molecules along the chain, a double bond will form between them and the fatty acid become unsaturated. Fatty acids with one double bond are referred to as monounsaturated and those with multiple double bonds along the chain are polyunsaturated. The double bonds formed along the length of the chain can be either in the *trans* or *cis* configuration. *Cis* configuration means that the carbon molecules adjacent to the double bond are both on the same side so the chain will be bent at a greater angle. *Trans* configuration is when the adjacent carbons are on opposite sides of the double bond and, therefore, the chain is straight with a kink at the sight of the double bond, and are the less common of the two found in biological systems and are generally produced by artificial hydrogenation. When multiple double bonds form along the chain, they occur at intervals of three carbons to form what is called a divinylmethane pattern.

Fatty acids are a major component of lipids; an amphiphilic class of organic molecules that are biologically useful in energy storage (e.g. triglycerides, wax esters), structure and cell signaling (e.g. glycerophospholipids, cholesterol). Triglycerides, the

main component of adipose tissue in most animals and therefore the most abundant form of energy storage, are composed of three fatty acids esterified to a glycerol backbone.

Although all organisms can synthesize a limited number of fatty acids de novo, in general most fatty acids are obtained through diet. Triglycerides and other forms of lipid are normally digested into free fatty acids (FFA) and monoglycerides before they are incorporated by the body. They are then immediately used as an energy source, and secondarily used as structural components or stored again typically as triglycerides in various organs and tissues (i.e. adipose tissue, liver, central nervous system and mammary glands). Because of biochemical restrictions to fatty acid synthesis, especially in higher organisms (e.g. fish, birds, mammals), and the fact that most fatty acids remain intact through digestion and are deposited in predator fat tissue in a predictable manner (reviewed in Budge et al. 2006), they can be very useful tracers of trophic relationships and diet. Fatty acid analysis could also be particularly useful in examining the diets of Procellariiformes, because the content of stomach oil, which is primarily fatty acid otherwise excluded from the analysis of undigested stomach contents, can be included in the analysis, likely representing different time frames than adipose tissue in diet consumption (e.g., Wang et al. in press).

Fatty acid signature analysis can be used to determine longer-term differences in predator diets by analyzing the proportions of FAs in the tissue of two or more groups of organisms (e.g., Iverson 1993; Iverson *et al.* 1997a, b; Logan *et al.*, 2000). Excess fatty acids that are stored in the fat storage sites (e.g., adipose tissue) of predators either experience little modification (e.g., Iverson *et al.*, 1995) or are stored in a predictable way after understanding predator FA metabolism (e.g., Iverson et al. 2004; Cooper et al. 2005,

2006). However, modification such as chain elongation and insertion of double bonds do occur in animals to some extent (Hagen *et al.* 1995; Pond *et al.*, 1997). Ackman, *et al.* (1988) demonstrated that 22:6n-3 is commonly derived from 20:5n-3 by chain elongation to 22:5n-3, and sequentially has a double bond inserted. Both of these reactions are catalyzed by multiple enzymes. Those fatty acids incorporated into membranes and other structural components are generally subject to greater modification or selective retention (Hagen *et al.*, 1995; Pond *et al.*, 1997). Thus, providing that it is the fat storage sites that are sampled, fatty acids can be used to evaluate diet. Captive studies have shown that different diets do result in predictable changes in the fatty acid signature of an individual's tissue (e.g., Sargent *et al.*, 1988; Fraser *et al.*, 1989; Iverson 1993; Kirsch *et al.*, 1998; 2000; Iverson et al. in press).

During the breeding season Leach's Storm-Petrels are the most abundant seabirds in the waters surrounding Newfoundland and in the North Atlantic as whole. Therefore, they play a significant role in trophic webs in that environment. Their dependence on concentrated marine lipids as a food source for their chicks and their wide feeding range makes it difficult to determine what adult and chicks are consuming over the breeding season. Conversely, this dependence also makes them excellent candidates for dietary analysis, using fatty acids as analysis tools. Their variability in foraging trip length, although not as dimorphic as some other Procellariiforme species, suggests that they make separate trips for chick and self/chick-provisioning. Combine this fact with the large foraging area they cover and the diversity of prey species within sections of that area, and you can hypothesize that adults provision their chicks with different proportions of prey species than they consume themselves. To date only two studies have been

performed on the diet of this species, one was performed almost 30 years ago and both used stomach contents as their analysis tool (Linton, 1978; Hedd & Montevecchi 2006; Hedd *et al.,* in press). In this study I used fatty acids to better understand foraging and diets in free-ranging Leach's Storm-Petrels. They are an excellent subject because of their importance of the species in the North Atlantic environment and lack of knowledge about their natural history. I first use fatty acids to examine qualitative differences in foraging among demographic groups and over two years. I then used these data to make quantitative estimates of species composition of petrel diets, using a prey database of potential prey of this Procellariiforme.

### 1.4 Objectives

1. To determine whether there is a change in diet of adult Leach's Storm-Petrels from incubation to chick-rearing periods.
2. To assess whether there are differences in the fatty acid composition among parental males and females and their chicks.
3. To determine species composition of Leach's Storm-Petrel diets by comparing fatty acid composition of adipose tissue with the fatty acid signatures of a variety of potential prey items using a statistical mixing model.

# Chapter 2 – Differences in parental and chick fatty acid signatures of Leach's Storm-Petrels

## 2.1 Introduction

Variability in foraging trips during chick-rearing is a common trait among the more pelagic species of procellariiformes. Leach's Storm-Petrels exhibit foraging trips of 1-5 days in duration (Ricklefs *et al.*, 1985). Other procellariiformes have been shown to vary the ocean environment in which they forage in relation to the trip's duration (Weimerskirch *et al.*, 1993, 1994; Chaurand & Weimerskirch, 1994; Sagar & Weimerskirch, 1996; Booth *et al.*, 2000). Short trips correspond to foraging on the neteric environment while longer trips correspond to the pelagic environment. The variation in foraging environment widens the breadth of forage species encountered, and has been observed to lead to differences in prey selection on long and short trips (Chaurand & Weimerskirch, 1994).

The function of specific foraging trips has also been linked to duration. Short trips allow parents rapid chick provisioning, while long trips are used to replace parental energy requirements as well as chick provisioning (Weimerskirch *et al.*, 1994, 1997; Booth *et al.* 2000). Morphological differences between male and female Wandering Albatross have also been linked to differences in foraging trip characteristics during the breeding season (Weimerskirch *et al.* 1993, 1997; Weimerskirch 1995; Berrow & Croxall, 2001). Leach's Storm-Petrels, however, are much less sexually dimorphic than Wandering Albatross and are not expected to exhibit observable dietary differences.

The differences that are linked to this bimodal foraging strategy exhibited by procellariiformes, suggests that adults may be providing a different diet for themselves than for their chicks. Traditionally, diet has been examined by the use of stomach and fecal contents which have provided very useful information. However, these methods can be biased due to differential digestion of hard and soft parts (Jobling & Brieby, 1986) and because they provide information on only the last meal. Using hard part analysis of stomach samples, Montevecchi *et al.* (1992; personal observations) showed that the main prey of Leach's Storm-Petrels are myctophids (particularly *Benthosema glaciale*), amphipods (particularly *Hyperia galba* and *Parathemisto* spp.), euphausiids (*Meganyctiphanes norvegica*) and capelin (*Mallotus villosus*). However, comparing the diets of Leach's Storm-Petrel parents to their chicks through traditional methods could prove daunting since one could not conclude that what adults bring back to the colony is of the same composition as the meals they digest at sea.

Chemical methods are becoming more prevalent in the study of trophic relationships between and within species of seabirds. Stable isotope ratios of carbon and nitrogen can be used to determine the relative trophic levels of groups of individuals within a particular ecosystem (Hobson, 1990; Hobson *et al.*, 1995; Hodum & Hobson, 2000; Sydeman *et al.*, 1997; Hedd & Montevecchi, 2006), which in turn can be used as evidence of dietary differences. Stable isotope studies of several seabirds have measured significant differences in trophic levels between adults and chicks (Forero *et al.*, 2005), including Wilson's Storm-Petrels (Quillfeldt *et al.*, 2005). This method may be able to relate predators to prey on a trophic scale, but cannot generally assess differences in species composition of diets. Determining differences in two groups that have similar

diets or forage on species with similar trophic profiles is problematic, because there are only two variables in these analyses. A multi-vartiate analysis system is more likely to detect differences in such situations.

Fatty acid profiles or "signatures" have been used to study aspects of diet and foraging in a wide array of predators for several decades. Fatty acids are carboxylic acids, connected to a carbon chain, that vary by the length of their carbon chain and number and position of double bonds that occur along that chain (e.g. 18:1n-3 [IPACU notation A: Bn- (or n-) C; Gurr and James, 1980 p. 3] has a chain length of 18 carbons and one double bond, three carbons from the methyl terminus). Triglycerides are a type of lipid used primary for energy storage which contains three fatty acids connected together on a glycerol backbone. When digested the fatty acids in the triglycerides are broken into free fatty acids and monoglycerides before they are incorporated into the body. Although some modification does occur, most fatty acids are transferred between trophic levels with little change to either their form or individual proportion. This means that the fatty acid signatures of a predator will tend to resemble that of its prey. Thus, organisms that eat different prey will tend to have different signatures.

Analysis of fatty acid signatures has been able to detect dietary differences in captive studies (Sargent *et al.*, 1988; Fraser *et al.*, 1989; Iverson, 1993; Kirsch *et al.*, 1998) and, consequently, between groups of ecologically or morphologically different animal populations (Iverson, 1993; Iverson *et al.*, 1997a, b; Logan *et al.*, 2000). Because some species of Procellariformes have been shown to vary their length of foraging trips and, therefore, provision their chicks with different prey than they consume themselves, parents would tend to exhibit differing fatty acid signatures than their chicks. Leach's

Storm-Petrels do show some variation in their trip lengths, although not as dimorphically as other Procellariformes, and, therefore, would be expected to exhibit differences in fatty acid signature between parents and offspring. Because of the difficulty of observing prey consumption at sea and the fact that some digestion and assimilation of prey has occurred, we can only analyze what parents are providing their chicks and use that to determine species prey consumption, therefore possibly misinterpreting the true adult diet. The purpose of this study is to determine if there is any difference between the fatty acid signature of parent Leach's Storm-Petrels and their offspring and to assess if those variations relate to differences in prey consumption. These differences in diet could also be linked to the observed variation in length of foraging trip. Leach's Storm-Petrels will serve as a model Procellariforme in determining the differences between parent and chick diets. Because no study has compared the fatty acid signatures of parental adipose tissue to their chicks this study will test the hypothesis that stomach content has led to misinterpretation of the diet of breeding Leach's Storm-Petrels and other Procellariforme species.

## 2.2 Methods

### *2.2.1 Study Site*

All bird regurgitate and tissue samples were collected in the Baccalieu Island Ecological Reserve, a large island reserve off the Avalon Peninsula on the eastern coast of Newfoundland, Canada (Fig. 2.1). Baccalieu Island Ecological Reserve (48° 07' N, 52° 48' W) is located in the mouth of Conception Bay and is the site of the largest Leach's Storm-Petrel colony in the world (~3.4 million pairs; Montevecchi & Tuck 1987,

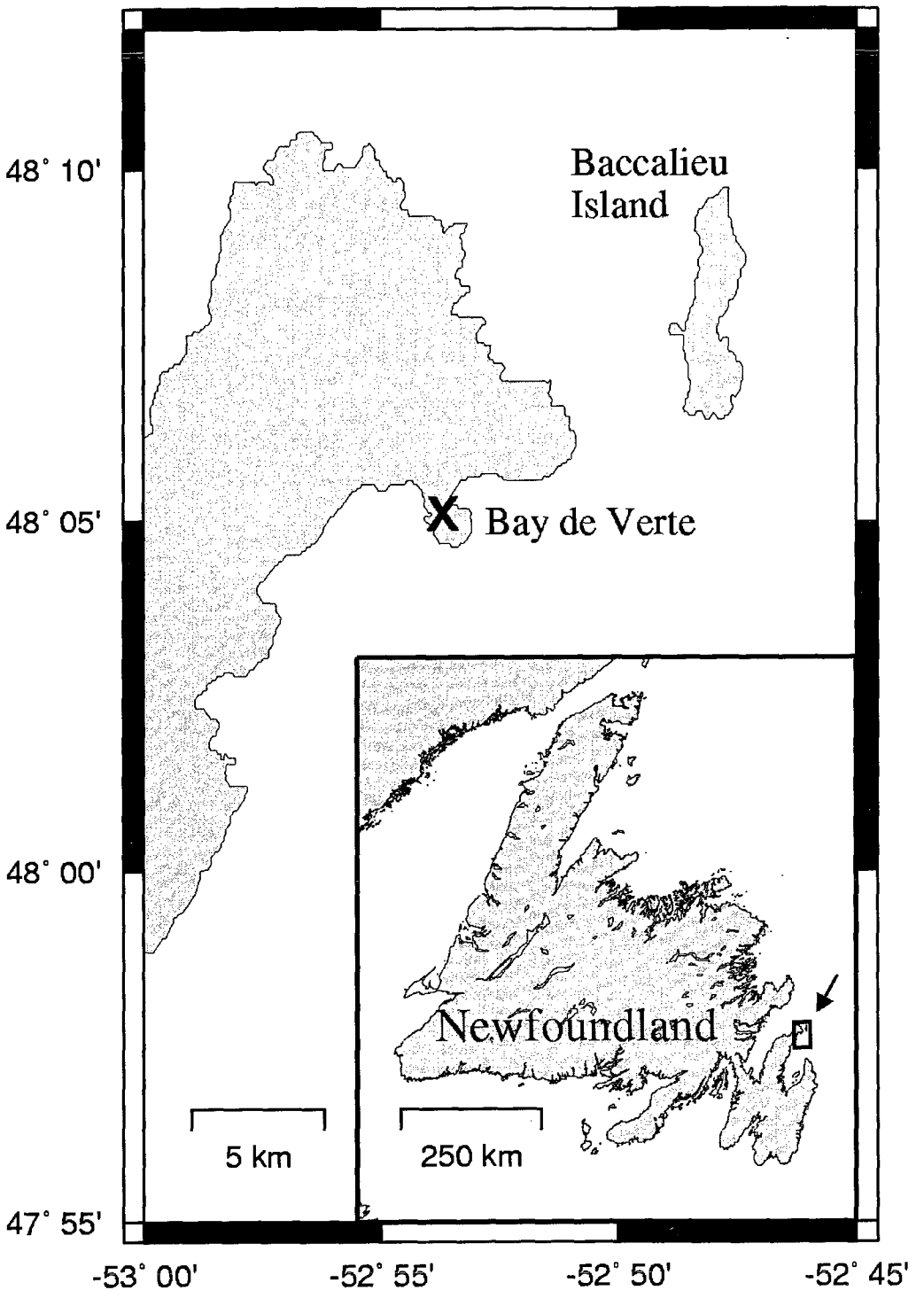


**Figure 2.1:** Map of the island of Newfoundland with an inset of Baccalieu Island.

Sklepkovych & Montevecchi 1989). Baccalieu Island (Fig. 2.1), is approximately 9 x 1-2 km, covered sporadically with fir/spruce forest, peaty meadows and heath. All locations for this study were within 500 m of the lighthouse station on the southern end of the island.

*2.2.2 Sample collection*

*2.2.2.1 Leach's Storm-Petrel regurgitate samples*

Regurgitate samples (n = 93) were collected in the Baccalieu Island Ecological Reserve throughout the 2001 breeding season (47 incubation, 46 chick-rearing). Sampling involved mist-netting adult birds flying into the colony and collecting regurgitate on plastic tarps spread beneath the nets. Samples were placed into glass vials that had been rinsed three times with both methanol and chloroform (henceforth known as lipid cleaning). Samples were then frozen at -20°C in the lighthouse until they were returned to the laboratory where they were capped and sealed under nitrogen and placed in a -20°C freezer until processing 4-12 weeks later. Birds were weighed, determined to be breeders or non-breeders on the basis of brood patch development, banded and released.

*2.2.2.2 Leach's Storm-Petrel adipose tissue*

Adults (n = 12, 2001; n = 17, 2002) and chicks (n = 10, 2001; n = 15, 2002) from the Baccalieu Island Ecological Preserve were collected just before fledging in early September of 2001 and 2002 (Permission was obtained from the Department of Tourism, Culture and Recreation, Natural Areas Division of the Government of Newfoundland and Labrador, and by the Memorial University Committee on Animal Care). Adults were

collected in 2001 at the burrow with sticky rodent traps, while in 2002 grass covered burrows were checked every 5 minutes for disturbance. All adults found in a trap or in a disturbed burrow were assumed to be a parent of the chick in that burrow. Chicks were taken from any burrow where at least one adult was caught. Initially attempts were made to extract small amounts of adipose tissue from live individuals using a small incision above the sternum and removing a biopsy with small forceps. All attempts to find a visible deposit of adipose tissue in adults were negative, although chicks had large visible sub dermal deposits covering the entire body. Tissue from adults had to be dissected either using major surgery to a live animal, or from a carcass, and any offspring of those individuals would not survive without parental foraging visits, therefore all individuals were killed for dissection in the lab. Collected individuals were killed by lethal injection of a solution that would not affect the results of the fatty acid analysis (0.4 mL/10 g dose of Avertin; 0.8 g 2,2,2 tribromoethanol, 0.5 Tert-amyl alcohol, 39.5 mL 0.9% saline solution) into the intraperitoneal cavity (Robert Brown, personal communication). Carcasses were frozen on dry ice in the field until they could be returned to a -20°C freezer for storage until they were processed. A small sample of sub-dermal adipose tissue (~ 0.1 g) was dissected from both chicks and parents. Adult's sex was determined by gonadal inspection.

*2.2.3 Lipid extraction and derivatization*

Regurgitate and adipose tissue samples were homogenized using a lipid cleaned Polytron tissue homogenizer (Brinkman Instruments, Rexdale, ON, Canada) and then solvent extracted in lipid cleaned glassware using 1:2:0.7 methanol/chloroform/ chloroform-extracted water solution (Folch *et al.*, 1957). All solvents were spectral grade

and kept on ice throughout the extraction process, all glassware seals consisted of either ground glass or Teflon. Samples were vortexed for at least 10 s, sonicated for 4 min and centrifuged at 3000 rpm for 5 min. The organic, chloroform (bottom) phase was then extracted from the inorganic, methanol/water (upper) phase by a procedure called double pipetting. This procedure consists of passing an ashed 27 cm glass pipette through the inorganic phase while bubbling air, removing the pipette bulb, and then placing a 14 cm pipette inside the 27 cm pipette. The organic phase is then removed with the 14 cm glass pipette into a second lipid cleaned vial. A volume of chloroform, equivalent to the initial extraction was then added to the inorganic phase and the procedure from vortexing to extraction was repeated three times or until no pigmentation was left in the organic phase. The organic fraction was then concentrated under nitrogen to a known volume and stored at -20 °C in a nitrogen flushed, air tight vial.

A small aliquot of extract of adipose tissue was derivatized to fatty acid methyl esters (FAME). Lipid aliquots stored in chloroform, were dried under nitrogen, and then redissolved in 0.5 mL of hexane. To this was added 1.5 mL of a 10% w/v solution of boron triflouride ($BF_3$) in methanol. The vial was sealed under nitrogen, vortexed, placed in an oven at 90°C for 1.5 h and shaken once during this time. Samples were then removed and allowed to cool to room temperature before 1 mL of chloroform-extracted water and 2 mL of hexane were added. The upper phase consisting of hexane, FAME and any underivatized lipid was then transferred to a 2 mL glass vial.

*2.2.4 Hard part and extract hue and chroma analysis*

Regurgitate samples were used to roughly estimate dietary composition throughout the breeding season through hard part analysis. Hard part identification

consisted of sorting through a regurgitate sample before homogenization to find skeletal bone, otoliths, scales, eye lenses, and carapaces to identify prey taxa. Occurrence of each prey marker was recorded. Whole carapaces of amphipods were measured in their longest dimension (from head to abdomen of an unstretched carapace).

Regurgitate samples exhibited a variety of colours. Therefore, measurements of hue were taken of the resulting extract using the "Munsell book of colors" (Munsell Color, 1976). Hue is the wavelength of light from the visible-light spectrum with the greatest intensity from the source and is measured with an alpha-numeric code where the letter represents the base colour (e.g. R = red, Y = yellow, YR = orange) and the number (ranging from 1 to 10) represents steps along the spectrum between the base colours (i.e. 1YR is orange and 10YR is a slightly orange yellow). All observations of hue were made on 20 mL of extract in clear glass 30 mL vials by me as to follow a single observer protocol.

*2.2.5 Thin layer chromatography (TLC) with flame ionization detection (FID)*

Aliquots from adipose tissue samples of three adults and chicks from each year, three of each prey type and corresponding blanks were separated into lipid classes, on silica-gel coated Chromarods-SIII using four different solvent systems and measured with an Iatroscan MK V (Iatron Laboratories) after each development (Parrish, 1987). A nine component standard was run on each set of rods for comparison of position of each peak in the samples.

Nine component standards were made with known quantities of each lipid class (i.e. hydrocarbons [HC], steryl/wax esters [SE/WE], ketones [KET], triacylglycerols [TG], free fatty acids [FFA], alcohols [ALC], sterols [ST], acetone mobile polar lipids

[AMPL], and polar lipids [PL]). Blanks (i.e. extractions performed without a sample) were used to control for any accumulation of non-sample lipid during the extraction process. Blanks and standards were then analyzed in the same manner as TLC/FID.

Aliquots of 0.5 – 4.0 μL of extract for each sample were spotted onto a single rod, with a 20 μL Hamilton syringe. Spots were then focused to a narrow band in 100% acetone and dried for 5 min in a constant humidity chamber. The rods were then developed for 25 min in 60 mL of 99:1:0.05 hexane/diethyl ether/formic acid solution, dried for 5 min, and then developed for a further 20 min in the same solution. The first partial FID scan (78% of the rod from the top) was performed to measure HC, SE/WE, and KET lipid classes that eluted from the origin.

The rods were then developed in a solution of 80:20:1 hexane/diethyl ether/formic acid (60 mL) for 40 min, dried for 5 min, and scanned by the FID (89% form the top) for TG, FFA, ALC and ST lipid classes.

The final stage consisted of two developments in different solvents; rods were dried after each development. First the rods were developed twice in 100% acetone (60 mL) for 15 min to elute the AMPL. The rods were then developed twice in a solution of 5:4:1 methanol/chloroform/water for 10 min and scanned over their entire length for AMPL and PL lipid classes.

The 3 resulting chromatograms from the 3 FID scans were then combined and the resulting chromatogram was analyzed using the T Data Scan Chromatography Analysis program (RSS, Bemis, TN, USA).

*2.2.6 Gas Chromatography*

All FAME samples of Leach's Storm-Petrel adipose tissue were analyzed using a Varian 3400 gas chromatograph (GC; Varian Instruments, Walnut Creek, CA, USA) with an Omegawax 320 fused silica capillary column (30 m x 0.23 mm x 0.25 μm film thickness of polyethylene glycol; temperature limit of 50–280°C; Supelco, Oakville, ON, Canada). The GC was fitted with a Varian 8200 auto-sampler (Varian Instruments, Walnut Creek, CA, USA) with a 10 μL Hamilton syringe, which delivered a 1.0 μL sample injection and a 0.8 μL hexane plug. The temperature program used was as follows: the GC injector was held at an initial temperature of 150°C for 30 s and then increased to 250°C at a rate of 200°C/min, where it remained for 10 min. The GC column was held at 65°C for 2 min, increased to 195°C at a rate of 40°C/min where it was held for 15 min, and increased again to 215°C at a rate of 2°C/min and where it was held for 75 s. The GC detector held a constant temperature of 260°C.

*2.2.7 Data collection and transformation*

Data acquisition, and chromatogram integration verification were performed with the Varian Star 5.5 software package (Varian Instruments, Walnut Creek, CA, USA). Retention times were compared with those of FAME in standards: Supelco 37 component, bacterial acid methyl ester, marine source PUFA 1, and menhaden oil PUFA 3 (Supelco, Oakville, ON, Canada). Peaks were identified for each set of samples analyzed on the GC using the four standards run at the beginning of each set. Peak area data collected for each fatty acid from the integration verification software was compiled and transformed into proportional data. Fatty acids which were below the detection limit in more than 25% of samples were eliminated from the data set.

*2.2.8 Data analysis*

A variety of statistical tools were used to analyze the data. Distributions of hue assignments of regurgitate extract were analysed with a Chi-square test. Proportions of storage and structural lipid classes were analysed with 2 sample t-tests of unequal variance.

Multivariate statistical analysis was performed to determine differences between comparable groups of samples. Principal components analysis was performed with Minitab 13.20 for Windows (Minitab Inc., State College, PA, USA), and SPSS 11.0 for Windows (SPSS Inc. Chicago, IL, USA) was used to carry out multiple analysis of variance (MANOVA) and discriminant analysis.

MANOVA was used to determine relationships in transformed data from 24 ($24 = n_{chicks}-1$) of the most abundant fatty acids (Table 2.1; excluding 18:0, because of its use in data transformation) between years, parents and chicks, and interaction. Individual F-tests were included to indicate which fatty acids were most likely accountable for the multivariate patterns. The α-value was set according to the sequential Bonferroni method ($a = 0.05 / 24 = 0.00208$; Rice, 1989).

The data from the 24 fatty acids ($24 = n_{chicks} - 1$) used in the MANOVA analysis were also analyzed with 2 multivariate analyses, principal components analysis (PCA) and discriminant function analysis (DFA). Both of these analyses reduce and classify multivariate data into more easily understood and visualized components. PCA allows multivariate data to be reduced without the influence of a sample classification. Therefore, clustering of sample scores shows the nature of the measured data. Conversely, DFA creates functions that attempt to cluster multivariate in relation to

sample definitions. The proportional data used in MANOVA and PCA was standardized for normality for DFA to the 18:0 peak and logarithm transformed with the formula:

$$x_i = \log(p_i / s_i + 1)$$

where $x_i$ = the resulting transformed data, $p_i$ = untransformed proportion of fatty acid for sample i and $s_i$ = the proportion of 18:0 for sample *i* in Aitchison (1986) because fatty acid proportional data tend not to be multivariate normal. The fatty acid 18:0 was used because it is consistently present and tends to provide little information about diet of a predator.

## 2.3 Results

### *2.3.1 Adult regurgitate hard part composition and extract colouration*

Two sets of regurgitate samples were taken: one during the incubation period (n = 47) and one during chick-rearing (n = 46). Regurgitate samples taken during the incubation period consisted of relatively higher proportions of liquid portion (>50% of samples with >67% liquid portion) than those during chick rearing (>90% of samples with <67% liquid portion; Fig. 2.2). Eight categories of undigested material were identified, three crustacean groups (Hyperid and Gammarid amphipods and euphausiids) and five fish markers (flesh, scales, eye lenses, skeletal bone, otoliths). All undigested material (with the exception of euphausiids and Gammarid amphipods) increased in frequency from the incubation period to the chick-rearing period (Fig. 2.3). Fish markers were present in 94% of incubation and 98% of chick-rearing stomach content samples (96% overall). Amphipods of 5-11 mm in body length made up 89.5% of individuals

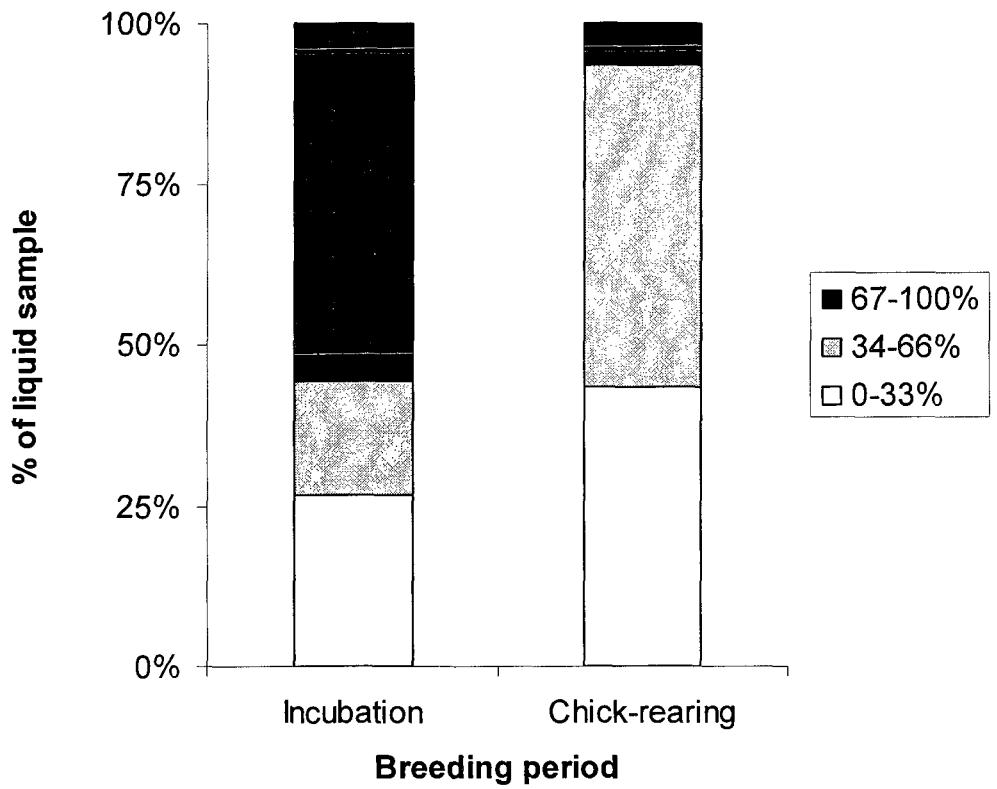


**Figure 2.2:** Proportion of adult Leach's Storm-Petrel regurgitate samples containing different percentages of stomach oil (0-33%, 34-66% and 67-100%) obtained during incubation (n = 47) and chick-rearing (n = 46).

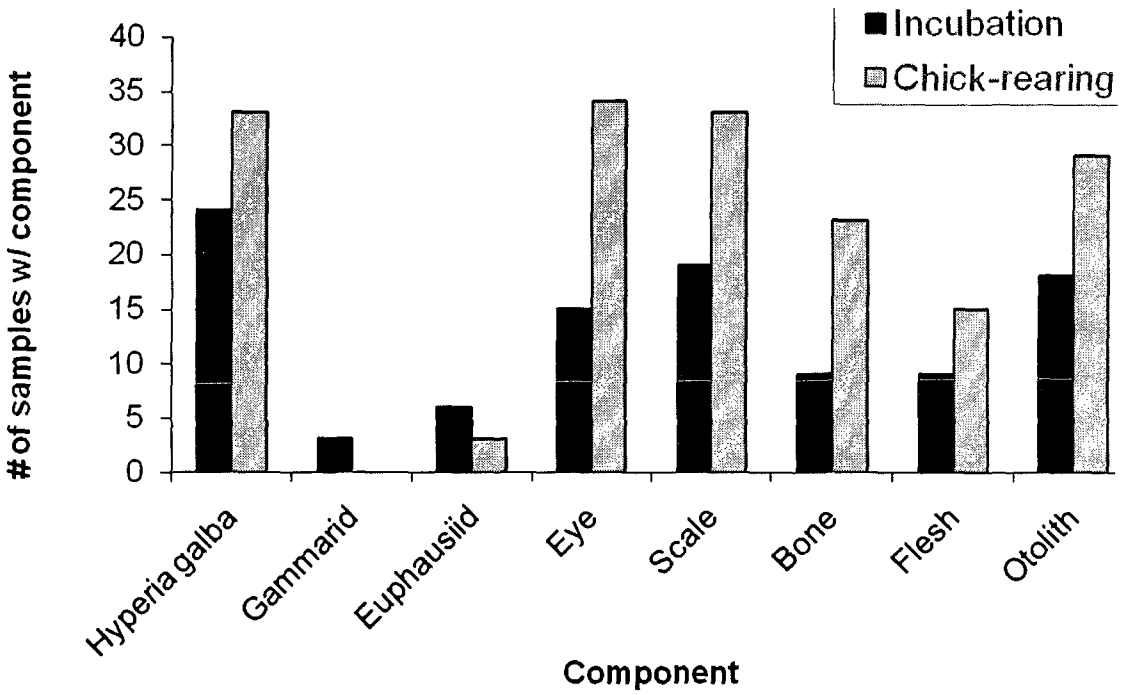


**Figure 2.3:** Presence of undigested components (i.e. exoskeleton, bone, flesh) in adult Leach Storm-Petrel regurgitate samples collected during incubation (n = 47) and chick-rearing (n = 46) periods. Fish markers include eye, scale, bone, flesh and otoliths.

found in regurgitate samples (mean 7.92 mm; range 3-15 mm). Only three capelin were measured from regurgitates (5.4, 6.0 and 9.1 cm).

Individual myctophids and euphausiids were too digested to determine size from hard part analysis, therefore, sampling reflected population size ranges, where no myctophid greater than 9 cm, and no euphausiid greater than 5 cm, was collected.

Observations of the colour of extracted regurgitate samples were also recorded and compared between the incubation and chick-rearing periods. Six different chroma readings were measured, ranging from 2.5YR (i.e. orange hue) to 5Y (i.e. a yellow hue). Of the 47 samples collected during the incubation period, 57% exhibited an orange hue (i.e. YR designation) and 43% of samples exhibited a yellow hue (i.e. Y designation; Fig. 2.4). During the chick-rearing period, only 14% of regurgitate extracts exhibited an orange hue and 86% exhibited a yellow hue (Fig. 2.4). The distribution of samples of each hue in the two periods were significantly different ($\chi^2 = 15.613$; df = 5; p = 0.012; Chi-square test).

*2.3.2 Leach's Storm-Petrel adipose tissue*

Subcutaneous adipose tissue was dissected from the pectoral area of 28 adult (14 male, 14 female) and 25 chicks between 2001 ($n_{Adult\ Male} = 6$, $n_{Adult\ Female} = 6$, $n_{Chick} = 10$) and 2002 ($n_{Adult\ Male} = 8$, $n_{Adult\ Female} = 8$, $n_{Chick} = 15$). The number of burrows where individuals were taken each year corresponded to the number of chicks that were taken in that year (i.e. one chick per burrow); 30 burrows were observed in 2001 and 35 in 2002. Adipose tissue in adults was much leaner than that of their chicks. Adults tended to have a thin layer of tissue (< 1 mm), covering the pectoral muscle to the sternum and in some

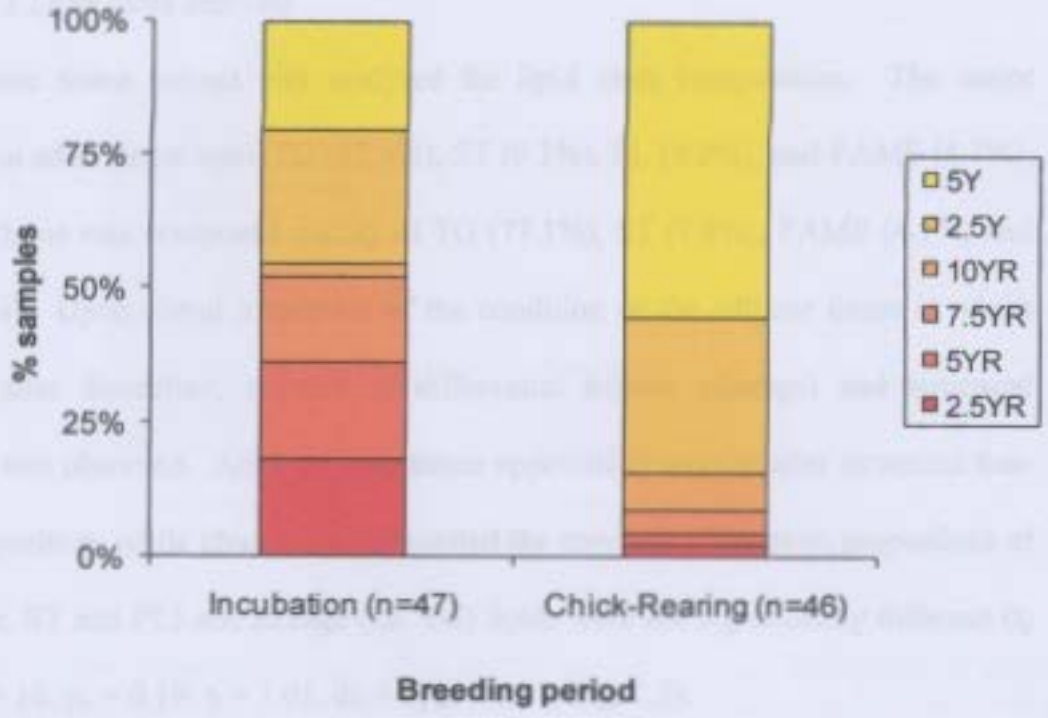


**Figure 2.4:** Hue of extracted adult Leach's Storm-Petrel regurgitate samples collected during the incubation (n = 47) and chick-rearing (n = 46) periods. Hues are derived from the Munsell colour scale (Munsell Color, 1976). The colours of the legend estimate the hue of the samples that are represented by each section of the columns.

cases only partially covering the muscle. Conversely, chick pectoral adipose tissue always covered the pectoral muscle completely and was usually 3-5 mm thick.

*2.3.2.1 Lipid class analysis*

Adipose tissue extract was analysed for lipid class composition. The major components in adult tissue were TG (67.9%), ST (9.1%), PL (8.2%), and FAME (4.7%), while chick tissue was composed mainly of TG (77.1%), ST (7.9%), FAME (4.1%) and AMPL (3.0%). Upon visual inspection of the condition of the adipose tissue in adults and chicks after dissection, a trend of differential trophic (storage) and structural composition was observed. Adult adipose tissue appeared to have greater structural than storage composition, while chick tissue suggested the opposite. However, proportions of structural (i.e. ST and PL) and storage (i.e. TG) lipids were not significantly different ($t_p$ = -0.91, $df_p$ = 10, $p_p$ = 0.19; $t_t$ = 1.01, $df_t$ = 9, $p_t$ = 0.17; Fig. 2.5).

*2.3.2.2 Major fatty acid characteristics*

Adipose tissue samples from adults and chicks in 2001 and 2002 were analyzed for fatty acid composition (Table 2.1). Four fatty acids in adults (in order of descending abundance, 22:1n-11(13), 20:1n-9, 18:1n-9, 16:0) made up 67.9% of the total fatty acids present, while 9 others (22:6n-3, 16:1n-7, 14:0, 22:1n-9, 18:0, 20:1n-11, 18:1n-7, 20:5n-3, 18:2n-6) were commonly greater than 1.0% each. Chicks displayed a similar pattern of composition with 4 fatty acids (18:1n-9, 20:1n-9, 22:1n-11(13), 16:0) comprising 69.8% of the total fatty acids. Other important fatty acids were 16:1n-7, 22:6n-3, 14:0, 18:1n-7, 20:1n-11, 18:0, 22:1n-9, 18:2n-6, 20:5n-3, accounting for greater than 1.0% each.

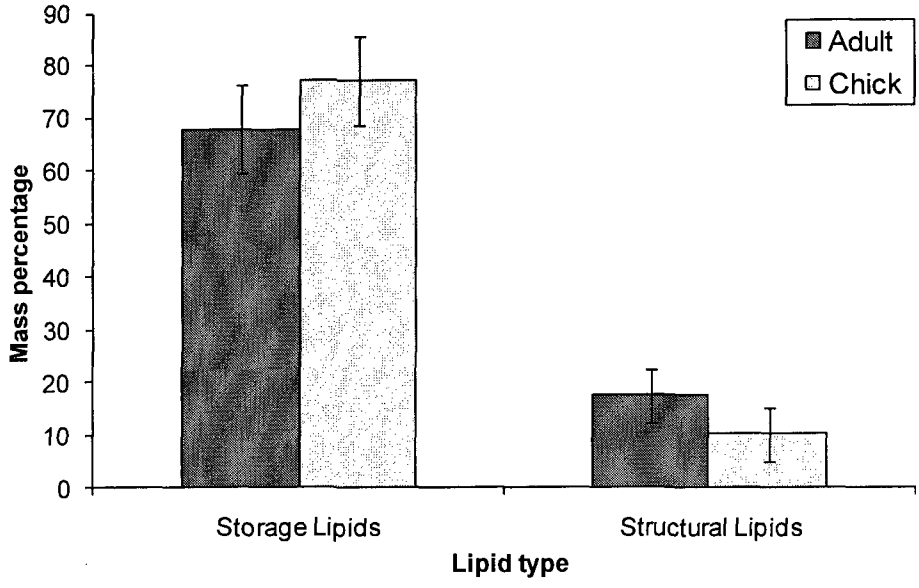


**Figure 2.5:** Proportion of storage (TG) and structural (ST and PL) lipids in adipose tissue of adult Leach's Storm-Petrels and their chicks taken in September of 2001 and 2002. Error bars represent 95% confidence limits.

**Table 2.1:** Mean ± 95% confidence interval for the 24 most abundant fatty acids used in the analysis of Leach's Storm-Petrel adipose tissue. Samples are separated between chicks and adults and years.

| | Chicks | Adults | 2001 | 2002 |
|---|---|---|---|---|
| Saturated Fatty acids | | | | |
| 14:0 | 2.70 ± 0.13 | 3.05 ± 0.24 | 3.22 ± 0.19 | 2.65 ± 0.17 |
| 15:0 | 0.25 ± 0.01 | 0.22 ± 0.02 | 0.26 ± 0.02 | 0.22 ± 0.01 |
| 16:0 | 11.85 ± 0.31 | 10.16 ± 0.73 | 11.50 ± 0.65 | 10.58 ± 0.62 |
| Monounsaturated Fatty acids | | | | |
| 16:1ω7 | 5.47 ± 0.26 | 3.84 ± 0.46 | 4.94 ± 0.49 | 4.37 ± 0.47 |
| 17:1 | 0.35 ± 0.01 | 0.25 ± 0.02 | 0.30 ± 0.03 | 0.29 ± 0.02 |
| 18:1ω9 | 22.52 ± 0.32 | 15.96 ± 0.57 | 18.79 ± 1.49 | 19.24 ± 1.22 |
| 18:1ω7 | 2.66 ± 0.08 | 1.92 ± 0.10 | 2.32 ± 0.16 | 2.24 ± 0.17 |
| 18:1ω5 | 0.45 ± 0.01 | 0.45 ± 0.02 | 0.50 ± 0.02 | 0.47 ± 0.02 |
| 20:1ω11 | 2.03 ± 0.24 | 2.45 ± 0.35 | 1.57 ± 0.18 | 2.74 ± 0.25 |
| 20:1ω9 | 18.97 ± 0.38 | 19.50 ± 0.94 | 19.61 ± 0.78 | 19.00 ± 0.70 |
| 20:1ω7 | 0.83 ± 0.04 | 0.96 ± 0.06 | 0.86 ± 0.06 | 0.93 ± 0.05 |
| 22:1ω11(13) | 16.41 ± 0.61 | 22.29 ± 1.39 | 18.42 ± 1.57 | 20.30 ± 1.50 |
| 22:1ω9 | 1.70 ± 0.08 | 2.71 ± 0.20 | 2.05 ± 0.24 | 2.36 ± 0.24 |
| 22:1ω7 | 0.22 ± 0.01 | 0.38 ± 0.03 | 0.27 ± 0.04 | 0.33 ± 0.04 |
| 24:1 | 0.26 ± 0.02 | 0.89 ± 0.12 | 0.46 ± 0.11 | 0.69 ± 0.16 |
| Polyunsaturated Fatty acids | | | | |
| 18:2ω6 | 1.56 ± 0.05 | 1.08 ± 0.04 | 1.35 ± 0.10 | 1.28 ± 0.10 |
| 18:3ω3 | 0.53 ± 0.03 | 0.31 ± 0.04 | 0.46 ± 0.05 | 0.38 ± 0.05 |
| 18:4ω3 | 0.52 ± 0.04 | 0.60 ± 0.09 | 0.66 ± 0.07 | 0.49 ± 0.05 |
| 20:2ω6 | 0.18 ± 0.01 | 0.19 ± 0.01 | 0.19 ± 0.19 | 0.01 ± 0.01 |
| 20:4ω6 | 0.19 ± 0.01 | 0.24 ± 0.01 | 0.22 ± 0.01 | 0.21 ± 0.01 |
| 20:4ω3 | 0.29 ± 0.02 | 0.28 ± 0.04 | 0.32 ± 0.03 | 0.26 ± 0.03 |
| 20:5ω3 | 1.15 ± 0.10 | 1.23 ± 0.27 | 1.36 ± 0.22 | 1.07 ± 0.18 |
| 22:5ω3 | 0.63 ± 0.03 | 0.75 ± 0.04 | 0.70 ± 0.04 | 0.69 ± 0.04 |
| 22:6ω3 | 4.18 ± 0.21 | 5.31 ± 0.38 | 4.98 ± 0.43 | 4.63 ± 0.34 |

*2.3.2.3 MANOVA*

Multivariate analyses of adipose tissue fatty acids revealed significant differences between adults and chicks ($p < 0.001$), years ($p < 0.001$) and the interaction ($p = 0.001$; Table 2.2). Significant differences in a single fatty acid's proportion between adults and chicks were found in 15 of the 24 most abundant fatty acids over all samples (Table 2.3). Adults had significantly more 14:0, 20:1n-9, 22:1n-11(13), 22:1n-9, 22:1n-7 and 24:1 while chicks had more 15:0, 16:0, 16:1n-7, 17:1, 18:1n-9, 18:1n-7, 18:1n-5, 18:2n-6, 18:3n-3, 18:4n-3 and 20:4n-3 (Fig. 2.6). Only 5 of the 24 most abundant fatty acids differed between collection years; birds collected in 2001 had significantly more 15:0, while birds from 2002 had significantly more 20:1n-11, 22:1n-9, 22:1n-7 and 24:1 (Fig. 2.7).

