

AUSTRALIAN RESEARCH ON ANTARCTIC BIRD AND SEAL DIETS

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Abstract

Many data on the diets of important vertebrate predator species in Prydz Bay and around the sub-Antarctic Heard and Macquarie Islands have been collected during the last seven years. Published and unpublished results are collated and summarised, and several important points emerge.

In Prydz Bay, on which is centered the CCAMLR Ecosystem Monitoring Programme's priority study area, *Euphausia superba* forms a rather low proportion of the diet of most vertebrate predators. *Euphausia crystallophias* and the fish *Pleuragramma antarcticum* are important in most diets, and many predators can switch between prey species. The use of these predators to monitor the state of prey populations is thus very limited, although continuing studies will be useful to assess the natural variability of the system.

Around the sub-Antarctic islands, the four penguin species feed more heavily on fish, especially myctophids, than at other comparable localities.

Résumé

Au cours des sept dernières années, ont été recueillies de nombreuses données relatives aux régimes alimentaires d'importantes espèces de vertébrés prédateurs dans la baie de Prydz et autour des îles subantarctiques Heard et Macquarie. Plusieurs considérations émergent après la confrontation et la récapitulation de résultats publiés et non publiés.

Dans la baie de Prydz, centre de la zone d'étude prioritaire du Programme de contrôle de l'écosystème de la CCAMLR, *Euphausia superba* entre en relativement faible proportions dans le régime alimentaire de la plupart des prédateurs vertébrés. *Euphausia crystallophias* et le poisson *Pleuragramma antarcticum* sont importants dans la plupart des régimes alimentaires, et de nombreux prédateurs peuvent passer d'une espèce-proie à une autre. L'utilisation de ces prédateurs pour contrôler l'état des populations-proies est donc très limitée, bien qu'il soit utile de poursuivre ces études pour évaluer la variabilité naturelle du système.

Autour des îles subantarctiques, les quatre espèces de manchots se nourrissent davantage de poissons - de myctophidés principalement - que dans d'autres lieux comparables.

Резюме

За последние семь лет было собрано большое количество информации о режиме питания ключевых видов позвоночных хищников, обитающих в районах залива Прюдз и субантарктических островов Херд и Маккуори. Опубликованные и неопубликованные данные сведены воедино, в результате чего возникает ряд важных вопросов.

В заливе Прюдз, который является центром района исследований первостепенной важности Программы АНТКОМа по мониторингу экосистемы, в рационе большинства позвоночных хищников *Euphausia superba* составляет довольно небольшую часть. В большинстве случаев в рационе большое место занимает *Euphausia cristallorophias* и рыбы *Pleuragramma antarcticum*, и многие хищники могут переключаться с одного потребляемого вида на другой. Поэтому использование этих хищников при мониторинге состояния популяций потребляемых видов весьма ограничено, однако продолжение исследовательских работ явится полезным при оценке естественной изменчивости системы.

В рацион четырех видов пингвинов в районе субантарктических островов входит гораздо больше рыбы, особенно миктофидов, чем в других похожих районах.

Resumen

Durante los últimos siete años se han reunido muchos datos sobre las dietas de importantes especies predatoras vertebradas en la bahía de Prydz y alrededor de las islas subantárticas de Heard y Macquarie. Se compilan y resumen los resultados publicados y no publicados, de los cuales surgen varios puntos importantes.

En la bahía de Prydz, lugar donde se centra la zona de estudio prioritaria del Programa de Seguimiento de la CCRVMA, la especie *Euphausia superba* constituye una proporción bastante baja de la dieta de la mayoría de predadores vertebrados. *Euphausia cristallorophias* y el pez *Pleuragramma antarcticum*, son importantes en la mayoría de dietas, y muchos predadores pueden pasar de una especie-presa a otra. El uso de estos predadores en el control del estado de las poblaciones de especies-presa es, por lo tanto, muy limitado, si bien, continuar con dichos estudios será muy útil para la evaluación de la variabilidad del sistema.

Alrededor de las islas subantárticas, las cuatro especies de pingüinos de alimentan mayoritariamente de peces, especialmente mictófidos, mucho más que en otras localidades comparables.