*2.3.2.4 Principal components analysis*

PCA was performed on the 24 fatty acids, with PC1 explaining 53.9% of the error and PC2 an additional 23.4%. The axis of PC1 showed a slight gradient from shorter chain acids ($\leq C_{18}$) and longer chain ($\geq C_{18}$) polyunsaturates on the left, to long chain ($\geq C_{20}$) monounsaturates on the right, while the gradient of PC2 showed a slight increase in carbon number from top to bottom (Fig. 2.8). The plot of coefficients of the variables for PC1 *vs.* PC2 exhibited a slight horseshoe effect across PC1, which is usuallyattributed to a gradient that is not included in the analysis (Fig. 2.8). When examined in relation to the fatty acids in the MANOVA analysis, those that were found to be significantly different between adults and chicks were separated along PC1 and those significant between years were separated along PC2. The scores plot of the same PCA when labeled

**Table 2.2:** Results of MANOVA on Leach's Storm-Petrel adipose tissue.

| Test | **Test Value** | F | df | p |
|---|---|---|---|---|
| **Adult/Chick** | | | | |
| Pillais | **0.76** | 3.38 | 26 | 0.002 |
| Hotellings | **3.12** | 3.38 | 26 | 0.002 |
| Wilks | **0.24** | 3.38 | 26 | 0.002 |
| Roys | **0.76** | | | |
| **Year** | | | | |
| Pillais | **0.99** | 81.41 | 26 | 0 |
| Hotellings | **75.15** | 81.41 | 26 | 0 |
| Wilks | **0.013** | 81.41 | 26 | 0 |
| Roys | **0.99** | | | |
| **Interaction** | | | | |
| Pillais | **0.89** | 8.45 | 26 | 0 |
| Hotellings | **7.80** | 8.45 | 26 | 0 |
| Wilks | **0.11** | 8.45 | 26 | 0 |
| Roys | **0.89** | | | |

**Table 2.3:** Results of individual 1-way ANOVAs of 24 fatty acids from stepwise MANOVA comparing adults and chicks, years, and interactions. ($\alpha = 0.05 / 24 = 0.00208$; df = 24 in all cases).

| | Adult/Chick | | Year | | Interaction | |
|---|---|---|---|---|---|---|
| Variable | F | p | F | p | F | p |
| 14:0 | 12.4 | 0.001 | 9.8 | 0.003 | 0.8 | 0.385 |
| 15:0 | 79.2 | < 0.001 | 10.2 | 0.002 | 0.2 | 0.693 |
| 16:0 | 119.9 | < 0.001 | 1.1 | 0.298 | 0.1 | 0.709 |
| 16:1ω7 | 94.3 | < 0.001 | 1.6 | 0.215 | 0.3 | 0.578 |
| 17:1 | 173.2 | < 0.001 | 0.3 | 0.568 | 0.1 | 0.792 |
| 18:1ω9 | 337.7 | < 0.001 | 3.4 | 0.070 | 0.7 | 0.398 |
| 18:1ω7 | 334.6 | < 0.001 | 0.0 | 0.957 | 1.2 | 0.275 |
| 18:1ω5 | 169.4 | < 0.001 | 0.5 | 0.480 | 2.2 | 0.146 |
| 18:2ω6 | 217.7 | < 0.001 | 0.1 | 0.711 | 0.0 | 0.908 |
| 18:3ω3 | 204.2 | < 0.001 | 7.5 | 0.008 | 0.1 | 0.702 |
| 18:4ω3 | 3.4 | 0.070 | 8.5 | 0.005 | 1.7 | 0.197 |
| 20:1ω11 | 0.9 | 0.349 | 56.8 | < 0.001 | 0.4 | 0.553 |
| 20:1ω9 | 27.8 | < 0.001 | 0.1 | 0.728 | 0.2 | 0.680 |
| 20:1ω7 | 4.4 | 0.040 | 6.9 | 0.011 | 1.7 | 0.201 |
| 20:2ω6 | 3.9 | 0.053 | 0.2 | 0.622 | 1.6 | 0.205 |
| 20:4ω6 | 2.3 | 0.135 | 0.0 | 0.963 | 0.1 | 0.740 |
| 20:4ω3 | 19.3 | < 0.001 | 6.1 | 0.017 | 1.4 | 0.248 |
| 20:5ω3 | 4.7 | 0.036 | 2.2 | 0.142 | 2.3 | 0.135 |
| 22:1ω11(13) | 0.3 | 0.612 | 8.8 | 0.005 | 0.0 | 0.878 |
| 22:1ω9 | 10.7 | 0.002 | 12.0 | 0.001 | 0.1 | 0.735 |
| 22:1ω7 | 18.7 | < 0.001 | 16.1 | < 0.001 | 0.2 | 0.664 |
| 22:5ω3 | 5.4 | 0.024 | 0.6 | 0.436 | 0.0 | 0.894 |
| 22:6ω3 | 0.7 | 0.415 | 0.0 | 0.856 | 0.8 | 0.377 |
| 24:1 | 99.2 | < 0.001 | 25.9 | < 0.001 | 3.3 | 0.074 |

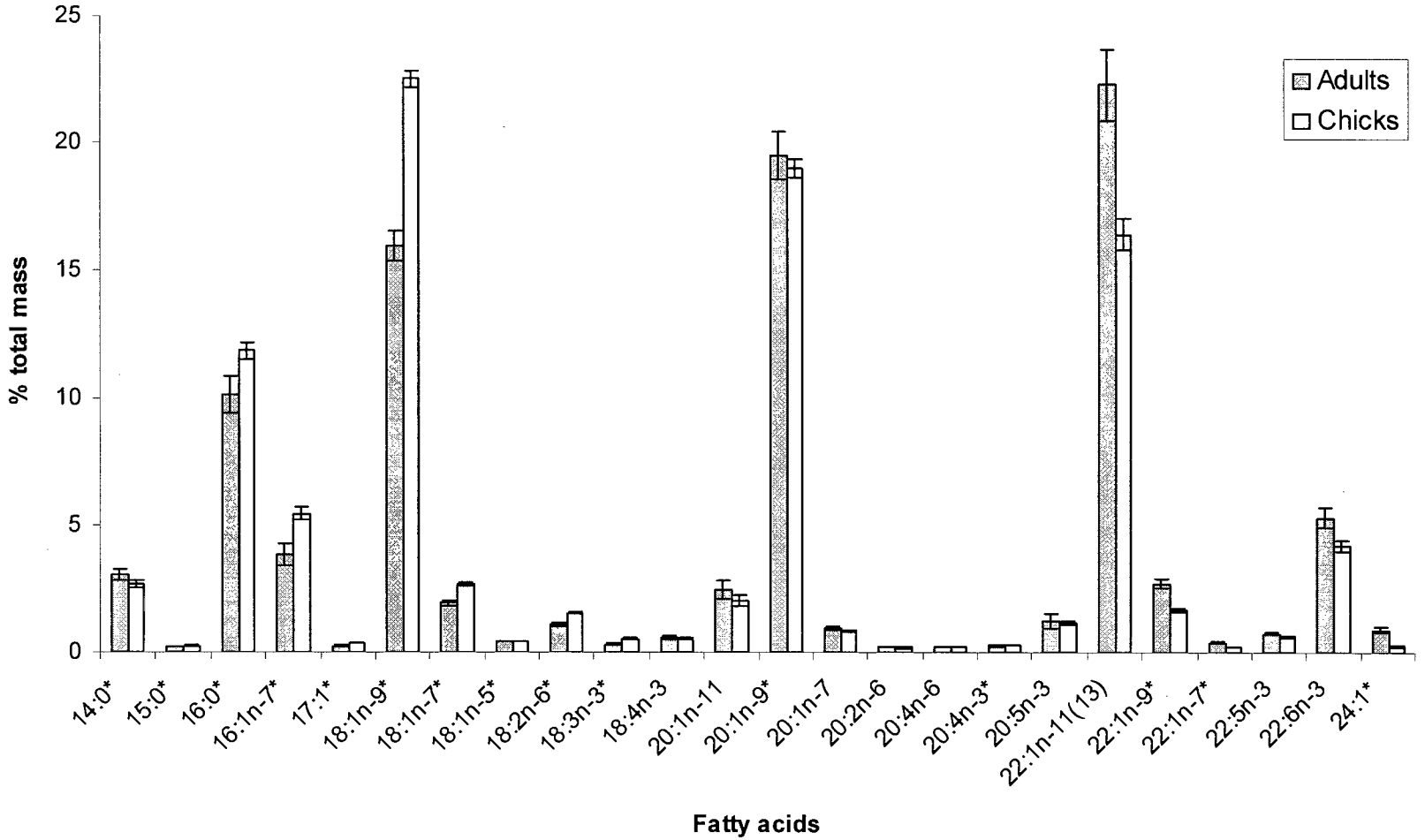


**Figure 2.6:** Histogram of the mean percentages of mass of the 24 fatty acids with highest mean % overall in Leach's Storm-Petrel adipose tissue samples. Each grouping contains mean for chicks and adults for both years. Error bars represent 95% confidence limits. Significant F-tests ($\alpha = 0.05/24 = 0.0021$) of each fatty acid from MANOVA analysis are labeled after each fatty acid for test between chicks and adults (*).

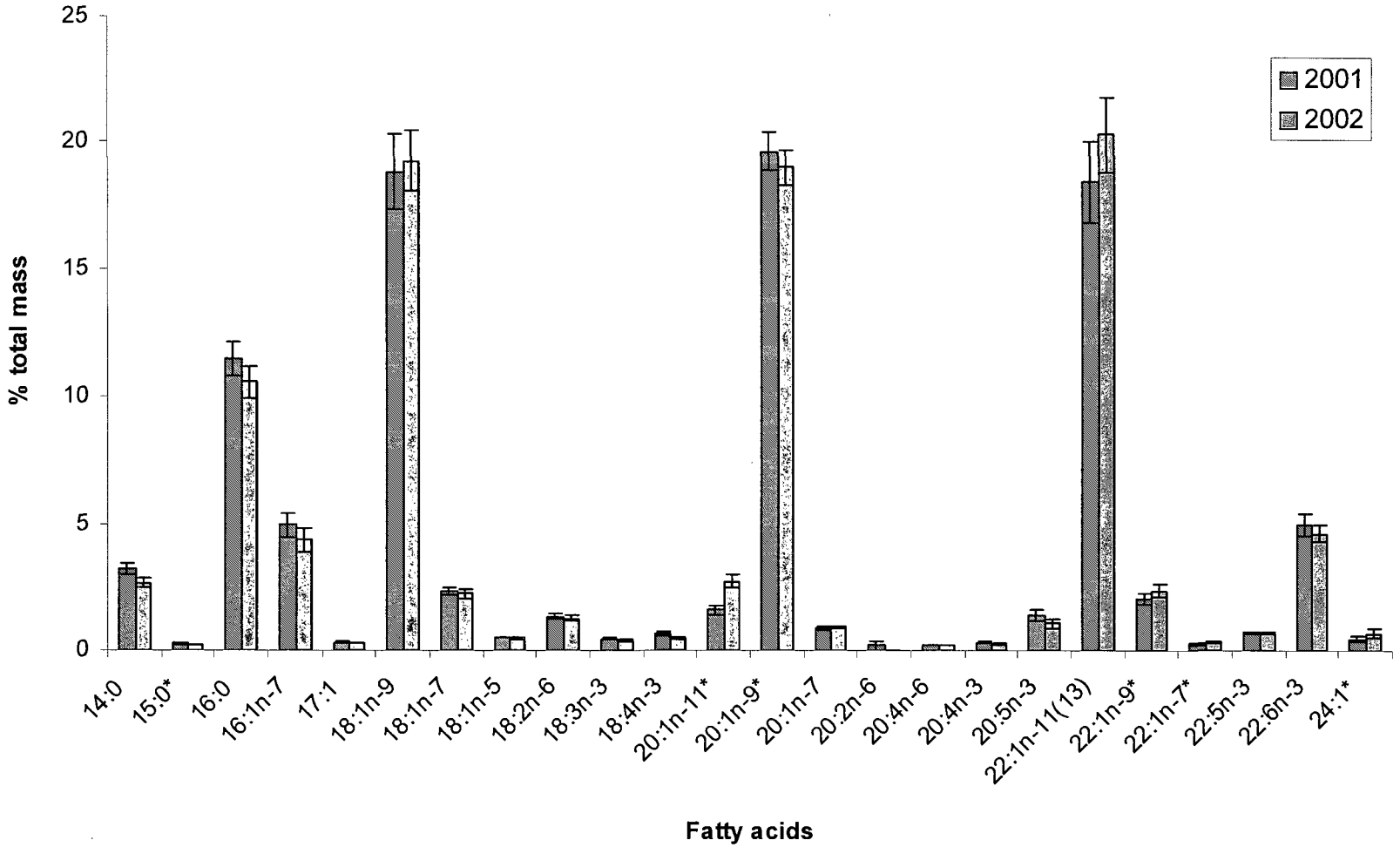


**Figure 2.7:** Histogram of the mean mass percentages of the 24 fatty acids with highest mean % over all Leach's storm-petrel adipose tissue samples. Each grouping contains mean for chicks and adults for both years. Error bars represent 95% confidence limits. Significant F-tests ($\alpha = 0.05/24 = 0.0021$) of each fatty acid from MANOVA analysis are labeled after each fatty acid for tests between collection years (*).

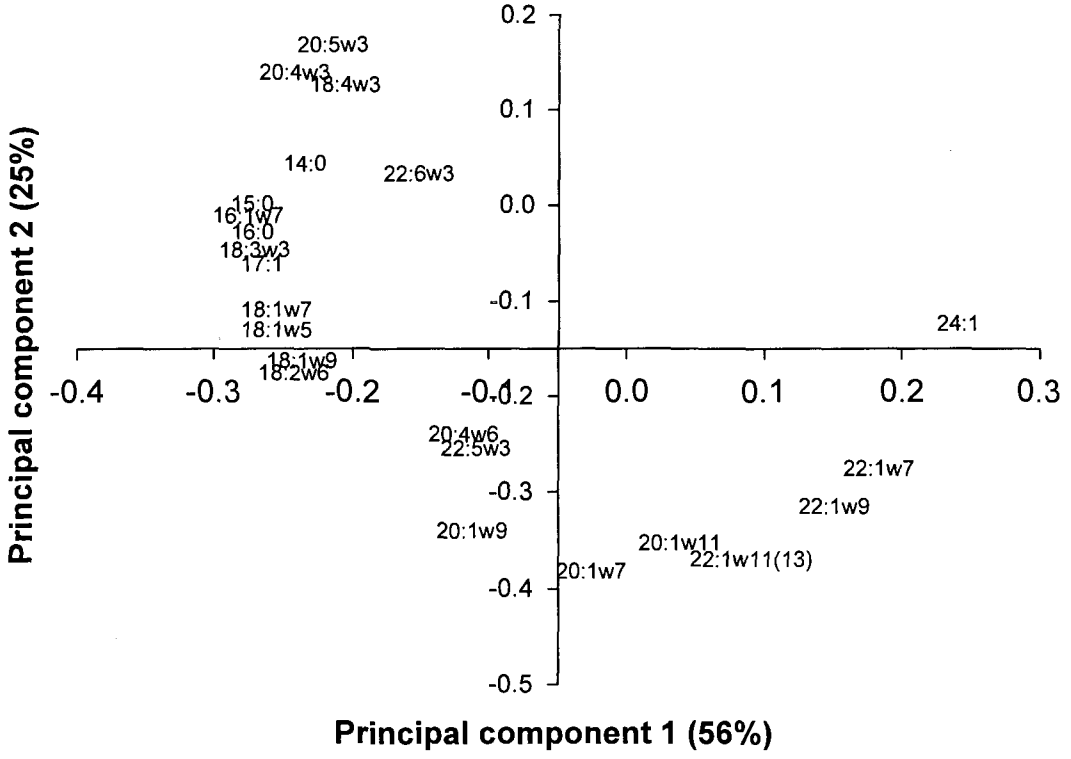


**Figure 2.8:** Scatter plot of PCA coefficients based on the 24 most abundant fatty acids in Leach's Storm-Petrel adipose tissue. All scores are labeled according to the fatty acid they represent.

according to adults/chicks and the year of sampling showed that adults and chicks tend to be arranged in clusters along PC1, while years are clustered along PC2 (Fig. 2.9). The 95% confidence limits showed no overlap between adults and chicks, however, the difference between years amongst chicks and adults was not as substantial (Fig. 2.9). Adults were also categorized by sex, although there were no apparent clusters in either year among males and females (Fig 2.10).

*2.3.2.5 Discriminant function analysis*

DFA produced 3 linear functions with the first explaining 88.5% of the variation and the second 8.9% (Fig. 2.11). The four groups of samples, categorized by state of maturity and year, were 100% correctly classified both in overall classification and probability of individual samples. The first two functions separated samples based upon one of the categories: function 1 separated adults from chicks into the right and left halves of the plot, respectively, and function 2, subsequently separated the years of collection (2001 and 2002) into the upper and lower halves of the plot, respectively (Fig. 2.11). The 95% confidence limits illustrate that all four groups of individuals (adults and chicks divided by year) were significantly different. The three most influential fatty acids in function 1, using variable coefficients as a measure of influence, were 18:3n-3, 20:1n-9 and 22:1n-11(13), while 15:0, 20:1n-9 and 22:1n-11(13) were most influential in function 2 (Table 2.4).

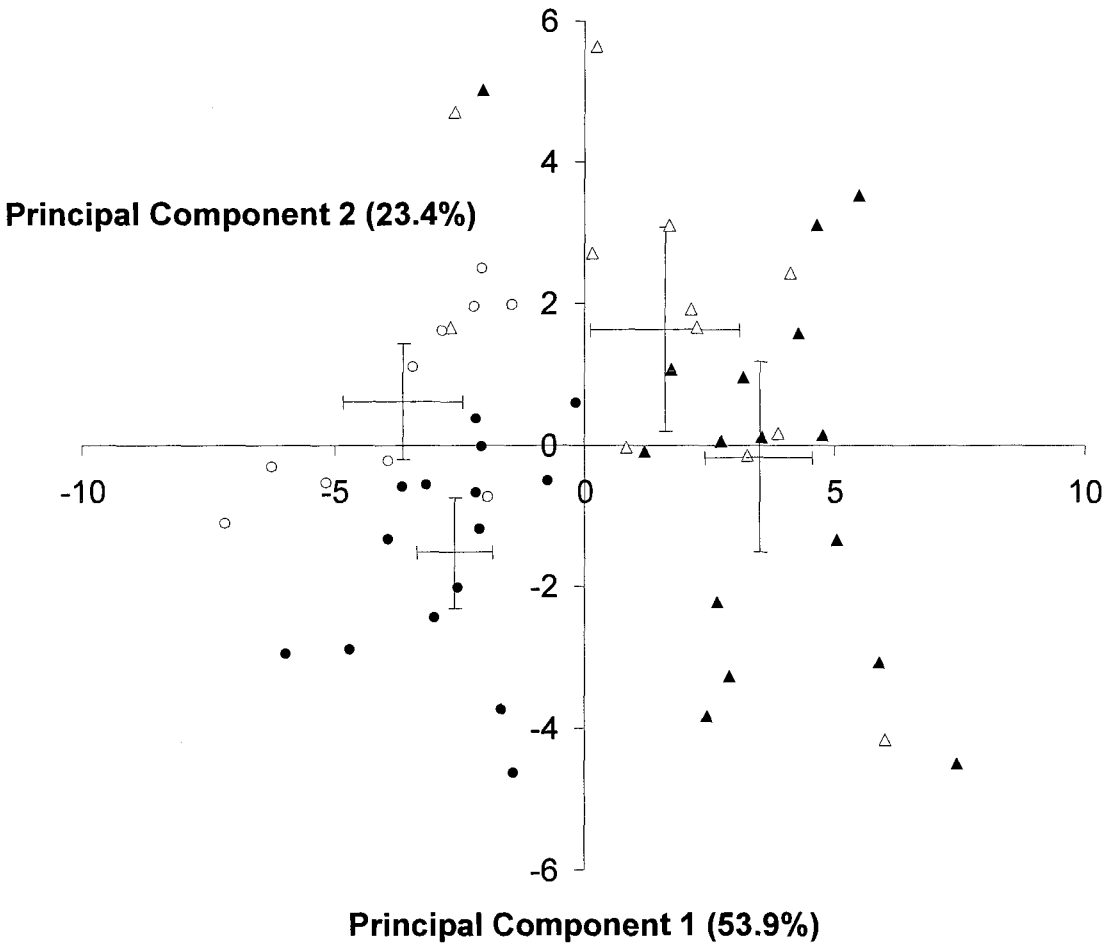


**Figure 2.9:** Scatter plot of PCA scores based on the 24 most abundant fatty acids in Leach's Storm-Petrel adipose tissue fatty acid composition for adults (Δ, ▲) and chicks (○, ●) during 2001 (Δ, ○) and 2002 (▲, ●). Whiskers represent 95% confidence from group centroid of scores for both PC 1 (x-axis) and PC 2 (y-axis).

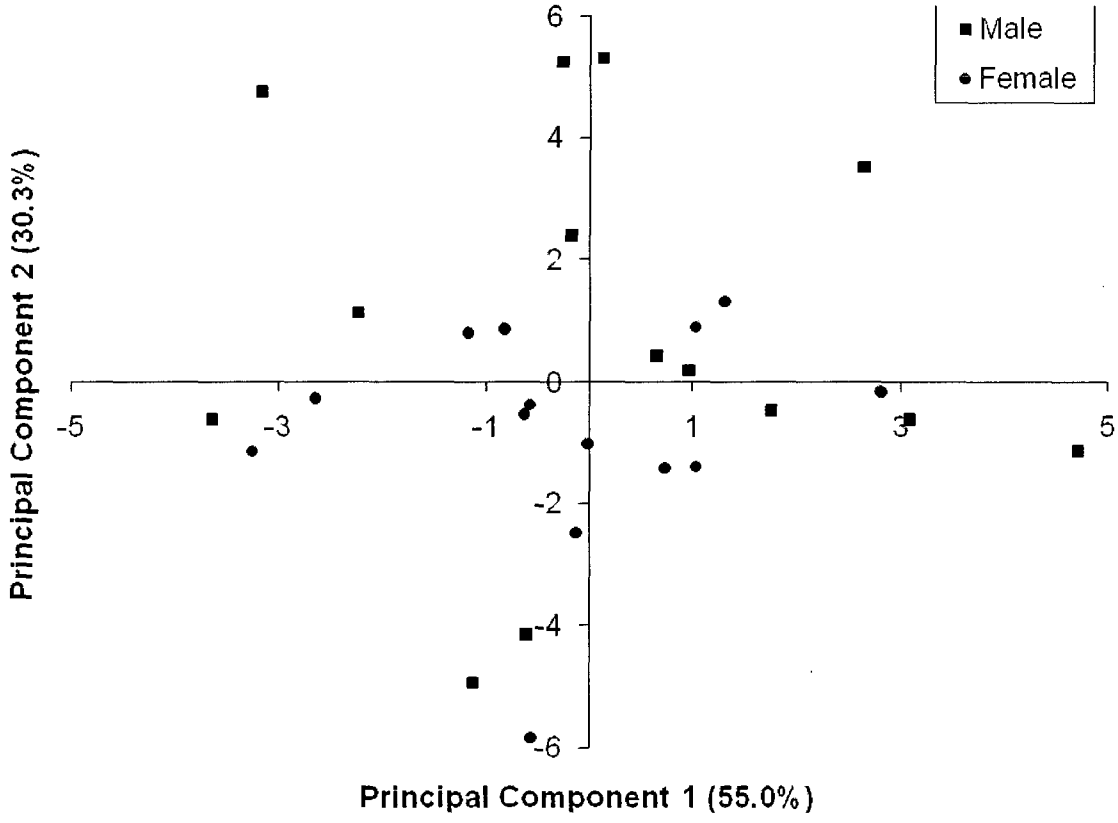


**Figure 2.10:** Scatter plot of PCA scores from PC 1 (x-axis) and PC 2 (y-axis) based on the 24 most abundant fatty acids in Leach's Storm-Petrel adipose tissue fatty acid composition for adult males (■) and females (♦).

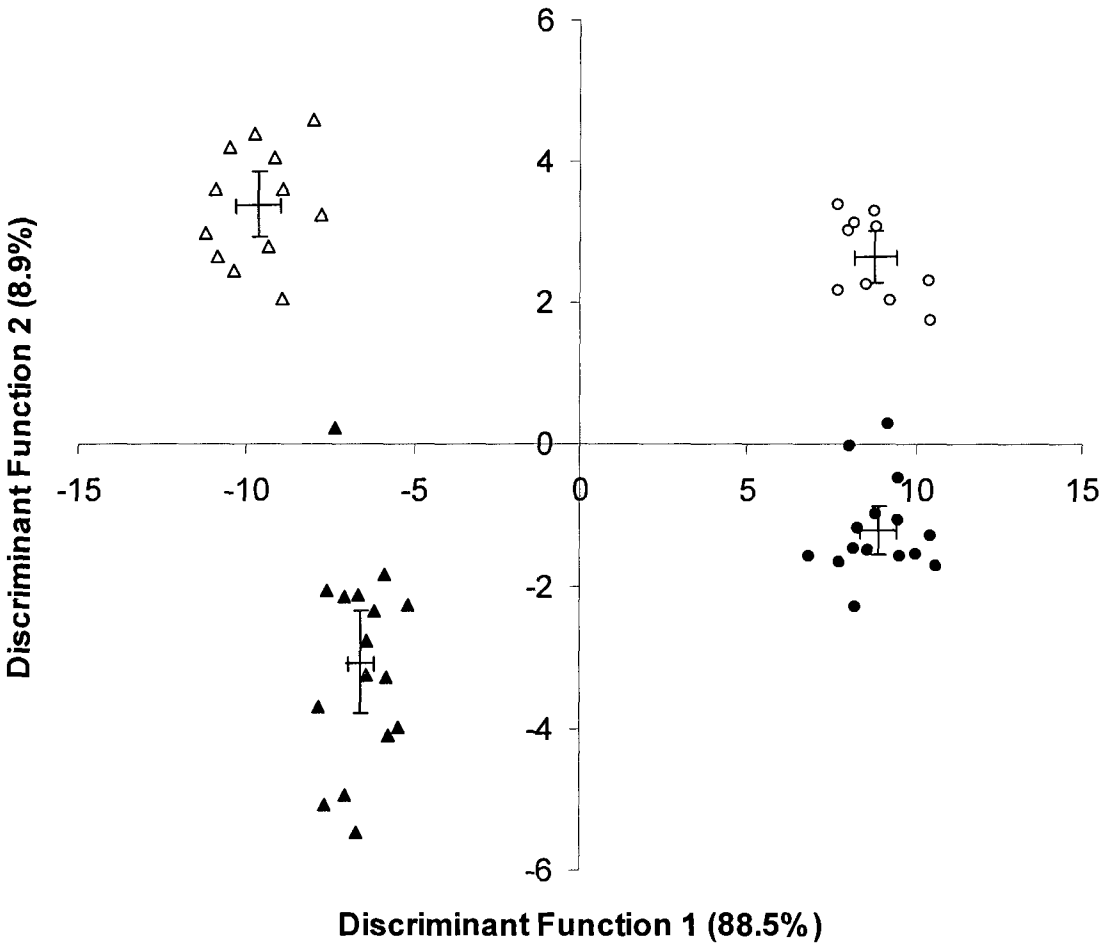


**Figure 2.11**: Scatter plot of discriminant analysis of adipose tissue samples from Leach's Storm-Petrel: scores for the first two discriminant functions are plotted. Analysis is based on transformed proportions of the 24 most abundant fatty acids across all samples and is labelled according to adult (Δ, ▲) and chick (○, ●) samples collected during the 2001 (Δ, ○) and 2002 (▲, ●) breeding seasons. Whiskers represent 95% confidence from group centroid of scores for both discriminant functions 1 (x-axis) and 2 (y-axis).

**Table 2.4:** Variable coefficients of functions 1 and 2 from a discriminant analysis performed on transformed proportions of the 24 most abundant fatty acids across all Leach's Storm-Petrel adipose tissue samples.

| Fatty acid | Function 1 | Function 2 |
|---|---|---|
| 14:0 | -1.18 | 2.07 |
| 15:0 | -1.48 | -3.03 |
| 16:0 | -0.99 | -1.75 |
| 16:1ω7 | 1.66 | 1.19 |
| 17:1 | -0.63 | 1.15 |
| 18:1ω9 | 0.74 | 1.55 |
| 18:1ω7 | 0.32 | 0.51 |
| 18:1ω5 | 0.27 | 0.12 |
| 18:2ω6 | 1.04 | -0.35 |
| 18:3ω3 | 3.40 | 0.72 |
| 18:4ω3 | -1.58 | 0.52 |
| 20:1ω11 | 0.30 | 0.49 |
| 20:1ω9 | -1.80 | -4.33 |
| 20:1ω7 | 0.19 | -0.64 |
| 20:4ω6 | -0.93 | 0.02 |
| 20:4ω3 | 1.08 | -0.36 |
| 20:5ω3 | -0.16 | -0.62 |
| 22:1ω11(13) | 2.07 | 2.94 |
| 22:1ω9 | 0.07 | 0.29 |
| 22:1ω7 | -0.99 | -0.59 |
| 22:5ω3 | 0.29 | 0.43 |
| 22:6ω3 | -1.47 | -0.99 |
| 24:1 | -0.03 | 0.88 |

## 2.4 Discussion

### *2.4.1 Regurgitate samples*

Visual observation of Leach's Storm-Petrel regurgitate suggested that there is a change in adult diet over the breeding season. Changes in proportions of stomach oil suggested a more advanced state of digestion of stomach contents present during the incubation period for birds caught on the wing in the colony (Fig. 2.2). This may reflect that adults go on longer feeding trips at this time, thus likely having the opportunity to travel further from the breeding colony on these trips. The increase in number of hard part components in the regurgitate during the chick-rearing period supports the hypothesis that Leach's Storm-Petrels go on shorter foraging trips during the chick-rearing period and return with less digested stomach contents. The conflicting hard part results showing a decrease of Euphausiids from incubation to chick-rearing (Fig. 2.3) may be due to an increased availability earlier in the breeding period.

Colouration of regurgitate extract (Fig. 2.4) also supports a change in adult diet in Leach's Storm-Petrels between the incubation and chick-rearing periods. Of the Leach's Storm-Petrel prey samples analyzed (Chapter 3), only extracts from euphausiids exhibited a strong orange hue, as observed in the majority of incubation samples; the two types of fish samples (capelin and myctophids) exhibited a slight yellow colouration and the amphipods had very low concentrations of any hue. This suggests that Leach's Storm-Petrels consumed higher proportions of euphausiids during the incubation period and supports the results of the hard part analysis in which more euphausiids were found at that time.

Somewhat similar dietary changes have been observed in other studies of Leach's Storm-Petrel in which fish species were less prevalent toward the beginning of the breeding season and more so toward the end (Watanuki, 1985; Vermeer & Devito 1988). Leach's Storm-Petrels may actively target different prey at different times of the breeding season. Adults may selectively consume one prey of better quality, then switch during the chick rearing period. Adults may also be more constrained in their foraging ranges and prey choices during the chick-rearing period, which may play a role in changing diets. There was an increase in fish (likely myctophids; Hedd & Montevecchi, 2006) in regurgitate during the chick-rearing period, and these prey may provide better nutrition for growing chicks than euphausiids. However, the second and more likely explanation is that the prey field changes during the breeding season and there may be lower numbers of euphausiids in the diet because of temporal (or spatial) availability (Endo & Wiebe, 2005) and thus adult Leach's Storm-Petrels may have to consume other prey. In the same vein, other prey items (such as myctophids) may have higher availability and therefore will be consumed at a great rate simply due to their abundance in relation to other suitable prey species.

*2.4.2 Fatty acid signatures*

Differences in fatty acid signatures among Leach's Storm-Petrels can be attributed to two different sources, diet and physiology. The fatty acids 14:0, 16:0 and 18:1n-9, while available from diet, can also be synthesized by any organism. Fatty acids 16:1n-7, 18:2n-6, and 18:3n-3 tend to be originally diatom markers, while 20:1n-9, 22:1n-9 and 24:1 are zooplankton markers, all of which have been carried through the food chain (Ackman, 1986; Ackman *et al.*, 1988; Arts *et al.*, 2001). Fatty acids 22:5n-3

and 22:6n-3 are abundant dietary fatty acids in marine organisms, but are also important physiologically in the construction of membranes, while 20:4n-6 is a biological precursor for membrane and other physiological uses (Ackman, 1986). When comparing the adipose tissue composition of parents to chicks using MANOVA, PCA and discriminant analyses, dietary fatty acids were more influential in determining differences in fatty acid signatures than those linked to membrane construction. Therefore, it is most likely, based on fatty acid signatures, that parental diets and what they feed to their chicks is different. There would not be enough fatty acids derived from structural tissue in the adult's adipose to conclude that the difference in fatty acid signatures was caused by the difference proportion of lipid reserves between adults and their offspring. It is also apparent that parents feed their chicks different proportions of their prey spectrum than they consume themselves, and the prey species within the spectrum have significantly different fatty acid signatures from one another (Chapter 3). This difference among fatty acid signatures among marine animals in the North Atlantic food-web has be demonstrated on many trophic levels (Iverson *et al.*, 1995; 1997a; Fraser *et al.*, 1989; Budge *et al.*, 2001; 2002). Also, as seen in the PCA and discriminate analysis, diets of adults varied in the two years of study.

*2.4.3 Statistical analysis*

Three statistical approaches were used in this chapter to determine differences found in fatty acid signatures of Leach's Storm-Petrel chicks and adults. Each has positive and negative points in their analytical capabilities and, individually, provide pertinent information. MANOVA allows each of a subset of fatty acids to be analyzed individually for significance in determining differences between groups of samples and

permit analysis of grand differences between groups of samples, but the representation of relationships between groups of samples, and to some extent individuals, is limited to p-values. Both principal component and discriminant analysis allow data from multiple variables to be compacted into scores related directly to individual samples. These values can also be used to measure statistical distance between groups graphically. The difference between the two is displayed in the precision that each shows in grouping related individuals together. Principal component analysis does not take into account the category of samples, while discriminate analysis does, therefore PCA is the more conservative of the two analyses with respect to the knowledge inherent to the calculations. However, discriminant analysis has more power to discern small differences between groups in a complex data set and has the capacity to be used as a predictor of sample classification. Therefore, discriminant analysis is better suited for analysis of fatty acid signatures and the possible differences between two or more groups of organisms.

Reiterating, with discriminant analysis, I discerned that the fatty acid signatures of parents and their chicks were significantly different from one another, as primarily defined by the fatty acids 18:3n-3, 20:1n-9 and 22:1n-11(13), all important diet-derived fatty acids. The two breeding seasons in which I collected adipose tissue samples were also significantly different with 15:0, 20:1n-9 and 22:1n-11(13) as the defining fatty acids in the discriminant analysis.

## 2.5 Conclusions

Variation in diet is apparent in many animal populations, and has been shown to differ by sex, time of year, location, developmental stage and many other factors. I have shown here that Leach's Storm-Petrels exhibit measurable variations of their diet with developmental stage (i.e. chick vs. parent), time of breeding season, and interannually. Stomach content analysis in adult petrels demonstrated differences in diet between breeding season phases (i.e. brooding, and chick-rearing). Differences in adipose tissue fatty acids signatures demonstrated differences between diets of parents and their chicks and to a lesser extent among adult males and females.

In all cases, multiple independent variables showed significant differences within the dependent variables. Stomach contents of adult petrels differed during incubation and chick-rearing periods, suggesting that either specific prey availability fluctuates during the season or that adults forage differently during these two periods. Although temporal changes in prey availability off the eastern coast of Newfoundland have been described (Linton, 1978; McKelvie, 1985), given the documented decreases in foraging trip length between incubation and chick-rearing periods, adults may also have access to different prey during these times because of spatial constraints. Analysis of fatty acid signatures demonstrated that adults have significantly different signatures than their offspring which is most likely due to a difference in diet. Although no clear link can be made between differences in fatty acid signatures and proportions of prey consumed with these sets of analysis, the hypothesis that adults supply their chicks with a different diet than they consume themselves is supported by these results. With the evidence provided by fatty acid signatures of parents and chicks, it is clear that dietary analysis using stomach

contents is misinterpreting the diet of breeding Leach's Storm-Petrels, and possibly other Procellariformes.

Stomach contents suggest that fish comprised a much higher proportion of chick diet than the typical adult diet during the chick-rearing period. Hedd and Montevecchi (2006) used stable isotopic analyses to demonstrate that, at least in some years, parents feed their offspring higher trophic level prey than they consume. The prey variation in the stomach contents indicates that adults may be consuming different prey than they collect for their chicks, which is supported by the results in the current chapter. Fatty acid signature analysis can not determine relationships that give a definite number associated with relative trophic levels, as stable isotope analysis can. However, statistical comparisons between two predator groups and a universal prey library can determine if one prey group is consuming more of a particular prey in fatty acid space by a particular predator. The question of which prey species contribute to the difference between parent and offspring in Leach's Storm-Petrel will be examined in Chapter 3.

## Chapter 3 – Dietary analysis of Leach's Storm-Petrels

### 3.1 Introduction

Leach's Storm-Petrels are the most common breeding seabird in the northwest Atlantic (Montevecchi *et al.*, 1992), with the species' largest colony on Baccalieu Island, Newfoundland (Sklepkovych & Montevecchi 1989), just off the northern tip of the Avalon Peninsula. However, because of their nocturnal behaviour at the breeding colony and their widespread and sparse distribution at sea (personal observations), little is known about their diet. Traditional methods (i.e. analysis of stomach contents) have been employed and have determined its composition to be planktonic and piscine in nature (Linton, 1978; Montevecchi *et al.,* 1992; Vermeer & Devito, 1988; Hedd & Montevecchi, 2006), consisting of mainly lantern fish (Family *Myctophiidae*) amphipods and euphausiids, with smaller proportions of gadid larvae and other planktonic crustaceans. All of these prey are found in the waters off of Newfoundland and, all together, range from the coast to the continental slope.

The previous traditional methods of diet analyses are relatively simple and efficient at identifying prey items that have clearly identifiable portions of their anatomy (i.e., hard parts) that are somewhat resistant to digestion. However, there are a number of well-recognized but unavoidable biases that are associated with these methods, including the ease of misidentification of species or characteristics of the prey item (i.e. extrapolated size, sex or level of maturity), inability to detect prey which lack hard parts, differential digestion of various types of hard parts, and finally, that inference is only possible to the most recent meal(s) (e.g., Jobling and Brieby, 1986; Bowen *et al.*, 1993). In particular, Leach's Storm-Petrels are susceptible to misinterpretation due to the fact

that stomach content samples are at various levels of digestion upon collection since foraging trips can take as long as 5 days, throughout which foraging is most likely continuous. If re-sampling is a requirement, and would be in a study of this nature; collection without seriously decreasing the offspring's dietary intake would be impossible and would compromise the nature of the study.

Fatty acid signature analysis provides another method to assess diet. Fatty acids are the main constituent of lipids and, as energy dense molecules, are important in the storage and transfer of energy in the marine ecosystem (Arts *et al.*, 2001). Given the restrictions to their biosynthesis, their unique occurrence or patterns among various organisms, and their great diversity (~70 fatty acids are routinely identified in marine samples), they can be important tracers of trophic relations (Fraser *et al.*, 1989; Iverson *et al.*, 1997a, b; Logan *et al.*, 2000; Budge *et al.*, 2006). When incorporated into the fat storage sites (e.g. adipose tissue) of a predator from prey consumed, there is either little change in relative composition or the pattern of deposition is predictable (Kirch *et al.*, 1998; Iverson & Springer, 2002; Cooper *et al.*, 2006; Iverson *et al.*, in press).

Fatty acid signatures alone can provide powerful insight into spatial and temporal differences in foraging patterns both among and within species of fish, birds and mammals (e.g., Fraser *et al.*, 1989; Iverson *et al.*, 1997a, b; Logan *et al.*, 2000; Iverson *et al.*, 2000; Iverson & Springer, 2002; Chapter 2). Connan (*et al.*, 2005) used fatty acids to estimate the prey composition of stomach oil of the Tasmanian Short-Tailed Shearwater (*Puffinus tenuirostris*). Recently, modeling tools have been developed to use fatty acid signatures of a predator, to quantitatively determine the species composition of its diet (Iverson *et al.*, 2004). Quantitative fatty acid signature analysis (QFASA) compares fatty

acid signatures of potential prey items to those of the predator, after accounting for predator metabolism effects on FA and, using a statistical mixing model, generates estimates of the proportion of each prey type consumed by an individual predator. These methods have been successfully validated and used in several species of phocid seals, mink (*Mustela vison*), polar bears (*Ursus maritimus*) and several species of seabirds (Iverson et al. 2004, 2006, in press).

Because Leach's Storm-Petrels foraging habits do not allow researchers to observe ingestion, the only tool for dietary analysis are chick provisions. Therefore, the true diet of adult breeding birds may be misrepresented, either by species or proportion there of, in those stomach contents. A comparison of fatty acids, however, supersedes the stomach contents and only analyses what an individual actually incorporates into their body. Results in Chapter 2 have shown that there is a difference in the fatty acid signatures of adults and their offspring. The quantative analysis of fatty acids in Leach's Storm-Petrels and their prey, will allow us to examine which of the prey species present in the diet are the major factors in determining where the differences are between those two groups. In the present study, I used QFASA to estimate the species composition of diets of adult and chick Leach's Storm-Petrels, using fatty acid signatures of their adipose tissue and a representative prey data base. Calibration coefficients calculated from species other than Leach's Storm-Petrels are evaluated on their ability to calculate estimates that are accurate to other measures of Leach's Storm-Petrel diet. I compare these estimates to previous examples of dietary analysis to assess the performance of QFASA to provide an ecologically reasonable estimate of Leach's Storm-Petrel diet.

## 3.2 Methods

### *3.2.1 Sample Collection*

#### *3.2.1.1 Leach's Storm-Petrel adipose tissue*

Data from adipose tissue of 28 adults (14 male, 14 female) and 25 chicks collected between 2001 ($n_{Adult\ Male} = 6$, $n_{Adult\ Female} = 6$, $n_{Chick} = 10$) and 2002 ($n_{Adult\ Male} = 8$, $n_{Adult\ Female} = 8$, $n_{Chick} = 15$) were used in all analyses in this study (these were the same tissue samples used in Chapter 2).

#### *3.2.1.2 Leach's Storm-Petrel prey samples*

Collection of Leach's Storm-Petrel prey occurred on board CCGS Teleost, cruise #404 (Spring capelin survey), from May 6-25, 2002, and September 9 and 12, 2002, on the Ocean Science Centre's (OSC), Boston-whaler. Tows aboard CCGS Teleost in both shelf (< 200 m) and continental slope environments (200-2000 m), were performed opportunistically during day and night. All tows were performed in areas where Leach's Storm-Petrels were observed foraging, and all prey samples collected, fell within the size ranges observed in regurgitate samples (Chapter 2). Capelin (*Mallotus villosus,* n = 20), myctophids (*Benthosema glaciale,* n = 22), euphausiids (*Meganyctiphanes norvegica* n = 20) and amphipods *Parathemisto* spp. (n = 12) were collected with standard capelin tows (12 mm mesh net). The amphipod *Hyperia galba* (n = 40), which are gonadal parasites of large Scyphomedusae, were collected with the OSC Boston-whaler just outside St. John's Harbour. Moon (*Aurelia aurita*) and Red Lion's Mane jellies (*Cyanea capillata*) were caught in pole nets and amphipods were removed by shaking in a plastic bag (Red Lion's Mane jellies) or by scraping them from gonadal pouches (Moon jellies).

All prey samples were placed immediately into pre-weighed lipid cleaned glass vials. Samples collected on the Teleost were frozen at –20°C until they could be processed, at which point the mass of the sample was recorded and were labeled for the area that they were collected. The mass of live *Hyperia galba* were recorded immediately, were separated according to host jelly species and sex, added to 1 ml of chloroform and frozen at -20 °C until processing.

*3.2.2 Lipid extraction, derivatization and Jones' reaction*

Lipids were extracted and derivatized in the same manner as described in Section 2.2.3 for Leach's Storm-Petrel adipose tissue. Fatty acid composition of all samples was analyzed as described in Sections 2.2.6 and 2.27. A sub-sample of three individuals of each prey species, with the exception of the amphipod *Hyperia galba* that had a sub-sample of six, three individuals from each host jelly species, were analyzed for lipid class composition as described in Section 2.2.5. Six individuals of each prey species were subject to the Jones' reaction.

Wax esters consist of a fatty acid esterified to an ALC, and when digested by a predator these two components are broken apart. The FFA is incorporated directly, while the ALC is oxidized into a FFA before it would be incorporated into the body and subsequently adipose tissue, therefore becoming a component of the fatty acid signature of the predator (Place and Roby, 1986; Roby *et al.*, 1986; Budge and Iverson 2003). This mode of lipid assimilation has been demonstrated to be quite effective in several planktonic seabirds (Roby *et al.*, 1986), especially Leach's Storm-Petrels (Place and Roby, 1986). However, normal $BF_3$ derivatization does not oxidize ALC, which would be difficult to identify in the gas chromatography (GC) analysis of FAME. Therefore, the

true fatty acid signatures of any prey item containing WE would not be analysed with this method. The procedure, called the Jones' reaction, oxidizes ALC into FFA so they can be analysed simultaneously and is outlined as follows according to Budge and Iverson (2003).

Fatty acid methyl ester samples were spotted onto lipid cleaned thin layer chromatography plates (5 x 20 cm, silica-gel 60, 250 μm gel thickness) 2 cm from the bottom of the plate. The plates were dried for 5 min in a constant humidity chamber, and allowed to develop in 1 cm deep 100% acetone until the solvent had run to 18 cm from the bottom of the plate approximately 75-80 min later. Plates were then removed and dried for 5 min, sprayed evenly lengthwise with 2, 5-dichlorofluorescein and dried again for 5 min. Plates were then observed in an ultraviolet light box so that ALC and FAME spots could be identified. ALC spots were found close to the origin and FAME spots eluted approximately 10 cm up the plate. Each spot was scrapped into a lipid cleaned glass vial. Scrapings were washed with 2 mL of hexane, vortexed for 10 s, sonicated and centrifuged for 4 min each and extracted for a total of 3 washing cycles. The final extracts were then dried under nitrogen. The FAME fraction was then redissolved in 1 mL of hexane, while the ALC fraction was dissolved in 2 mL of acetone.

Ten drops of the Jones' reagent (13.5 g chromium oxide [$CrO_3$], 43.6 mL chloroform extracted water and 11.4 g [6.4 mL] sulfuric acid [$H_2SO_3$]) were then added to the ALC fraction in acetone, which was then vortexed for 30 s (precipitate was formed) and left at room temperature for 1 hr, vortexing once more during the hour. After the hour, 1 mL of water and 2 mL of hexane were added and the solution was vortexed until the precipitate dissolved, after which the tube was centrifuged for 5 min, so

two phases were formed. The upper, hexane phase was removed into a second lipid cleaned glass vial and the lower phase was washed 2 more times with 2 mL of hexane, followed by vortexing and centrifuging each time. The hexane fraction was then washed with 1 mL of water to remove any remaining Jones' reagent and the hexane fraction was transferred to the vial containing the FAME fraction. The water was then washed twice more with 1 mL of hexane and both hexane washes were added to the FAME fraction. The FAME fraction, which now contained the ALC that had been oxidized into FFA, was rederivatized with the method described in Chapter 2, section 2.2.3.

*3.2.3 Data collection and transformation*

All lipid and fatty acid data were collected and trimmed as in Chapter 2 (Section 2.2.7) for all prey samples. All analysis was done with the same software listed in Chapter 2 (Section 2.2.8).

*3.2.4 Multivariate analysis*

MANOVA and discriminant analysis were performed on the 11 most abundant fatty acids ($n_{\text{least abundant prey}} - 1 = 11$). These analyses were performed to obtain information about relationships between prey species. Hierarchical cluster analysis was also performed to insure that the mean FAS of each prey species were distinguishable.

*3.2.5 Quantative fatty acid signature analysis*

Recently, a model has been developed to estimate proportionate prey consumption of predators by modeling fatty acid signatures of potential prey species and intraspecies groups onto the predator fatty acid signature (Iverson *et al.* 2004). The model is based on fitting predator fatty acid signatures to those of their potential prey by minimizing the statistical distance between predator signatures and weighted mean prey signatures. The

predator signatures must also be corrected for modification that may occur due to the predator's FA metabolism using calibration coefficients.

*3.2.5.1 Calibration Coefficients*

Calibration coefficients are developed using long-term controlled diet studies to estimate differences between patterns of fatty acid intake and deposition in predator adipose tissue. The coefficients correspond to the ratio of prey composition to predator adipose tissue composition for each fatty acid, after assuming it has consumed the diet long enough to have completely turned over all previously stored fatty acids, and therefore resemble diet as much as it ever will. The calibration coefficients are calculated by the 10% trimmed means of the quotient of the following formula:

$$r^{j}_{li} = \text{predator}_{ij}/\text{diet}_{lj}$$

where $r^{j}_{li}$ is the ratio between the proportions of the *j*th fatty acid for the *i*th predator to the proportion of the *j*th fatty acid for the *l*th prey. The 10% trimmed mean of the collection of ratios then gives $c_j$, the calibration coefficient for fatty acid *j*. Previously determined calibration coefficients were used from Iverson *et al.* (2004; Fig 3.1) based on grey seal pups and Iverson *et al.* (in press) for common murres *Uria aalge* and black-legged kittiwakes (*Rissa tridactyla*). The purpose of using these three sets of coefficients was to determine which is the best in relation to this system at determining the closest estimate to other dietary studies of Leach's Storm-Petrels.

*3.2.5.2 Fatty acid subsets*

As stated previously, the fatty acid profile can change in relative proportions of individual fatty acids between ingestion and deposition. Some of those changes are due to non-proportional metabolism of specific fatty acids (e.g., 22:1n-11; Bremer & Norum,

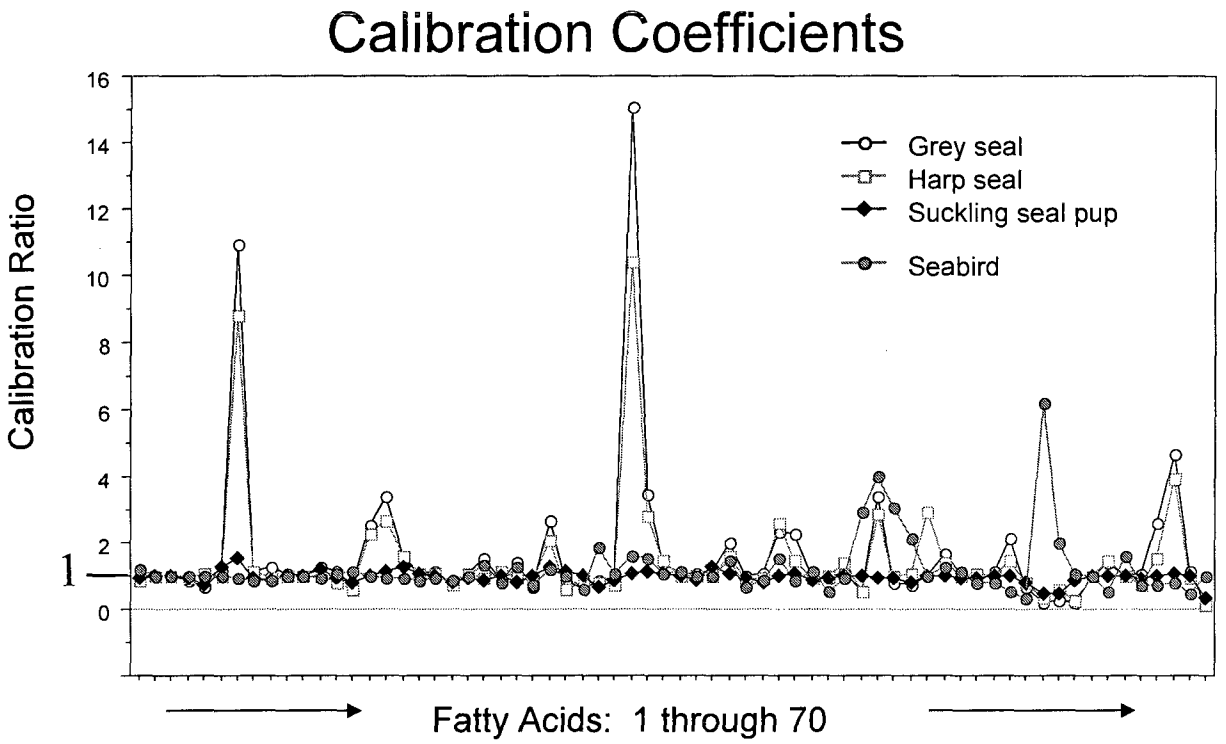


**Figure 3.1**: Figure taken from Iverson and Springer (2002). Calibration coefficients used for seabird (represented by ●) and seal pups (represented by ♦; seal data from Iverson *et al.* 2004). The two other sets of coefficients in the figure denote other adult seal coefficient sets. A mean of the seabird and seal pup coefficients were used to manufacture the seabird/seal pup coefficient set to create a more conservative set of coefficients. The one:one line represents the point of no deviation of a given fatty acid from the proportions detected in a predator relative to that consumed in its diet.

1982; Copper et al. 2006), and others are due to biosynthesis in the predator. Other fatty acids can only arise from dietary intake (especially PUFA with n-3 n-6 double bonds) and, therefore, may be most suitable for modeling diet. Some fatty acids can have multiple factors that influence their proportions in predators; such as, 22:5n-3 which may be mainly a modification product but can also be found at high levels in the diet (Ackman *et al.*, 1988; Iverson 1993), or some shorter chain length fatty acids (e.g., 16:0, 18:1) can be biosynthesized but are also important in differentiating prey items (Iverson, 1993; Budge *et al.*, 2001; Iverson *et al.*, 2001). Hence, fatty acid subsets were developed, along with the calibration coefficients described previously, for use in the QFASA model to determine which fatty acids were most suitable to estimate diets of predators. Three subsets were used for these estimates (Table 3.1); a "dietary" subset used the 27 fatty acids only influenced by diet and an "extended" subset which added the 35 fatty acids that are primarily influenced by diet but can be modified physiologically, both as specified in Iverson et al. (2004), and a "full" fatty acid set containing all fatty acids (n = 45) included in both the data set and the calibration curves.

*3.2.5.3 Simulations*

The simulations preformed on Leach's Storm-Petrel fatty acid signatures used to determine the proportion of prey species in their diet were based on the model developed by Iverson (*et al.*, 2004; detailed discription in Appendix B). Each simulation uses a subset of individuals from each prey type (to simulate the variation that is inherent in any prey population) to determine a bootstrapped mean of that prey type (Iverson *et al.*, 2004). The estimation of deitary composition of the predator is determined by

minimizing the statistical distance between a randomly selected predator fatty acid signature and a weighted combination of bootstrapped mean prey signatures (Iverson *et al.*, 2004). The Kulback-Liebler distance, a means of comparing distributions (*Encyclopedia of Statistics*, 1983), is the statistical measure used by the model to determine the weight of a particular combination of prey signatures (Iverson *et al.*, 2004). Initially, simulations with no calibration were performed to determine the properties of the estimation procedures and robustness of dietary determination by the model using the prey database and separating by prey species only.

The three main prey components of Leach's Storm-Petrel diet, as determined by preliminary hard part analysis of stomach contents in Chapter 2 (myctophids, amphipods, euphausiids) were used to construct two diets. Diet 1 were proportions estimated by Montevecchi *et al.* (1992, 55% myctophids, 30% amphipods, 10% euphausiids) and diet 2 was in equal proportion of the three prey items (33.3% each).

Simulations were then run on a pseudo-Leach's Storm-Petrel signature calculated by the weightings of the two diets above to examine the influence of two factors on the model: 1) the model of prey that was used (models 1-2), and 2) the group of fatty acids used (i.e. dietary, extended, or full). The two models used were: 1) based on prey species separated by area, sex (where applicable), and 2) model 2 based on prey species only. The pseudo-Leach's Storm-Petrel was calculated using the method described in Iverson *et al.* (2004) with 10% noise and 30 prey sampled from the prey set presented here. Simulations to predict diet were then run with 1000 iterations and examined according to proportion of prey used to construct the pseudo Leach's Storm-Petrel for the two diets above.

*3.2.5.4 QFASA modeling of diets*

When prey types were determined to be discernable from one another, fatty acid signatures of Leach's Storm-Petrel adipose tissue were then input into the model and 1000 iterations of prey fatty acid composition were estimated. Proportionate mass was calculated using the mean proportion of lipid measured for each prey item with the formula:

$$M_i = \frac{\left(100 \times \left(\frac{100 \times f_i}{l_i}\right)\right)}{\sum_{i=1}^{n}\left(\frac{100 \times f_i}{l_i}\right)}$$

where $M_i$ is the proportionate mass for prey item $i$, $f_i$ is the proportionate fatty acid estimate and $l_i$ is the proportionate body lipid. The mean of all estimates of each prey item was then calculated for each individual Leach's storm-petrel. Two dietary models were used to determine whether prey signatures could be reliably differentiated with the QFASA model using the two models described above. A third model (model 3) was used when capelin were believed to be substantially over estimated in the first two models and were removed. Prey items with lipid profiles consisting of at least 10% wax esters and fatty alcohols had data from post-Jones' reaction included in the models. Estimates were calculated for each model (1-3), each set of fatty acids and with four sets of calibration coefficients; seal pup, seabird, the mean of the seal pup and seabird, and one:one coefficients. These different sets of calibration coefficients provided a variety of levels for physiological modification to compare for individual fatty acids since there was no specific set of coefficients calculated for Leach's Storm-Petrels for this thesis.

## 3.3 Results

### *3.3.1 Leach's Storm-Petrel prey items*

A total of 114 samples of five species of the most likely potential prey were analyzed for total lipid content, and lipid class and fatty acid composition (Table 3.1). Data from all samples were used in analysis with MANOVA and discriminant analysis.

#### *3.3.1.1 Lipid class analysis*

Lipid classes of Leach's Storm-Petrel prey were used to determine if Jones reaction was a required step in the analysis of Leach's Storm-Petrel dietary modeling. Wax esters (in the combined wax ester/steryl ester peak) and fatty alcohols were targeted as potential sources of error in the QFASA modeling and, therefore, prey items were assessed as to the levels of these two components. Of the five groups of prey, myctophids displayed the highest proportion, with 25% of lipids consisting of WE/SE and ALC (WE confirmed by Place & Roby, 1986), while the amphipod *Parathemisto* spp. (the prey with the second highest proportion of these lipids) comprised only 5.73% of its lipids as WE/SE and ALC (Table 3.1).

#### *3.3.1.2 Major prey fatty acid characteristics*

Sixty-four fatty acids were regularly identified in the 114 samples of the five species of prey analyzed. Four of the 64 fatty acids (22:6n-3, 20:5n-3, 18:1n-9 and 16:0) comprised 52% of the total composition across prey species (Table 3.1). All fatty acids identified were considered to be in the cis configuration with the exception of 16:1n-7, which was found in both cis and trans configurations. The proportions of major fatty acids differed among all species, but shared some similarities between species collected in similar environments (i.e., myctophids and euphausiids from pelagic waters and

**Table 3.1**: Summary table of lipid and fatty acid composition for prey species. Values are means and standard deviations of percentages. Total lipid is mass% of sample, lipid classes are mass % of total lipid, and fatty acids are mass % of total fatty acids. The species of euphausiids analysed was *Meganyctiphanes norvegica* and the species of myctophid was *Benthosema glaciale*. Subscript 1, 2, and 3 indicate the fatty acid subsets that a particular fatty acid fell into (1 is only the full subset, 2 is the full and extended subsets and 3 is full, extended and dietary). Note: Jones-ed Myctophids were a sub-set of those characterized under "Myctophids".

| | *Hyperia galba* *n = 40* | Capelin *n = 20* | Euphausiids *n = 21* | Myctophids *n = 21* | *Parathimisto spp.* *n = 12* |
|---|---|---|---|---|---|
| **Total lipids** | 1.1 ± 0.4 | 2.25 ± 0.78 | 5.53 ± 1.09 | 7.41 ± 4.09 | 2.43 ± 1.65 |
| | | | **Lipid components** | | |
| **HC** | 4.16 ± 2.75 | 2.13 ± 0.90 | 4.69 ± 1.08 | 3.77 ± 2.56 | 2.69 ± 2.74 |
| **SE** | 0.44 ± 0.99 | 1.25 ± 1.44 | 0.00 | 24.73 ± 21.42 | 3.23 ± 1.67 |
| **KET** | 1.53 ± 1.43 | 1.03 ± 0.49 | 0.00 | 0.03 ± 0.06 | 0.14 ± 0.23 |
| **TG** | 23.64 ± 8.62 | 25.57 ± 14.39 | 70.67 ± 6.42 | 27.90 ± 45.05 | 14.33 ± 4.40 |
| **FFA** | 0.78 ± 1.15 | 16.25 ± 4.77 | 3.72 ± 2.98 | 1.53 ± 1.47 | 20.93 ± 5.59 |
| **FA** | 0.07 ± 0.15 | 0.00 ± 0.00 | 1.59 ± 1.51 | 0.63 ± 0.55 | 2.50 ± 4.34 |
| **ST** | 8.67 ± 2.95 | 12.56 ± 3.19 | 4.19 ± 0.61 | 1.70 ± 0.44 | 10.68 ± 6.79 |
| **AMPL** | 20.20 ± 10.87 | 10.72 ± 3.55 | 10.14 ± 4.35 | 5.29 ± 3.70 | 12.10 ± 2.68 |
| **PL** | 37.00 ± 11.14 | 27.17 ± 6.78 | 5.00 ± 3.31 | 9.62 ± 5.12 | 30.55 ± 2.57 |

**Table 3.1 cont'd:**

| | *Hyperia galba* *n = 40* | Capelin *n = 20* | Euphausiids *n = 21* | Myctophids *n = 21* | Jones-ed Myctophids *n = 6* | *Parathimisto spp.* *n = 12* |
|---|---|---|---|---|---|---|
| | | | **11 most abundant fatty acids** | | | |
| **Proportion** | 79.4 | 89.0 | 89.0 | 84.9 | 88.8 | 87.4 |
| | | | **Saturated fatty acids** | | | |
| **14:0$_2$** | 1.82 ± 0.88 | 5.15 ± 1.55 | 6.62 ± 0.89 | 4.59 ± 0.77 | 5.14 ±1.04 | 4.27 ± 1.11 |
| **15:0 *iso*$_1$** | 0.40 ± 0.21 | 0.12 ± 0.05 | 0.24 ± 0.06 | 0.32 ± 0.10 | 0.32 ± 0.06 | 0.26 ± 0.10 |
| **15:0 *anti-iso*$_1$** | 0.08 ± 0.12 | 0.04 ± 0.02 | 0.11 ± 0.04 | 0.14 ± 0.05 | 0.01 ± 0.03 | 0.11 ± 0.12 |
| **15:0$_1$** | 0.85 ± 0.29 | 0.31 ± 0.03 | 0.35 ± 0.05 | 0.22 ± 0.09 | 0.37 ± 0.09 | 0.42 ± 0.18 |
| **16:0 *iso*$_1$** | 0.16 ± 0.04 | 0.05 ± 0.03 | 0.12 ± 0.04 | 0.06 ± 0.03 | 0.12 ± 0.04 | 0.05 ± 0.05 |
| **16:0 *anti-iso*$_1$** | 0.33 ± 1.75 | 0.20 ± 0.05 | 0.09 ± 0.07 | 0.04 ± 0.03 | 0.08 ± 0.10 | 0.11 ± 0.15 |
| **16:0$_2$** | 10.48 ± 2.35 | 15.16 ± 2.26 | 13.96 ± 1.74 | 5.97 ± 3.34 | 11.55 ± 5.39 | 12.21 ± 1.76 |
| **17:0 *iso*$_1$** | 0.60 ± 0.14 | 0.26 ± 0.09 | 0.26 ± 0.04 | 0.32 ± 0.16 | 0.22 ± 0.06 | 0.22 ± 0.12 |
| **17:0 *anti-iso*** | 0.29 ± 0.07 | 0.07 ± 0.02 | 0.12 ± 0.02 | 0.07 ± 0.03 | 0.03 ± 0.05 | 0.09 ± 0.12 |
| **17:0$_2$** | 1.22 ± 0.30 | 0.11 ± 0.02 | 0.11 ± 0.04 | 0.11 ± 0.03 | 0.18 ± 0.10 | 0.25 ± 0.11 |
| **18:0$_2$** | 3.58 ± 0.70 | 1.44 ± 0.30 | 0.98 ± 0.42 | 1.14 ± 0.59 | 2.47 ± 1.36 | 0.84 ± 0.26 |
| **19:0** | 0.30 ± 0.01 | 0.03 ± 0.02 | 0.07 ± 0.02 | 0.08 ± 0.05 | 0.11 ± 0.14 | 0.08 ± 0.10 |
| **20:0$_2$** | 0.40 ± 0.16 | 0.05 ± 0.02 | 0.08 ± 0.02 | 0.08 ± 0.03 | 0.16 ± 0.05 | 0.04 ± 0.04 |
| **21:0** | 0.10 ± 0.05 | 0.01 ± 0.01 | 0.003 ± 0.01 | 0.02 ± 0.01 | 0.02 ± 0.03 | 0.01 ± 0.02 |
| **22:0** | 0.05 ± 0.04 | 0.00 | 0.03 ± 0.02 | 0.03 ± 0.02 | 0.02 ± 0.03 | 0.00 |
| **24:0** | 0.00 | 0.08 ± 0.03 | 0.01 ± 0.02 | 0.03 ± 0.03 | 0.06 ± 0.08 | 0.00 |

**Table 3.1 cont'd**:

| | *Hyperia galba* *n = 40* | Capelin *n = 20* | Euphausiids *n = 21* | Myctophids *n = 21* | Jones-ed Myctophids *n = 6* | *Parathimisto spp.* *n = 12* |
|---|---|---|---|---|---|---|
| | | | **Mono-unsaturated fatty acids** | | | |
| **14:1$_1$** | 0.02 ± 0.04 | 0.06 ± 0.05 | 0.14 ± 0.05 | 0.22 ± 0.09 | 0.13 ± 0.08 | 0.06 ± 0.04 |
| **15:1$_1$** | 0.46 ± 0.22 | 0.09 ± 0.04 | 0.06 ± 0.04 | 0.06 ± 0.03 | 0.01 ± 0.02 | 0.29 ± 0.13 |
| **16:1ω9$_1$** | 0.08 ± 0.03 | 0.17 ± 0.05 | 0.08 ± 0.02 | 0.08 ± 0.05 | 0.11 ± 0.04 | 0.27 ± 0.22 |
| **16:1tr,ω7** | 2.77 ± 1.17 | 0.19 ± 0.04 | 0.14 ± 0.03 | 0.29 ± 0.58 | 0.00 | 0.18 ± 0.07 |
| **16:1ω7$_2$** | 1.14 ± 1.04 | 6.19 ± 1.90 | 8.29 ± 1.38 | 10.22 ± 2.72 | 8.41 ± 1.99 | 7.08 ± 2.51 |
| **16:1ω5$_1$** | 0.12 ± 0.07 | 0.37 ± 0.05 | 0.43 ± 0.07 | 0.33 ± 0.07 | 0.27 ± 0.03 | 0.47 ± 0.24 |
| **17:1$_1$** | 0.97 ± 0.57 | 0.13 ± 0.03 | 0.21 ± 0.06 | 0.42 ± 0.16 | 0.45 ± 0.12 | 0.20 ± 0.06 |
| **18:1ω11$_1$** | 0.21 ± 0.08 | 0.22 ± 0.08 | 0.00 | 0.00 | 0.00 | 0.01 ± 0.02 |
| **18:1ω9$_2$** | 12.03 ± 1.78 | 8.52 ± 0.76 | 13.43 ± 1.81 | 16.87 ± 3.60 | 17.24 ± 4.11 | 10.32 ± 2.03 |
| **18:1ω7$_2$** | 2.60 ± 0.70 | 2.35 ± 0.35 | 3.92 ± 0.99 | 2.03 ± 0.42 | 2.18 ± 0.42 | 2.60 ± 0.33 |
| **18:1ω6** | 0.14 ± 0.13 | 0.04 ± 0.02 | 0.20 ± 0.30 | 0.10 ± 0.09 | 0.49 ± 0.04 | 0.07 ± 0.02 |
| **18:1ω5$_1$** | 0.62 ± 0.23 | 0.73 ± 0.09 | 0.80 ± 0.32 | 0.51 ± 0.12 | 0.05 ± 0.06 | 0.87 ± 0.12 |
| **20:1ω11$_3$** | 0.32 ± 0.39 | 0.40 ± 0.12 | 0.67 ± 0.14 | 1.66 ± 0.55 | 1.53 ± 0.46 | 1.47 ± 1.24 |
| **20:1ω9$_3$** | 1.96 ± 0.37 | 8.41 ± 3.02 | 12.63 ± 2.68 | 13.97 ± 2.42 | 15.72 ± 2.98 | 5.33 ± 4.57 |
| **20:1ω7$_3$** | 1.84 ± 0.93 | 0.52 ± 0.17 | 0.83 ± 0.20 | 0.97 ± 0.86 | 0.92 ± 0.35 | 0.60 ± 0.31 |
| **22:1ω11(13)$_3$** | 0.71 ± 0.82 | 8.19 ± 3.59 | 11.42 ± 2.88 | 14.50 ± 2.70 | 19.32 ± 3.58 | 3.14 ± 3.96 |
| **22:1ω9$_3$** | 0.82 ± 0.32 | 1.13 ± 0.46 | 1.59 ± 0.42 | 1.95 ± 0.65 | 2.80 ± 1.49 | 0.77 ± 0.61 |
| **22:1ω7$_3$** | 0.47 ± 0.28 | 0.18 ± 0.08 | 0.26 ± 0.09 | 0.28 ± 0.08 | 0.31 ± 0.07 | 0.08 ± 0.06 |
| **24:1$_1$** | 0.65 ± 0.30 | 1.35 ± 0.12 | 0.81 ± 0.14 | 1.19 ± 0.31 | 1.48 ± 0.29 | 0.30 ± 0.17 |

**Table 3.1 cont'd**:

| | *Hyperia galba* *n = 40* | Capelin *n = 20* | Euphausiids *n = 21* | Myctophids *n = 21* | Jones-ed Myctophids *n = 6* | *Parathimisto spp.* *n = 12* |
|---|---|---|---|---|---|---|
| | | | **Poly-unsaturated fatty acids** | | | |
| **16:2ω4$_3$** | 0.64 ± 0.14 | 0.53 ± 0.13 | 0.33 ± 0.10 | 0.51 ± 0.17 | 0.23 ± 0.09 | 0.35 ± 0.17 |
| **16:3ω4$_3$** | 0.22 ± 0.08 | 0.12 ± 0.05 | 0.07 ± 0.02 | 0.22 ± 0.12 | 0.09 ± 0.05 | 0.18 ± 0.11 |
| **16:4ω3$_3$** | 0.06 ± 0.04 | 0.003 ± 0.01 | 0.12 ± 0.09 | 0.04 ± 0.07 | 0.01 ± 0.04 | 0.08 ± 0.12 |
| **16:4ω1$_3$** | 0.04 ± 0.04 | 0.12 ± 0.08 | 0.12 ± 0.06 | 0.37 ± 0.24 | 0.10 ± 0.08 | 0.37 ± 0.21 |
| **18:2ω6$_3$** | 1.38 ± 0.48 | 0.98 ± 0.14 | 1.06 ± 0.21 | 1.32 ± 0.18 | 0.93 ± 0.11 | 2.47 ± 0.97 |
| **18:2ω4$_3$** | 0.57 ± 0.13 | 0.13 ± 0.03 | 0.14 ± 0.01 | 0.08 ± 0.02 | 0.02 ± 0.02 | 0.16 ± 0.04 |
| **18:3ω6$_3$** | 0.24 ± 0.09 | 0.01 ± 0.01 | 0.01 ± 0.02 | 0.06 ± 0.06 | 0.04 ± 0.02 | 0.11 ± 0.08 |
| **18:3ω4$_3$** | 0.22 ± 0.10 | 0.10 ± 0.06 | 0.07 ± 0.02 | 0.16 ± 0.08 | 0.16 ± 0.17 | 0.06 ± 0.03 |
| **18:3ω3$_3$** | 0.66 ± 0.48 | 0.37 ± 0.10 | 0.37 ± 0.11 | 0.75 ± 0.20 | 0.36 ± 0.08 | 0.85 ± 0.32 |
| **18:4ω3$_3$** | 0.50 ± 0.57 | 0.64 ± 0.15 | 0.68 ± 0.32 | 2.17 ± 0.82 | 0.74 ± 0.42 | 3.35 ± 1.26 |
| **18:4ω1$_3$** | 0.08 ± 0.09 | 0.07 ± 0.02 | 0.06 ± 0.03 | 0.20 ± 0.1 | 0.11 ± 0.14 | 0.10 ± 0.04 |
| **20:2a** | 0.01 ± 0.06 | 0.00 | 0.00 | 0.00 | 0.24 ± 0.32 | 0.00 |
| **20:2b** | 0.08 ± 0.05 | 0.01 ± 0.01 | 0.01 ± 0.01 | 0.01 ± 0.02 | 0.00 | 0.04 ± 0.05 |
| **20:2ω6$_3$** | 0.59 ± 0.15 | 0.13 ± 0.02 | 0.27 ± 0.03 | 0.22 ± 0.08 | 0.17 ± 0.03 | 0.39 ± 0.08 |
| **20:3ω6$_3$** | 0.16 ± 0.18 | 0.02 ± 0.04 | 0.03 ± 0.02 | 0.08 ± 0.01 | 0.04 ± 0.01 | 0.04 ± 0.06 |
| **20:4ω6$_3$** | 2.02 ± 0.84 | 0.49 ± 0.13 | 0.45 ± 0.11 | 0.48 ± 0.52 | 0.30 ± 0.24 | 0.26 ± 0.16 |
| **20:3ω3$_3$** | 0.45 ± 0.20 | 0.05 ± 0.08 | 0.25 ± 0.05 | 0.09 ± 0.03 | 0.06 ± 0.04 | 0.17 ± 0.07 |
| **20:4ω3$_3$** | 0.88 ± 0.29 | 1.06 ± 3.02 | 0.49 ± 0.21 | 0.90 ± 0.26 | 0.32 ± 0.09 | 0.53 ± 0.07 |
| **20:5ω3$_3$** | 20.90 ± 2.51 | 11.18 ± 3.55 | 7.86 ± 1.93 | 5.09 ± 1.32 | 1.36 ± 0.23 | 19.13 ± 5.09 |
| **22:2NIMDb** | 0.02 ± 0.04 | 0.00 | 0.01 ± 0.02 | 0.02 ± 0.02 | 0.00 | 0.00 |
| **21:5ω3** | 0.18 ± 0.09 | 0.29 ± 0.06 | 0.21 ± 0.04 | 0.30 ± 0.06 | 0.07 ± 0.09 | 0.37 ± 0.09 |
| **22:4ω6$_3$** | 0.43 ± 0.18 | 0.13 ± 0.04 | 0.10 ± 0.03 | 0.11 ± 0.14 | 0.06 ± 0.07 | 0.07 ± 0.05 |
| **22:4ω3$_3$** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 ± 0.04 |
| **22:5ω6$_3$** | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 ± 0.03 | 0.01 ± 0.04 |
| **22:5ω3$_2$** | 3.21 ± 1.47 | 1.12 ± 0.26 | 0.45 ± 0.21 | 0.72 ± 0.59 | 0.17 ± 0.09 | 0.45 ± 0.06 |
| **22:6ω3$_3$** | 17.87 ± 2.00 | 20.14 ± 4.89 | 8.39 ± 1.66 | 7.26 ± 1.13 | 1.99 ± 0.44 | 17.34 ± 3.05 |

capelin and amphipods from neritic; Table 3.1). The colouration of each type of sample was noted for comparison to regurgitation samples from Chapter 2. Euphausiids had a dark orange coloured lipid extract, both myctophids and capelin were coloured faint yellow, and both types of amphipods had no discernable pigmentation by simple visual inspection.

*3.3.1.3 MANOVA*

The 11 fatty acids with the highest proportions over all prey samples (Table 3.1) were analyzed using MANOVA to assess overall differences among species. Fatty acid signatures of the five prey species differed significantly ($df = 44$, $p < 0.001$; Table 3.2; Fig. 3.2). Stepwise analysis revealed that all 11 fatty acids used were significantly different among all prey species with p-values all less than 0.001 (Table 3.3).

When comparing the individual rank of fatty acid proportion within each prey species euphausiids and Jones'ed Myctophids had the most number of common fatty acids within their individual eleven most abundant fatty acids (nine of eleven; 14:0, 16:0, 16:1n-7, 18:1n-9, 18:1n-7, 20:1n-9, 22:1n-11, 22:1n-9, 22:6n-3); the two groups of amphipods and Capelin shared eight of eleven (anti-iso 15:0, 16:1n-7, 16:4n-3, 18:4n-3, 20:1n-9, 20:2n-6, 20:4n-3, 22:5n-3). Only two fatty acids were common between these two groupings; 16:1n-7 and 20:1n-9. These two groupings also correspond to the areas they were sampled; euphausids and Myctophids over the continental slope, and the 2 amphipods and capelin over the continental shelf.

**Table 3.2:** Results of MANOVA to determine overall difference between Leach's Storm-Petrel prey species.

| Test Name | Value | F | Hypothesis. DF | Error DF | p |
|---|---|---|---|---|---|
| Pillais | 2.5 | 16.1 | 44 | 408 | 0 |
| Hotellings | 13.1 | 29.1 | 44 | 390 | 0 |
| Wilks | 0.0065 | 23.6 | 44 | 380.7 | 0 |
| Roys | 0.86 | | | | |

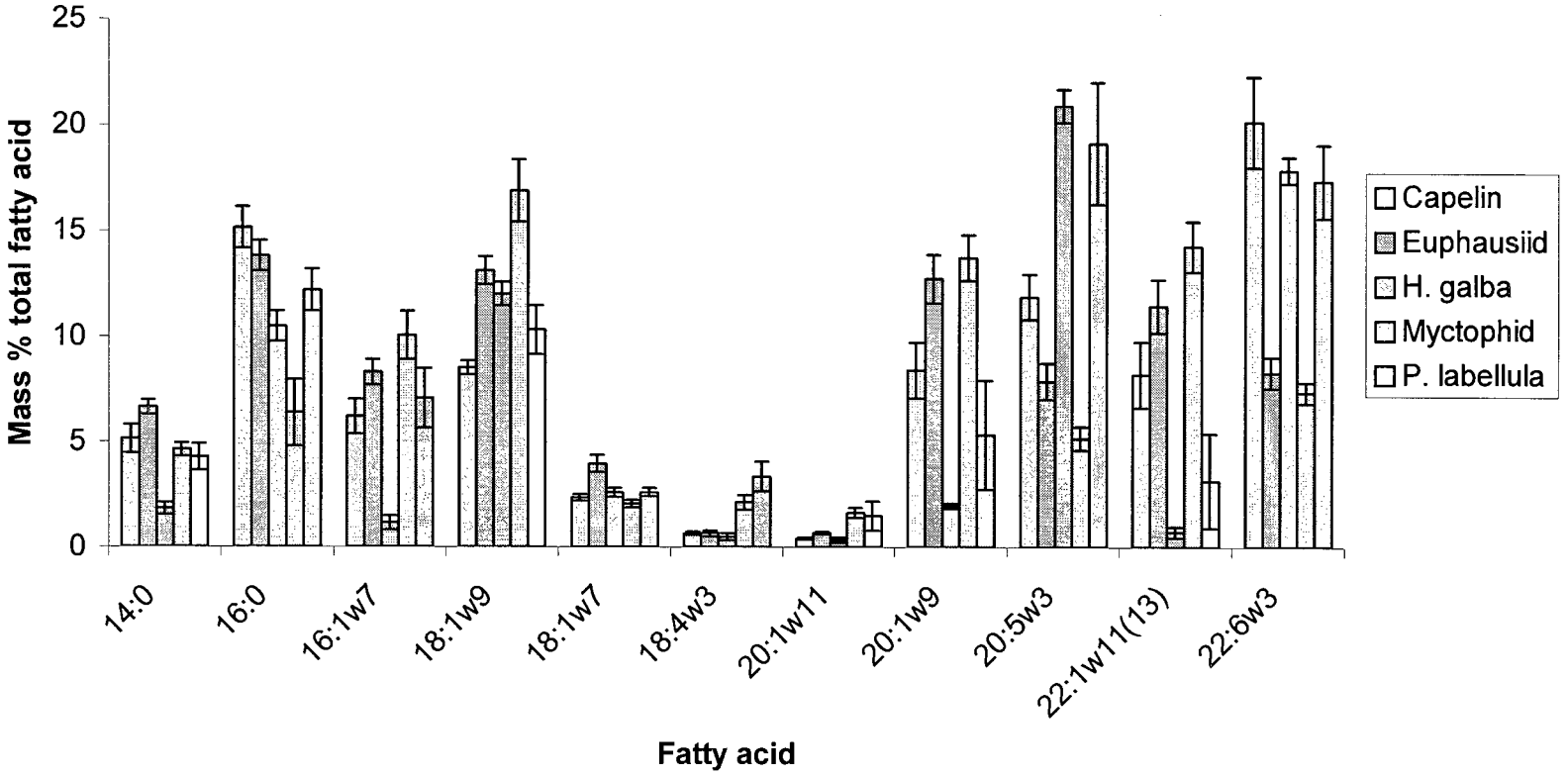


**Figure 3.2:** Histogram of the mean mass percentages of the 11 most abundant fatty acids in the potential prey items of Leach's Storm-Petrel. Error bars represent 95% confidence limits. All individual F-tests of each fatty acid from MANOVA analysis were significant ($\alpha = 0.05/11 = 0.0021$).

**Table 3.3:** Results of F-tests of 11 fatty acids from stepwise MANOVA comparing Leach's Storm-Petrel prey species. ($\alpha = 0.05 / 11 = 0.00454$).

| Variable | F | p |
|---|---|---|
| 14:0 | 51.0 | < 0.001 |
| 16:0 | 23.9 | < 0.001 |
| 16:1ω7 | 68.5 | < 0.001 |
| 18:1ω9 | 76.1 | < 0.001 |
| 18:1ω7 | 26.9 | < 0.001 |
| 18:4ω3 | 49.1 | < 0.001 |
| 20:1ω11 | 55.9 | < 0.001 |
| 20:1ω9 | 73.3 | < 0.001 |
| 20:5ω3 | 33.0 | < 0.001 |
| 22:1ω11(13) | 82.2 | < 0.001 |
| 22:6ω3 | 41.6 | < 0.001 |

*3.3.1.4 Discriminant function analysis*

To investigate the among species variation in prey FA profiles prior to QFASA modeling, a discriminant analysis was performed on the five potential Leach's Storm-Petrel prey. The analysis produced four discriminant functions, with the first two functions explaining 75% of the variance. The first two discriminant functions showed prey items separated into three groups of similar fatty acid signatures, with 22:1n-11, 20:1n-9 and 20:1n-11 being the three fatty acids that contributed the most to function 1, and 22:6n-3, 18:1n-9 and 16:0 contributing the most to function two (Table 3.4). *Parathemisto* spp. displayed a distinct group in the upper right quadrant, while the other two groups consisted of *H. galba* and myctophids (groups 2, in the lower left quadrant), and euphausiids and capelin (group 3, in the upper left quadrant; Fig. 3.3). The two species making up group three were more closely associated than the two species in group (Fig. 3.3). Myctophid samples that had undergone the Jones' reaction and *H. galba* were shown to separate easily when functions three and four were used (Fig. 3.4) while in group 3 capelin and euphausiids still showed considerable overlap (Fig. 3.5).

*3.3.1.5 QFASA Modeling*

*3.3.1.5.1 Simulations*

Quantitative analysis of Leach's Storm-Petrel fatty acid signatures was performed with a new modeling system developed at Dalhousie University (Halifax, Canada). First, to examine the ability to distinguish prey species in the QFASA model, simulations were performed on pseudo-Leach's Storm-Petrel fatty acid signatures, constructed using the method described by Iverson *et al.* (2004) from diet 1 (55% myctophids, 30% amphipods and 10% euphausiids; Fig. 3.6) and diet 2 (equal proportions of the amphipod *H. galba*,

**Table 3.4:** Variable coefficients of functions 1 through 4 from a discriminant analysis performed on transformed proportions of the 11 most abundant fatty acids across all Leach's Storm-Petrel prey samples.

| Standardized Canonical Discriminant Function Coefficients | | | | |
|---|---|---|---|---|
| Function | 1 | 2 | 3 | 4 |
| Variance | 50.2% | 24.8% | 15.3% | 9.7% |
| 14:0 | 0.07 | 0.067 | 0.954 | -0.791 |
| 16:0 | 0.972 | 0.672 | -0.931 | 0.05 |
| 16:1ω7 | -0.059 | 0.505 | 0.663 | 0.089 |
| 18:1ω9 | -0.704 | 0.694 | -1.293 | -0.602 |
| 18:1ω7 | -0.112 | 0.08 | 0.155 | -0.201 |
| 18:4ω3 | 0.715 | -0.004 | -0.422 | 0.555 |
| 20:1ω11 | 1.015 | 0.365 | 0.422 | 0.306 |
| 20:1ω9 | 1.735 | -0.32 | 0.044 | 1.384 |
| 20:5ω3 | 0.326 | -0.017 | -0.97 | -0.058 |
| 22:1ω11 | -2.634 | -0.109 | -0.114 | -0.443 |
| 22:6ω3 | -0.071 | -0.963 | 1.713 | -0.09 |

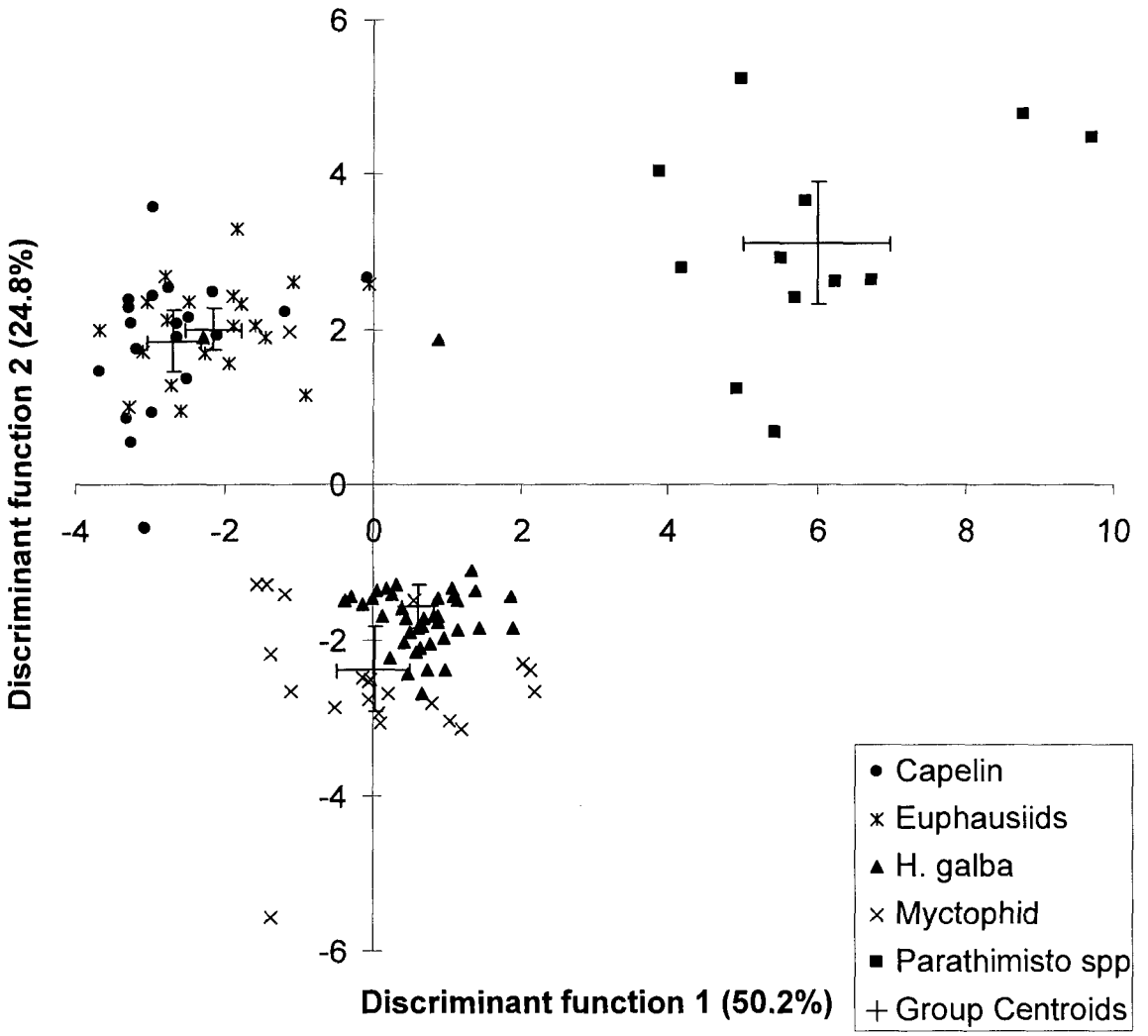


**Figure 3.3**: Scatter plot of discriminant analysis sample scores for discriminant functions 1 and 2 of five species of potential Leach's Storm-Petrel prey. Analysis is based on transformed proportions of the 11 fatty acids with the highest % composition across all samples. Whiskers represent 95% confidence from group centroid of scores for both discriminant functions 1 (x-axis) and 2 (y-axis). Note: Myctophids were the non-Jones-ed analyses.

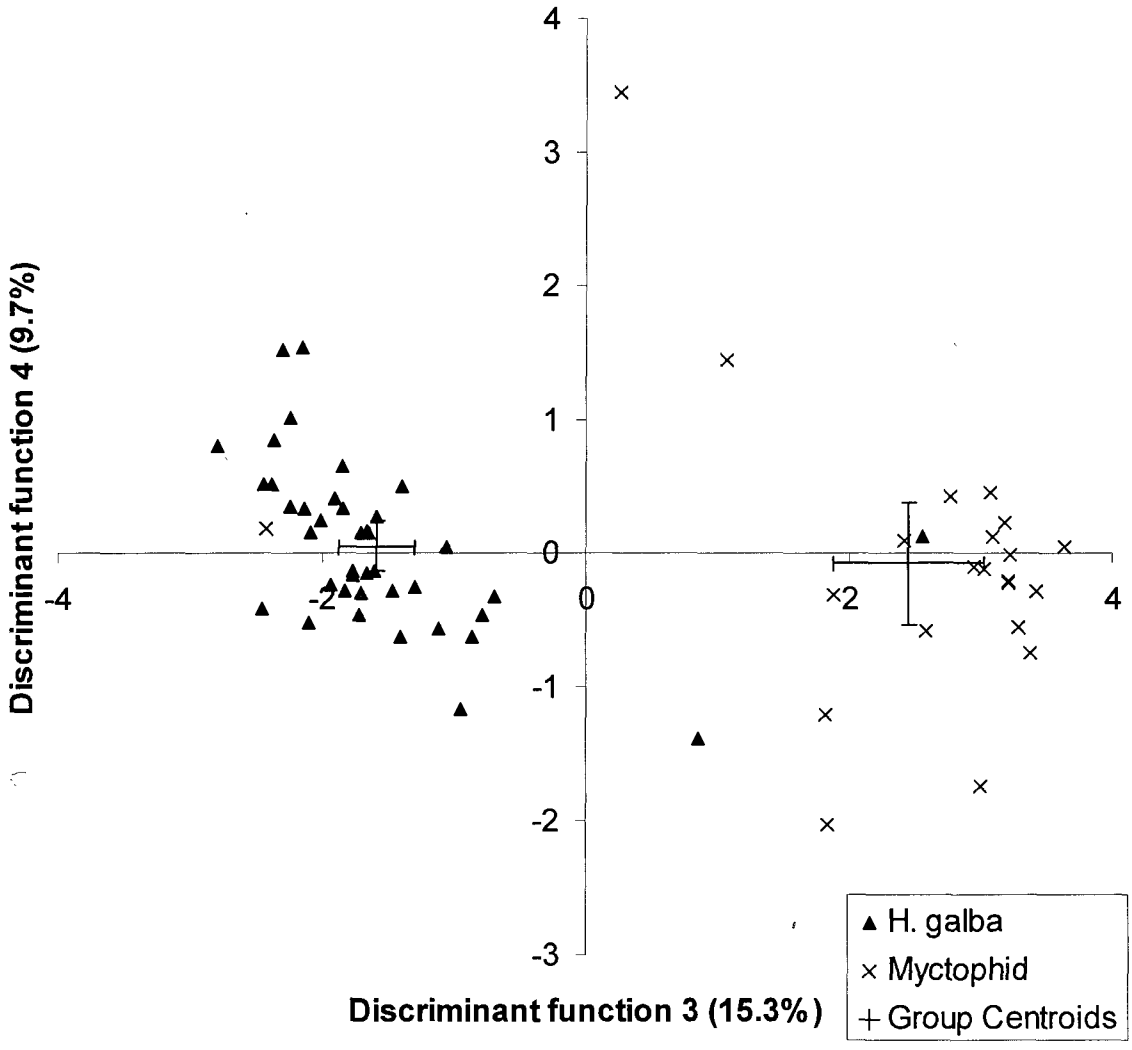


**Figure 3.4**: Scatter plot scores for discriminant functions 3 and 4 of *H. galba* (▲) and Myctophids (x). Whiskers represent 95% confidence from group centroid of scores for both discriminant functions 3 (x-axis) and 4 (y-axis). Note: Myctophids were the non-Jones-ed analyses.

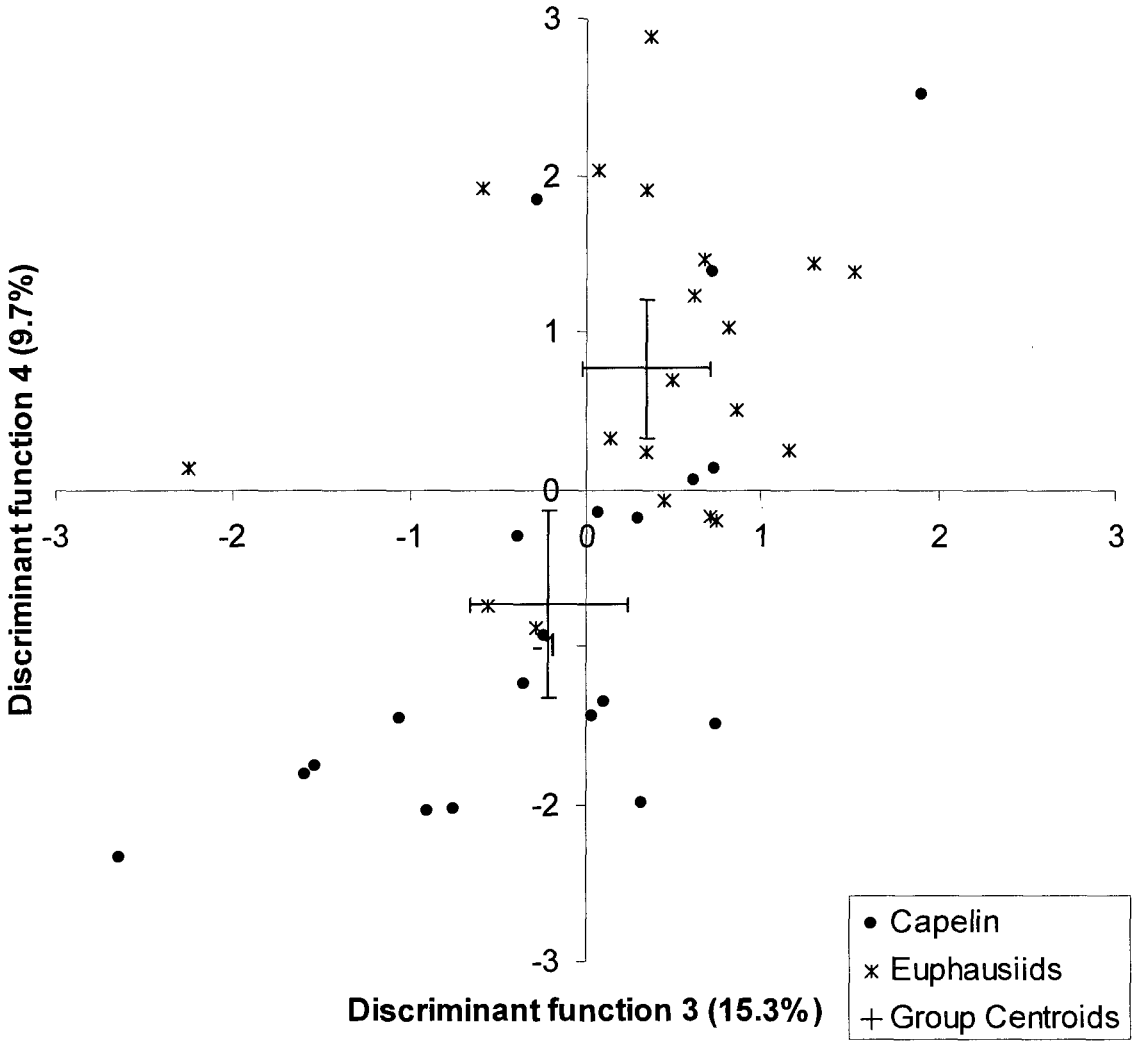


**Figure 3.5**: Scatter plot scores for discriminant functions 3 and 4 of Capelin (•) and Euphausiids (*). Whiskers represent 95% confidence from group centroid of scores for both discriminant functions 3 (x-axis) and 4 (y-axis).

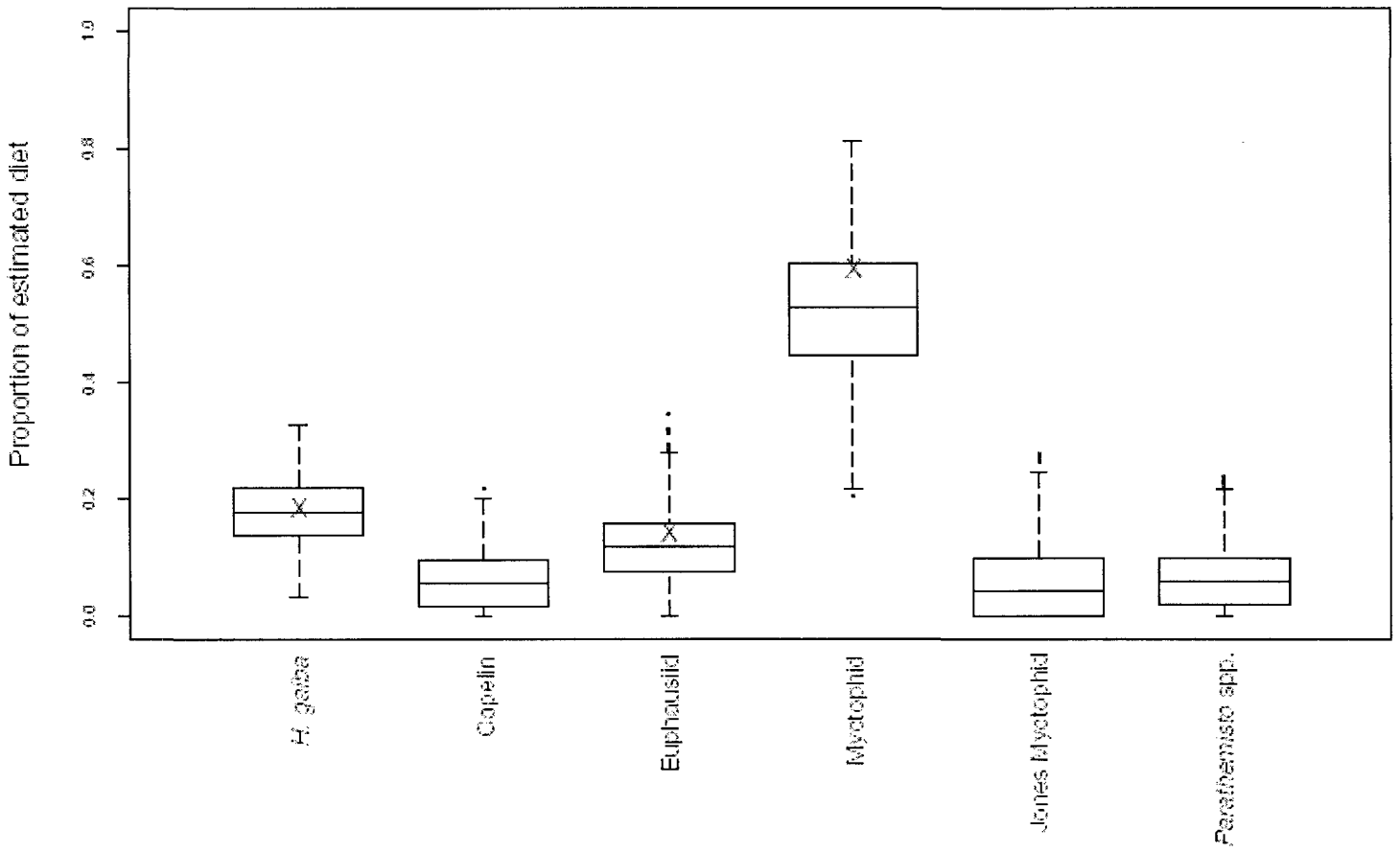


Figure 3.6: Non-calibrated estimates of pseudo-Leach's storm-petrel, calculated by diet estimate 1 (60% myctophids, 20% *H. galba* and 15% euphausiid with 10% error), using the extended fatty acid subset and prey model 2 including both Jones and non-Jones Myctophids. Symbol "X" represents prey proportion used to calculate the pseudo-Leach's storm-petrel.

myctophids, and euphausiids; Fig. 3.7) using both dietary and extended fatty acid subsets and prey model 2 (Table 3.1), over 1000 iterations. For these simulations we included both non-jones-ed and jones-ed myctophids to examine the degree to which the jones-ing procedure affected the correct interpretation of myctophod FA signatures. All prey items specified in pseudo diets were estimated to be composed of proportions very close to that specified (Figs. 3.6 and 3.7). Of particular note, there was almost no overlap between non-jones-ed and jones-ed myctophids, indicating the degree to which jones-ing affected the inter-relation of myctophid FA signatures. These initial simulations showed that all prey items were discernable from one another by the model, and that Jones' myctophids would generally not be mistaken as non-Jones myctophids.

*3.3.1.5.2 Diet estimations*

Three models of potential Leach's Storm-Petrel prey items were modeled onto fatty acid signatures of adults and chicks. Estimates of prey composition for all adult and chick Leach's Storm-Petrel adipose tissue fatty acid signatures were initially calculated for prey models 1 and 2 and the three fatty acid subsets using the three calibration sets. Jones' myctophids were shown to be the prominent of the two variations of myctophids (Fig. 3.8), so non-Jones' myctophids were eliminated from the model and simulations were repeated. When non-Jones' myctophids were eliminated the value of Jones' myctophids tended to increase but not in direct proportion to the amount of non-Jones' myctophids eliminated. Model 1 showed a range of results, depending on the set of calibration coefficients used (Fig. 3.9). Capelin tended to be a major component when using the bird coefficient set and the dietary fatty acid subset for adults (75%) and chicks (67%). However, when the extended and full fatty acid subsets were used, the free-living

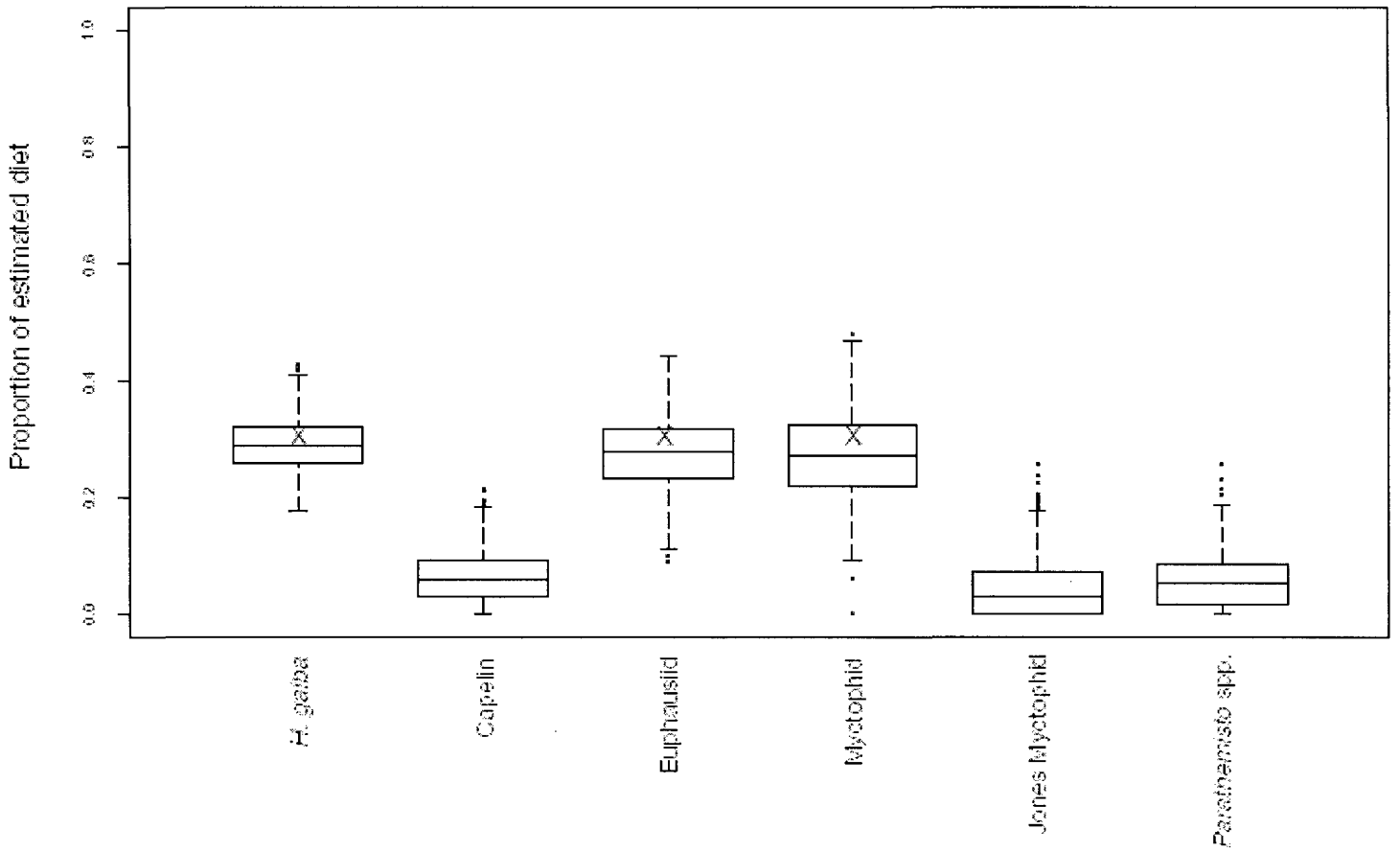


Figure 3.7: Non-calibrated estimates of pseudo-Leach's storm-petrel, calculated by diet estimate 2 (30% myctophids, 30% *H. galba* and 30% euphausiid with 10% error), using the extended fatty acid subset and prey model 2 including both Jones and non-Jones Myctophids. Symbol "X" represents prey proportion used to calculate the pseudo-Leach's storm-petrel.

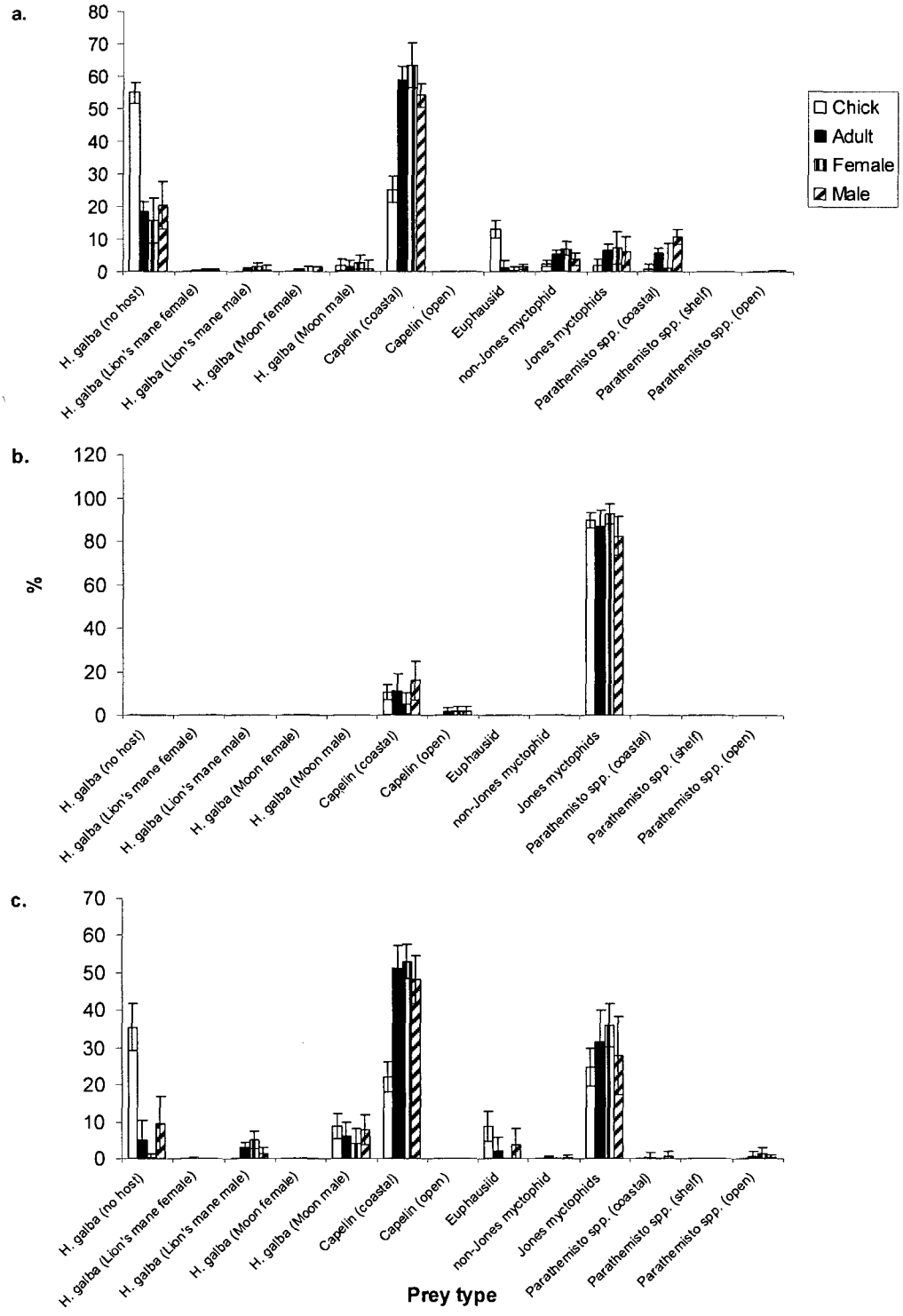


**Figure 3.8:** Diet estimates of Leach's Storm-Petrels using QFASA model 1, the extended fatty acid subset and the three sets of calibration coefficients: bird (a), seal pup (b) and bird/seal pup (c), that include both non-Jones and Jones myctophids.

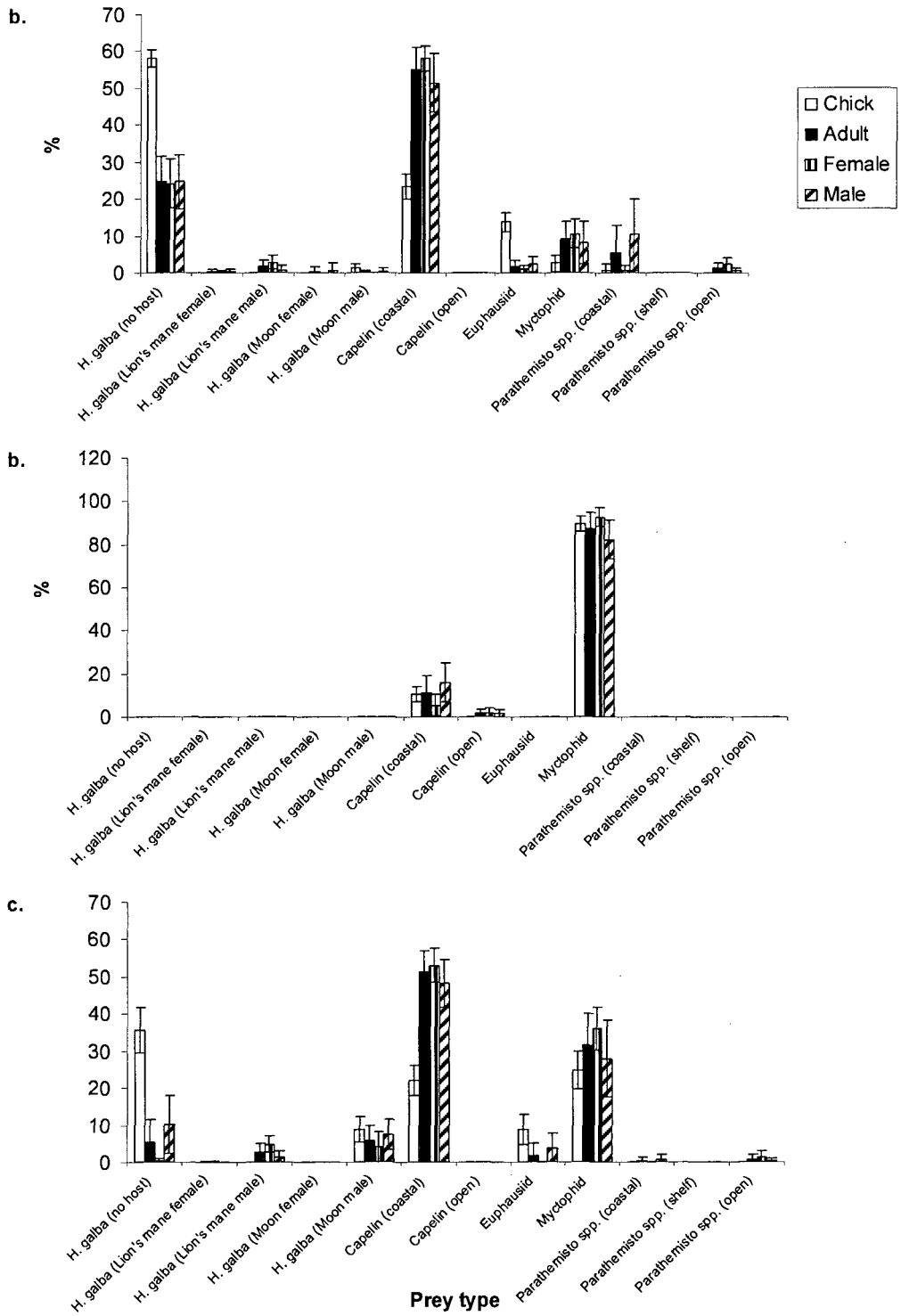


**Figure 3.9:** Diet estimates of Leach's Storm-Petrels using QFASA model 1, the extended fatty acid subsets and the three sets of calibration coefficients: bird (a), seal pup (b) and bird/seal pup (c).

specimen of *H. galba* was estimated at much higher levels for adults (22-25%) and chicks (55-58%; Fig. 3.10). The estimates of myctophids for the seal pup coefficients were almost exclusive for both adults (87-94%) and chicks (89-90%; Fig. 3.9 b), and the mean of the two sets of coefficients produced an estimation similar to the mean of the other two estimates (Fig. 3.9 c). No large patterns of differences were observed between male and female adults, although females tended to have lower estimates of both fish species (Fig. 3.9). Subsets of prey within species were not utilized by the model when available since one subset of each prey dominated the contribution of that prey to the total estimate; therefore, model 2 was used in further estimations of dietary composition of Leach's Storm-Petrels.

Model 2 showed similar distribution between prey items as was shown in the total proportion within prey species as in model 1 (e.g. proportions of near-shore capelin and shelf-edge capelin in model 1 totaled, were approximately equal to the proportion of capelin in model 2) for all combinations of calibration coefficients (Fig. 3.11) and fatty acid subsets (Fig. 3.12). Capelin were estimated to be a major proportion of adult diet for both the bird (55-76%; Fig. 3.12) and bird/pup (46-61%; Fig. 3.11 c) calibration coefficients, and chick estimates exhibited the same pattern as in model 1 with higher proportions of capelin for the dietary subset (46-59%; Fig. 3.12 a) than for the extended (9% per bird CC; Fig. 3.11 b; and 12% per bird/pup CC; Fig. 3.11 c) and full (6-9%; Fig. 3.11 c) fatty acid subsets. The remaining proportion of chick diet estimates was spread between the three crustacean species. The seal pup calibration coefficients were again dominated by myctophids for both adults (87-94%) and chicks (90-96%) and the only other species to be calculated in the estimate was capelin ranging from 4-10% for chicks

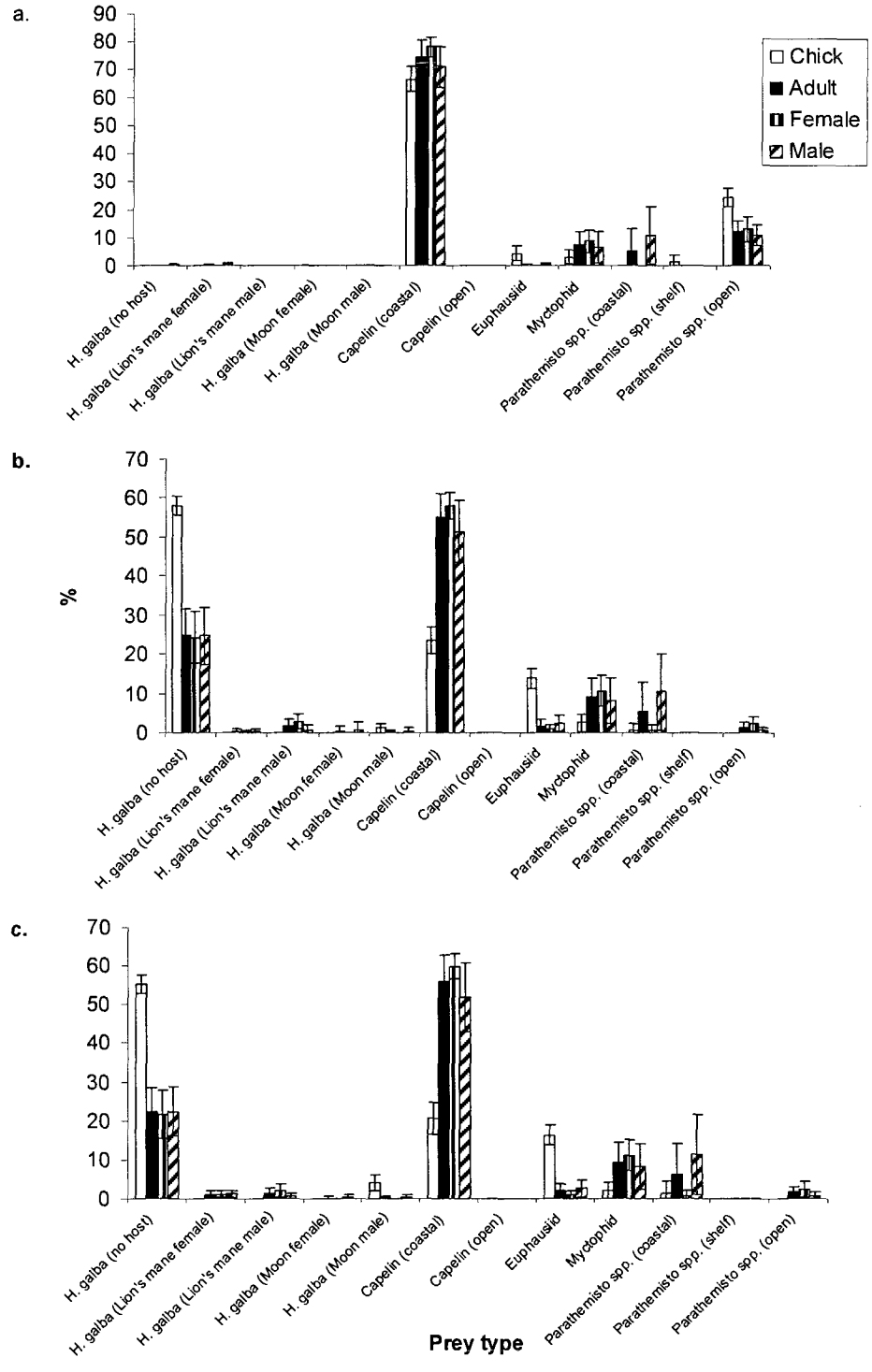


**Figure 3.10:** Diet estimates of Leach's Storm-Petrel s using QFASA model 1, the bird calibration coefficients and the three fatty acid subsets: dietary (a), extended (b) and full

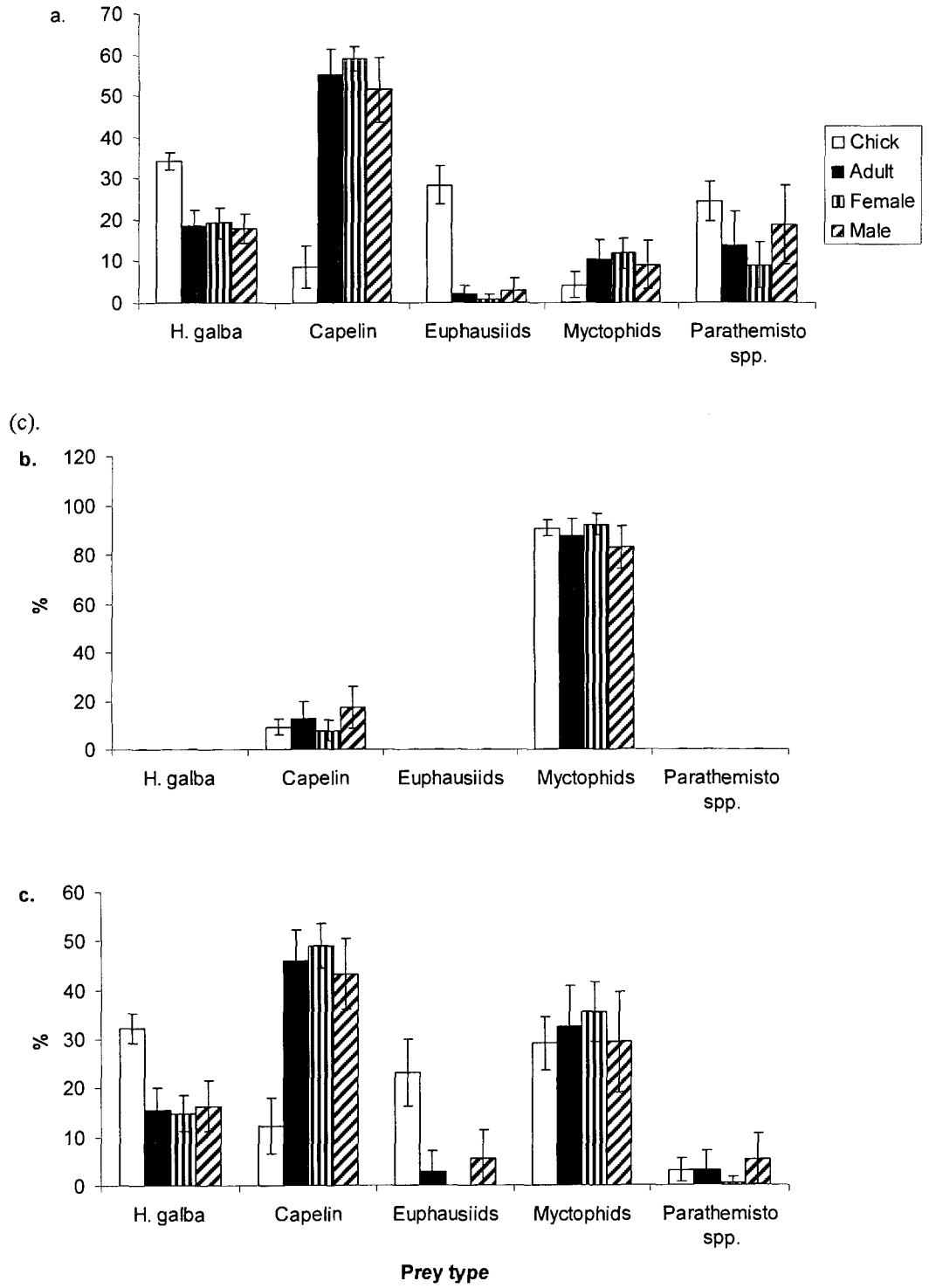


**Figure 3.11:** Diet estimates of Leach's Storm-Petrels using QFASA model 2, the extended fatty acid subsets and the three sets of calibration coefficients: bird (a), seal pup (b) and bird/seal pup (c).

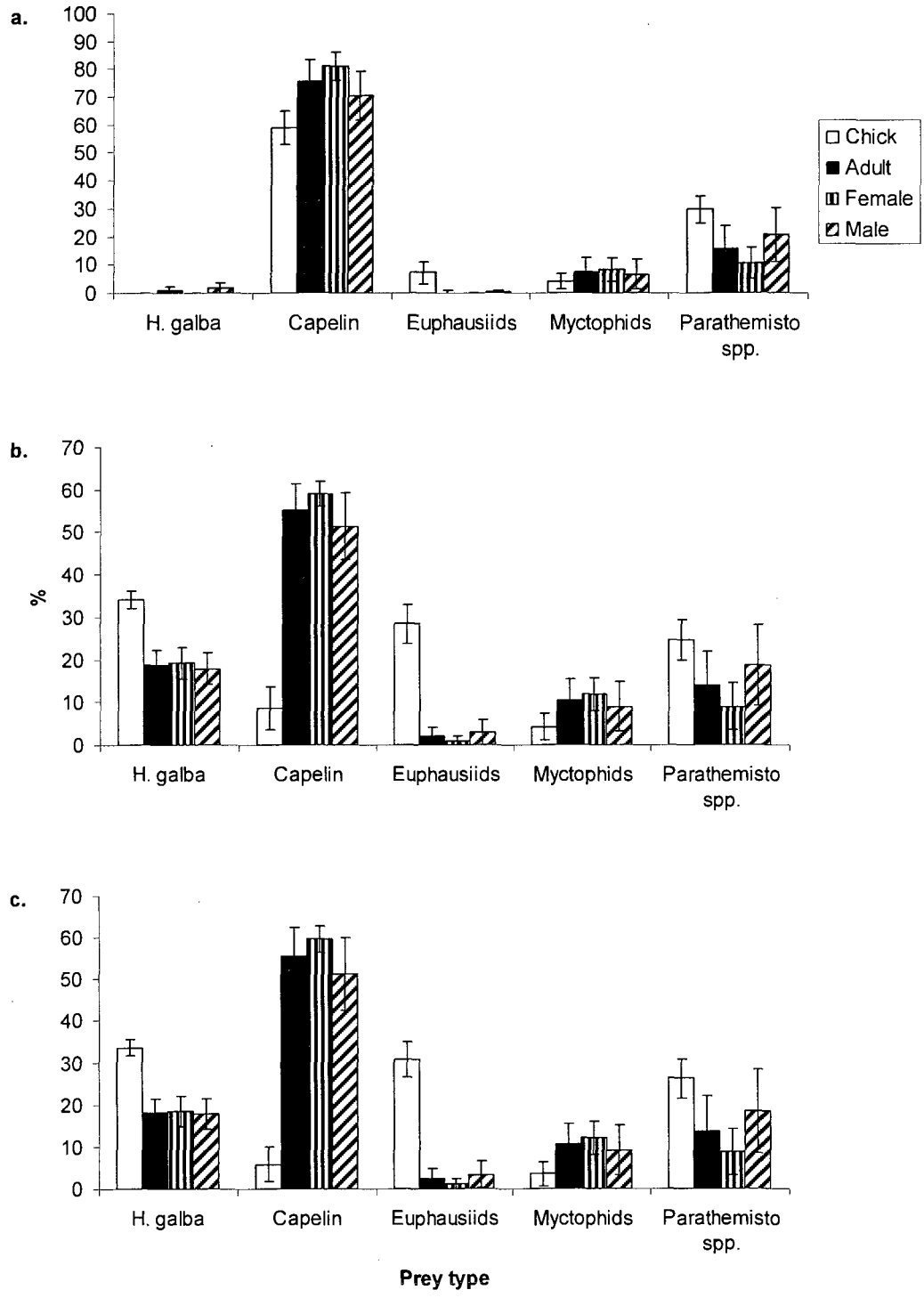


**Figure 3.12:** Diet estimates of Leach's Storm-Petrels using QFASA model 2, the bird calibration coefficients and the three fatty acid subsets: dietary (a), extended (b) and full (c).

and 6-13% for adults (Fig 3.11 b). As in model 1, adult males and females showed no large variation in the pattern of estimates, although females did exhibit lower proportions of fish species and higher proportions of crustaceans.

Because estimates either tended to favor capelin for adults and to some extent chicks, or were dominated almost exclusively by myctophids, model 3 was created without capelin to assess which prey species they might be mistaken for. Both confounding species were not eliminated because, in previous studies capelin had been observed as either a minor component of the diet or was not observed at all, while myctophids had been estimated as a major dietary component. Estimates were also calculated on the mean capelin fatty acid signature, among the rest of the prey species in model 2 using the three fatty acid subsets, to observe how capelin might be mistaken for some other species in the model. When corrected for proportions of total lipid, capelin was found to resemble mostly *H. galba* in all three subsets (42-57%), the amphipod *Parathemisto* spp. (20-32%) and euphausiids (22-25%) calculated the remainder of the estimate, and myctophids were excluded by the model (Fig 3.13). However, before correction for proportion of total lipid, capelin most resembled euphausiids (52-53%) as was similarly determined by discriminant analysis (Fig. 3.2).

Model 3 estimates were calculated in the same manner as models 1 and 2, although the pup calibration coefficient set was not used since for the previous two models it estimated the extremely high proportion of myctophids in Leach's Storm-Petrel diets. The bird (Fig. 3.14) and bird/pup (Fig. 3.15) calibration coefficients provided estimates with similar proportional distribution between fatty acid subsets. The only estimation of diet that was pronouncedly dissimilar from the others was that of the dietary

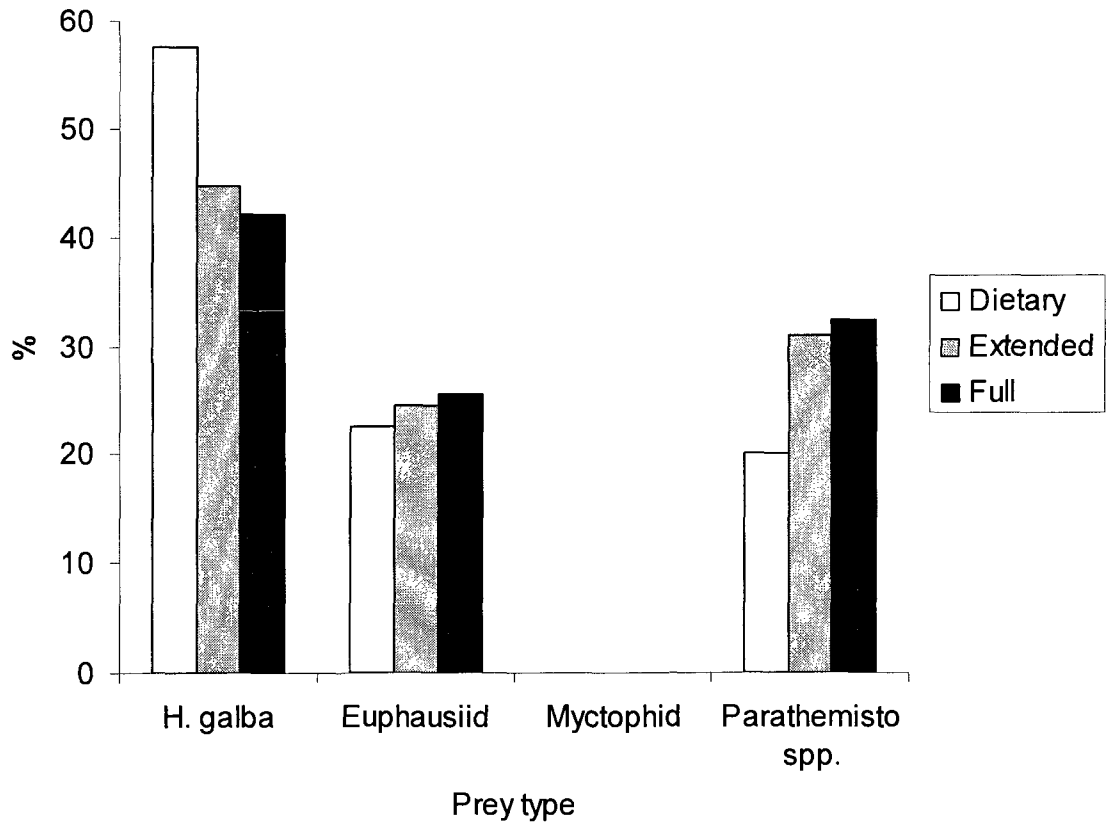


**Figure 3.13:** Estimation of the mean fatty acid signature of capelin by the QFASA model using the remaining four prey.

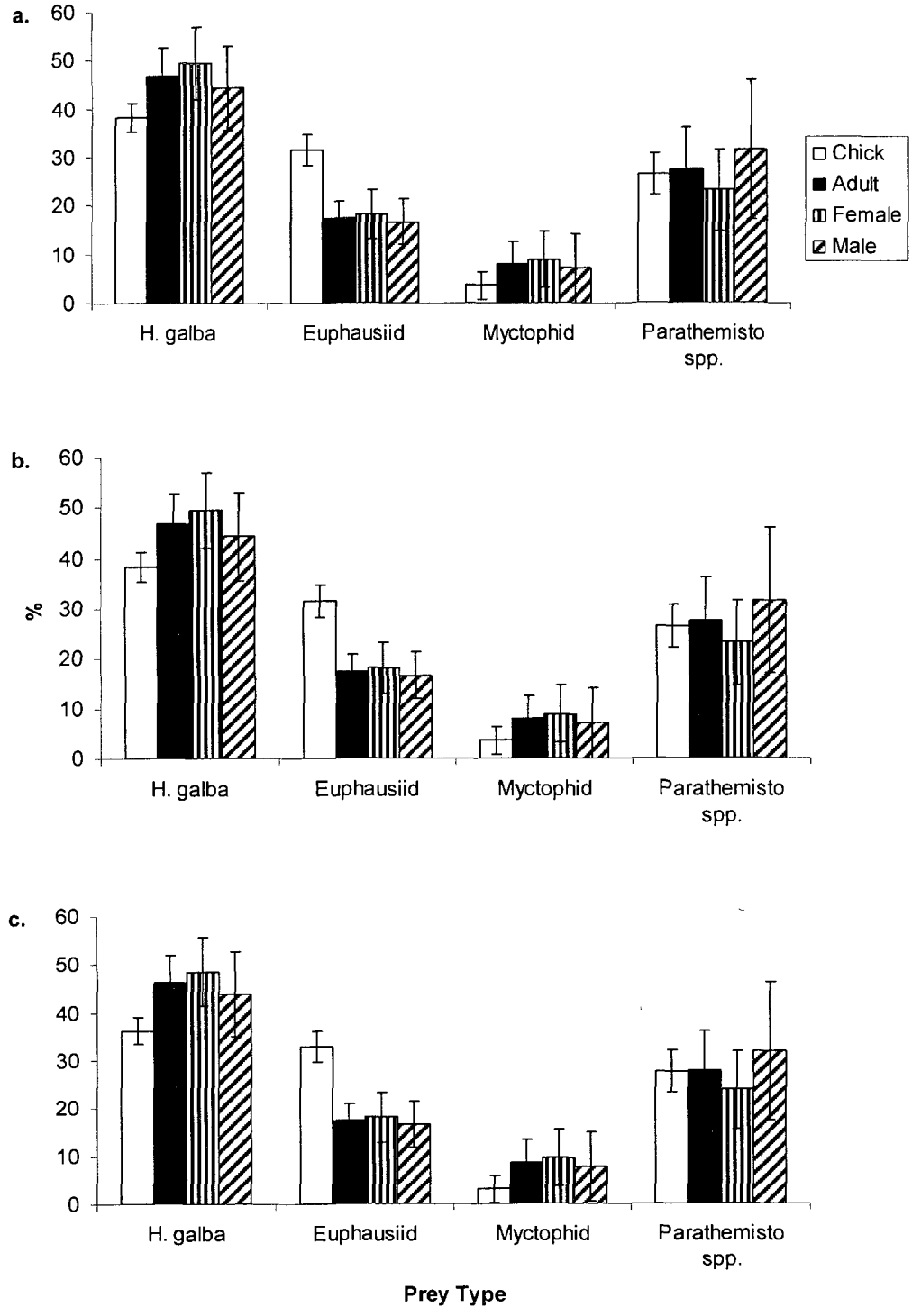


**Figure 3.14:** Estimates by QFASA model 3 for Leach's Storm-Petrel diets using the bird calibration coefficients and the three fatty acid subsets: dietary (a), extended (b) and full (c).

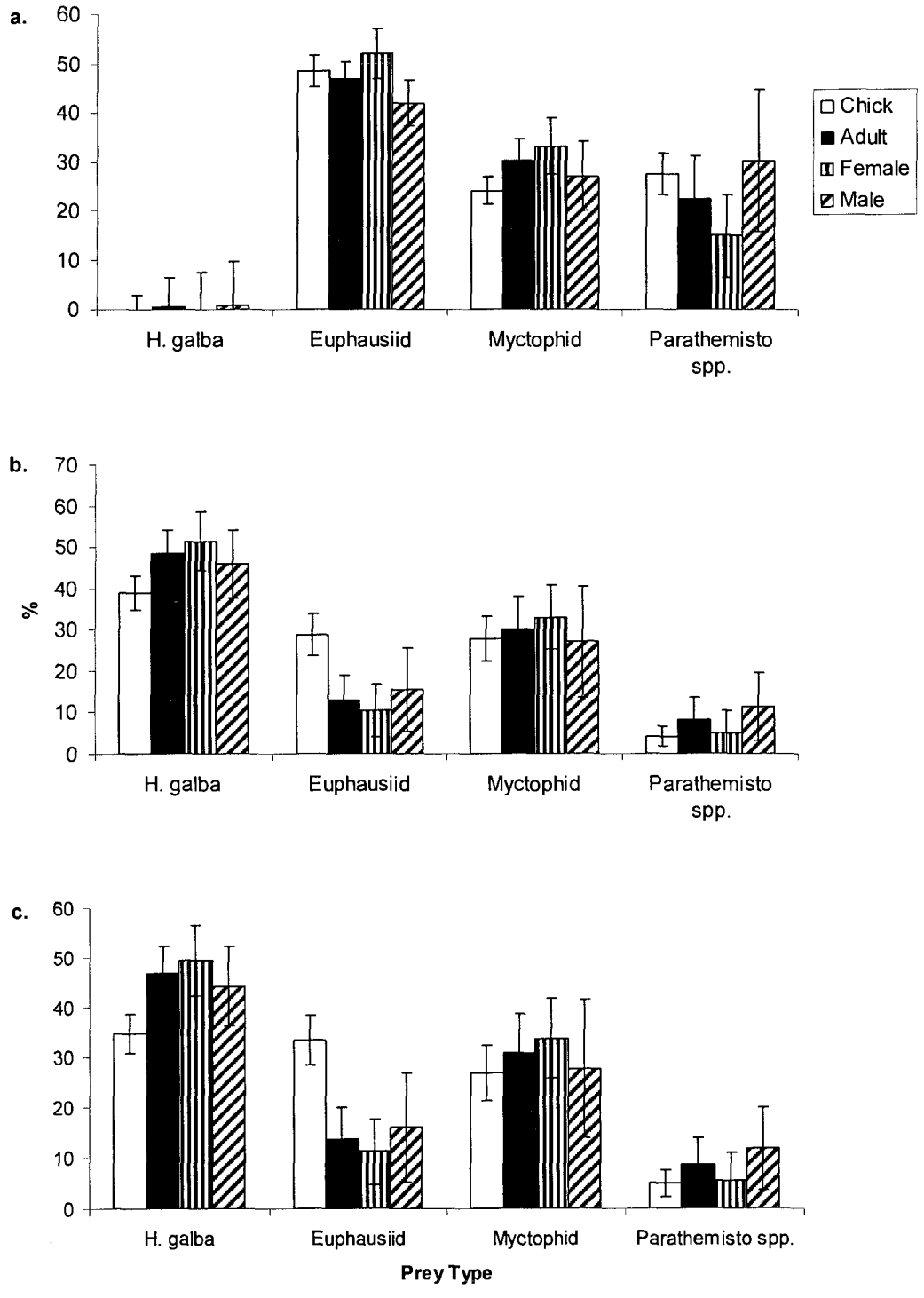


**Figure 3.15:** Estimates by QFASA model 3 for Leach's Storm-Petrel diets using the bird/seal pup calibration coefficients and the three fatty acid subsets: dietary (a), extended (b) and full (c).

subset in the bird/pup calibration coefficients which had very little of the amphipod *H. galba* (Fig. 3.15 a). Excluding the above estimation, the bird calibration estimated a lower proportion myctophids (6.0%) than the bird/pup calibration estimates (27-31%). A t-test using the data created by the full fatty acid subset, between myctophid estimates of the two calibration coefficient sets, among adults and chicks, showed a significant difference between them ($p < 0.001$, $df = 85$, $t = 11.87$). The full fatty acid subset was used because it contains the broadest set of fatty acids and, therefore, is the most robust and conservative model for observing differences.

When estimates from both calibration coefficients of the full fatty acid subset were pooled, significant differences were observed between chicks and adults. Chick estimates were significantly lower than adults for myctophids ($p = 0.003$, $df = 77$, $t = 2.81$) and the amphipod *H. galba* ($p < 0.001$, $df = 90$, $t = -7.19$) and higher in euphausiids ($p < 0.001$, $df = 102$, $t = 11.28$; Fig. 3.12c & 3.13c). The amphipod *Parathemisto* spp. was predicted in lower proportions for the bird/pup estimation but when pooled was found to be a non-significant difference ($p = 0.25$, $df = 103$, $t = -0.69$).

Among adults no significant differences were found between males and females in either of the coefficient estimates. For the bird/pup calibration set the ratio of male to female proportion resembled the ratio of adult to chick proportions, in three of the four prey items (*H. galba* and myctophids were lower in males and euphausiids were higher). The bird coefficient estimates showed no such pattern in greater proportion then chance (i.e. 50%).

### 3.4 Discussion

Initial results from the discriminant analysis showed that the fatty acid signatures of prey items of Leach's Storm-Petrels can be identified and differentiated with multi-variate statistical calculations (Fig. 3.3-5). However, some of the prey species tended to group together, such as myctophids and *H. galba*, and to a greater extent (Fig. 3.4), capelin and euphausiids (Fig. 3.5). These two groupings were not clustered by phylogenetic relationships but could be interpreted loosely by predator prey similarities such that, for example, euphausiids may represent, or closely resemble, a large portion of capelin diet and therefore would more closely associate with them in fatty acid space. However, capelin of the size used in this study (<10 cm in length) are planktivores that would generally consume much smaller prey than euphausiids (i.e. copeopods, isopods, amphipods). The connection between myctophids and *H. galba*, although less powerful, is similar since myctophids would most likely have very little contact with *H. galba* (since they are a parasite to Scyphozoan polyps), but would consume other planktonic crustaceans such as copeopods and euphausiids (Gjösæter, 1973).

Modeling of capelin by the QFASA model also illustrated that capelin and myctophids exhibit no evidence of similarity, the estimates for capelin consistently calculated the three planktonic crustaceans as components and eliminated myctophids (Fig. 3.13). This would suggest that because capelin, to this point, have been recorded as a minor component of Leach's Storm-Petrel diet. Those estimations that calculated capelin as a major component could perhaps have exaggerated the true nature of its proportion. To reduce the variance in the data set the model would more likely choose a single prey item to represent that variance than multiple prey items, when it is possible to

do so. This is observed most clearly when comparing between the estimates of model 1 (prey categorized by sampling factors; e.g. sex, location of collection; Fig. 3.8-10) and model 2 (no categories; Fig. 3.11 & 3.12). Results showed that the proportions of prey species in model 2 were very similar to the total of the proportions of categorized prey items for each species in model 1. Model 2, although it collapsed data into more broad categories, it created more interpretable and realistic estimates using QFASA and, therefore, would be the better of the two models for estimating diet.

Using model 2 as the first reasonable representation of QFASA modeling on Leach's Storm-Petrel diet estimates, the other factors in creating estimates can be examined (fatty acid subset and calibration coefficient set). The estimations using the pup calibration coefficients should be considered unreasonable for estimating the diet of Leach's Storm-Petrels for two reasons. First, they contradict the findings of Chapter 2 and all other previous studies done on Leach's Storm-Petrel diet. The simulations totally exclude any crustaceans from the calculated estimates (Fig. 3.11b) while crustaceans have been shown to make up a visible portion of the diet in the colony in question (Chapter 2) and many other colonies where Leach's Storm-Petrel diet has been studied (Linton, 1978; Rickleffs *et al.*, 1985; Montevecchi *et al.*, 1992; Hedd & Montevecchi, 2006; Hedd *et al.*, in press). Secondly, pup diets are completely subject to their mother's milk. Therefore, not only is pup diet based on a totally separate portion of the North Atlantic food web, it has also been physiologically modified three times before it was analyzed and calculated into calibration coefficients, and is biologically unsuited for modeling this system. The bird and bird/pup estimates exhibited a more diverse range of included species; therefore, these more conservative estimates would also better represent

a more realistic representation of Leach's Storm-Petrel diet (Fig. 3.11a&c) even though the seal pup calibration coefficients are still party included in the pup/bird set.

Within each set of estimates using a particular set of calibration coefficient, three subsets of fatty acids were used as a basis for which fatty acids entered calculations. The extended and full subsets exhibited similar distribution for each prey species (Fig. 3.12 b&c), while the dietary subset estimated very low proportions of *H. galba*, and low proportions of the other two crustacean species in most estimations (Fig. 3.12a). This would suggest that the dietary subset of fatty acids is another factor providing unreliable estimations and would suggest that the extended and full fatty acid subsets provide better estimates of diet. One anomaly still arose amidst all of the estimations using the bird and bird/pup calibration coefficients, capelin were a dominant dietary component, especially in all estimations of adults. Capelin have never been seen as a major component of Leach's Storm-Petrel diet, although other species of fish are (namely Myctophids and larval forms of several larger species; Hedd *et al.*, in press). To attend to this discrepancy between the modeled diet and that seen in this and other studies, a third model was created without capelin.

Model 3 exhibited prey distribution as a combination of those shown by the model of capelin on the remaining four prey species and the already existing estimation made in model 2 (Fig. 3.14 & 3.15). The estimates for both sets of calibration coefficients exhibited representation for all four if the remaining prey items. As reported in Chapter 2, fish remains were observed in 96% of all Leach's Storm-Petrel stomach content, however, the dietary estimates of myctophid using the bird calibration coefficients had maximum mean of 6.0% (mean of all adult and chick adipose tissue samples) and 29.1%

for the bird/pup set. Several other studies (Linton, 1978; Montevecchi *et al.*, 1992; Hedd *et al.*, in press), and the stomach composition observed in Chapter 2, suggest that the estimates of myctophids from the bird calibration curve would be much too low to accurately describe the proportion of myctophids that Leach's Storm-Petrels actually consume. Therefore, for the purpose of defining a best fit set of calibration coefficients for this data, the bird/pup calibration of model 3 would likely be the most accurate of the estimations calculated for this study, using the dietary or extended fatty acid subsets (Fig. 3.15 a, c). The reasoning I have provided previously would suggest that this set of coefficients is not the most biologically accurate of the three used in this analysis.

Proportions of myctophids, and therefore other prey items, in Leach's Storm-Petrel diet have been shown to vary according to season (Watanuki, 1985; Vermeer & Devito, 1988) and location (Linton, 1978). Therefore, even though the proportions are somewhat different from other studies they could be considered an alternate estimate of dietary proportions for these prey items over a long-term of lipid accumulation. However, I would conclude that because of two major components of the data being used (a limited prey signature library and non-species specific calibration coefficients), the present model is too inaccurate for Leach's Storm-Petrels to provide realistic estimates of their diet.

However accurate or inaccurate this estimate may be of the actual diet of Leach's Storm-Petrels, other studies have shown that their diet is more diverse than five prey species. As was observed in model 1 and 2, an addition of a more minor dietary element can significantly change the estimate. A more complete collection of potential prey fatty acid signatures could change the estimates substantially and provide more realistic

results. It is important to underscore, that if a prey species present in the actual diet, but not represented in the database, QFASA will still provide a diet estimate with the remaining prey, even if it is not very accurate.

The other factor influencing the accuracy of the model is the calibration coefficients used in calculating the dietary composition estimates. The bird coefficients were obtained from an alcid species (common murre), a piscivorous seabird that exploits different aspects of the North Atlantic food-web, and is a member of a different taxonomic family than Leach's Storm-Petrels. This species would come in contact with many of the same fatty acids as Leach's Storm-Petrels, but there might be species-specific characteristics in their FA metabolism. The seal pup coefficients as were described earlier are derived from suckling pups which would also encounter the same fatty acids that are then processed by a mammalian metabolism three times before deposition, certainly causing changes in FA metabolism not specific to Leach's Storm-Petrels. An investigation into fatty acid physiology of Leach's Storm-Petrels and modifications that are made between consumption and deposition would allow for a species specific set of calibration coefficients and, therefore, the most accurate estimates of diet.

The QFASA model was able to distinguish differences within the Leach's Storm-Petrel sample set provided here. The estimates for model 3 using the full fatty acid subset showed significant differences between adults and offspring in three of the four prey species (Fig. 3.14c &3.15c). These results are consistent with those found in Chapter 2 and show that the adipose tissue can exhibit differences in fatty acid signature through

prey proportions. The specific diet differences between adults and offspring, as estimated by the model, have potential ecological interpretations.

As was postulated in Chapter 2 parents may consume more offshore prey than they feed to offspring. Short one day trips in neritic waters are most likely chick foraging trips while longer trips to the pelagic environment are more likely adult replenishment trips, with chick foraging appended at the end. If we were to assume that the differences in prey composition between adults chicks estimated through QFASA were relevant, however, inaccurate they may be, do they show any ecological conformity to this hypothesis?

The prey particular to the pelagic environment, myctophids, was estimated to have significantly lower proportions in chicks than adults, although it still remained a significant proportion of the diet. The largest difference in prey proportion between adults and chicks was for euphausiids that can be found in both the neritic and pelagic environments. If Leach's Storm-Petrel parents are foraging on these euphausiids in neritic waters, as euphausiids do congregate at the surface in this environment, then the model's estimations confirm the hypothesis. The only other significant difference found between adults and chicks was for *H. galba,* and this is contrary to this hypothesis of feeding patterns. *H. galba* are found in large quantities in Leach's Storm-Petrel stomach contents at the colony where, presumably, a majority of the stomach contents would be fed to chicks. The natural history of these amphipods would also suggest that they were collected not at a great distance from shore, but near the colony. The only plausible ecological explanation that supports these conflicting findings might be that adults are feeding on these amphipods continuously and bring back a smaller percentage of them to

their offspring then are assimilated through digestion. Alternatively, *H. galba* were found to have a relatively low total lipid percentage (1.10%) when compared to other prey in this study, therefore, the stomach oil that adults bring back to their offspring may offset the numbers of *H. galba*. The low proportion of lipid provided by *H. galba* may also influence the estimates calculated by the model. A lower lipid proportion relative to other prey could impart a higher variability on dietary composition relative to proportion of the predator's fatty acid signature.

*H. galba* tended to be accompanied by larger amounts of orange coloured stomach oil in adult stomach content (personal observations from Chapter 2; yellow stomach oil was accompanied predominantly by fish hard parts) which was initially thought to be directly attributed to them. However, this orange hued lipid was found to be a product of euphausiids extraction only (Chapter 2), and could be the factor that provides the significantly higher proportion of euphausiids in chick diet.

The total proportion of *H. galba* estimated in model 3 was much higher than any other estimate that has been made for Leach's Storm-Petrels (Fig 3.14). This could most likely be a product of the model since *H. galba* fatty acid signatures resemble myctophids most closely according to discriminant analysis. Therefore, there may be a certain proportion of myctophid in Leach's Storm-Petrel diet that were mistaken by the model as *H. galba*. Regardless of the nature of the proportions of *H. galba*, lipid in adult stomach oil must still contain a reasonable proportion of fatty acids derived from myctophids by the time they reach the colony and are therefore being fed to chicks.

### 3.5 Conclusions

Dietary analysis of Leach's Storm-Petrels using quantitative fatty acid signature analysis has shown that some ecological interpretations could be extracted from the estimates calculated. Adults were shown to have significantly higher proportions of pelagic prey species in their diets than their offspring. Although this cannot be directly attributed to trip length, species preyed upon offshore must be consumed during a multi-day foraging trip. Neritic prey species were mixed in their estimates of dietary proportion between adults and their offspring, although the larger of the two differences (euphausiids) showed chicks with a higher proportion.

The reliability of the model's estimates could be questioned due to the lack of a species-specific set of calibration coefficients and an incomplete set of potential prey species. However, the model did confirm the differences found in Chapter 2 between adults and chicks and the trends observed between males and females. A significant difference observed in fatty acid signature can be translated into a significant difference between dietary compositions calculated by the model. A more complete prey library and Leach's Storm-Petrel calibration coefficients would most likely produce a more reliable estimate of prey composition in the future.

## Chapter 4 – Conclusions

### *4.1 Findings*

As stated in Chapter 1, the three main objectives for this study were: 1) to observe if there were any seasonal changes in diet of Leach's Storm-Petrels, 2) to access differences in the fatty acid signatures of parents and their offspring and 3) reconstruct the diet of Leach's Storm-Petrels from the fatty acid signatures of their tissue modeled onto the fatty acid signatures of their prey.

The contents of stomach regurgitation samples taken from the incubation and chick-rearing periods showed significant changes in hard part contents and stomach oil proportion and colour. These strongly suggest that the Leach's Storm-Petrels on Baccalieu Island, Newfoundland, alter diet through the breeding season, and corroborates findings from other populations of Leach's Storm-Petrels (Watanuki, 1985; Vermeer & Devito, 1988).

Fatty acid signatures of parents and their offspring were significantly different throughout two years. Minor differences were observed in the ratio of structural to storage lipid classes between parents and offspring but were not found to be significant and would not offer enough evidence to counter the differences in fatty acid signatures. These results suggest that there is strong evidence for parents to be consuming different proportions of prey items than they are feeding to their offspring. Other studies of this nature have shown differences in diet provided by stomach contents to add strength to the fatty acid signature evidence (Kirch, 1998; Logan *et al.* 2000). No significant differences were observed between adult males and females in fatty acid signature, unlike dietary

differences that have been observed between males and females of other more sexually dimorphic Procellariiforme species. Since Leach's Storm-Petrels are fairly sexually monomorphic this lack of significance is not unexpected.

The third objective of this study was to estimate the proportional distribution of several major and minor prey in petrel diets using a quantitative fatty acid signature analysis model. Several estimations calculated bore no resemblance to any estimates that had been obtained for Leach's Storm-Petrel (domination by one prey item or large proportions of previously minor prey species). With modification of factors used to calculate the estimations and the prey items included, a more reasonable estimate of Leach's Storm-Petrel diet was calculated. Proportions were not entirely similar to previous calculations (Linton, 1978; Montevecchi *et al.*, 1992), but the results should differ in any case, since previous studies used stomach contents as their measure of prey proportions and would provide an analysis of a time scale limited to the recent meal(s) before capture.

Although the estimates warrant further work and verification, the results suggest that there may be a bias for more neritic prey species in chick diets relative to that of their parents. This conclusion would support the hypothesis that short parental foraging trips in the neritic environment are used to gather food for their offspring while longer foraging trips in the pelagic environment are used to provide food for both parents and chicks, which has been observed in other species of Procellariiformes.

## 4.2 Data Analysis

Many types of analysis were used in this thesis which drew on multiple variables to provide predictions about dietary and physiological hypotheses, each one providing different information about the diets of Leach's Storm-Petrels. Stomach contents revealed information about short term changes in diet and allowed for a preliminary dietary analysis, identifying the important prey items to be collected for the prey signature library. However, stomach contents collected at the colony could not be used to determine any difference between adults and chicks since adults digest part of their diet at sea. Broad distinctions made between breeding season periods can only be used to speculate about differences that may arise between adults and chicks and provide no evidence for the period specific to chick rearing.

Analysis of fatty acid signatures using MANOVA, PCA and discriminant analysis, all revealed adults and chicks were significantly different relative to particular fatty acids. However, each of these analyses provided unique perspectives on the data depending upon the information that is supplied to each model. The most comprehensive of the three models is discriminant analysis which integrates data from independent variables into the analysis while at the same time providing graphical representation of the relationships between groups of samples within independent variable groups. The other two analysis procedures provide one of these two features; MANOVA requires an independent variable to be integrated into the model, and PCA reduces the multivariate data into a series of scores allowing for a single graphical representation of multiple variables.

Quantative fatty acid signature analysis adds another level of knowledge to Leach's Storm-Petrel diet that stomach contents cannot provide. For the same reason that stomach contents could not adequately discern differences between adult and chick diets, there were some difficulties discerning the proportion of particular prey components. We are unsure of what prey may be digested at sea, not to mention that a majority of Leach's Storm-Petrel stomach contents are isolated lipid. The modification that occurs between ingestion and deposition is the main factor that must be controlled for, and can only be evaluated with coefficients produced from controlled diet studies on the species in question.

With all of its problems stomach content analysis does provide some information that chemical analysis cannot. With a large sample size, minor dietary components can be observed and changes in diet over a short term are more noticeable (i.e. during a mating season). Chemical dietary analysis can potentially provide more integrated information about diets and changes, but requires careful assessments in the parameters used in quantitatively estimating species composition of diets.

### 4.3 Future research concerns

It will be important in future investigations to resolve problems that were encountered, which would provide better understanding of the behaviour, physiology and ecology of Leach's Storm-Petrels. First, a more detailed study into the timing of individual foraging periods and patterns would resolve the amount of time that is likely spent in neritic and pelagic environments. However, the only true way to determine foraging locations would be to track the location of individuals for a significant time to

determine these patterns, and current GPS and radio tracking technology is not feasible for an animal of this size and foraging range respectively.

Other problems were apparent in the modeling process for estimating the diet of Leach's Storm-Petrels. First, a more complete library of potential prey items could provide a more realistic estimation of the breath of species preyed on by Leach's Storm-Petrels. Although one of the suspected minor elements included in these models caused significant changes to estimated proportions, a more complete prey library might change the outcome. More extensive simulation studies would also provide better insight into species differences and overlaps. The other important modeling concern was the set of calibration coefficients that were used to account for modification of fatty acid signatures between consumption by Leach's Storm-Petrels and its deposition into adipose tissue. A captive study with a controlled diet similar to the one performed by Iverson *et al.* (in press) would control for potential species-specific modifications that Leach's Storm-Petrels may impart on consumed fatty acids.

**Literature Cited**


Ackman, R. G. 1986. WCOT (Capillary) Gas-Liquid Chromatography. In R. J. Hamilton & J. B. Rossell, ed. *Analysis of Oils and Fats.* Elsevier Applied Science Publishers, New York, NY, USA. 137-206.

Ackman R. G., W. M. N. Ratnayake, & B. Olsson. 1988. The 'basic' fatty acid composition of Atlantic fish oils: potential similarities useful for enrichment of polyunsaturated fatty acids by urea complexation. *J. Am. Oil Chem. Soc.* **65:** 136-138.

Aitchison, J., 1986. The Statistical Analysis of Compositional Data. Chapman & Hall, New York, NY, USA, 416 pp

Arts, M. T., R. G. Ackman & B. J. Holub 2001. "Essential fatty acids" in aquatic ecosystems: A crucial link between diet and human health and evolution. *Can. J. Fish. Aquati. Sci.* **58:** 122-37.

Berrow, S. D. & J. P. Croxall. 2001. Provisioning rate and attendance patterns of Wandering Albatrosses at Bird Island, South Georgia. *Condor* **103:** 230-9.

Bligh, E. G. & W. J. Dyer. 1959. A rapid method of total lipid extraction and purification. *Can. J. Biochem. Physiol.* **37:** 911-7.

Booth A. M., E. O. Minot, R. A. Fordham & M. J. Imber. 2000. Co-ordinated food provisioning in the Little Shearwater *Puffinus assimilis haurakiensis*: a previously undescribed foraging strategy in Procellariidae. *Ibis* **142:** 144-6.

Bowen, W. D. J. W. Lawson & B. Beck. 1993. Seasonal and geographic variation in the species composition and size of prey consumed by grey seals (*Halichoerus grypus*) on the Scotian shelf. *Can. J. Fish. Aquat. Sci.* **50:** 1768-78.

Bremer, J. & K. R. Norum. 1982. Metabolism of very long-chain monounsaturated fatty acids (22:1). *J. Lipid. Res.* **23:** 243-56.

Bryant, S. L. 1993. Influences of *Larus* gulls and nocturnal environment condition on Leach's Storm-Petrel activity patterns at the breeding colony. M. Sc. Thesis, Memorial University, St. John's, Newfoundland, Canada.

Budge, S. M., S. J. Iverson, D. W. Bowen & R. G Ackman. 2002. Among- and within-species variability in fatty acids signatures of marine fish and invertebrates on the Scotian Shelf, Georges Bank, and southern Gulf of St. Lawrence. *Can. J. Fish. Aquatic. Sci.* **59:** 886-98.

Budge, S. M., S. J. Iverson, & H. N. Koopman. 2006. Studying trophic ecology in marine ecosystems using fatty acids: A primer on analysis and interpretation. *Mar. Mamm. Sci.* **22:** 759-801.

Budge, S. M., C. C. Parrish & C. H. McKenzie. 2001. Fatty acid composition of phytoplankton, settling particulate matter and sediments at a sheltered bivalve aquaculture site. *Mar. Chem.* **76:** 285-303.

Cairns, D. K., Montevecchi, W. A. & Threlfal, W. 1989. *A Researcher's Guide to the Seabird Colonies of Newfoundland.* Memorial University of Newfoundland Occasional in Population Biology, 14.

Cherel, Y., P. Bocher, C. Trouvé & H. Weimerskirch. 2002. Diet and feeding ecology of blue petrels *Halobaena caerulea* at Iles Kerguelen, Southern Indian Ocean. *Mar. Ecol. Prog. Ser.* **228:** 283-99.

Chaurand, T., H. Weimerskirch. 1994. The regular alteration of short and long foraging trips in the blue petrel *Halobaena caerulea*: a previously undescribed strategy of food provisioning in a pelagic seabird. *J. Anim. Ecol.* **63:** 275-82.

Christie, W. W. 2003. http://www.lipid.co.uk/infores/ms/ms01/index.htm.

Clarke, A. & P. A. Prince. 1980. Chemical composition and calorific value of food fed to molymauk chicks *Diomedea melanophris* and *D. chrysostoma* at Bird Island, South Georgia. *Ibis*. **122:** 488-94.

Connan, M., P. Mayzaud, M. Boutoute, H. Weimerskirch & Y. Cherel. 2005. Lipid composition of stomach oil in a procellariiform seabird *Puffinus tenuirostris* : implications for food web studies. *Mar. Ecol., Prog. Ser.* **290:** 277-90.

Cooper, M. H., Iverson, S. J. & Heras, H. 2005. Dynamics of blood chylomicron fatty acids in a marine carnivore: implications for lipid metabolism and quantitative estimation of predator diets. *J. Comp. Physiol. B* **175:** 133-145.

Cooper, M. H., Iverson, S. J. & Rouvinen-Watt, K. 2006. Metabolism of dietary cetoleic acid (22:1n-11) in mink (*Mustela vison*) and grey seals (*Halichoerus grypus*) studied using radiolabelled fatty acids. Physiological and Biochemical Zoology 79: 820-829.

Croxall, J. P., H. J. Hill, R. Lidstone-Scott, M. J. O'Connell & P. A. Prince. 1988. Food and feeding ecology of Wilson's Storm-Petrel *Oceanites oceanicus* at South Georgia. *J. Zool. Lond.* **216:** 83-102.

Croxall, J. P. & A. W. North. 1988, Fish prey of Wilson's Storm-Petrel *Oceanites oceanicus* at South Georgia. *Br. Antarct. Surv. Bull.* **78:** 37-42.

Encyclopedia of Statistics. 1983. S. Kotz & N. L. Johnson ed. *The Kulback distance*. John Wiley and Sons. New York, New York, USA 421-5

Endo, Y. & P. H. Wiebe. 2005. Euphausiid distribution, abundance and succession in North Atlantic warm-core ring 82B. *J. Plank. Res.* **27:** 175-88.

Folch, J. M. Lees & G. H. Sloane Stanley. 1957. A simple method for the isolation and purification of total lipids from animal tissue. *J. Biol. Chem.* **226:** 497-509.

Forero, M. G., J. González-Solís, K. A. Hobson, J. A. Donázar, M. Bertellotti, G. Blanco & G. R. Bortolotti. 2005. Stable isotopes reveal trophic segregation by sex and age in the southern giant petrel in two different food webs. *Mar. Ecol. Prog. Ser.* **296:** 107-13

Fraser, A. J., and J. R. Sargent, J. C. Gamble, and D. D. Seaton. 1989. Formation and transfer of fatty acids in an enclosed marine food chain comprising phytoplankton, zooplankton and herring (*Clupea harengus* L.) larvae. *Mar. Chem.* **27:** 1-18.

Gjösæter, J. 1973. The food of the myctophid fish, *Benthosema glaciale* (Reinhardt), from Western Norway. *Sarsia.* **52:** 53-8.

Gurr, M. I., & A. T. James. 1980. Lipid Biochemistry: An introduction. Chapman and Hall, London, UK.

Hamer, K. C., J. K. Hill, J. S. Bradley & R. D. Wooller. 2000. Contrasting patterns of nestling obesity and food provisioning in three species of *Puffinus* shearwaters: the role of predictability. *Ibis.* **142:** 139-58.

Hagen, W., G. Kattner & M. Graeve. 1995. On the lipid biochemistry of polar copepods: compositional differences in the Antarctic calanoids *Euchaeta antarctica* and *Euchirella rostromagna*. *Mar. Biol.* **123:** 451-7.

Hedd, A. & R. Gales. 2001. The diet of shy albatrosses (*Thalassarche cauta*) at Albatross Island, Tasmania. *J. Zool. Lond.* **253:** 69-90.

Hedd, A. & W. A. Montevecchi. 2006. Diet and trophic position of Leach's Storm-Petrel *Oceanodroma leucorhoa* during breeding and moult, inferred from stable isotope analysis of feathers. *Mar. Ecol. Prog. Ser.* **322:** 291-301

Hedd, A., W. A. Montevecchi & G. K. Davoran. In press. Parental diet and distribution of Leach's Storm-Petrel *Oceanodroma leucorhoa* in the Northwest Atlantic. *Mar. Ecol. Prog. Ser.*

Hobson, K. A.. 1990. Stable isotope analysis of marbled murrelets: evidence for freshwater feeding and determination of trophic level. *Condor* **92:** 897-903

Hobson, K. A., J. F. Piatt & J. Pitocchelli. 1994. Using stable isotopes to determine seabird trophic relationships. *J. Anim. Ecol.* **63:** 786-98

Hodum P. J. & K. A. Hobson. 2000. Trophic relationships between Antarctic fulmarine petrels: insights into dietary overlap and chick provisioning strategies inferred from stable-isotope ($\delta^{15}N$ and $\delta^{13}C$) analyses. *Mar. Ecol. Prog. Ser.* **198:** 273-81

Huntington, C. E., R. G. Butler & R. A. Mauk. 1996. Leach's Storm-Petrel (*Oceanodroma leucorhoa*). *In* The Birds of North America. No: 233. A. Poole & F. Gill. The American Ornithologists' Union, Washington, D.C., U.S.A.

Iverson, S. J. 1993. Milk secretion in marine mammals in relation to foraging: Can milk fatty acids predict diet? *Symp. Zool. Soc. Lond.* **66:** 263-91.

Iverson, S. J., J. P. Arnould, and I. L. Boyd. 1997a. Milk fatty acid signatures indicate both major and minor shifts in foraging ecology of lactating Antarctic fur seals. *Can. J. Zool.* **75:** 188-97.

Iverson, S.J., C. Field, W. D. Bowen, & W. Blanchard. 2004. Quantitative fatty acid analysis: A new method of estimating predator diets. *Ecol. Monogr.* **74:** 211-35.

Iverson, S. J., K. J. Frost, and L.F. Lowery. 1997b. Fatty acid signatures reveal fine scale structures of foraging distribution of harbour seals and their prey in Prince William Sound, Alaska. *Mar. Ecol. Prog. Ser.* **151:** 255-71.

Iverson, S. J., J. E. McDonald & L. H. Smith. 2001. Changes in diet of free-ranging black bears in years of contrasting food availability revealed through milk fatty acids. *Can. J. Zool.* **79:** 2268-79.

Iverson, S. J., O. T. Oftedal, W. D. Bowen, D. J. Boness & J. Sampugna. 1995. Parental and postnatal transfer of fatty acids from mother to pup in the hooded seal. *J. Comp. Physiol.* **B 165:**1-12.

Iverson, S. J. & A. M. Springer. 2002. Estimating seabird diets using fatty acids: protocol development and testing of ReFER hypotheses. Report to the National Pacific Marine Research Program, University of Alaska, Fairbanks, 27 pp.

Iverson, S.J., A.M.Springer, & A.S.Kitaysky. in press. Seabirds as indicators of food web structure and ecosystem variability: qualitative and quantitative diet analyses using fatty acids. *Mar. Ecol. Pro. Ser.*

Iverson, S. J., Stirling, I. & Lang, S. L. C. 2006. Spatial and temporal variation in the diets of polar bears across the Canadian arctic: indicators of changes in prey populations and environment. *Symp. Zoological Soc. Lond.: Conservation Biol. Ser.* 12: 98-117.

Jobling, M. & A. Brieby. 1986. The use and abuse of fish otoliths in studies of feeding habits of marine piscivores. *Sarsia* **71:** 265-74.

Kirsch, P. E., S. J. Iverson, & W. D. Bowen. 2000. Effect of a low-fat diet on body composition and blubber fatty acids in captive harp seals (Phoca groenlandica). *Physiol. & Biochem. Zool.* **73:** 45-59

Kirsch, P. E., S. J. Iverson, W. D. Bowen, S. R. Kerr & R. G. Ackman. 1998. Dietary effects on the fatty acid signature of whole Atlantic cod (*Gadus moehua*). *Can. J. Fish. Aquatic Sci.* **55:** 1378-86.

Klages, N., R. Gales & D. Pemberton. 1990. The stomach contents of Antarctic petrels *Thalassoica Antarctica*, feeding young chicks at Scullin Monolith, Mawson Coast, Antarctica. *Polar Biol.* **10:** 545-7

Linton, A. 1978. The food and feeding habits of the Leach's Storm-Petrel (*Oceanodroma leucorhoa*) at Pearl Island, Nova Scotia and Middle Lawn Island, Newfoundland. M.Sc. thesis. Dalhousie University, Halifax, NS, Canada.

Logan, M. S., S. J. Iverson, D. E. Ruzzante, S. J. Walde, P. J. Macchi, M. F. Alonso & V. E. Cussac. 2000. Long term diet differences between morphs in tropically polymorphic *Percichthys trucha* (Pices: Percichthyidae) populations from the southern Andes. *Biologi. J. Linnean Soc.* **69:** 599-616.

Mauck R. A. & R. E. Ricklefs. 2005. Control of fledging age in Leach's Storm-Petrel, *Oceanodroma leucorhoa*: chick development and prefledging mass loss. *Functional Ecol.* **19:** 73-80

McKelvie, D. S. 1985. The mesopelagic fish fauna of the Newfoundland Basin. *Can. J. Zool.* **63:** 2176-82.

Moku, M., K. Kawaguchi, H. Watanabe & A. Ohno. 2000. Feeding habits of three dominant myctophid fishes, *Diaphus theta*, *Stenobrachius leucopsarus* and *S. nannochir*, in the subarctic and transitional waters of the western North Pacific *Mar. Ecol. Prog. Ser.* **207:** 129-40.

Montevecchi, W. A., V. L. Birt-Friesen & D. K. Cairns. 1992. Reproductive energetics and prey harvest of Leach's Storm-Petrels in the Northwest Atlantic. *Ecology* **73:** 823-32.

Montevecchi, W. A. & Tuck, L. M. 1987. Newfoundland birds: Exploitation, study, conservation. Nuttall, Cambridge, U.S.A.

Munsell Color, MacBeth Div. Kollmorgen Corp. 1976. *Munsell Book of Color: Glossy Finish Collection.* Baltimore, MA, USA.

Nager, R. G., P. Monaghan, D. C. Houston & M. Genovart. 2000. Parental condition, brood sex ratio and differential young survival: an experimental study in gulls (*Larus fuscus*). *Behav. Ecol. Sociobiol.* 42: 452-7.

Parrish C. C. 1987. Separation of aquatic lipid classes by Chromarod thin-layer chromatography with measurement by Iatroscan flame ionization detection. *Can. J. Fish. Aquat. Sci.* **44:** 722-31.

Pennycuick, C. J. 1997. Actual and 'optimal' flight speeds: Field data reassessed. *J. Exp. Biol.* **200:** 2355-61.

Place, A. R., D. D. Roby. 2005. Assimilation and deposition of dietary fatty alcohols in Leach's storm-petrel, *Oceanodroma leucorhoa. J. Exp. Zool.* **240:** 149-61.

Place, A. R., N. C. Stoyan, R. E. Ricklefs, & R. G. Butler. 1989. Physiological basis of stomach oil formation in Leach's Storm-Petrel (*Oceanodroma leucorhoa*). *Auk* **106:** 687-99.

Pond, D. W, D. R. Dixon, M. V. Bell, A. E. Fallick & J. R. Sargent. 1997. Occurrence of 16:2(*n*-4) and 18:2(*n*-4) fatty acids in the lipids of the hydrothermal vent shrimps *Rimicaris exoculata* and *Alvinocaris markensi*: nutritional and trophic implications. *Mar. Ecol. Prog. Ser.* **156:** 167-74.

Quillfeldt, P. & H. U. Peter. 200. Provisioning and growth in chicks of Wilson's Storm-Petrels (*Oceanites oceanicus*) on King George Island, South Shetland Islands. *Polar Biol.* **23:** 817-24.

Quillfeldt, P., R. A. R. McGill & R. W. Furness. 2005. Diet and foraging areas of Southern Ocean seabirds and their prey inferred from stable isotopes: review and case study of Wilson's storm-petrel. *Mar. Ecol. Prog. Ser.* **295:** 295-304.

Reid, K., P. A. Prince & J. P. Croxall. 2000. Fly or die: the role of fat stores in the growth and development of grey-headed albatross *Diomedea chrysostoma* chicks. *Ibis.* **142:** 188-96.

Rice, W. R. 1989. Analyzing tables of statistical tests. *Evolution.* **43:** 223-5.

Ricklefs, R. E., C. H. Day, C. E. Huntington & J. B. Williams. 1985. Variability of feeding rate and meal size of Leach's Storm-Petrel at Kent Island, New Brunswick. *J. Anim. Ecol.* **54:** 883-98.

Ricklefs, R. E., S. C. White & J. Cullen. 1980. Energetics of postnatal growth in Leach's storm-petrel. *Auk* **97:** 566-75.

Ricklefs, R. E., S. C. White & J. Cullen. 1980. Postnatal development in Leach's storm-petrel. *Auk* **97:** 768-81.

Roby, D. D. 1989. Chick feeding in diving petrels *Pelecanoides georgicus* and *P. urinatrix exsul. Antarti. Sci.* **1:** 337-42.

Roby, D. D. 1991. Diet and postnatal energetics in convergent taxa of plankton-feeding seabirds. *Auk* **108:** 131-46.

Roby, D. D., A. R. Place & R. E. Ricklefs. 1986. Assimilation and deposition of dietary wax esters in planktivorous seabirds. *J. Exp. Zool.* **238:** 29-41.

Roby, D. D., J. R. E. Taylor, & A. R. Place. 1997. Significance of stomach oil for reproduction in seabirds: an interspecific cross-fostering experiment. *Auk* **114:** 725-36.

Sagar, P. M. & H. Weimerskirch. 1996. Satellite tracking of southern Buller's albatrosses form the Snares, New Zealand. *Condor* **98:** 649-652.

Schultz, M. A. & N. I. Klomp. 2000. Does the foraging strategy of adult Short-tailed shearwaters cause obesity in their chicks? *J. Avian Biol.* **31:** 287

Shaffer, S. A., H. Weimerskirch & D. P. Costa. 2001. Functional significance of sexual dimorphism in wandering albatrosses, *Diomedea exulans*. *Functional Ecology* **15**: 203-10.

Smith, S. J., S. J. Iverson & W. D. Bowen. 1997. Fatty acid signatures and classification trees: new tools for investigating the foraging ecology of seals. *Can. J. Fish. Aquat.* **54:** 1377-86.

Sklepkovych, B. O. & W. A. Montevecchi. 1989. The world's largest known nesting colony of Leach's Storm-Petrels on Baccalieu Island, Newfoundland. *Am. Birds* **43:** 38-42.

Stenhouse, I. J. & W. A. Montevecchi. 2000. Habitat utilization and breeding success in Leach's storm-petrel: the importance of sociality. *Can. J. Zool.* **78:** 1267-74.

Stenhouse, I. J., G. J. Robertson & W. A. Montevecchi. 2000. Herring gull *Larus argentatus* predation on Leach's Storm-Petrels *Oceanodroma leucorhoa* breeding on Great Island, Newfoundland. *Atlantic Seabirds* **2:** 35-44

Vermeer, K. & K. Devito. 1988. The importance of the *Paracallisoma coecus* and myctophid fishes to nesting fork-tailed and Leach's Storm-Petrels in the Queen Charlotte Islands, British Columbia. *J. Plankton Res.* **10:** 63-75.

Wang, S. W., Iverson, S.J., Springer, A.M. and Hatch S.C. (in press) Fatty acid signatures of stomach oil and adipose tissue of northern fulmars (*Fulmarus glacialis*) in Alaska: implications for diet analysis of Procellariiform birds. *Journal of Comparative Physiology – B.*

Warham, J. 1977. The incidence, functions, and ecological significance of petrel stomach oils. *Proc. New Zealand Ecol. Soc.* **24:** 83-93.

Warham, J., R. Watts, R. J. Dainty. 1976. The composition, energy content and function of the stomach oils of petrels (Order, *Procellariiformes*). *J. Exp. Mar. Biol. Ecol.* **23:** 1-13.

Watanabe, H., M. Moku, K. Kawaguchi, K. Ishimaru & A. Ohno. 1999. Diel vertical migration of myctophid fishes (Family *Myctophidae*) in the transitional waters of the western North Pacific. *Fish. Oceanogr.* **8:** 115-27.

Watanuki, Y. 1985. Food of breeding Leach's Storm-Petrels (*Oceanodroma leucorhoa*). *Auk* **102:** 884-6.

Weimerskirch, H. 1995. Regulation of foraging trips and incubation routine in male and female wandering albatrosses. *Oecologia* **102:** 37-43.

Weimerskirch, H., O. Chastel, L. Ackermann, T. Chaurand, F. Cuenot-Chaillet, X. Hindermeyer & J. Judas. 1994. Alternate long and short foraging trips in pelagic seabird parents. *Anim. Behav.* **47:** 472-6.

Weimerskirch, H., Y. Cherel, F. Cuenot-Chaillet & V. Ridoux. 1997a. Alternative foraging strategies and resource allocation by male and female wandering albatrosses. *Ecology* **78:** 2051-63.

Weimerskirch, H., M. Salamolard, F. Sarrazin & P. Jouventin. 1993. Foraging strategy of wandering albatrosses through the breeding season: A study using satellite telemetry. *Auk* **110:** 325-42.

Appendix 1: Base data for adult Leach's storm-petrel fatty acid proportions

| Fatty Acid | Ad'02,1a | Ad'02,3a | Ad'02,4a | Ad'02,5a | Ad'02,5b | Ad'02,6a |
|---|---|---|---|---|---|---|
| 14:0 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.02 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 | 0.11 | 0.09 | 0.09 | 0.11 | 0.10 | 0.06 |
| 16:1n-9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:1n-7 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.02 |
| 16:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:0 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.02 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 0.17 | 0.15 | 0.17 | 0.17 | 0.16 | 0.13 |
| 18:1n-7 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 |
| 18:1n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:2n-6 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:4n-3 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 |
| 18:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.03 | 0.03 | 0.04 | 0.02 | 0.03 | 0.05 |
| 20:1n-9 | 0.17 | 0.21 | 0.19 | 0.19 | 0.18 | 0.23 |
| 20:1n-7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 1: Continued

| Fatty Acid | Ad'02,1a | Ad'02,3a | Ad'02,4a | Ad'02,5a | Ad'02,5b | Ad'02,6a |
|---|---|---|---|---|---|---|
| 20:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.22 | 0.26 | 0.24 | 0.23 | 0.23 | 0.30 |
| 22:1n-9 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 | 0.04 |
| 22:1n-7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 0.06 | 0.04 | 0.05 | 0.05 | 0.06 | 0.03 |
| 24:1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

| Fatty Acid | Ad'02,7a | Ad'02,8a | Ad'02,11a | Ad'02,12a | Ad'02,19a |
|---|---|---|---|---|---|
| 14:0 | 0.02 | 0.02 | 0.03 | 0.04 | 0.03 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 | 0.09 | 0.10 | 0.11 | 0.14 | 0.11 |
| 16:1n-9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:1n-7 | 0.03 | 0.04 | 0.04 | 0.07 | 0.04 |
| 16:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:0 | 0.02 | 0.03 | 0.02 | 0.03 | 0.03 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 |

Appendix 1: Continued

| Fatty Acid | Ad'02,7a | Ad'02,8a | Ad'02,11a | Ad'02,12a | Ad'02,19a |
|---|---|---|---|---|---|
| 18:1n-7 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 18:1n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 18:2n-6 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-3 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 18:4n-3 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| 18:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 |
| 20:1n-9 | 0.20 | 0.18 | 0.19 | 0.14 | 0.19 |
| 20:1n-7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-3 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 20:5n-3 | 0.01 | 0.01 | 0.01 | 0.03 | 0.01 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.23 | 0.23 | 0.22 | 0.15 | 0.23 |
| 22:1n-9 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 |
| 22:1n-7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 0.05 | 0.05 | 0.05 | 0.07 | 0.05 |
| 24:1 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |

| Fatty Acid | Ad'02,20a | Ad'02,25a | Ad'02,27a | Ad'02,34a | Ad'02,35a |
|---|---|---|---|---|---|
| 14:0 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 1: Continued

| Fatty Acid | Ad'02,20a | Ad'02,25a | Ad'02,27a | Ad'02,34a | Ad'02,35a |
|---|---|---|---|---|---|
| 15:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 | 0.07 | 0.10 | 0.09 | 0.09 | 0.10 |
| 16:1n-9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:1n-7 | 0.02 | 0.04 | 0.03 | 0.03 | 0.03 |
| 16:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:0 | 0.02 | 0.03 | 0.02 | 0.03 | 0.03 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 0.14 | 0.16 | 0.17 | 0.18 | 0.16 |
| 18:1n-7 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 18:1n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:2n-6 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:4n-3 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 |
| 18:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 |
| 20:1n-9 | 0.25 | 0.20 | 0.19 | 0.19 | 0.17 |
| 20:1n-7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 1: Continued

| Fatty Acid | Ad'02,20a | Ad'02,25a | Ad'02,27a | Ad'02,34a | Ad'02,35a |
|---|---|---|---|---|---|
| 20:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:5n-3 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.29 | 0.22 | 0.22 | 0.24 | 0.23 |
| 22:1n-9 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 22:1n-7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 0.04 | 0.05 | 0.06 | 0.05 | 0.07 |
| 24:1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

Appendix 2: Base data for chick Leach's storm-petrel fatty acid proportions

| Fatty Acid | Ch'02,1 | Ch'02,3 | Ch'02,4 | Ch'02,5 | Ch'02,6 |
|---|---|---|---|---|---|
| 14:0 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 | 0.10 | 0.12 | 0.11 | 0.12 | 0.12 |
| 16:1n-9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:1n-7 | 0.04 | 0.05 | 0.05 | 0.06 | 0.05 |
| 16:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:0 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 0.22 | 0.22 | 0.22 | 0.21 | 0.22 |
| 18:1n-7 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 |
| 18:1n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-5 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 |
| 18:2n-6 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-3 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 |
| 18:4n-3 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 18:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 |
| 20:1n-9 | 0.21 | 0.18 | 0.20 | 0.18 | 0.20 |
| 20:1n-7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | |
|---|---|---|---|---|---|
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 2: Continued

| Fatty Acid | Ch'02,1 | Ch'02,3 | Ch'02,4 | Ch'02,5 | Ch'02,6 |
|---|---|---|---|---|---|
| 20:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.20 | 0.16 | 0.19 | 0.18 | 0.17 |
| 22:1n-9 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 22:1n-7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 0.03 | 0.04 | 0.04 | 0.04 | 0.03 |
| 24:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Fatty Acid | Ch'02,7 | Ch'02,8 | Ch'02,11 | Ch'02,12 | Ch'02,19 |
|---|---|---|---|---|---|
| 14:0 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 | 0.10 | 0.11 | 0.12 | 0.12 | 0.11 |
| 16:1n-9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:1n-7 | 0.04 | 0.06 | 0.06 | 0.05 | 0.05 |
| 16:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:0 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | |
|---|---|---|---|---|---|
| 18:1n-9 | 0.22 | 0.23 | 0.24 | 0.22 | 0.22 |

Appendix 2: Continued

| Fatty Acid | Ch'02,7 | Ch'02,8 | Ch'02,11 | Ch'02,12 | Ch'02,19 |
|---|---|---|---|---|---|
| 18:1n-7 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 |
| 18:1n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| 18:2n-6 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |
| 18:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-3 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18:4n-3 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 |
| 18:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 |
| 20:1n-9 | 0.20 | 0.19 | 0.18 | 0.18 | 0.19 |
| 20:1n-7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.19 | 0.15 | 0.15 | 0.16 | 0.17 |
| 22:1n-9 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 22:1n-7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 |
| 24:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Fatty Acid | Ch'02,20 | Ch'02,25 | Ch'02,27 | Ch'02,34 | Ch'02,35 |
|---|---|---|---|---|---|
| 14:0 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |

| | | | | | |
|---|---|---|---|---|---|
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 2: Continued

| Fatty Acid | Ch'02,20 | Ch'02,25 | Ch'02,27 | Ch'02,34 | Ch'02,35 |
|---|---|---|---|---|---|
| 15:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:0 | 0.12 | 0.11 | 0.12 | 0.12 | 0.12 |
| 16:1n-9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:1n-7 | 0.06 | 0.05 | 0.06 | 0.05 | 0.06 |
| 16:1n-5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 anti-iso | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:0 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 0.20 | 0.23 | 0.23 | 0.24 | 0.23 |
| 18:1n-7 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |
| 18:1n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-5 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| 18:2n-6 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 |
| 18:2n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:3n-3 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 |
| 18:4n-3 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 |
| 18:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 |
| 20:1n-9 | 0.18 | 0.19 | 0.18 | 0.19 | 0.19 |
| 20:1n-7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | |
|---|---|---|---|---|---|
| 20:3n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 2: Continued

| Fatty Acid | Ch'02,20 | Ch'02,25 | Ch'02,27 | Ch'02,34 | Ch'02,35 |
|---|---|---|---|---|---|
| 20:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:5n-3 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.17 | 0.18 | 0.16 | 0.17 | 0.16 |
| 22:1n-9 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 22:1n-7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 0.04 | 0.05 | 0.04 | 0.04 | 0.04 |
| 24:1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 3: Base data for Leach's storm-petrel prey fatty acid proportions

| **Sample #** | pp001 | pp002 | pp003 | pp006 | pp007 | pp008 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid |
| 14:0 | 6.53 | 6.16 | 8.13 | 7.50 | 7.58 | 6.09 |
| 14:1 | 0.13 | 0.10 | 0.20 | 0.19 | 0.16 | 0.12 |
| 15:0 iso | 0.24 | 0.22 | 0.32 | 0.31 | 0.23 | 0.21 |
| 15:0 anti-iso | 0.07 | 0.06 | 0.11 | 0.11 | 0.11 | 0.09 |
| 15:0 | 0.30 | 0.32 | 0.47 | 0.42 | 0.33 | 0.32 |
| 15:1 | 0.01 | 0.04 | 0.11 | 0.06 | 0.02 | 0.02 |
| 16:0 iso | 0.09 | 0.09 | 0.14 | 0.12 | 0.11 | 0.09 |
| 16:0 anti-iso | 0.20 | 0.06 | 0.06 | 0.04 | 0.09 | 0.17 |
| 16:0 | 12.71 | 14.30 | 16.48 | 15.16 | 15.47 | 13.23 |
| 16:1n-9 | 0.07 | 0.09 | 0.08 | 0.07 | 0.06 | 0.06 |
| 16:1tr,n-7 | 0.10 | 0.13 | 0.14 | 0.13 | 0.11 | 0.11 |
| 16:1n-7 | 10.44 | 8.03 | 8.14 | 6.77 | 10.24 | 7.20 |
| 16:1n-5 | 0.43 | 0.36 | 0.46 | 0.38 | 0.44 | 0.34 |
| 17:0 iso | 0.21 | 0.22 | 0.30 | 0.31 | 0.23 | 0.23 |
| 17:0 anti-iso | 0.09 | 0.10 | 0.13 | 0.13 | 0.11 | 0.09 |
| 16:2n-4 | 0.43 | 0.33 | 0.09 | 0.23 | 0.27 | 0.29 |
| 17:0 | 0.06 | 0.11 | 0.15 | 0.12 | 0.10 | 0.09 |
| 16:3n-4 | 0.08 | 0.04 | 0.05 | 0.04 | 0.08 | 0.06 |
| 17:1 | 0.16 | 0.20 | 0.29 | 0.25 | 0.19 | 0.24 |
| 16:4n-3 | 0.03 | 0.18 | 0.25 | 0.29 | 0.22 | 0.19 |
| 16:4n-1 | 0.11 | 0.06 | 0.07 | 0.07 | 0.10 | 0.05 |
| 18:0 | 0.70 | 0.79 | 1.20 | 0.81 | 1.09 | 0.76 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 11.44 | 13.94 | 15.20 | 15.36 | 13.27 | 15.09 |
| 18:1n-7 | 3.57 | 4.21 | 4.69 | 4.26 | 4.27 | 4.47 |
| 18:1n-6 | 0.09 | 0.13 | 0.13 | 0.14 | 0.07 | 0.07 |
| 18:1n-5 | 0.97 | 0.87 | 1.05 | 0.97 | 0.99 | 0.89 |
| 18:2n-6 | 1.13 | 0.95 | 1.08 | 1.20 | 1.16 | 0.87 |
| 18:2n-4 | 0.14 | 0.14 | 0.17 | 0.13 | 0.13 | 0.14 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.06 | 0.05 | 0.09 | 0.06 | 0.09 | 0.07 |
| 18:3n-4 | 0.04 | 0.07 | 0.10 | 0.07 | 0.06 | 0.07 |
| 18:3n-3 | 0.31 | 0.34 | 0.47 | 0.39 | 0.21 | 0.28 |
| 18:4n-3 | 0.72 | 0.43 | 0.49 | 0.05 | 0.54 | 0.33 |
| 18:4n-1 | 0.05 | 0.04 | 0.07 | 0.03 | 0.10 | 0.00 |
| 20:0 | 0.06 | 0.07 | 0.11 | 0.06 | 0.08 | 0.07 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.51 | 0.64 | 0.86 | 0.54 | 0.53 | 0.89 |
| 20:1n-9 | 14.76 | 12.48 | 13.81 | 11.44 | 12.68 | 13.68 |
| 20:1n-7 | 0.90 | 0.68 | 0.94 | 0.75 | 0.89 | 0.85 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.03 | 0.04 | 0.01 | 0.00 | 0.02 | 0.04 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20:2n-6 | 0.22 | 0.24 | 0.29 | 0.33 | 0.28 | 0.24 |

Appendix 3: Continued

| **Sample #** | pp001 | pp002 | pp003 | pp006 | pp007 | pp008 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid |
| 20:3n-6 | 0.02 | 0.03 | 0.04 | 0.03 | 0.02 | 0.00 |
| 21:0 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.31 | 0.55 | 0.61 | 0.50 | 0.36 | 0.45 |
| 20:3n-3 | 0.21 | 0.24 | 0.36 | 0.34 | 0.22 | 0.27 |
| 20:4n-3 | 0.39 | 0.38 | 0.51 | 0.60 | 0.38 | 0.38 |
| 20:5n-3 | 6.79 | 8.88 | 8.50 | 8.01 | 6.29 | 6.71 |
| 22:0 | 0.02 | 0.04 | 0.03 | 0.00 | 0.03 | 0.02 |
| 22:1n-11(13) | 13.48 | 11.28 | 12.70 | 8.84 | 10.22 | 13.57 |
| 22:1n-9 | 1.72 | 1.24 | 1.64 | 1.02 | 1.62 | 1.63 |
| 22:1n-7 | 0.27 | 0.17 | 0.23 | 0.13 | 0.31 | 0.33 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.02 | 0.03 | 0.03 | 0.00 | 0.04 | 0.02 |
| 21:5n-3 | 0.19 | 0.21 | 0.24 | 0.19 | 0.20 | 0.15 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.08 | 0.11 | 0.13 | 0.07 | 0.07 | 0.08 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.38 | 0.38 | 0.47 | 0.43 | 0.35 | 0.32 |
| 24:0 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 |
| 22:6n-3 | 7.07 | 8.48 | 9.48 | 9.81 | 6.29 | 7.19 |
| 24:1 | 0.83 | 0.64 | 0.80 | 0.74 | 0.89 | 0.77 |

| **Sample #** | pp009 | pp010 | pp011 | pp012 | pp013 | pp035 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid |
| 14:0 | 7.54 | 7.56 | 7.39 | 6.81 | 5.23 | 6.19 |
| 14:1 | 0.19 | 0.22 | 0.16 | 0.19 | 0.07 | 0.12 |
| 15:0 iso | 0.25 | 0.32 | 0.23 | 0.26 | 0.23 | 0.25 |
| 15:0 anti-iso | 0.09 | 0.15 | 0.11 | 0.09 | 0.06 | 0.09 |
| 15:0 | 0.35 | 0.43 | 0.32 | 0.32 | 0.39 | 0.37 |
| 15:1 | 0.12 | 0.01 | 0.00 | 0.06 | 0.00 | 0.05 |
| 16:0 iso | 0.00 | 0.15 | 0.11 | 0.13 | 0.10 | 0.12 |
| 16:0 anti-iso | 0.05 | 0.10 | 0.07 | 0.05 | 0.00 | 0.12 |
| 16:0 | 15.19 | 14.45 | 16.67 | 14.20 | 14.84 | 12.71 |
| 16:1n-9 | 0.07 | 0.05 | 0.07 | 0.04 | 0.08 | 0.07 |
| 16:1tr,n-7 | 0.11 | 0.16 | 0.17 | 0.08 | 0.22 | 0.11 |
| 16:1n-7 | 8.13 | 7.50 | 10.46 | 9.01 | 6.94 | 7.33 |
| 16:1n-5 | 0.42 | 0.45 | 0.43 | 0.37 | 0.26 | 0.40 |
| 17:0 iso | 0.25 | 0.31 | 0.26 | 0.23 | 0.25 | 0.22 |
| 17:0 anti-iso | 0.13 | 0.18 | 0.14 | 0.11 | 0.10 | 0.09 |
| 16:2n-4 | 0.30 | 0.33 | 0.35 | 0.26 | 0.62 | 0.32 |
| 17:0 | 0.12 | 0.12 | 0.09 | 0.08 | 0.27 | 0.11 |
| 16:3n-4 | 0.05 | 0.06 | 0.11 | 0.04 | 0.09 | 0.05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17:1 | 0.20 | 0.26 | 0.16 | 0.20 | 0.44 | 0.25 |

Appendix 3: Continued

| **Sample #** | pp009 | pp010 | pp011 | pp012 | pp013 | pp035 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid |
| 16:4n-3 | 0.18 | 0.21 | 0.17 | 0.19 | 0.25 | 0.03 |
| 16:4n-1 | 0.09 | 0.09 | 0.24 | 0.06 | 0.11 | 0.13 |
| 18:0 | 1.00 | 0.95 | 1.34 | 0.75 | 2.66 | 0.80 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 15.07 | 13.30 | 13.03 | 13.63 | 17.53 | 13.14 |
| 18:1n-7 | 4.50 | 3.90 | 4.21 | 4.65 | 2.64 | 3.64 |
| 18:1n-6 | 0.00 | 0.82 | 0.94 | 0.92 | 0.12 | 0.08 |
| 18:1n-5 | 0.97 | 0.13 | 0.11 | 0.09 | 0.57 | 0.90 |
| 18:2n-6 | 0.95 | 0.95 | 1.39 | 1.05 | 1.17 | 0.98 |
| 18:2n-4 | 0.16 | 0.16 | 0.16 | 0.14 | 0.14 | 0.12 |
| 18:3n-6 | 0.00 | 0.01 | 0.00 | 0.00 | 0.10 | 0.00 |
| 19:0 | 0.07 | 0.08 | 0.08 | 0.05 | 0.13 | 0.07 |
| 18:3n-4 | 0.07 | 0.10 | 0.05 | 0.06 | 0.13 | 0.05 |
| 18:3n-3 | 0.29 | 0.53 | 0.32 | 0.23 | 0.70 | 0.39 |
| 18:4n-3 | 0.42 | 0.60 | 1.00 | 0.33 | 1.19 | 1.05 |
| 18:4n-1 | 0.07 | 0.06 | 0.08 | 0.00 | 0.15 | 0.03 |
| 20:0 | 0.08 | 0.08 | 0.09 | 0.08 | 0.12 | 0.08 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.52 | 0.64 | 0.51 | 0.70 | 0.88 | 0.75 |
| 20:1n-9 | 12.80 | 13.58 | 8.72 | 13.65 | 8.94 | 14.45 |
| 20:1n-7 | 0.95 | 1.21 | 0.78 | 1.00 | 0.52 | 0.63 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| 20:2b | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.30 | 0.27 | 0.27 | 0.32 | 0.28 | 0.26 |
| 20:3n-6 | 0.02 | 0.03 | 0.02 | 0.03 | 0.10 | 0.00 |
| 21:0 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.39 | 0.37 | 0.28 | 0.41 | 0.41 | 0.42 |
| 20:3n-3 | 0.27 | 0.26 | 0.27 | 0.27 | 0.11 | 0.24 |
| 20:4n-3 | 0.45 | 0.52 | 0.45 | 0.41 | 1.34 | 0.47 |
| 20:5n-3 | 6.81 | 6.53 | 8.70 | 6.88 | 6.52 | 7.59 |
| 22:0 | 0.02 | 0.03 | 0.00 | 0.02 | 0.00 | 0.04 |
| 22:1n-11(13) | 9.96 | 11.24 | 7.88 | 11.12 | 9.49 | 12.77 |
| 22:1n-9 | 1.63 | 1.84 | 1.38 | 1.63 | 1.31 | 1.48 |
| 22:1n-7 | 0.26 | 0.34 | 0.24 | 0.30 | 0.17 | 0.21 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.04 | 0.04 | 0.00 | 0.05 | 0.00 | 0.00 |
| 21:5n-3 | 0.19 | 0.20 | 0.26 | 0.18 | 0.25 | 0.20 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.06 | 0.07 | 0.10 | 0.09 | 0.22 | 0.09 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.39 | 0.39 | 0.44 | 0.38 | 1.36 | 0.42 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 |

Appendix 3: Continued

| **Sample #** | pp009 | pp010 | pp011 | pp012 | pp013 | pp035 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid |
| 22:6n-3 | 6.75 | 7.03 | 8.27 | 6.95 | 9.11 | 8.69 |
| 24:1 | 0.69 | 0.65 | 0.89 | 0.82 | 1.01 | 0.83 |

| **Sample #** | pp036 | pp037 | pp038 | pp039 | pp040 | pp041 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid |
| 14:0 | 5.04 | 5.64 | 6.48 | 6.43 | 5.96 | 5.70 |
| 14:1 | 0.10 | 0.12 | 0.14 | 0.19 | 0.15 | 0.17 |
| 15:0 iso | 0.22 | 0.23 | 0.26 | 0.28 | 0.23 | 0.27 |
| 15:0 anti-iso | 0.16 | 0.09 | 0.20 | 0.17 | 0.17 | 0.08 |
| 15:0 | 0.29 | 0.31 | 0.31 | 0.33 | 0.32 | 0.35 |
| 15:1 | 0.07 | 0.08 | 0.08 | 0.09 | 0.07 | 0.10 |
| 16:0 iso | 0.15 | 0.10 | 0.17 | 0.16 | 0.14 | 0.12 |
| 16:0 anti-iso | 0.18 | 0.22 | 0.20 | 0.05 | 0.14 | 0.06 |
| 16:0 | 10.97 | 12.07 | 11.20 | 14.67 | 11.41 | 12.03 |
| 16:1n-9 | 0.08 | 0.09 | 0.08 | 0.11 | 0.11 | 0.10 |
| 16:1tr,n-7 | 0.15 | 0.16 | 0.13 | 0.15 | 0.14 | 0.16 |
| 16:1n-7 | 8.88 | 7.34 | 9.16 | 7.93 | 8.43 | 8.17 |
| 16:1n-5 | 0.47 | 0.48 | 0.52 | 0.49 | 0.46 | 0.43 |
| 17:0 iso | 0.26 | 0.28 | 0.27 | 0.31 | 0.26 | 0.25 |
| 17:0 anti-iso | 0.14 | 0.12 | 0.15 | 0.15 | 0.12 | 0.12 |
| 16:2n-4 | 0.32 | 0.36 | 0.39 | 0.36 | 0.42 | 0.33 |
| 17:0 | 0.10 | 0.09 | 0.09 | 0.10 | 0.11 | 0.10 |
| 16:3n-4 | 0.06 | 0.09 | 0.09 | 0.08 | 0.12 | 0.07 |
| 17:1 | 0.17 | 0.20 | 0.15 | 0.22 | 0.17 | 0.17 |
| 16:4n-3 | 0.03 | 0.05 | 0.04 | 0.03 | 0.03 | 0.02 |
| 16:4n-1 | 0.11 | 0.21 | 0.17 | 0.22 | 0.19 | 0.11 |
| 18:0 | 0.80 | 0.88 | 0.81 | 0.95 | 0.80 | 0.91 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 11.64 | 12.09 | 11.41 | 13.73 | 11.42 | 10.05 |
| 18:1n-7 | 4.02 | 0.11 | 4.14 | 4.31 | 3.83 | 4.10 |
| 18:1n-6 | 0.00 | 0.00 | 0.00 | 0.11 | 0.12 | 0.10 |
| 18:1n-5 | 0.95 | 1.02 | 1.05 | 1.04 | 0.88 | 0.70 |
| 18:2n-6 | 0.91 | 0.94 | 0.96 | 1.09 | 0.91 | 0.95 |
| 18:2n-4 | 0.12 | 0.14 | 0.14 | 0.15 | 0.14 | 0.11 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.06 | 0.06 | 0.06 | 0.09 | 0.07 | 0.07 |
| 18:3n-4 | 0.07 | 0.06 | 0.04 | 0.11 | 0.07 | 0.06 |
| 18:3n-3 | 0.32 | 0.37 | 0.29 | 0.36 | 0.33 | 0.33 |
| 18:4n-3 | 0.53 | 1.04 | 0.65 | 1.07 | 0.69 | 1.04 |
| 18:4n-1 | 0.03 | 0.06 | 0.05 | 0.07 | 0.08 | 0.07 |
| 20:0 | 0.09 | 0.11 | 0.10 | 0.08 | 0.10 | 0.08 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20:1n-11 | 0.74 | 0.76 | 0.68 | 0.73 | 0.83 | 0.70 |

Appendix 3: Continued

| **Sample #** | pp036 | pp037 | pp038 | pp039 | pp040 | pp041 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid | Euphausiid |
| 20:1n-9 | 14.72 | 15.13 | 13.96 | 11.06 | 14.76 | 16.13 |
| 20:1n-7 | 0.92 | 0.79 | 0.90 | 0.77 | 0.90 | 1.15 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2n-6 | 0.30 | 0.25 | 0.25 | 0.30 | 0.27 | 0.26 |
| 20:3n-6 | 0.03 | 0.05 | 0.03 | 0.02 | 0.02 | 0.02 |
| 21:0 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.57 | 0.40 | 0.36 | 0.38 | 0.39 | 0.46 |
| 20:3n-3 | 0.25 | 0.32 | 0.20 | 0.28 | 0.22 | 0.23 |
| 20:4n-3 | 0.38 | 0.48 | 0.37 | 0.49 | 0.34 | 0.34 |
| 20:5n-3 | 7.32 | 8.30 | 7.38 | 8.22 | 7.03 | 7.15 |
| 22:0 | 0.03 | 0.08 | 0.04 | 0.02 | 0.02 | 0.02 |
| 22:1n-11(13) | 14.58 | 14.53 | 14.12 | 10.23 | 15.05 | 14.47 |
| 22:1n-9 | 1.83 | 2.11 | 1.99 | 1.42 | 2.05 | 2.37 |
| 22:1n-7 | 0.32 | 0.29 | 0.40 | 0.25 | 0.33 | 0.39 |
| 22:2NIMDa | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.21 | 0.26 | 0.20 | 0.27 | 0.22 | 0.17 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.13 | 0.10 | 0.11 | 0.09 | 0.09 | 0.12 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.40 | 0.53 | 0.38 | 0.42 | 0.43 | 0.35 |
| 24:0 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.02 |
| 22:6n-3 | 8.76 | 9.43 | 7.68 | 8.55 | 7.59 | 7.35 |
| 24:1 | 1.01 | 0.92 | 0.98 | 0.80 | 0.85 | 0.82 |

| **Sample #** | pp042 | pp043 | pp044 | pp005 | pp014 | pp015 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Myctophid | Myctophid | Myctophid |
| 14:0 | 6.94 | 7.92 | 6.15 | 4.31 | 5.88 | 5.20 |
| 14:1 | 0.16 | 0.00 | 0.12 | 0.09 | 0.09 | 0.28 |
| 15:0 iso | 0.27 | 0.00 | 0.27 | 0.21 | 0.27 | 0.35 |
| 15:0 anti-iso | 0.09 | 0.09 | 0.08 | 0.03 | 0.11 | 0.14 |
| 15:0 | 0.33 | 0.40 | 0.36 | 0.38 | 0.42 | 0.24 |
| 15:1 | 0.09 | 0.00 | 0.10 | 0.00 | 0.07 | 0.06 |
| 16:0 iso | 0.11 | 0.09 | 0.13 | 0.10 | 0.10 | 0.05 |
| 16:0 anti-iso | 0.06 | 0.00 | 0.06 | 0.00 | 0.09 | 0.04 |
| 16:0 | 14.44 | 16.04 | 14.98 | 16.35 | 8.75 | 5.34 |
| 16:1n-9 | 0.08 | 0.10 | 0.11 | 0.08 | 0.09 | 0.07 |
| 16:1tr,n-7 | 0.13 | 0.15 | 0.16 | 0.30 | 0.14 | 0.21 |
| 16:1n-7 | 6.19 | 11.12 | 6.64 | 6.32 | 6.40 | 11.34 |
| 16:1n-5 | 0.37 | 0.57 | 0.46 | 0.21 | 0.36 | 0.46 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17:0 iso | 0.29 | 0.28 | 0.33 | 0.26 | 0.22 | 0.43 |

Appendix 3: Continued

| **Sample #** | pp042 | pp043 | pp044 | pp005 | pp014 | pp015 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Myctophid | Myctophid | Myctophid |
| 17:0 anti-iso | 0.11 | 0.10 | 0.11 | 0.08 | 0.12 | 0.08 |
| 16:2n-4 | 0.25 | 0.44 | 0.26 | 0.44 | 0.31 | 0.45 |
| 17:0 | 0.11 | 0.10 | 0.11 | 0.28 | 0.23 | 0.09 |
| 16:3n-4 | 0.06 | 0.08 | 0.05 | 0.06 | 0.12 | 0.17 |
| 17:1 | 0.18 | 0.20 | 0.20 | 0.48 | 0.35 | 0.60 |
| 16:4n-3 | 0.05 | 0.05 | 0.04 | 0.24 | 0.22 | 0.02 |
| 16:4n-1 | 0.05 | 0.15 | 0.07 | 0.07 | 0.12 | 0.31 |
| 18:0 | 1.04 | 0.53 | 1.01 | 3.16 | 1.81 | 0.87 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 15.66 | 12.15 | 13.96 | 21.58 | 9.64 | 19.11 |
| 18:1n-7 | 4.35 | 3.82 | 4.65 | 2.91 | 1.61 | 2.29 |
| 18:1n-6 | 0.09 | 0.10 | 0.12 | 0.15 | 0.49 | 0.10 |
| 18:1n-5 | 0.95 | 0.73 | 1.05 | 0.62 | 0.06 | 0.64 |
| 18:2n-6 | 0.93 | 1.78 | 0.97 | 0.94 | 1.28 | 1.48 |
| 18:2n-4 | 0.14 | 0.14 | 0.14 | 0.10 | 0.11 | 0.09 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| 19:0 | 0.07 | 0.09 | 0.06 | 0.14 | 0.09 | 0.14 |
| 18:3n-4 | 0.08 | 0.08 | 0.08 | 0.13 | 0.49 | 0.14 |
| 18:3n-3 | 0.33 | 0.56 | 0.44 | 0.64 | 0.88 | 0.93 |
| 18:4n-3 | 0.35 | 1.03 | 0.72 | 0.88 | 1.06 | 2.44 |
| 18:4n-1 | 0.06 | 0.04 | 0.07 | 0.12 | 0.07 | 0.24 |
| 20:0 | 0.10 | 0.02 | 0.09 | 0.14 | 0.09 | 0.07 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.64 | 0.34 | 0.62 | 0.85 | 0.64 | 1.82 |
| 20:1n-9 | 11.97 | 4.35 | 12.23 | 8.10 | 17.30 | 13.68 |
| 20:1n-7 | 0.71 | 0.30 | 0.90 | 0.45 | 1.30 | 0.71 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.08 | 0.02 | 0.00 |
| 20:2n-6 | 0.26 | 0.22 | 0.30 | 0.25 | 0.22 | 0.18 |
| 20:3n-6 | 0.00 | 0.05 | 0.02 | 0.08 | 0.06 | 0.08 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.03 |
| 20:4n-6 | 0.55 | 0.72 | 0.51 | 0.38 | 0.86 | 0.30 |
| 20:3n-3 | 0.23 | 0.32 | 0.25 | 0.12 | 0.15 | 0.07 |
| 20:4n-3 | 0.43 | 0.61 | 0.47 | 1.39 | 1.12 | 0.74 |
| 20:5n-3 | 7.63 | 15.59 | 8.14 | 5.50 | 4.37 | 3.57 |
| 22:0 | 0.04 | 0.00 | 0.03 | 0.07 | 0.03 | 0.02 |
| 22:1n-11(13) | 10.90 | 2.78 | 10.53 | 8.33 | 18.81 | 14.85 |
| 22:1n-9 | 1.47 | 0.38 | 1.56 | 1.40 | 4.07 | 1.67 |
| 22:1n-7 | 0.22 | 0.03 | 0.29 | 0.20 | 0.22 | 0.20 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 |
| 21:5n-3 | 0.19 | 0.29 | 0.20 | 0.21 | 0.24 | 0.22 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 3: Continued

| **Sample #** | pp042 | pp043 | pp044 | pp005 | pp014 | pp015 |
|---|---|---|---|---|---|---|
| **Prey type** | Euphausiid | Euphausiid | Euphausiid | Myctophid | Myctophid | Myctophid |
| 22:4n-6 | 0.08 | 0.09 | 0.10 | 0.20 | 0.16 | 0.06 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.39 | 0.41 | 0.35 | 1.47 | 1.02 | 0.40 |
| 24:0 | 0.00 | 0.01 | 0.00 | 0.03 | 0.01 | 0.05 |
| 22:6n-3 | 9.01 | 14.17 | 8.46 | 8.24 | 6.70 | 5.61 |
| 24:1 | 0.76 | 0.36 | 0.87 | 0.84 | 0.48 | 1.21 |

| **Sample #** | pp016 | pp017 | pp018 | pp019 | pp020 | pp021 |
|---|---|---|---|---|---|---|
| **Prey type** | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid |
| 14:0 | 5.46 | 4.68 | 5.16 | 4.58 | 3.57 | 5.13 |
| 14:1 | 0.35 | 0.27 | 0.28 | 0.07 | 0.22 | 0.27 |
| 15:0 iso | 0.38 | 0.31 | 0.38 | 0.26 | 0.25 | 0.31 |
| 15:0 anti-iso | 0.21 | 0.14 | 0.26 | 0.11 | 0.09 | 0.20 |
| 15:0 | 0.19 | 0.18 | 0.23 | 0.46 | 0.12 | 0.18 |
| 15:1 | 0.08 | 0.09 | 0.07 | 0.05 | 0.08 | 0.03 |
| 16:0 iso | 0.06 | 0.06 | 0.09 | 0.11 | 0.02 | 0.05 |
| 16:0 anti-iso | 0.01 | 0.04 | 0.09 | 0.10 | 0.01 | 0.05 |
| 16:0 | 4.35 | 5.01 | 5.25 | 14.44 | 3.63 | 4.70 |
| 16:1n-9 | 0.09 | 0.06 | 0.05 | 0.08 | 0.09 | 0.07 |
| 16:1tr,n-7 | 0.18 | 0.17 | 0.23 | 0.16 | 0.12 | 0.15 |
| 16:1n-7 | 12.49 | 11.18 | 9.40 | 6.60 | 13.39 | 13.58 |
| 16:1n-5 | 0.41 | 0.38 | 0.37 | 0.34 | 0.33 | 0.37 |
| 17:0 iso | 0.35 | 0.37 | 0.49 | 0.32 | 0.22 | 0.16 |
| 17:0 anti-iso | 0.09 | 0.07 | 0.07 | 0.11 | 0.06 | 0.08 |
| 16:2n-4 | 0.69 | 0.53 | 0.25 | 0.17 | 0.68 | 0.83 |
| 17:0 | 0.08 | 0.09 | 0.10 | 0.18 | 0.05 | 0.07 |
| 16:3n-4 | 0.33 | 0.18 | 0.10 | 0.06 | 0.44 | 0.40 |
| 17:1 | 0.41 | 0.49 | 0.78 | 0.57 | 0.21 | 0.34 |
| 16:4n-3 | 0.01 | 0.02 | 0.14 | 0.02 | 0.03 | 0.00 |
| 16:4n-1 | 0.55 | 0.39 | 0.19 | 0.07 | 0.77 | 0.79 |
| 18:0 | 0.81 | 1.08 | 0.90 | 1.62 | 0.70 | 0.81 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 18:1n-9 | 16.07 | 17.64 | 22.66 | 15.88 | 12.18 | 15.80 |
| 18:1n-7 | 1.56 | 1.68 | 2.09 | 2.43 | 1.64 | 2.15 |
| 18:1n-6 | 0.08 | 0.08 | 0.09 | 0.09 | 0.05 | 0.09 |
| 18:1n-5 | 0.53 | 0.52 | 0.58 | 0.53 | 0.49 | 0.47 |
| 18:2n-6 | 1.36 | 1.31 | 1.66 | 1.34 | 1.06 | 1.27 |
| 18:2n-4 | 0.08 | 0.09 | 0.06 | 0.10 | 0.10 | 0.08 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| 19:0 | 0.17 | 0.13 | 0.15 | 0.08 | 0.14 | 0.04 |
| 18:3n-4 | 0.13 | 0.13 | 0.18 | 0.11 | 0.14 | 0.16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18:3n-3 | 0.92 | 0.85 | 1.09 | 0.55 | 0.58 | 0.71 |

Appendix 3: Continued

| **Sample #** | pp016 | pp017 | pp018 | pp019 | pp020 | pp021 |
|---|---|---|---|---|---|---|
| **Prey type** | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid |
| 18:4n-3 | 2.61 | 3.08 | 2.03 | 0.84 | 2.73 | 1.72 |
| 18:4n-1 | 0.27 | 0.20 | 0.12 | 0.08 | 0.33 | 0.38 |
| 20:0 | 0.08 | 0.08 | 0.07 | 0.11 | 0.07 | 0.07 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 1.48 | 1.18 | 1.90 | 1.36 | 1.88 | 1.41 |
| 20:1n-9 | 14.70 | 14.06 | 11.07 | 11.05 | 17.07 | 13.89 |
| 20:1n-7 | 0.81 | 0.73 | 0.42 | 0.13 | 1.22 | 0.80 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.02 | 0.02 | 0.00 | 0.00 | 0.03 | 0.00 |
| 20:2n-6 | 0.19 | 0.17 | 0.23 | 0.16 | 0.17 | 0.18 |
| 20:3n-6 | 0.07 | 0.07 | 0.08 | 0.06 | 0.06 | 0.10 |
| 21:0 | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 |
| 20:4n-6 | 0.34 | 0.35 | 0.38 | 0.33 | 0.19 | 0.38 |
| 20:3n-3 | 0.08 | 0.08 | 0.12 | 0.05 | 0.06 | 0.07 |
| 20:4n-3 | 0.86 | 0.81 | 0.84 | 0.49 | 0.70 | 0.81 |
| 20:5n-3 | 4.81 | 4.93 | 4.46 | 4.25 | 5.71 | 5.58 |
| 22:0 | 0.07 | 0.02 | 0.02 | 0.04 | 0.00 | 0.06 |
| 22:1n-11(13) | 14.26 | 14.51 | 13.01 | 15.40 | 15.97 | 14.03 |
| 22:1n-9 | 1.70 | 1.61 | 1.04 | 1.36 | 2.53 | 1.76 |
| 22:1n-7 | 0.29 | 0.24 | 0.16 | 0.22 | 0.36 | 0.28 |
| 22:2NIMDa | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.02 | 0.04 | 0.06 | 0.00 | 0.09 | 0.00 |
| 21:5n-3 | 0.33 | 0.31 | 0.29 | 0.18 | 0.36 | 0.34 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.07 | 0.08 | 0.12 | 0.11 | 0.04 | 0.07 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 22:5n-3 | 0.56 | 0.51 | 0.46 | 0.57 | 0.60 | 0.63 |
| 24:0 | 0.07 | 0.08 | 0.04 | 0.06 | 0.05 | 0.00 |
| 22:6n-3 | 6.51 | 7.25 | 8.30 | 9.49 | 7.27 | 6.71 |
| 24:1 | 1.26 | 1.35 | 1.31 | 2.01 | 1.06 | 1.23 |

| **Sample #** | pp022 | pp023 | pp024 | pp025 | pp026 | pp027 |
|---|---|---|---|---|---|---|
| **Prey type** | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid |
| 14:0 | 5.29 | 4.60 | 4.39 | 4.97 | 2.97 | 4.33 |
| 14:1 | 0.23 | 0.30 | 0.31 | 0.29 | 0.18 | 0.26 |
| 15:0 iso | 0.34 | 0.30 | 0.34 | 0.33 | 0.17 | 0.32 |
| 15:0 anti-iso | 0.17 | 0.11 | 0.17 | 0.13 | 0.09 | 0.12 |
| 15:0 | 0.19 | 0.18 | 0.19 | 0.21 | 0.11 | 0.18 |
| 15:1 | 0.08 | 0.05 | 0.05 | 0.04 | 0.03 | 0.05 |
| 16:0 iso | 0.06 | 0.07 | 0.06 | 0.05 | 0.03 | 0.05 |
| 16:0 anti-iso | 0.05 | 0.03 | 0.05 | 0.04 | 0.04 | 0.04 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16:0 | 4.95 | 4.52 | 4.90 | 4.88 | 3.82 | 4.66 |

Appendix 3: Continued

| **Sample #** | pp022 | pp023 | pp024 | pp025 | pp026 | pp027 |
|---|---|---|---|---|---|---|
| **Prey type** | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid |
| 16:1n-9 | 0.04 | 0.07 | 0.07 | 0.05 | 0.07 | 0.06 |
| 16:1tr,n-7 | 0.18 | 0.18 | 0.15 | 0.17 | 0.08 | 0.16 |
| 16:1n-7 | 9.64 | 10.33 | 10.68 | 11.21 | 13.31 | 10.12 |
| 16:1n-5 | 0.32 | 0.31 | 0.28 | 0.36 | 0.27 | 0.33 |
| 17:0 iso | 0.32 | 0.05 | 0.36 | 0.34 | 0.16 | 0.33 |
| 17:0 anti-iso | 0.07 | 0.05 | 0.05 | 0.06 | 0.05 | 0.04 |
| 16:2n-4 | 0.39 | 0.28 | 0.43 | 0.59 | 0.67 | 0.45 |
| 17:0 | 0.09 | 0.10 | 0.08 | 0.07 | 0.04 | 0.09 |
| 16:3n-4 | 0.18 | 0.09 | 0.13 | 0.27 | 0.35 | 0.18 |
| 17:1 | 0.44 | 0.60 | 0.56 | 0.42 | 0.19 | 0.43 |
| 16:4n-3 | 0.02 | 0.00 | 0.01 | 0.02 | 0.00 | 0.02 |
| 16:4n-1 | 0.40 | 0.22 | 0.21 | 0.41 | 0.64 | 0.32 |
| 18:0 | 1.20 | 0.82 | 0.87 | 0.87 | 0.83 | 0.90 |
| 18:1n-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 18.73 | 22.85 | 22.25 | 15.61 | 12.06 | 17.97 |
| 18:1n-7 | 2.08 | 1.79 | 2.20 | 1.90 | 2.05 | 1.93 |
| 18:1n-6 | 0.08 | 0.09 | 0.09 | 0.07 | 0.02 | 0.07 |
| 18:1n-5 | 0.49 | 0.55 | 0.52 | 0.50 | 0.49 | 0.50 |
| 18:2n-6 | 1.43 | 1.48 | 1.46 | 1.42 | 1.16 | 1.37 |
| 18:2n-4 | 0.06 | 0.02 | 0.05 | 0.07 | 0.08 | 0.05 |
| 18:3n-6 | 0.13 | 0.00 | 0.08 | 0.11 | 0.12 | 0.10 |
| 19:0 | 0.03 | 0.11 | 0.03 | 0.06 | 0.04 | 0.03 |
| 18:3n-4 | 0.13 | 0.13 | 0.17 | 0.13 | 0.12 | 0.14 |
| 18:3n-3 | 0.85 | 0.99 | 0.74 | 0.90 | 0.37 | 0.81 |
| 18:4n-3 | 1.96 | 3.04 | 2.44 | 3.11 | 1.70 | 3.07 |
| 18:4n-1 | 0.16 | 0.13 | 0.12 | 0.20 | 0.43 | 0.16 |
| 20:0 | 0.09 | 0.07 | 0.06 | 0.07 | 0.07 | 0.09 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 1.79 | 1.49 | 1.83 | 1.55 | 1.48 | 1.54 |
| 20:1n-9 | 16.14 | 10.04 | 12.54 | 14.24 | 16.35 | 14.33 |
| 20:1n-7 | 0.63 | 0.53 | 0.65 | 0.70 | 1.92 | 0.75 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 |
| 20:2n-6 | 0.21 | 0.22 | 0.22 | 0.24 | 0.19 | 0.19 |
| 20:3n-6 | 0.08 | 0.07 | 0.09 | 0.09 | 0.07 | 0.08 |
| 21:0 | 0.02 | 0.03 | 0.02 | 0.05 | 0.00 | 0.03 |
| 20:4n-6 | 0.32 | 0.35 | 0.37 | 0.41 | 0.29 | 0.35 |
| 20:3n-3 | 0.08 | 0.10 | 0.07 | 0.10 | 0.06 | 0.07 |
| 20:4n-3 | 0.69 | 1.08 | 0.80 | 0.88 | 1.63 | 0.97 |
| 20:5n-3 | 3.11 | 5.74 | 4.32 | 5.02 | 6.95 | 5.02 |
| 22:0 | 0.00 | 0.00 | 0.03 | 0.03 | 0.04 | 0.00 |
| 22:1n-11(13) | 16.12 | 12.26 | 12.63 | 15.25 | 16.02 | 15.28 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 22:1n-9 | 1.83 | 1.37 | 1.64 | 1.85 | 3.03 | 1.86 |

Appendix 3: Continued

| **Sample #** | pp022 | pp023 | pp024 | pp025 | pp026 | pp027 |
|---|---|---|---|---|---|---|
| **Prey type** | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid |
| 22:1n-7 | 0.24 | 0.19 | 0.24 | 0.27 | 0.48 | 0.24 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| 21:5n-3 | 0.25 | 0.33 | 0.26 | 0.33 | 0.37 | 0.34 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.06 | 0.11 | 0.08 | 0.07 | 0.05 | 0.08 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.45 | 0.55 | 0.43 | 0.53 | 0.81 | 0.46 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 5.83 | 9.72 | 7.83 | 7.18 | 6.40 | 7.39 |
| 24:1 | 1.29 | 1.31 | 1.40 | 1.28 | 0.95 | 1.28 |

| **Sample #** | pp028 | pp029 | pp030 | pp032 | pp033 | pp034 |
|---|---|---|---|---|---|---|
| **Prey type** | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid |
| 14:0 | 4.64 | 5.09 | 4.69 | 4.46 | 2.69 | 4.39 |
| 14:1 | 0.26 | 0.23 | 0.21 | 0.19 | 0.00 | 0.23 |
| 15:0 iso | 0.30 | 0.27 | 0.26 | 0.25 | 0.69 | 0.32 |
| 15:0 anti-iso | 0.16 | 0.18 | 0.11 | 0.13 | 0.08 | 0.13 |
| 15:0 | 0.17 | 0.19 | 0.17 | 0.20 | 0.29 | 0.18 |
| 15:1 | 0.05 | 0.04 | 0.05 | 0.04 | 0.12 | 0.05 |
| 16:0 iso | 0.05 | 0.09 | 0.05 | 0.05 | 0.00 | 0.06 |
| 16:0 anti-iso | 0.03 | 0.03 | 0.04 | 0.02 | 0.00 | 0.03 |
| 16:0 | 4.22 | 4.43 | 4.26 | 5.35 | 7.04 | 4.56 |
| 16:1n-9 | 0.04 | 0.04 | 0.08 | 0.06 | 0.28 | 0.06 |
| 16:1tr,n-7 | 0.13 | 0.13 | 0.15 | 0.15 | 2.84 | 0.17 |
| 16:1n-7 | 12.95 | 10.51 | 11.07 | 11.54 | 2.83 | 9.66 |
| 16:1n-5 | 0.34 | 0.28 | 0.32 | 0.33 | 0.16 | 0.30 |
| 17:0 iso | 0.27 | 0.34 | 0.29 | 0.27 | 0.86 | 0.37 |
| 17:0 anti-iso | 0.06 | 0.05 | 0.05 | 0.06 | 0.17 | 0.06 |
| 16:2n-4 | 0.65 | 0.67 | 0.60 | 0.55 | 0.61 | 0.47 |
| 17:0 | 0.07 | 0.09 | 0.07 | 0.10 | 0.34 | 0.08 |
| 16:3n-4 | 0.41 | 0.38 | 0.27 | 0.21 | 0.07 | 0.18 |
| 17:1 | 0.34 | 0.33 | 0.31 | 0.44 | 0.08 | 0.48 |
| 16:4n-3 | 0.01 | 0.02 | 0.02 | 0.07 | 0.00 | 0.03 |
| 16:4n-1 | 0.65 | 0.64 | 0.44 | 0.42 | 0.07 | 0.03 |
| 18:0 | 0.78 | 0.95 | 0.79 | 0.99 | 2.14 | 0.95 |
| 18:1n-11 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 14.16 | 14.28 | 15.23 | 14.77 | 16.69 | 19.09 |
| 18:1n-7 | 1.96 | 1.64 | 1.71 | 2.10 | 3.18 | 1.77 |
| 18:1n-6 | 0.06 | 0.06 | 0.05 | 0.06 | 0.08 | 0.08 |
| 18:1n-5 | 0.51 | 0.48 | 0.50 | 0.57 | 0.72 | 0.54 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18:2n-6 | 1.38 | 1.21 | 1.28 | 1.43 | 0.91 | 1.50 |

Appendix 3: Continued

| **Sample #** | pp028 | pp029 | pp030 | pp032 | pp033 | pp034 |
|---|---|---|---|---|---|---|
| **Prey type** | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid | Myctophid |
| 18:2n-4 | 0.08 | 0.06 | 0.05 | 0.11 | 0.10 | 0.05 |
| 18:3n-6 | 0.13 | 0.12 | 0.11 | 0.12 | 0.00 | 0.10 |
| 19:0 | 0.04 | 0.03 | 0.02 | 0.03 | 0.05 | 0.03 |
| 18:3n-4 | 0.14 | 0.14 | 0.13 | 0.13 | 0.19 | 0.15 |
| 18:3n-3 | 0.64 | 0.65 | 0.68 | 0.84 | 0.26 | 0.82 |
| 18:4n-3 | 2.28 | 2.45 | 2.42 | 3.12 | 0.37 | 2.18 |
| 18:4n-1 | 0.29 | 0.21 | 0.18 | 0.20 | 0.27 | 0.11 |
| 20:0 | 0.09 | 0.09 | 0.08 | 0.04 | 0.00 | 0.09 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 1.79 | 1.76 | 2.08 | 1.55 | 3.45 | 2.15 |
| 20:1n-9 | 16.59 | 15.37 | 15.88 | 14.21 | 12.05 | 14.68 |
| 20:1n-7 | 0.97 | 0.84 | 0.90 | 0.97 | 4.40 | 0.65 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.01 |
| 20:2n-6 | 0.18 | 0.19 | 0.20 | 0.22 | 0.55 | 0.24 |
| 20:3n-6 | 0.09 | 0.06 | 0.09 | 0.07 | 0.08 | 0.08 |
| 21:0 | 0.02 | 0.02 | 0.02 | 0.03 | 0.00 | 0.03 |
| 20:4n-6 | 0.31 | 0.33 | 0.37 | 0.34 | 2.70 | 0.34 |
| 20:3n-3 | 0.07 | 0.06 | 0.08 | 0.09 | 0.19 | 0.09 |
| 20:4n-3 | 0.63 | 0.72 | 0.85 | 0.97 | 1.01 | 0.84 |
| 20:5n-3 | 4.71 | 5.16 | 5.07 | 5.71 | 9.43 | 3.52 |
| 22:0 | 0.05 | 0.03 | 0.05 | 0.03 | 0.00 | 0.03 |
| 22:1n-11(13) | 16.59 | 17.03 | 16.03 | 13.48 | 7.56 | 17.11 |
| 22:1n-9 | 2.06 | 2.06 | 1.95 | 1.86 | 2.44 | 1.76 |
| 22:1n-7 | 0.34 | 0.32 | 0.33 | 0.33 | 0.43 | 0.26 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| 21:5n-3 | 0.32 | 0.34 | 0.32 | 0.36 | 0.17 | 0.27 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.05 | 0.06 | 0.07 | 0.07 | 0.72 | 0.07 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.45 | 0.55 | 0.59 | 0.65 | 3.05 | 0.42 |
| 24:0 | 0.00 | 0.05 | 0.04 | 0.03 | 0.00 | 0.05 |
| 22:6n-3 | 5.40 | 7.29 | 7.22 | 8.53 | 6.87 | 6.69 |
| 24:1 | 1.06 | 1.34 | 1.13 | 1.07 | 0.69 | 1.44 |

| **Sample #** | pp004 | pp045 | pp046 | pp048 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (free living) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) |
| 14:0 | 4.37 | 1.69 | 1.95 | 1.78 |
| 14:1 | 0.00 | 0.03 | 0.02 | 0.03 |

| | | | | |
|---|---|---|---|---|
| 15:0 iso | 1.14 | 0.71 | 0.87 | 0.09 |

Appendix 3: Continued

| **Sample #** | pp004 | pp045 | pp046 | pp048 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (free living) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) |
| 15:0 anti-iso | 0.11 | 0.03 | 0.06 | 0.02 |
| 15:0 | 0.26 | 0.80 | 0.99 | 0.53 |
| 15:1 | 0.10 | 0.50 | 0.78 | 0.63 |
| 16:0 iso | 0.07 | 0.14 | 0.17 | 0.07 |
| 16:0 anti-iso | 0.00 | 0.12 | 0.02 | 0.00 |
| 16:0 | 8.57 | 10.98 | 10.72 | 14.31 |
| 16:1n-9 | 0.10 | 0.09 | 0.07 | 0.10 |
| 16:1tr,n-7 | 0.40 | 2.46 | 3.55 | 1.78 |
| 16:1n-7 | 6.18 | 0.80 | 0.97 | 0.81 |
| 16:1n-5 | 0.22 | 0.11 | 0.11 | 0.07 |
| 17:0 iso | 0.31 | 0.54 | 0.49 | 0.73 |
| 17:0 anti-iso | 0.08 | 0.25 | 0.19 | 0.27 |
| 16:2n-4 | 0.42 | 0.96 | 0.76 | 0.73 |
| 17:0 | 0.26 | 1.13 | 1.24 | 1.15 |
| 16:3n-4 | 0.09 | 0.10 | 0.15 | 0.23 |
| 17:1 | 0.26 | 1.80 | 1.51 | 0.31 |
| 16:4n-3 | 0.19 | 0.05 | 0.05 | 0.11 |
| 16:4n-1 | 0.12 | 0.04 | 0.03 | 0.00 |
| 18:0 | 1.12 | 3.31 | 2.77 | 4.81 |
| 18:1n-11 | 0.00 | 0.14 | 0.15 | 0.30 |
| 18:1n-9 | 20.09 | 11.15 | 9.87 | 13.63 |
| 18:1n-7 | 2.83 | 3.01 | 2.53 | 1.36 |
| 18:1n-6 | 0.92 | 0.12 | 0.11 | 0.17 |
| 18:1n-5 | 0.89 | 0.40 | 0.42 | 0.88 |
| 18:2n-6 | 1.74 | 0.98 | 1.20 | 1.33 |
| 18:2n-4 | 0.51 | 0.48 | 0.42 | 0.91 |
| 18:3n-6 | 0.00 | 0.22 | 0.17 | 0.38 |
| 19:0 | 0.13 | 0.33 | 0.35 | 0.20 |
| 18:3n-4 | 0.07 | 0.21 | 0.27 | 0.21 |
| 18:3n-3 | 1.23 | 0.38 | 1.07 | 0.57 |
| 18:4n-3 | 2.53 | 0.24 | 0.56 | 0.30 |
| 18:4n-1 | 0.21 | 0.03 | 0.02 | 0.10 |
| 20:0 | 0.14 | 0.29 | 0.37 | 0.19 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 2.65 | 0.21 | 0.21 | 0.14 |
| 20:1n-9 | 1.37 | 1.74 | 1.87 | 0.91 |
| 20:1n-7 | 0.80 | 1.64 | 1.44 | 0.19 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.08 | 0.11 | 0.06 |
| 20:2n-6 | 0.33 | 0.48 | 1.21 | 0.43 |
| 20:3n-6 | 0.41 | 0.05 | 0.04 | 0.00 |

| | | | | |
|---|---|---|---|---|
| 21:0 | 0.00 | 0.11 | 0.11 | 0.00 |

Appendix 3: Continued

| **Sample #** | pp004 | pp045 | pp046 | pp048 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (free living) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) |
| 20:4n-6 | 0.89 | 1.62 | 1.07 | 0.00 |
| 20:3n-3 | 0.22 | 0.31 | 1.46 | 0.26 |
| 20:4n-3 | 1.04 | 0.82 | 1.57 | 0.44 |
| 20:5n-3 | 15.12 | 22.67 | 20.05 | 24.60 |
| 22:0 | 0.00 | 0.09 | 0.09 | 0.17 |
| 22:1n-11(13) | 4.69 | 0.18 | 0.14 | 0.53 |
| 22:1n-9 | 1.82 | 0.48 | 0.56 | 0.41 |
| 22:1n-7 | 0.00 | 0.84 | 0.58 | 0.15 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.03 | 0.06 |
| 21:5n-3 | 0.53 | 0.17 | 0.16 | 0.13 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.19 | 0.36 | 0.45 | 0.15 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.74 | 3.40 | 4.09 | 1.28 |
| 24:0 | 0.00 | 0.02 | 0.01 | 0.00 |
| 22:6n-3 | 13.30 | 19.07 | 19.04 | 20.03 |
| 24:1 | 0.22 | 1.04 | 0.74 | 0.96 |

| **Sample #** | pp049 | pp050 | pp051 | pp052 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) |
| 14:0 | 3.30 | 2.09 | 2.65 | 3.11 |
| 14:1 | 0.06 | 0.05 | 0.06 | 0.08 |
| 15:0 iso | 0.63 | 0.78 | 0.42 | 0.51 |
| 15:0 anti-iso | 0.08 | 0.08 | 0.08 | 0.10 |
| 15:0 | 0.65 | 1.26 | 0.62 | 0.57 |
| 15:1 | 0.04 | 0.70 | 0.82 | 0.54 |
| 16:0 iso | 0.16 | 0.22 | 0.12 | 0.12 |
| 16:0 anti-iso | 0.04 | 0.11 | 0.12 | 0.00 |
| 16:0 | 14.01 | 10.28 | 10.45 | 13.04 |
| 16:1n-9 | 0.09 | 0.05 | 0.07 | 0.08 |
| 16:1tr,n-7 | 2.13 | 4.08 | 2.49 | 2.08 |
| 16:1n-7 | 1.69 | 0.93 | 1.23 | 1.51 |
| 16:1n-5 | 0.21 | 0.13 | 0.15 | 0.20 |
| 17:0 iso | 0.69 | 0.49 | 0.50 | 0.53 |
| 17:0 anti-iso | 0.24 | 0.25 | 0.26 | 0.22 |
| 16:2n-4 | 0.53 | 0.68 | 0.50 | 0.39 |
| 17:0 | 0.90 | 1.34 | 1.03 | 0.82 |
| 16:3n-4 | 0.28 | 0.22 | 0.20 | 0.31 |

| | | | | |
|---|---|---|---|---|
| 17:1 | 0.37 | 1.92 | 1.31 | 0.22 |

Appendix 3: Continued

| **Sample #** | pp049 | pp050 | pp051 | pp052 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) |
| 16:4n-3 | 0.15 | 0.06 | 0.13 | 0.11 |
| 16:4n-1 | 0.04 | 0.05 | 0.06 | 0.04 |
| 18:0 | 4.24 | 2.98 | 3.14 | 3.74 |
| 18:1n-11 | 0.20 | 0.33 | 0.19 | 0.15 |
| 18:1n-9 | 12.49 | 10.35 | 12.33 | 12.01 |
| 18:1n-7 | 1.31 | 2.96 | 2.57 | 1.17 |
| 18:1n-6 | 0.12 | 0.08 | 0.13 | 0.10 |
| 18:1n-5 | 0.89 | 0.52 | 0.66 | 0.85 |
| 18:2n-6 | 1.96 | 0.85 | 1.68 | 2.00 |
| 18:2n-4 | 0.49 | 0.82 | 0.55 | 0.44 |
| 18:3n-6 | 0.24 | 0.00 | 0.31 | 0.24 |
| 19:0 | 0.22 | 0.33 | 0.25 | 0.22 |
| 18:3n-4 | 0.06 | 0.34 | 0.19 | 0.12 |
| 18:3n-3 | 1.28 | 0.26 | 1.21 | 1.48 |
| 18:4n-3 | 1.22 | 0.41 | 1.13 | 1.71 |
| 18:4n-1 | 0.17 | 0.34 | 0.08 | 0.14 |
| 20:0 | 0.24 | 0.36 | 0.25 | 0.21 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.35 | 0.17 | 0.35 | 0.32 |
| 20:1n-9 | 1.69 | 1.75 | 1.76 | 1.71 |
| 20:1n-7 | 0.40 | 1.66 | 0.71 | 0.38 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.07 | 0.04 | 0.10 | 0.08 |
| 20:2n-6 | 0.48 | 0.41 | 0.50 | 0.53 |
| 20:3n-6 | 0.06 | 0.04 | 0.08 | 0.09 |
| 21:0 | 0.06 | 0.06 | 0.09 | 0.08 |
| 20:4n-6 | 1.60 | 1.44 | 2.03 | 1.80 |
| 20:3n-3 | 0.50 | 0.26 | 0.58 | 0.53 |
| 20:4n-3 | 0.97 | 0.58 | 1.08 | 1.14 |
| 20:5n-3 | 17.78 | 23.05 | 21.01 | 17.71 |
| 22:0 | 0.00 | 0.00 | 0.04 | 0.07 |
| 22:1n-11(13) | 1.21 | 0.13 | 0.82 | 1.47 |
| 22:1n-9 | 0.36 | 0.67 | 0.63 | 0.43 |
| 22:1n-7 | 0.16 | 0.48 | 0.43 | 0.22 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.04 | 0.05 |
| 21:5n-3 | 0.24 | 0.13 | 0.24 | 0.26 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.30 | 0.39 | 0.35 | 0.39 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | |
|---|---|---|---|---|
| 22:5n-3 | 1.01 | 3.12 | 1.53 | 1.14 |

Appendix 3: Continued

| **Sample #** | pp049 | pp050 | pp051 | pp052 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) |
| 24:0 | 0.03 | 0.00 | 0.00 | 0.03 |
| 22:6n-3 | 20.33 | 18.21 | 18.61 | 21.15 |
| 24:1 | 0.99 | 0.71 | 1.11 | 1.29 |

| **Sample #** | pp053 | pp054 | pp055 | pp056 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, female) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) |
| 14:0 | 3.33 | 1.79 | 1.23 | 1.51 |
| 14:1 | 0.07 | 0.05 | 0.00 | 0.23 |
| 15:0 iso | 0.70 | 0.39 | 0.26 | 0.07 |
| 15:0 anti-iso | 0.10 | 0.05 | 0.06 | 0.58 |
| 15:0 | 0.59 | 1.05 | 0.77 | 0.42 |
| 15:1 | 0.55 | 0.53 | 0.22 | 0.12 |
| 16:0 iso | 0.15 | 0.18 | 0.13 | 0.11 |
| 16:0 anti-iso | 0.04 | 0.15 | 0.10 | 0.00 |
| 16:0 | 13.24 | 10.49 | 11.63 | 11.65 |
| 16:1n-9 | 0.10 | 0.05 | 0.09 | 0.09 |
| 16:1tr,n-7 | 1.38 | 2.94 | 2.67 | 1.29 |
| 16:1n-7 | 2.10 | 2.13 | 0.94 | 0.77 |
| 16:1n-5 | 0.25 | 0.11 | 0.09 | 0.11 |
| 17:0 iso | 0.55 | 0.60 | 0.98 | 0.99 |
| 17:0 anti-iso | 0.22 | 0.35 | 0.34 | 0.32 |
| 16:2n-4 | 0.35 | 0.82 | 0.66 | 0.75 |
| 17:0 | 0.80 | 1.30 | 1.32 | 1.24 |
| 16:3n-4 | 0.37 | 0.44 | 0.27 | 0.18 |
| 17:1 | 0.21 | 0.31 | 0.47 | 0.51 |
| 16:4n-3 | 0.11 | 0.08 | 0.00 | 0.06 |
| 16:4n-1 | 0.04 | 0.05 | 0.00 | 0.00 |
| 18:0 | 3.58 | 3.24 | 4.27 | 5.10 |
| 18:1n-11 | 0.13 | 0.24 | 0.12 | 0.21 |
| 18:1n-9 | 11.37 | 10.76 | 13.80 | 12.38 |
| 18:1n-7 | 1.31 | 2.74 | 3.01 | 2.42 |
| 18:1n-6 | 0.12 | 0.10 | 0.10 | 0.16 |
| 18:1n-5 | 0.86 | 0.53 | 0.61 | 0.96 |
| 18:2n-6 | 2.01 | 1.00 | 1.71 | 1.32 |
| 18:2n-4 | 0.42 | 0.65 | 0.49 | 0.61 |
| 18:3n-6 | 0.21 | 0.34 | 0.26 | 0.26 |
| 19:0 | 0.21 | 0.35 | 0.15 | 0.29 |
| 18:3n-4 | 0.09 | 0.35 | 0.21 | 0.18 |
| 18:3n-3 | 1.55 | 0.41 | 0.69 | 0.58 |
| 18:4n-3 | 1.63 | 0.33 | 0.61 | 0.36 |

| | | | | |
|---|---|---|---|---|
| 18:4n-1 | 0.14 | 0.04 | 0.00 | 0.07 |

Appendix 3: Continued

| **Sample #** | pp053 | pp054 | pp055 | pp056 |
|---|---|---|---|---|
| | *H. galba* | *H. galba* | *H. galba* | *H. galba* |
| **Prey type** | (*A. aurita*, female) | (*A. aurita*, female) | (*A. aurita*, male) | (*A. aurita*, male) |
| 20:0 | 0.20 | 0.35 | 0.48 | 0.38 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.35 | 0.48 | 0.25 | 0.20 |
| 20:1n-9 | 2.03 | 2.03 | 2.16 | 2.12 |
| 20:1n-7 | 0.58 | 1.79 | 2.35 | 1.39 |
| 20:2a | 0.04 | 0.00 | 0.00 | 0.01 |
| 20:2b | 0.13 | 0.07 | 0.09 | 0.00 |
| 20:2n-6 | 0.68 | 0.47 | 0.69 | 0.64 |
| 20:3n-6 | 0.13 | 0.14 | 0.23 | 0.09 |
| 21:0 | 0.08 | 0.09 | 0.15 | 0.09 |
| 20:4n-6 | 1.46 | 1.81 | 2.27 | 1.16 |
| 20:3n-3 | 0.54 | 0.33 | 0.41 | 0.43 |
| 20:4n-3 | 1.20 | 0.60 | 0.85 | 0.63 |
| 20:5n-3 | 19.24 | 22.69 | 17.53 | 22.32 |
| 22:0 | 0.07 | 0.06 | 0.00 | 0.00 |
| 22:1n-11(13) | 1.55 | 0.33 | 1.02 | 0.78 |
| 22:1n-9 | 0.39 | 0.63 | 0.90 | 0.68 |
| 22:1n-7 | 0.15 | 0.79 | 0.48 | 0.15 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.06 | 0.00 | 0.00 |
| 21:5n-3 | 0.29 | 0.16 | 0.22 | 0.11 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.29 | 0.41 | 0.43 | 0.26 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 1.11 | 4.20 | 2.83 | 2.36 |
| 24:0 | 0.02 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 19.48 | 16.48 | 17.87 | 19.69 |
| 24:1 | 1.09 | 1.06 | 0.57 | 0.60 |

| **Sample #** | pp057 | pp058 | pp059 | pp060 |
|---|---|---|---|---|
| | *H. galba* | *H. galba* | *H. galba* | *H. galba* |
| **Prey type** | (*A. aurita*, male) | (*A. aurita*, male) | (*A. aurita*, male) | (*A. aurita*, male) |
| 14:0 | 1.21 | 2.64 | 3.60 | 3.13 |
| 14:1 | 0.00 | 0.00 | 0.11 | 0.04 |
| 15:0 iso | 0.34 | 0.22 | 0.38 | 0.28 |
| 15:0 anti-iso | 0.05 | 0.10 | 0.16 | 0.11 |
| 15:0 | 0.94 | 0.53 | 0.63 | 0.57 |
| 15:1 | 0.57 | 0.67 | 0.49 | 0.38 |
| 16:0 iso | 0.18 | 0.10 | 0.13 | 0.12 |
| 16:0 anti-iso | 0.03 | 0.00 | 0.00 | 0.00 |

| | | | | |
|---|---|---|---|---|
| 16:0 | 10.26 | 13.66 | 13.00 | 13.13 |

Appendix 3: Continued

| **Sample #** | pp057 | pp058 | pp059 | pp060 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) |
| 16:1n-9 | 0.09 | 0.13 | 0.11 | 0.09 |
| 16:1tr,n-7 | 0.53 | 1.71 | 1.81 | 1.49 |
| 16:1n-7 | 3.36 | 1.49 | 2.54 | 1.93 |
| 16:1n-5 | 0.11 | 0.23 | 0.32 | 0.25 |
| 17:0 iso | 0.79 | 0.59 | 0.52 | 0.52 |
| 17:0 anti-iso | 0.36 | 0.27 | 0.26 | 0.23 |
| 16:2n-4 | 0.80 | 0.47 | 0.49 | 0.46 |
| 17:0 | 1.35 | 0.90 | 0.72 | 0.77 |
| 16:3n-4 | 0.26 | 0.33 | 0.43 | 0.33 |
| 17:1 | 0.89 | 0.24 | 0.19 | 0.17 |
| 16:4n-3 | 0.04 | 0.09 | 0.05 | 0.06 |
| 16:4n-1 | 0.05 | 0.00 | 0.00 | 0.00 |
| 18:0 | 3.41 | 3.94 | 3.23 | 3.41 |
| 18:1n-11 | 0.25 | 0.16 | 0.15 | 0.13 |
| 18:1n-9 | 12.52 | 14.09 | 14.00 | 14.08 |
| 18:1n-7 | 3.96 | 1.61 | 1.52 | 1.61 |
| 18:1n-6 | 0.16 | 0.17 | 0.15 | 0.17 |
| 18:1n-5 | 0.67 | 1.05 | 1.06 | 1.07 |
| 18:2n-6 | 1.17 | 2.35 | 2.54 | 2.25 |
| 18:2n-4 | 0.67 | 0.49 | 0.48 | 0.49 |
| 18:3n-6 | 0.33 | 0.23 | 0.21 | 0.24 |
| 19:0 | 0.30 | 0.13 | 0.14 | 0.16 |
| 18:3n-4 | 0.28 | 0.09 | 0.09 | 0.08 |
| 18:3n-3 | 0.62 | 1.56 | 2.04 | 1.78 |
| 18:4n-3 | 0.17 | 0.91 | 1.62 | 1.33 |
| 18:4n-1 | 0.08 | 0.09 | 0.08 | 0.02 |
| 20:0 | 0.44 | 0.18 | 0.17 | 0.16 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.24 | 0.28 | 0.35 | 0.27 |
| 20:1n-9 | 2.26 | 1.96 | 2.31 | 2.16 |
| 20:1n-7 | 2.60 | 0.50 | 0.47 | 0.57 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.08 | 0.09 | 0.07 | 0.08 |
| 20:2n-6 | 0.58 | 0.69 | 0.66 | 0.71 |
| 20:3n-6 | 0.07 | 0.35 | 0.09 | 0.00 |
| 21:0 | 0.12 | 0.00 | 0.04 | 0.10 |
| 20:4n-6 | 1.18 | 1.61 | 1.44 | 1.16 |
| 20:3n-3 | 0.51 | 0.55 | 0.56 | 0.59 |
| 20:4n-3 | 0.79 | 1.21 | 1.32 | 1.28 |
| 20:5n-3 | 20.75 | 18.42 | 15.82 | 18.57 |
| 22:0 | 0.04 | 0.00 | 0.00 | 0.06 |

| | | | | |
|---|---|---|---|---|
| 22:1n-11(13) | 0.51 | 1.68 | 2.31 | 1.63 |

Appendix 3: Continued

| **Sample #** | pp057 | pp058 | pp059 | pp060 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) |
| 22:1n-9 | 1.03 | 0.53 | 0.48 | 0.44 |
| 22:1n-7 | 0.40 | 0.08 | 0.06 | 0.05 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.12 | 0.25 | 0.24 | 0.23 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.25 | 0.23 | 0.27 | 0.30 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 3.70 | 1.13 | 0.92 | 1.15 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 17.20 | 17.92 | 18.11 | 18.75 |
| 24:1 | 0.30 | 1.12 | 1.06 | 0.89 |

| **Sample #** | pp061 | pp062 | pp063 | pp064 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) |
| 14:0 | 1.55 | 1.51 | 1.55 | 2.15 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.31 | 0.31 | 0.13 | 0.33 |
| 15:0 anti-iso | 0.05 | 0.09 | 0.00 | 0.07 |
| 15:0 | 0.70 | 0.63 | 0.47 | 1.15 |
| 15:1 | 0.77 | 0.84 | 0.76 | 0.49 |
| 16:0 iso | 0.20 | 0.20 | 0.19 | 0.18 |
| 16:0 anti-iso | 0.07 | 0.18 | 0.00 | 0.06 |
| 16:0 | 11.58 | 11.00 | 13.08 | 10.03 |
| 16:1n-9 | 0.05 | 0.07 | 0.08 | 0.09 |
| 16:1tr,n-7 | 1.55 | 1.20 | 1.24 | 3.57 |
| 16:1n-7 | 0.64 | 0.60 | 0.60 | 1.38 |
| 16:1n-5 | 0.12 | 0.09 | 0.15 | 0.15 |
| 17:0 iso | 0.64 | 0.64 | 0.66 | 0.55 |
| 17:0 anti-iso | 0.38 | 0.41 | 0.28 | 0.29 |
| 16:2n-4 | 0.69 | 0.88 | 0.66 | 0.60 |
| 17:0 | 1.19 | 1.12 | 1.04 | 1.25 |
| 16:3n-4 | 0.18 | 0.19 | 0.15 | 0.24 |
| 17:1 | 0.92 | 0.95 | 0.51 | 1.09 |
| 16:4n-3 | 0.07 | 0.09 | 0.09 | 0.06 |
| 16:4n-1 | 0.06 | 0.04 | 0.00 | 0.05 |
| 18:0 | 4.49 | 4.90 | 4.44 | 3.47 |
| 18:1n-11 | 0.20 | 0.22 | 0.13 | 0.35 |
| 18:1n-9 | 11.89 | 9.98 | 12.20 | 12.86 |

| | | | | |
|---|---|---|---|---|
| 18:1n-7 | 2.87 | 3.62 | 2.07 | 2.72 |

Appendix 3: Continued

| **Sample #** | pp061 | pp062 | pp063 | pp064 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) | *H. galba* (*A. aurita*, male) |
| 18:1n-6 | 0.18 | 0.15 | 0.13 | 0.17 |
| 18:1n-5 | 0.88 | 0.68 | 0.91 | 0.66 |
| 18:2n-6 | 1.41 | 1.18 | 1.56 | 2.62 |
| 18:2n-4 | 0.54 | 0.47 | 0.55 | 0.51 |
| 18:3n-6 | 0.27 | 0.24 | 0.26 | 0.22 |
| 19:0 | 0.28 | 0.27 | 0.16 | 0.29 |
| 18:3n-4 | 0.16 | 0.12 | 0.10 | 0.26 |
| 18:3n-3 | 0.63 | 0.53 | 0.60 | 0.70 |
| 18:4n-3 | 0.34 | 0.25 | 0.25 | 0.41 |
| 18:4n-1 | 0.05 | 0.05 | 0.11 | 0.03 |
| 20:0 | 0.36 | 0.30 | 0.24 | 0.42 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.20 | 0.26 | 0.15 | 0.51 |
| 20:1n-9 | 1.93 | 1.76 | 0.99 | 1.96 |
| 20:1n-7 | 1.66 | 1.48 | 0.42 | 2.27 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.30 | 0.11 | 0.14 | 0.06 |
| 20:2n-6 | 0.68 | 0.45 | 0.45 | 0.85 |
| 20:3n-6 | 0.09 | 0.10 | 0.06 | 0.06 |
| 21:0 | 0.11 | 0.13 | 0.11 | 0.11 |
| 20:4n-6 | 1.89 | 2.06 | 1.09 | 1.77 |
| 20:3n-3 | 0.50 | 0.35 | 0.28 | 0.36 |
| 20:4n-3 | 0.78 | 0.61 | 0.52 | 0.75 |
| 20:5n-3 | 20.75 | 22.50 | 23.95 | 18.09 |
| 22:0 | 0.07 | 0.03 | 0.08 | 0.08 |
| 22:1n-11(13) | 0.58 | 1.00 | 0.48 | 0.66 |
| 22:1n-9 | 0.71 | 0.75 | 0.41 | 0.98 |
| 22:1n-7 | 0.17 | 0.23 | 0.13 | 0.53 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.06 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.20 |
| 21:5n-3 | 0.15 | 0.16 | 0.22 | 0.25 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.32 | 0.38 | 0.15 | 0.43 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 2.23 | 2.10 | 1.54 | 3.95 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 20.12 | 21.01 | 22.87 | 16.18 |
| 24:1 | 0.46 | 0.54 | 0.58 | 0.43 |

Appendix 3: Continued

| **Sample #** | pp065 | pp066 | pp067 | pp068 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) |
| 14:0 | 2.04 | 1.62 | 1.75 | 0.67 |
| 14:1 | 0.02 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.52 | 0.35 | 0.34 | 0.33 |
| 15:0 anti-iso | 0.04 | 0.00 | 0.00 | 0.09 |
| 15:0 | 1.11 | 0.94 | 0.78 | 0.75 |
| 15:1 | 0.55 | 0.61 | 0.55 | 0.00 |
| 16:0 iso | 0.20 | 0.16 | 0.13 | 0.20 |
| 16:0 anti-iso | 0.10 | 0.11 | 0.09 | 0.00 |
| 16:0 | 10.51 | 10.99 | 10.98 | 9.75 |
| 16:1n-9 | 0.05 | 0.04 | 0.11 | 0.08 |
| 16:1tr,n-7 | 4.00 | 3.25 | 2.72 | 3.13 |
| 16:1n-7 | 0.78 | 0.85 | 0.66 | 0.81 |
| 16:1n-5 | 0.10 | 0.10 | 0.09 | 0.09 |
| 17:0 iso | 0.58 | 0.54 | 0.58 | 0.64 |
| 17:0 anti-iso | 0.29 | 0.24 | 0.28 | 0.22 |
| 16:2n-4 | 0.57 | 0.59 | 0.58 | 0.46 |
| 17:0 | 1.34 | 1.16 | 1.25 | 1.17 |
| 16:3n-4 | 0.19 | 0.21 | 0.20 | 0.02 |
| 17:1 | 1.76 | 1.81 | 1.58 | 0.24 |
| 16:4n-3 | 0.03 | 0.05 | 0.06 | 0.00 |
| 16:4n-1 | 0.02 | 0.06 | 0.00 | 0.00 |
| 18:0 | 3.13 | 3.21 | 2.95 | 2.75 |
| 18:1n-11 | 0.24 | 0.30 | 0.17 | 0.04 |
| 18:1n-9 | 11.19 | 11.62 | 12.08 | 10.52 |
| 18:1n-7 | 2.90 | 2.51 | 2.48 | 2.90 |
| 18:1n-6 | 0.10 | 0.11 | 0.11 | 0.11 |
| 18:1n-5 | 0.42 | 0.49 | 0.49 | 0.30 |
| 18:2n-6 | 1.15 | 1.04 | 1.23 | 1.42 |
| 18:2n-4 | 0.61 | 0.64 | 0.47 | 0.14 |
| 18:3n-6 | 0.31 | 0.27 | 0.18 | 0.00 |
| 19:0 | 0.37 | 0.35 | 0.24 | 0.38 |
| 18:3n-4 | 0.30 | 0.17 | 0.27 | 0.22 |
| 18:3n-3 | 0.44 | 0.52 | 0.30 | 0.60 |
| 18:4n-3 | 0.21 | 0.24 | 0.16 | 0.47 |
| 18:4n-1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.41 | 0.52 | 0.31 | 0.37 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.23 | 0.20 | 0.20 | 0.24 |
| 20:1n-9 | 2.29 | 2.29 | 1.52 | 2.46 |
| 20:1n-7 | 2.29 | 2.20 | 1.37 | 2.25 |

| | | | | |
|---|---|---|---|---|
| 20:2a | 0.00 | 0.00 | 0.03 | 0.36 |

Appendix 3: Continued

| **Sample #** | pp065 | pp066 | pp067 | pp068 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) |
| 20:2b | 0.08 | 0.06 | 0.10 | 0.00 |
| 20:2n-6 | 0.53 | 0.55 | 0.53 | 0.61 |
| 20:3n-6 | 0.35 | 0.07 | 0.16 | 0.67 |
| 21:0 | 0.14 | 0.11 | 0.08 | 0.13 |
| 20:4n-6 | 1.24 | 2.52 | 1.67 | 2.33 |
| 20:3n-3 | 0.39 | 0.45 | 0.45 | 0.61 |
| 20:4n-3 | 0.87 | 0.95 | 0.79 | 1.78 |
| 20:5n-3 | 22.17 | 19.07 | 22.64 | 23.35 |
| 22:0 | 0.04 | 0.11 | 0.11 | 0.08 |
| 22:1n-11(13) | 0.37 | 0.52 | 0.15 | 0.29 |
| 22:1n-9 | 0.93 | 1.40 | 0.76 | 0.79 |
| 22:1n-7 | 0.80 | 0.76 | 0.62 | 0.71 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.07 | 0.00 |
| 21:5n-3 | 0.15 | 0.18 | 0.20 | 0.25 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.30 | 0.66 | 0.36 | 0.66 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 3.34 | 3.67 | 3.34 | 4.23 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 16.00 | 17.77 | 19.83 | 18.63 |
| 24:1 | 0.89 | 0.77 | 0.88 | 0.71 |

| **Sample #** | pp069 | pp070 | pp071 | pp072 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) |
| 14:0 | 2.17 | 0.92 | 0.56 | 1.82 |
| 14:1 | 0.05 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.47 | 0.27 | 0.23 | 0.41 |
| 15:0 anti-iso | 0.06 | 0.04 | 0.57 | 0.00 |
| 15:0 | 1.33 | 1.18 | 0.66 | 1.11 |
| 15:1 | 0.68 | 0.39 | 0.22 | 0.46 |
| 16:0 iso | 0.21 | 0.16 | 0.14 | 0.19 |
| 16:0 anti-iso | 0.04 | 0.07 | 0.00 | 0.07 |
| 16:0 | 10.34 | 8.17 | 9.52 | 10.55 |
| 16:1n-9 | 0.06 | 0.06 | 0.09 | 0.11 |
| 16:1tr,n-7 | 5.14 | 4.09 | 3.52 | 3.91 |
| 16:1n-7 | 0.62 | 0.55 | 0.56 | 0.92 |

| | | | | |
|---|---|---|---|---|
| 16:1n-5 | 0.11 | 0.06 | 0.12 | 0.10 |

Appendix 3: Continued

| **Sample #** | pp069 | pp070 | pp071 | pp072 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) |
| 17:0 iso | 0.56 | 0.62 | 0.60 | 0.65 |
| 17:0 anti-iso | 0.29 | 0.32 | 0.31 | 0.29 |
| 16:2n-4 | 0.49 | 0.69 | 0.71 | 0.60 |
| 17:0 | 1.33 | 1.81 | 1.34 | 1.43 |
| 16:3n-4 | 0.22 | 0.21 | 0.16 | 0.25 |
| 17:1 | 2.15 | 1.60 | 0.90 | 1.49 |
| 16:4n-3 | 0.07 | 0.06 | 0.00 | 0.05 |
| 16:4n-1 | 0.04 | 0.03 | 0.00 | 0.00 |
| 18:0 | 2.85 | 3.91 | 3.55 | 3.18 |
| 18:1n-11 | 0.27 | 0.29 | 0.31 | 0.32 |
| 18:1n-9 | 10.75 | 11.10 | 11.98 | 11.74 |
| 18:1n-7 | 2.85 | 2.49 | 2.40 | 2.41 |
| 18:1n-6 | 0.10 | 0.10 | 0.10 | 0.10 |
| 18:1n-5 | 0.53 | 0.40 | 0.52 | 0.49 |
| 18:2n-6 | 0.98 | 0.83 | 1.19 | 1.06 |
| 18:2n-4 | 0.67 | 0.67 | 0.66 | 0.63 |
| 18:3n-6 | 0.31 | 0.36 | 0.33 | 0.26 |
| 19:0 | 0.36 | 0.54 | 0.39 | 0.37 |
| 18:3n-4 | 0.33 | 0.41 | 0.26 | 0.24 |
| 18:3n-3 | 0.46 | 0.22 | 0.37 | 0.41 |
| 18:4n-3 | 0.27 | 0.09 | 0.15 | 0.23 |
| 18:4n-1 | 0.02 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.37 | 0.57 | 0.56 | 0.50 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.27 | 0.20 | 0.25 | 0.27 |
| 20:1n-9 | 2.01 | 1.61 | 2.37 | 2.17 |
| 20:1n-7 | 1.95 | 2.60 | 2.43 | 2.38 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.07 | 0.07 | 0.07 | 0.07 |
| 20:2n-6 | 0.47 | 0.44 | 0.65 | 0.58 |
| 20:3n-6 | 0.06 | 0.24 | 0.94 | 0.21 |
| 21:0 | 0.11 | 0.12 | 0.10 | 0.12 |
| 20:4n-6 | 1.12 | 3.01 | 3.31 | 3.83 |
| 20:3n-3 | 0.35 | 0.32 | 0.55 | 0.41 |
| 20:4n-3 | 0.82 | 0.51 | 1.04 | 0.89 |
| 20:5n-3 | 22.26 | 23.91 | 18.40 | 18.11 |
| 22:0 | 0.09 | 0.08 | 0.07 | 0.00 |
| 22:1n-11(13) | 0.24 | 0.18 | 0.49 | 0.32 |
| 22:1n-9 | 0.72 | 0.72 | 1.54 | 1.26 |
| 22:1n-7 | 0.85 | 0.89 | 0.89 | 0.79 |

| | | | | |
|---|---|---|---|---|
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 3: Continued

| **Sample #** | pp069 | pp070 | pp071 | pp072 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) |
| 22:2NIMDb | 0.00 | 0.07 | 0.00 | 0.00 |
| 21:5n-3 | 0.21 | 0.13 | 0.20 | 0.14 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.33 | 0.71 | 0.80 | 0.90 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 3.62 | 5.58 | 4.54 | 3.84 |
| 24:0 | 0.00 | 0.02 | 0.02 | 0.00 |
| 22:6n-3 | 16.22 | 14.85 | 17.94 | 16.56 |
| 24:1 | 0.70 | 0.49 | 0.42 | 0.79 |

| **Sample #** | pp073 | pp074 | pp075 | pp076 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, male) | *H. galba* (*C. capillata*, male) |
| 14:0 | 0.25 | 1.04 | 1.87 | 1.70 |
| 14:1 | 0.00 | 0.01 | 0.00 | 0.00 |
| 15:0 iso | 0.12 | 0.31 | 0.43 | 0.51 |
| 15:0 anti-iso | 0.00 | 0.03 | 0.09 | 0.06 |
| 15:0 | 0.48 | 1.11 | 0.72 | 1.11 |
| 15:1 | 0.25 | 0.24 | 0.45 | 0.42 |
| 16:0 iso | 0.09 | 0.16 | 0.16 | 0.16 |
| 16:0 anti-iso | 0.04 | 0.06 | 0.08 | 0.03 |
| 16:0 | 8.66 | 8.41 | 10.46 | 9.01 |
| 16:1n-9 | 0.06 | 0.05 | 0.09 | 0.10 |
| 16:1tr,n-7 | 2.23 | 4.03 | 2.25 | 4.14 |
| 16:1n-7 | 0.61 | 0.62 | 1.18 | 0.71 |
| 16:1n-5 | 0.10 | 0.07 | 0.14 | 0.09 |
| 17:0 iso | 0.59 | 0.54 | 0.74 | 0.52 |
| 17:0 anti-iso | 0.26 | 0.28 | 0.38 | 0.31 |
| 16:2n-4 | 0.54 | 0.65 | 0.71 | 0.61 |
| 17:0 | 1.49 | 1.61 | 0.97 | 1.46 |
| 16:3n-4 | 0.17 | 0.23 | 0.15 | 0.33 |
| 17:1 | 1.19 | 1.06 | 0.95 | 1.36 |
| 16:4n-3 | 0.05 | 0.00 | 0.04 | 0.04 |
| 16:4n-1 | 0.04 | 0.00 | 0.00 | 0.00 |
| 18:0 | 3.62 | 3.56 | 3.91 | 3.14 |
| 18:1n-11 | 0.20 | 0.22 | 0.34 | 0.30 |
| 18:1n-9 | 12.32 | 11.20 | 13.83 | 13.49 |
| 18:1n-7 | 2.31 | 2.47 | 4.32 | 3.51 |

| | | | | |
|---|---|---|---|---|
| 18:1n-6 | 0.09 | 0.10 | 0.14 | 0.13 |

Appendix 3: Continued

| **Sample #** | pp073 | pp074 | pp075 | pp076 |
|---|---|---|---|---|
| **Prey type** | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, female) | *H. galba* (*C. capillata*, male) | *H. galba* (*C. capillata*, male) |
| 18:1n-5 | 0.48 | 0.39 | 0.92 | 0.57 |
| 18:2n-6 | 1.10 | 0.90 | 1.41 | 1.03 |
| 18:2n-4 | 0.50 | 0.60 | 0.82 | 0.59 |
| 18:3n-6 | 0.20 | 0.26 | 0.38 | 0.28 |
| 19:0 | 0.39 | 0.47 | 0.35 | 0.35 |
| 18:3n-4 | 0.22 | 0.43 | 0.16 | 0.43 |
| 18:3n-3 | 0.26 | 0.37 | 0.54 | 0.47 |
| 18:4n-3 | 0.12 | 0.10 | 0.29 | 0.14 |
| 18:4n-1 | 0.06 | 0.00 | 0.00 | 0.00 |
| 20:0 | 0.42 | 0.56 | 0.44 | 0.56 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.24 | 0.25 | 0.38 | 0.31 |
| 20:1n-9 | 1.91 | 1.75 | 2.91 | 2.47 |
| 20:1n-7 | 1.40 | 2.53 | 3.17 | 2.84 |
| 20:2a | 0.00 | 0.01 | 0.00 | 0.02 |
| 20:2b | 0.13 | 0.10 | 0.17 | 0.07 |
| 20:2n-6 | 0.48 | 0.51 | 0.64 | 0.62 |
| 20:3n-6 | 0.16 | 0.06 | 0.17 | 0.10 |
| 21:0 | 0.12 | 0.13 | 0.14 | 0.10 |
| 20:4n-6 | 3.78 | 2.92 | 1.75 | 2.79 |
| 20:3n-3 | 0.36 | 0.35 | 0.41 | 0.41 |
| 20:4n-3 | 0.81 | 0.63 | 0.91 | 0.86 |
| 20:5n-3 | 24.14 | 23.46 | 17.68 | 19.67 |
| 22:0 | 0.11 | 0.07 | 0.00 | 0.05 |
| 22:1n-11(13) | 0.68 | 0.19 | 0.84 | 0.37 |
| 22:1n-9 | 1.01 | 0.80 | 1.10 | 1.14 |
| 22:1n-7 | 0.68 | 0.92 | 0.31 | 0.31 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.05 | 0.05 | 0.00 | 0.00 |
| 21:5n-3 | 0.17 | 0.14 | 0.15 | 0.15 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.73 | 0.68 | 0.38 | 0.50 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 3.35 | 5.25 | 2.34 | 3.90 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 19.53 | 16.43 | 16.49 | 15.41 |
| 24:1 | 0.67 | 0.61 | 0.34 | 0.26 |

Appendix 3: Continued

| **Sample #** | pp077 | pp078 | pp079 | pp080 |
|---|---|---|---|---|
| | *H. galba* | *H. galba* | *H. galba* | *H. galba* |
| **Prey type** | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) |
| 14:0 | 0.38 | 1.27 | 1.44 | 1.34 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.20 | 0.24 | 0.30 | 0.39 |
| 15:0 anti-iso | 0.03 | 0.00 | 0.00 | 0.00 |
| 15:0 | 0.64 | 1.07 | 1.06 | 0.98 |
| 15:1 | 0.28 | 0.35 | 0.39 | 0.60 |
| 16:0 iso | 0.14 | 0.16 | 0.19 | 0.18 |
| 16:0 anti-iso | 0.05 | 0.00 | 0.00 | 0.16 |
| 16:0 | 8.92 | 9.19 | 10.19 | 9.68 |
| 16:1n-9 | 0.06 | 0.09 | 0.15 | 0.09 |
| 16:1tr,n-7 | 2.81 | 3.22 | 3.98 | 2.48 |
| 16:1n-7 | 0.46 | 0.45 | 0.67 | 0.41 |
| 16:1n-5 | 0.07 | 0.00 | 0.00 | 0.00 |
| 17:0 iso | 0.61 | 0.70 | 0.65 | 0.63 |
| 17:0 anti-iso | 0.33 | 0.30 | 0.41 | 0.36 |
| 16:2n-4 | 0.68 | 0.76 | 0.75 | 0.82 |
| 17:0 | 1.17 | 1.72 | 1.26 | 1.49 |
| 16:3n-4 | 0.17 | 0.17 | 0.20 | 0.16 |
| 17:1 | 1.12 | 0.93 | 0.90 | 1.51 |
| 16:4n-3 | 0.05 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.09 | 0.14 | 0.00 | 0.07 |
| 18:0 | 3.76 | 4.08 | 3.38 | 3.73 |
| 18:1n-11 | 0.18 | 0.12 | 0.23 | 0.23 |
| 18:1n-9 | 11.25 | 12.07 | 10.80 | 10.38 |
| 18:1n-7 | 2.96 | 3.22 | 2.96 | 3.04 |
| 18:1n-6 | 0.11 | 0.13 | 0.13 | 0.09 |
| 18:1n-5 | 0.44 | 0.50 | 0.47 | 0.35 |
| 18:2n-6 | 1.27 | 1.27 | 1.37 | 1.30 |
| 18:2n-4 | 0.54 | 0.68 | 0.69 | 0.54 |
| 18:3n-6 | 0.25 | 0.27 | 0.33 | 0.26 |
| 19:0 | 0.37 | 0.38 | 0.36 | 0.33 |
| 18:3n-4 | 0.27 | 0.13 | 0.16 | 0.26 |
| 18:3n-3 | 0.51 | 0.13 | 0.31 | 0.29 |
| 18:4n-3 | 0.15 | 0.05 | 0.15 | 0.17 |
| 18:4n-1 | 0.18 | 0.10 | 0.13 | 0.13 |
| 20:0 | 0.63 | 0.54 | 0.56 | 0.56 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.25 | 0.19 | 0.28 | 0.16 |
| 20:1n-9 | 2.04 | 1.98 | 2.03 | 1.90 |
| 20:1n-7 | 2.91 | 2.64 | 2.87 | 2.29 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.09 | 0.00 | 0.04 | 0.07 |

| | | | | |
|---|---|---|---|---|
| 20:2n-6 | 0.77 | 0.43 | 0.58 | 0.64 |

Appendix 3: Continued

| **Sample #** | pp077 | pp078 | pp079 | pp080 |
|---|---|---|---|---|
| | *H. galba* | *H. galba* | *H. galba* | *H. galba* |
| **Prey type** | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) |
| 20:3n-6 | 0.17 | 0.27 | 0.21 | 0.22 |
| 21:0 | 0.14 | 0.00 | 0.07 | 0.17 |
| 20:4n-6 | 2.30 | 2.99 | 2.19 | 2.34 |
| 20:3n-3 | 0.59 | 0.21 | 0.51 | 0.44 |
| 20:4n-3 | 1.08 | 0.61 | 0.97 | 0.71 |
| 20:5n-3 | 22.98 | 23.35 | 21.59 | 22.85 |
| 22:0 | 0.07 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.21 | 0.20 | 0.20 | 0.37 |
| 22:1n-9 | 0.93 | 0.82 | 0.92 | 0.88 |
| 22:1n-7 | 0.53 | 0.41 | 0.48 | 0.29 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.15 | 0.00 | 0.18 | 0.00 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.43 | 0.51 | 0.38 | 0.35 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 5.27 | 4.12 | 5.13 | 3.64 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 17.65 | 16.47 | 16.59 | 19.36 |
| 24:1 | 0.28 | 0.34 | 0.24 | 0.31 |

| **Sample #** | pp081 | pp082 | pp114 | pp115 |
|---|---|---|---|---|
| | *H. galba* | *H. galba* | *H. galba* | *H. galba* |
| **Prey type** | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) |
| 14:0 | 1.27 | 1.84 | 1.31 | 1.55 |
| 14:1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15:0 iso | 0.40 | 0.42 | 0.31 | 0.40 |
| 15:0 anti-iso | 0.11 | 0.05 | 0.00 | 0.07 |
| 15:0 | 1.09 | 1.26 | 1.07 | 1.48 |
| 15:1 | 0.46 | 0.22 | 0.34 | 0.33 |
| 16:0 iso | 0.15 | 0.18 | 0.19 | 0.20 |
| 16:0 anti-iso | 0.09 | 0.04 | 11.15 | 0.05 |
| 16:0 | 9.50 | 10.06 | 0.00 | 9.22 |
| 16:1n-9 | 0.06 | 0.05 | 0.00 | 0.03 |
| 16:1tr,n-7 | 2.78 | 4.38 | 4.12 | 4.33 |
| 16:1n-7 | 0.39 | 0.60 | 0.55 | 0.72 |
| 16:1n-5 | 0.07 | 0.11 | 0.00 | 0.02 |
| 17:0 iso | 0.67 | 0.62 | 0.21 | 0.36 |
| 17:0 anti-iso | 0.33 | 0.31 | 0.31 | 0.43 |
| 16:2n-4 | 0.66 | 0.66 | 0.64 | 0.69 |
| 17:0 | 1.44 | 1.42 | 1.30 | 1.67 |

| | | | | |
|---|---|---|---|---|
| 16:3n-4 | 0.13 | 0.23 | 0.22 | 0.21 |

Appendix 3: Continued

| **Sample #** | pp081 | pp082 | pp114 | pp115 |
|---|---|---|---|---|
| | *H. galba* | *H. galba* | *H. galba* | *H. galba* |
| **Prey type** | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) |
| 17:1 | 1.43 | 0.56 | 1.09 | 1.04 |
| 16:4n-3 | 0.04 | 0.04 | 0.00 | 0.00 |
| 16:4n-1 | 0.08 | 0.07 | 0.16 | 0.00 |
| 18:0 | 4.05 | 3.62 | 3.30 | 4.11 |
| 18:1n-11 | 0.20 | 0.24 | 0.31 | 0.25 |
| 18:1n-9 | 10.39 | 10.71 | 11.14 | 10.56 |
| 18:1n-7 | 2.90 | 2.54 | 2.71 | 2.86 |
| 18:1n-6 | 0.10 | 0.10 | 0.10 | 0.09 |
| 18:1n-5 | 0.41 | 0.44 | 0.48 | 0.41 |
| 18:2n-6 | 0.97 | 0.89 | 1.17 | 0.72 |
| 18:2n-4 | 0.61 | 0.57 | 0.74 | 0.67 |
| 18:3n-6 | 0.26 | 0.23 | 0.18 | 0.21 |
| 19:0 | 0.36 | 0.38 | 0.16 | 0.20 |
| 18:3n-4 | 0.18 | 0.26 | 0.14 | 0.30 |
| 18:3n-3 | 0.24 | 0.26 | 0.36 | 0.13 |
| 18:4n-3 | 0.13 | 0.15 | 0.14 | 0.09 |
| 18:4n-1 | 0.24 | 0.15 | 0.30 | 0.07 |
| 20:0 | 0.61 | 0.60 | 0.59 | 0.78 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.17 | 0.29 | 0.26 | 0.18 |
| 20:1n-9 | 1.76 | 2.23 | 2.26 | 1.83 |
| 20:1n-7 | 2.82 | 3.06 | 2.83 | 3.34 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.08 | 0.08 | 0.00 | 0.00 |
| 20:2n-6 | 0.56 | 0.67 | 0.66 | 0.55 |
| 20:3n-6 | 0.06 | 0.04 | 0.05 | 0.00 |
| 21:0 | 0.15 | 0.13 | 0.20 | 0.18 |
| 20:4n-6 | 2.73 | 2.73 | 3.18 | 2.84 |
| 20:3n-3 | 0.33 | 0.42 | 0.50 | 0.30 |
| 20:4n-3 | 0.61 | 0.81 | 0.95 | 0.53 |
| 20:5n-3 | 23.44 | 21.59 | 19.76 | 22.85 |
| 22:0 | 0.10 | 0.09 | 0.11 | 0.03 |
| 22:1n-11(13) | 0.34 | 0.29 | 0.37 | 0.26 |
| 22:1n-9 | 0.83 | 1.07 | 1.07 | 0.86 |
| 22:1n-7 | 0.55 | 0.68 | 0.54 | 0.81 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.10 | 0.15 | 0.13 | 0.08 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.50 | 0.57 | 0.58 | 0.62 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | |
|---|---|---|---|---|
| 22:5n-3 | 4.43 | 4.93 | 4.68 | 5.59 |

Appendix 3: Continued

| **Sample #** | pp081 | pp082 | pp114 | pp115 |
|---|---|---|---|---|
| | *H. galba* | *H. galba* | *H. galba* | *H. galba* |
| **Prey type** | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) | (*C. capillata*, male) |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 17.34 | 15.66 | 16.29 | 14.54 |
| 24:1 | 0.30 | 0.27 | 0.79 | 0.33 |

| **Sample #** | pp132 | pp133 | pp134 | pp135 |
|---|---|---|---|---|
| | *Parathemisto* spp. | *Parathemisto* spp. | *Parathemisto* spp. | *Parathemisto* spp. |
| **Prey type** | (neritic) | (neritic) | (neritic) | (neritic) |
| 14:0 | 5.51 | 4.46 | 5.20 | 4.78 |
| 14:1 | 0.08 | 0.00 | 0.10 | 0.03 |
| 15:0 iso | 0.32 | 0.23 | 0.33 | 0.29 |
| 15:0 anti-iso | 0.09 | 0.00 | 0.08 | 0.12 |
| 15:0 | 0.54 | 0.35 | 0.50 | 0.48 |
| 15:1 | 0.26 | 0.15 | 0.16 | 0.27 |
| 16:0 iso | 0.10 | 0.00 | 0.06 | 0.00 |
| 16:0 anti-iso | 0.08 | 0.10 | 0.00 | 0.13 |
| 16:0 | 11.19 | 15.01 | 12.42 | 12.15 |
| 16:1n-9 | 0.24 | 0.44 | 0.14 | 0.37 |
| 16:1tr,n-7 | 0.26 | 0.12 | 0.18 | 0.25 |
| 16:1n-7 | 6.04 | 12.26 | 7.61 | 7.22 |
| 16:1n-5 | 0.83 | 0.34 | 0.35 | 0.55 |
| 17:0 iso | 0.29 | 0.40 | 0.27 | 0.23 |
| 17:0 anti-iso | 0.07 | 0.28 | 0.00 | 0.00 |
| 16:2n-4 | 0.38 | 0.00 | 0.42 | 0.54 |
| 17:0 | 0.24 | 0.24 | 0.25 | 0.24 |
| 16:3n-4 | 0.13 | 0.07 | 0.18 | 0.17 |
| 17:1 | 0.27 | 0.15 | 0.20 | 0.16 |
| 16:4n-3 | 0.02 | 0.00 | 0.05 | 0.09 |
| 16:4n-1 | 0.32 | 0.16 | 0.43 | 0.51 |
| 18:0 | 0.48 | 0.78 | 0.69 | 0.43 |
| 18:1n-11 | 0.07 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 8.78 | 10.27 | 9.42 | 9.38 |
| 18:1n-7 | 2.45 | 3.26 | 2.71 | 2.63 |
| 18:1n-6 | 0.10 | 0.04 | 0.07 | 0.06 |
| 18:1n-5 | 1.03 | 0.83 | 0.87 | 0.83 |
| 18:2n-6 | 2.56 | 4.64 | 1.86 | 2.56 |
| 18:2n-4 | 0.21 | 0.15 | 0.25 | 0.20 |
| 18:3n-6 | 0.17 | 0.00 | 0.07 | 0.10 |
| 19:0 | 0.06 | 0.33 | 0.05 | 0.08 |
| 18:3n-4 | 0.06 | 0.02 | 0.06 | 0.06 |
| 18:3n-3 | 1.31 | 0.56 | 0.64 | 1.05 |
| 18:4n-3 | 5.76 | 2.00 | 2.92 | 4.81 |
| 18:4n-1 | 0.10 | 0.04 | 0.14 | 0.09 |

| | | | | |
|---|---|---|---|---|
| 20:0 | 0.03 | 0.00 | 0.12 | 0.00 |

Appendix 3: Continued

| **Sample #** | pp132 | pp133 | pp134 | pp135 |
|---|---|---|---|---|
| **Prey type** | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (neritic) |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.94 | 0.52 | 0.75 | 0.56 |
| 20:1n-9 | 2.15 | 1.97 | 3.62 | 1.30 |
| 20:1n-7 | 0.44 | 0.54 | 0.67 | 0.48 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.08 | 0.00 | 0.07 | 0.11 |
| 20:2n-6 | 0.37 | 0.47 | 0.31 | 0.41 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.06 |
| 20:4n-6 | 0.23 | 0.16 | 0.19 | 0.19 |
| 20:3n-3 | 0.17 | 0.09 | 0.12 | 0.19 |
| 20:4n-3 | 0.62 | 0.45 | 0.54 | 0.57 |
| 20:5n-3 | 22.46 | 19.55 | 22.85 | 24.61 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.72 | 0.70 | 1.39 | 0.30 |
| 22:1n-9 | 0.31 | 0.49 | 0.62 | 0.30 |
| 22:1n-7 | 0.08 | 0.06 | 0.15 | 0.00 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.40 | 0.21 | 0.50 | 0.46 |
| 23:0 | 0.00 | 0.07 | 0.00 | 0.00 |
| 22:4n-6 | 0.06 | 0.00 | 0.11 | 0.10 |
| 22:4n-3 | 0.12 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.44 | 0.39 | 0.50 | 0.49 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 19.81 | 16.40 | 18.49 | 18.86 |
| 24:1 | 0.21 | 0.23 | 0.31 | 0.18 |

| **Sample #** | pp140 | pp141 | pp139 | pp142 |
|---|---|---|---|---|
| **Prey type** | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) |
| 14:0 | 3.15 | 4.87 | 1.86 | 4.81 |
| 14:1 | 0.08 | 0.05 | 0.04 | 0.07 |
| 15:0 iso | 0.45 | 0.23 | 0.11 | 0.34 |
| 15:0 anti-iso | 0.47 | 0.07 | 0.07 | 0.17 |
| 15:0 | 0.88 | 0.41 | 0.17 | 0.45 |
| 15:1 | 0.60 | 0.25 | 0.31 | 0.48 |
| 16:0 iso | 0.10 | 0.04 | 0.06 | 0.16 |
| 16:0 anti-iso | 0.56 | 0.07 | 0.05 | 0.08 |
| 16:0 | 13.38 | 14.05 | 9.20 | 13.31 |

| | | | | |
|---|---|---|---|---|
| 16:1n-9 | 0.84 | 0.23 | 0.13 | 0.39 |

Appendix 3: Continued

| **Sample #** | pp140 | pp141 | pp139 | pp142 |
|---|---|---|---|---|
| **Prey type** | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) |
| 16:1tr,n-7 | 0.24 | 0.18 | 0.05 | 0.30 |
| 16:1n-7 | 4.69 | 7.88 | 3.01 | 6.92 |
| 16:1n-5 | 0.80 | 0.50 | 0.14 | 0.81 |
| 17:0 iso | 0.46 | 0.18 | 0.11 | 0.18 |
| 17:0 anti-iso | 0.40 | 0.00 | 0.06 | 0.08 |
| 16:2n-4 | 0.30 | 0.42 | 0.10 | 0.63 |
| 17:0 | 0.54 | 0.21 | 0.13 | 0.33 |
| 16:3n-4 | 0.47 | 0.16 | 0.04 | 0.20 |
| 17:1 | 0.32 | 0.17 | 0.25 | 0.22 |
| 16:4n-3 | 0.05 | 0.46 | 0.01 | 0.09 |
| 16:4n-1 | 0.24 | 0.00 | 0.09 | 0.56 |
| 18:0 | 0.98 | 0.79 | 0.97 | 0.94 |
| 18:1n-11 | 0.00 | 0.04 | 0.00 | 0.00 |
| 18:1n-9 | 8.28 | 10.18 | 14.59 | 9.07 |
| 18:1n-7 | 3.00 | 2.77 | 2.27 | 2.55 |
| 18:1n-6 | 0.08 | 0.07 | 0.07 | 0.12 |
| 18:1n-5 | 0.78 | 0.92 | 1.05 | 0.93 |
| 18:2n-6 | 2.78 | 3.18 | 1.62 | 2.80 |
| 18:2n-4 | 0.13 | 0.14 | 0.11 | 0.14 |
| 18:3n-6 | 0.26 | 0.16 | 0.06 | 0.16 |
| 19:0 | 0.14 | 0.02 | 0.03 | 0.05 |
| 18:3n-4 | 0.13 | 0.06 | 0.06 | 0.09 |
| 18:3n-3 | 0.90 | 1.24 | 0.38 | 1.12 |
| 18:4n-3 | 2.36 | 3.83 | 4.85 | 3.57 |
| 18:4n-1 | 0.14 | 0.09 | 0.08 | 0.11 |
| 20:0 | 0.08 | 0.04 | 0.06 | 0.03 |
| 18:5n-3 | 0.00 | 0.02 | 0.00 | 0.00 |
| 20:1n-11 | 0.56 | 0.71 | 3.68 | 0.83 |
| 20:1n-9 | 2.11 | 2.00 | 11.51 | 3.97 |
| 20:1n-7 | 0.09 | 0.37 | 0.95 | 0.40 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.03 | 0.00 | 0.10 |
| 20:2n-6 | 0.43 | 0.46 | 0.28 | 0.46 |
| 20:3n-6 | 0.00 | 0.21 | 0.11 | 0.00 |
| 21:0 | 0.00 | 0.01 | 0.00 | 0.06 |
| 20:4n-6 | 0.25 | 0.15 | 0.47 | 0.16 |
| 20:3n-3 | 0.17 | 0.17 | 0.06 | 0.21 |
| 20:4n-3 | 0.41 | 0.47 | 0.55 | 0.54 |
| 20:5n-3 | 22.34 | 20.47 | 9.01 | 20.31 |
| 22:0 | 0.00 | 0.00 | 0.02 | 0.00 |
| 22:1n-11(13) | 0.76 | 0.92 | 13.26 | 1.14 |

| | | | | |
|---|---|---|---|---|
| 22:1n-9 | 0.40 | 0.30 | 2.33 | 0.44 |

Appendix 3: Continued

| **Sample #** | pp140 | pp141 | pp139 | pp142 |
|---|---|---|---|---|
| **Prey type** | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (neritic) | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) |
| 22:1n-7 | 0.05 | 0.13 | 0.16 | 0.08 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.01 | 0.00 |
| 21:5n-3 | 0.35 | 0.38 | 0.21 | 0.41 |
| 23:0 | 0.00 | 0.09 | 0.00 | 0.00 |
| 22:4n-6 | 0.07 | 0.08 | 0.00 | 0.06 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 0.41 | 0.48 | 0.36 | 0.41 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.01 |
| 22:6n-3 | 22.35 | 18.29 | 14.08 | 17.97 |
| 24:1 | 0.19 | 0.29 | 0.77 | 0.14 |

| **Sample #** | pp143 | pp144 | pp145 | pp146 |
|---|---|---|---|---|
| **Prey type** | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) |
| 14:0 | 4.74 | 5.06 | 4.11 | 2.76 |
| 14:1 | 0.02 | 0.13 | 0.03 | 0.04 |
| 15:0 iso | 0.21 | 0.22 | 0.18 | 0.14 |
| 15:0 anti-iso | 0.08 | 0.10 | 0.05 | 0.05 |
| 15:0 | 0.39 | 0.24 | 0.36 | 0.28 |
| 15:1 | 0.23 | 0.20 | 0.30 | 0.26 |
| 16:0 iso | 0.00 | 0.06 | 0.06 | 0.00 |
| 16:0 anti-iso | 0.00 | 0.13 | 0.03 | 0.15 |
| 16:0 | 12.32 | 9.60 | 13.19 | 10.70 |
| 16:1n-9 | 0.18 | 0.10 | 0.12 | 0.10 |
| 16:1tr,n-7 | 0.19 | 0.13 | 0.13 | 0.17 |
| 16:1n-7 | 7.55 | 10.66 | 5.27 | 5.83 |
| 16:1n-5 | 0.45 | 0.32 | 0.25 | 0.25 |
| 17:0 iso | 0.22 | 0.13 | 0.08 | 0.06 |
| 17:0 anti-iso | 0.00 | 0.07 | 0.07 | 0.04 |
| 16:2n-4 | 0.43 | 0.44 | 0.30 | 0.29 |
| 17:0 | 0.22 | 0.14 | 0.26 | 0.17 |
| 16:3n-4 | 0.12 | 0.20 | 0.22 | 0.16 |
| 17:1 | 0.14 | 0.20 | 0.19 | 0.07 |
| 16:4n-3 | 0.05 | 0.03 | 0.04 | 0.06 |
| 16:4n-1 | 0.46 | 0.52 | 0.70 | 0.49 |
| 18:0 | 0.86 | 0.74 | 1.37 | 1.10 |
| 18:1n-11 | 0.03 | 0.00 | 0.00 | 0.00 |
| 18:1n-9 | 8.64 | 14.14 | 10.48 | 10.59 |
| 18:1n-7 | 2.80 | 2.10 | 2.28 | 2.41 |

| | | | | |
|---|---|---|---|---|
| 18:1n-6 | 0.04 | 0.04 | 0.05 | 0.05 |

Appendix 3: Continued

| **Sample #** | pp143 | pp144 | pp145 | pp146 |
|---|---|---|---|---|
| **Prey type** | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) | *Parathemisto* spp. (pelagic) |
| 18:1n-5 | 0.74 | 0.67 | 0.76 | 1.03 |
| 18:2n-6 | 3.31 | 1.62 | 1.38 | 1.34 |
| 18:2n-4 | 0.15 | 0.13 | 0.15 | 0.20 |
| 18:3n-6 | 0.00 | 0.16 | 0.08 | 0.06 |
| 19:0 | 0.17 | 0.02 | 0.00 | 0.00 |
| 18:3n-4 | 0.04 | 0.07 | 0.05 | 0.05 |
| 18:3n-3 | 1.03 | 0.53 | 0.48 | 0.94 |
| 18:4n-3 | 3.29 | 2.80 | 1.72 | 2.31 |
| 18:4n-1 | 0.10 | 0.06 | 0.10 | 0.18 |
| 20:0 | 0.00 | 0.02 | 0.05 | 0.05 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.41 | 2.47 | 3.17 | 3.09 |
| 20:1n-9 | 1.46 | 12.77 | 9.17 | 11.88 |
| 20:1n-7 | 0.46 | 0.76 | 0.77 | 1.29 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.11 |
| 20:2n-6 | 0.47 | 0.26 | 0.36 | 0.43 |
| 20:3n-6 | 0.07 | 0.03 | 0.04 | 0.03 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.16 | 0.29 | 0.68 | 0.21 |
| 20:3n-3 | 0.22 | 0.09 | 0.30 | 0.24 |
| 20:4n-3 | 0.52 | 0.53 | 0.64 | 0.56 |
| 20:5n-3 | 24.86 | 11.42 | 15.61 | 16.09 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 0.60 | 6.34 | 4.95 | 6.66 |
| 22:1n-9 | 0.56 | 0.91 | 1.22 | 1.39 |
| 22:1n-7 | 0.00 | 0.06 | 0.07 | 0.16 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.42 | 0.32 | 0.39 | 0.36 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.10 | 0.07 | 0.17 | 0.06 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.14 |
| 22:5n-3 | 0.48 | 0.39 | 0.54 | 0.46 |
| 24:0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:6n-3 | 19.85 | 11.20 | 16.62 | 14.18 |
| 24:1 | 0.18 | 0.34 | 0.42 | 0.31 |

Appendix 3: Continued

| **Sample #** | pp083 | pp084 | pp085 | pp086 | pp087 | pp088 | pp089 |
|---|---|---|---|---|---|---|---|
| **Prey type** | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) |
| 14:0 | 4.03 | 5.63 | 3.17 | 6.84 | 6.41 | 3.63 | 2.74 |
| 14:1 | 0.04 | 0.08 | 0.00 | 0.09 | 0.10 | 0.00 | 0.00 |
| 15:0 iso | 0.09 | 0.15 | 0.05 | 0.18 | 0.22 | 0.12 | 0.08 |
| 15:0 anti-iso | 0.01 | 0.04 | 0.10 | 0.05 | 0.06 | 0.03 | 0.03 |
| 15:0 | 0.28 | 0.28 | 0.34 | 0.32 | 0.36 | 0.35 | 0.30 |
| 15:1 | 0.15 | 0.10 | 0.10 | 0.11 | 0.11 | 0.13 | 0.12 |
| 16:0 iso | 0.05 | 0.05 | 0.00 | 0.06 | 0.05 | 0.05 | 0.03 |
| 16:0 anti-iso | 0.14 | 0.26 | 0.15 | 0.25 | 0.20 | 0.05 | 0.10 |
| 16:0 | 15.54 | 15.73 | 19.51 | 14.82 | 15.11 | 19.13 | 19.34 |
| 16:1n-9 | 0.16 | 0.23 | 0.26 | 0.11 | 0.13 | 0.19 | 0.16 |
| 16:1tr,n-7 | 0.22 | 0.18 | 0.20 | 0.16 | 0.23 | 0.32 | 0.19 |
| 16:1n-7 | 6.13 | 4.72 | 4.18 | 5.82 | 4.62 | 4.54 | 3.82 |
| 16:1n-5 | 0.39 | 0.28 | 0.46 | 0.31 | 0.31 | 0.46 | 0.42 |
| 17:0 iso | 0.33 | 0.19 | 0.31 | 0.25 | 0.27 | 0.27 | 0.33 |
| 17:0 anti-iso | 0.00 | 0.08 | 0.06 | 0.05 | 0.05 | 0.08 | 0.05 |
| 16:2n-4 | 0.55 | 0.48 | 0.80 | 0.51 | 0.55 | 0.69 | 0.76 |
| 17:0 | 0.08 | 0.09 | 0.14 | 0.13 | 0.15 | 0.12 | 0.12 |
| 16:3n-4 | 0.20 | 0.14 | 0.06 | 0.14 | 0.07 | 0.10 | 0.07 |
| 17:1 | 0.20 | 0.13 | 0.09 | 0.07 | 0.11 | 0.08 | 0.13 |
| 16:4n-3 | 0.03 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| 16:4n-1 | 0.38 | 0.08 | 0.10 | 0.12 | 0.05 | 0.16 | 0.10 |
| 18:0 | 1.46 | 1.49 | 2.10 | 1.41 | 1.50 | 1.85 | 2.00 |
| 18:1n-11 | 0.45 | 0.37 | 0.29 | 0.12 | 0.18 | 0.12 | 0.14 |
| 18:1n-9 | 7.77 | 8.44 | 8.58 | 8.89 | 9.44 | 8.81 | 8.26 |
| 18:1n-7 | 2.49 | 2.37 | 3.40 | 2.08 | 2.19 | 2.56 | 3.15 |
| 18:1n-6 | 0.03 | 0.03 | 0.05 | 0.05 | 0.07 | 0.04 | 0.05 |
| 18:1n-5 | 0.79 | 0.55 | 0.64 | 0.66 | 0.69 | 0.91 | 0.62 |
| 18:2n-6 | 0.92 | 1.01 | 1.21 | 1.05 | 1.21 | 1.13 | 1.10 |
| 18:2n-4 | 0.16 | 0.11 | 0.07 | 0.12 | 0.10 | 0.17 | 0.12 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19:0 | 0.03 | 0.03 | 0.00 | 0.04 | 0.05 | 0.00 | 0.00 |
| 18:3n-4 | 0.05 | 0.12 | 0.14 | 0.03 | 0.12 | 0.18 | 0.04 |
| 18:3n-3 | 0.28 | 0.33 | 0.51 | 0.43 | 0.53 | 0.52 | 0.39 |
| 18:4n-3 | 0.73 | 0.60 | 0.92 | 0.71 | 0.66 | 0.80 | 0.78 |
| 18:4n-1 | 0.14 | 0.04 | 0.06 | 0.05 | 0.03 | 0.06 | 0.03 |
| 20:0 | 0.04 | 0.07 | 0.00 | 0.06 | 0.05 | 0.00 | 0.02 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.39 | 0.39 | 0.17 | 0.33 | 0.57 | 0.22 | 0.20 |
| 20:1n-9 | 7.42 | 9.38 | 2.20 | 11.29 | 9.29 | 3.95 | 3.14 |
| 20:1n-7 | 0.53 | 0.50 | 0.23 | 0.42 | 0.44 | 0.34 | 0.29 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20:2b | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Appendix 3: Continued

| **Sample #** | pp083 | pp084 | pp085 | pp086 | pp087 | pp088 | pp089 |
|---|---|---|---|---|---|---|---|
| **Prey type** | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) |
| 20:2n-6 | 0.10 | 0.12 | 0.14 | 0.14 | 0.13 | 0.15 | 0.16 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:0 | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.46 | 0.50 | 0.76 | 0.44 | 0.51 | 0.56 | 0.69 |
| 20:3n-3 | 0.36 | 0.01 | 0.03 | 0.04 | 0.05 | 0.05 | 0.06 |
| 20:4n-3 | 13.88 | 0.30 | 0.40 | 0.39 | 0.42 | 0.43 | 0.40 |
| 20:5n-3 | 0.00 | 11.97 | 16.05 | 9.87 | 9.00 | 12.76 | 16.32 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 6.97 | 9.28 | 1.46 | 9.35 | 10.12 | 2.23 | 2.11 |
| 22:1n-9 | 1.18 | 1.26 | 0.23 | 1.08 | 1.12 | 0.39 | 0.37 |
| 22:1n-7 | 0.22 | 0.16 | 0.04 | 0.10 | 0.19 | 0.07 | 0.07 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.32 | 0.26 | 0.32 | 0.27 | 0.21 | 0.34 | 0.38 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:4n-6 | 0.17 | 0.13 | 0.17 | 0.15 | 0.14 | 0.19 | 0.21 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 1.37 | 1.14 | 1.36 | 0.86 | 0.91 | 1.12 | 1.45 |
| 24:0 | 0.08 | 0.08 | 0.12 | 0.06 | 0.08 | 0.09 | 0.11 |
| 22:6n-3 | 20.82 | 18.54 | 26.99 | 17.66 | 19.34 | 28.26 | 27.18 |
| 24:1 | 1.41 | 1.42 | 1.28 | 1.37 | 1.50 | 1.23 | 1.25 |

| **Sample #** | pp090 | pp091 | pp092 | pp093 | pp094 | pp095 | pp096 |
|---|---|---|---|---|---|---|---|
| **Prey type** | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) |
| 14:0 | 3.76 | 4.70 | 6.62 | 7.43 | 6.45 | 4.09 | 4.51 |
| 14:1 | 0.00 | 0.03 | 0.09 | 0.14 | 0.13 | 0.02 | 0.03 |
| 15:0 iso | 0.10 | 0.08 | 0.20 | 0.18 | 0.17 | 0.09 | 0.09 |
| 15:0 anti-iso | 0.04 | 0.02 | 0.03 | 0.04 | 0.05 | 0.02 | 0.02 |
| 15:0 | 0.31 | 0.31 | 0.38 | 0.31 | 0.29 | 0.26 | 0.29 |
| 15:1 | 0.09 | 0.02 | 0.06 | 0.03 | 0.08 | 0.07 | 0.07 |
| 16:0 iso | 0.05 | 0.14 | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 |
| 16:0 anti-iso | 0.21 | 0.18 | 0.20 | 0.24 | 0.20 | 0.26 | 0.18 |
| 16:0 | 16.58 | 17.01 | 14.03 | 12.02 | 12.79 | 15.26 | 14.71 |
| 16:1n-9 | 0.16 | 0.24 | 0.15 | 0.12 | 0.13 | 0.27 | 0.20 |
| 16:1tr,n-7 | 0.24 | 0.17 | 0.23 | 0.14 | 0.15 | 0.20 | 0.18 |
| 16:1n-7 | 4.49 | 4.65 | 5.49 | 9.94 | 8.30 | 5.33 | 6.90 |
| 16:1n-5 | 0.38 | 0.36 | 0.35 | 0.40 | 0.34 | 0.35 | 0.34 |
| 17:0 iso | 0.30 | 0.16 | 0.13 | 0.14 | 0.14 | 0.28 | 0.13 |
| 17:0 anti-iso | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.09 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16:2n-4 | 0.53 | 0.69 | 0.53 | 0.33 | 0.40 | 0.48 | 0.62 |

Appendix 3: Continued

| **Sample #** | pp090 | pp091 | pp092 | pp093 | pp094 | pp095 | pp096 |
|---|---|---|---|---|---|---|---|
| **Prey type** | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) |
| 17:0 | 0.11 | 0.14 | 0.13 | 0.08 | 0.07 | 0.10 | 0.10 |
| 16:3n-4 | 0.07 | 0.09 | 0.14 | 0.23 | 0.14 | 0.09 | 0.09 |
| 17:1 | 0.10 | 0.14 | 0.17 | 0.13 | 0.11 | 0.11 | 0.15 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.08 | 0.10 | 0.26 | 0.19 | 0.10 | 0.07 | 0.08 |
| 18:0 | 1.60 | 1.55 | 1.39 | 0.95 | 1.18 | 1.39 | 1.34 |
| 18:1n-11 | 0.21 | 0.23 | 0.20 | 0.16 | 0.16 | 0.26 | 0.27 |
| 18:1n-9 | 7.71 | 9.21 | 9.07 | 8.19 | 9.00 | 7.91 | 7.96 |
| 18:1n-7 | 2.29 | 2.42 | 2.02 | 2.02 | 2.23 | 2.26 | 2.38 |
| 18:1n-6 | 0.04 | 0.08 | 0.05 | 0.04 | 0.04 | 0.03 | 0.05 |
| 18:1n-5 | 0.63 | 0.84 | 0.71 | 0.78 | 0.82 | 0.68 | 0.77 |
| 18:2n-6 | 1.06 | 0.99 | 1.23 | 0.92 | 0.87 | 0.78 | 0.87 |
| 18:2n-4 | 0.10 | 0.16 | 0.12 | 0.15 | 0.15 | 0.13 | 0.14 |
| 18:3n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| 19:0 | 0.05 | 0.06 | 0.04 | 0.05 | 0.03 | 0.03 | 0.05 |
| 18:3n-4 | 0.14 | 0.18 | 0.03 | 0.02 | 0.03 | 0.16 | 0.04 |
| 18:3n-3 | 0.42 | 0.37 | 0.57 | 0.36 | 0.25 | 0.24 | 0.27 |
| 18:4n-3 | 0.55 | 0.72 | 0.92 | 0.71 | 0.48 | 0.39 | 0.48 |
| 18:4n-1 | 0.06 | 0.08 | 0.06 | 0.08 | 0.05 | 0.09 | 0.09 |
| 20:0 | 0.06 | 0.02 | 0.06 | 0.07 | 0.05 | 0.05 | 0.06 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.33 | 0.26 | 0.51 | 0.49 | 0.50 | 0.36 | 0.51 |
| 20:1n-9 | 7.59 | 5.50 | 10.70 | 12.75 | 11.89 | 7.72 | 7.72 |
| 20:1n-7 | 0.35 | 0.35 | 0.48 | 0.75 | 0.69 | 0.51 | 0.67 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:2b | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 |
| 20:2n-6 | 0.09 | 0.11 | 0.16 | 0.13 | 0.12 | 0.09 | 0.10 |
| 20:3n-6 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.03 | 0.04 |
| 21:0 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.00 | 0.00 |
| 20:4n-6 | 0.71 | 0.52 | 0.52 | 0.28 | 0.34 | 0.50 | 0.51 |
| 20:3n-3 | 0.04 | 0.04 | 0.06 | 0.03 | 0.03 | 0.00 | 0.00 |
| 20:4n-3 | 0.38 | 0.39 | 0.48 | 0.35 | 0.34 | 0.36 | 0.39 |
| 20:5n-3 | 12.64 | 13.58 | 9.00 | 8.52 | 9.08 | 13.95 | 13.11 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 6.27 | 4.60 | 9.92 | 13.85 | 12.28 | 7.97 | 8.07 |
| 22:1n-9 | 0.80 | 0.62 | 1.19 | 1.81 | 1.67 | 1.19 | 1.27 |
| 22:1n-7 | 0.15 | 0.07 | 0.22 | 0.31 | 0.29 | 0.17 | 0.21 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.31 | 0.36 | 0.20 | 0.24 | 0.20 | 0.35 | 0.31 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22:4n-6 | 0.11 | 0.16 | 0.13 | 0.07 | 0.11 | 0.15 | 0.10 |

Appendix 3: Continued

| **Sample #** | pp090 | pp091 | pp092 | pp093 | pp094 | pp095 | pp096 |
|---|---|---|---|---|---|---|---|
| **Prey type** | Capelin (neritic) | Capelin (neritic) | Capelin (neritic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 1.58 | 1.16 | 0.85 | 0.85 | 0.86 | 1.66 | 1.31 |
| 24:0 | 0.11 | 0.07 | 0.06 | 0.00 | 0.03 | 0.08 | 0.10 |
| 22:6n-3 | 24.50 | 24.45 | 18.28 | 11.71 | 14.80 | 21.68 | 20.60 |
| 24:1 | 1.42 | 1.52 | 1.41 | 1.11 | 1.24 | 1.38 | 1.33 |

| **Sample #** | pp097 | pp098 | pp099 | pp100 | pp101 | pp102 |
|---|---|---|---|---|---|---|
| **Prey type** | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) |
| 14:0 | 4.03 | 3.66 | 5.98 | 7.87 | 4.51 | 6.84 |
| 14:1 | 0.04 | 0.03 | 0.07 | 0.12 | 0.05 | 0.12 |
| 15:0 iso | 0.07 | 0.11 | 0.11 | 0.16 | 0.10 | 0.13 |
| 15:0 anti-iso | 0.02 | 0.02 | 0.03 | 0.05 | 0.04 | 0.00 |
| 15:0 | 0.28 | 0.26 | 0.31 | 0.33 | 0.30 | 0.25 |
| 15:1 | 0.15 | 0.12 | 0.08 | 0.08 | 0.08 | 0.00 |
| 16:0 iso | 0.04 | 0.07 | 0.04 | 0.05 | 0.06 | 0.00 |
| 16:0 anti-iso | 0.23 | 0.20 | 0.23 | 0.23 | 0.20 | 0.22 |
| 16:0 | 13.63 | 15.67 | 12.28 | 13.54 | 13.99 | 12.58 |
| 16:1n-9 | 0.19 | 0.14 | 0.16 | 0.11 | 0.20 | 0.10 |
| 16:1tr,n-7 | 0.16 | 0.17 | 0.17 | 0.15 | 0.23 | 0.14 |
| 16:1n-7 | 6.83 | 4.96 | 7.68 | 8.07 | 7.06 | 10.37 |
| 16:1n-5 | 0.37 | 0.38 | 0.34 | 0.33 | 0.43 | 0.34 |
| 17:0 iso | 0.37 | 0.29 | 0.31 | 0.32 | 0.48 | 0.21 |
| 17:0 anti-iso | 0.07 | 0.04 | 0.07 | 0.08 | 0.08 | 0.05 |
| 16:2n-4 | 0.56 | 0.56 | 0.40 | 0.42 | 0.52 | 0.28 |
| 17:0 | 0.10 | 0.08 | 0.10 | 0.10 | 0.09 | 0.07 |
| 16:3n-4 | 0.09 | 0.08 | 0.09 | 0.17 | 0.10 | 0.17 |
| 17:1 | 0.12 | 0.16 | 0.14 | 0.18 | 0.15 | 0.10 |
| 16:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16:4n-1 | 0.05 | 0.08 | 0.07 | 0.15 | 0.08 | 0.12 |
| 18:0 | 1.42 | 1.51 | 1.17 | 1.11 | 1.35 | 1.00 |
| 18:1n-11 | 0.13 | 0.28 | 0.23 | 0.18 | 0.23 | 0.28 |
| 18:1n-9 | 7.89 | 7.91 | 8.13 | 10.91 | 8.29 | 8.10 |
| 18:1n-7 | 2.30 | 2.14 | 2.20 | 2.24 | 2.22 | 2.10 |
| 18:1n-6 | 0.06 | 0.00 | 0.05 | 0.04 | 0.04 | 0.03 |
| 18:1n-5 | 0.83 | 0.73 | 0.74 | 0.76 | 0.81 | 0.73 |
| 18:2n-6 | 0.90 | 0.96 | 0.83 | 0.95 | 0.92 | 0.78 |
| 18:2n-4 | 0.12 | 0.14 | 0.17 | 0.17 | 0.16 | 0.12 |
| 18:3n-6 | 0.00 | 0.00 | 0.03 | 0.01 | 0.02 | 0.02 |
| 19:0 | 0.00 | 0.00 | 0.04 | 0.03 | 0.01 | 0.02 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18:3n-4 | 0.17 | 0.17 | 0.04 | 0.05 | 0.15 | 0.07 |

Appendix 3: Continued

| **Sample #** | pp097 | pp098 | pp099 | pp100 | pp101 | pp102 |
|---|---|---|---|---|---|---|
| **Prey type** | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) | Capelin (pelagic) |
| 18:3n-3 | 0.29 | 0.37 | 0.30 | 0.33 | 0.32 | 0.27 |
| 18:4n-3 | 0.50 | 0.75 | 0.46 | 0.69 | 0.58 | 0.47 |
| 18:4n-1 | 0.07 | 0.05 | 0.07 | 0.07 | 0.07 | 0.09 |
| 20:0 | 0.06 | 0.00 | 0.08 | 0.05 | 0.04 | 0.06 |
| 18:5n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:1n-11 | 0.45 | 0.45 | 0.55 | 0.43 | 0.40 | 0.58 |
| 20:1n-9 | 8.57 | 6.54 | 11.39 | 9.95 | 9.03 | 12.25 |
| 20:1n-7 | 0.59 | 0.45 | 0.74 | 0.65 | 0.54 | 0.85 |
| 20:2a | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| 20:2b | 0.00 | 0.00 | 0.01 | 0.03 | 0.00 | 0.03 |
| 20:2n-6 | 0.11 | 0.10 | 0.11 | 0.16 | 0.13 | 0.13 |
| 20:3n-6 | 0.18 | 0.00 | 0.03 | 0.00 | 0.00 | 0.03 |
| 21:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20:4n-6 | 0.51 | 0.53 | 0.38 | 0.31 | 0.45 | 0.30 |
| 20:3n-3 | 0.00 | 0.00 | 0.04 | 0.06 | 0.03 | 0.04 |
| 20:4n-3 | 0.37 | 0.37 | 0.34 | 0.41 | 0.41 | 0.35 |
| 20:5n-3 | 13.30 | 13.71 | 9.79 | 10.24 | 11.81 | 8.91 |
| 22:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:1n-11(13) | 8.63 | 6.55 | 12.85 | 9.68 | 8.56 | 13.07 |
| 22:1n-9 | 1.17 | 0.98 | 1.65 | 1.35 | 1.30 | 1.91 |
| 22:1n-7 | 0.20 | 0.24 | 0.28 | 0.17 | 0.22 | 0.32 |
| 22:2NIMDa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:2NIMDb | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21:5n-3 | 0.28 | 0.35 | 0.25 | 0.29 | 0.28 | 0.22 |
| 23:0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| 22:4n-6 | 0.16 | 0.16 | 0.09 | 0.09 | 0.07 | 0.08 |
| 22:4n-3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22:5n-3 | 1.16 | 1.17 | 0.91 | 0.85 | 1.00 | 0.89 |
| 24:0 | 0.15 | 0.05 | 0.06 | 0.05 | 0.09 | 0.03 |
| 22:6n-3 | 20.77 | 24.87 | 16.01 | 13.75 | 20.10 | 12.51 |
| 24:1 | 1.29 | 1.38 | 1.34 | 1.43 | 1.60 | 1.21 |