1. INTRODUCTION

Australia has been conducting research on the diets of Antarctic birds and seals since 1982. This was initially in response to the need identified by the BIOMASS Programme for data on the diets of vertebrate predators of krill (*Euphausia superba*). Latterly, the requirements of the CCAMLR Environmental Monitoring Programme (CEMP) have been a stimulus to continue and expand the work. This paper summarises the results obtained to date, and lists the papers already published or in preparation.

Most work has been done at Davis Station (68°30'S:77°50'E), in the south-eastern corner of the Prydz Bay Priority Area of CEMP, although more recently, considerable work has been done at sub-Antarctic Heard and Macquarie Islands as well as other locations in Prydz Bay. Most work has concentrated on the Adelie penguin, *Pygoscelis adeliae*, because of its supposed value to ecosystem monitoring and its accessibility and ease of handling. Seven seasons of data are now available for this species. Other major, although shorter term studies, have been conducted on the Weddell seal (*Leptonychotes weddelli*) and Emperor penguin (*Aptenodytes forsteri*), in Prydz Bay; the four penguins at Macquarie and Heard Islands (Gentoo, *Pygoscelis papua*, King, *Aptenodytes patagonicus*, and Rockhopper, *Eudyptes chrysocome* plus Royal, *Eudyptes schlegeli* at Macquarie Island and Macaroni, *E. chrysolophus* at Heard Island). A few data are available also on the diets of Crabeater seals (*Lobodon carcinophagus*) and Leopard seals (*Hydrurga leptonyx*) and various petrel species in Prydz Bay.

Work in the 1987/88 season has concentrated on Adelie and Emperor penguins at Mawson, and on Antarctic Fur seals (*Arctocephalus gazella*) at Heard Island, but results are not yet available from these studies.

2. SUMMARY OF FINDINGS

2.1 Adelie Penguin

Location: Davis Station (68°30'S: 77°50'E)

Time: December 1981 to January 1982

Source of material: Six samples obtained from each of two sampling periods using Ipecac (emetic)

Reference: Whitehead, Johnstone and Burton (in preparation)

Mean weight of all food: 450g (post-hatching period only)

Diet composition (% by weight):

<i>Euphausia crystallorophias</i>	44
<i>Euphausia superba</i>	24
Fish	28
Amphipods	4

Location: Davis Station (68°30'S: 77°50'E)

Time: December 1982 to February 1983 and October to December 1983

Source of material: 574 stomach samples obtained by single water offloading

Reference: Puddicombe and Johnstone (1988)

Mean weight of all food: Pre-hatching 2-20g, post hatching 90-100g, creche stage 110-215g

Diet composition (% by weight):

	Overall	Prehatch	Posthatch
<i>E. crystallophias</i>	41.99	46.02	41.69
<i>E. superba</i>	23.21	5.49	24.51
Fish	30.32	3.29	32.32
Amphipods	3.73	39.43	1.09
Others	0.75	5.76	0.38

Fish were mostly *Pleuragramma antarcticum* (frequency of occurrence, F = 36.2%), *Trematomus/Pagothenia* benthic species (F = 20.7%), and channichthiid juveniles (F = 17.1%). Amphipods were mostly *Hyperia macrocephala*, *Cylopus magellanicus*, other Lysianassidae and Eusiridae.

Prey size (length range, mean \pm SD millimetres):

<i>E. superba</i>	20-57	40.63 \pm 7.85
<i>E. crystallophias</i>	21-34	27.36 \pm 1.83

Location: Davis Station (68°30'S: 77°50'E)

Time: January to February 1984; October 1984 to January 1985

Source of material: 10 stomach samples per week obtained by single water offloading

Reference: Green and Johnstone (1988)

Mean weight of all food: Prehatch 4-53g, posthatch (1984) 138-276g, posthatch (1985) 94-135g

Diet composition (% by weight):

	Overall	Prehatch	Posthatch (1984)	Posthatch (1985)
<i>E. crystallophias</i>	12.10	6.20	18.00	13.30
<i>E. superba</i>	42.60	5.20	76.90	66.30
Fish	4.15	3.60	4.70	20.00
Amphipods	29.15	58.20	0.10	0.50
Others	13.60	26.80	0.30	0.00

Fish were mostly *Pleuragramma antarcticum* (F = 97.2%) and benthic inshore species (F = 8.3%).

Prey size (mean \pm SD millimetres):

	Prehatch	Posthatch (1984)	Posthatch (1985)
<i>E. superba</i>	40.7 \pm 4.7	40.1 \pm 4.3	36.6 \pm 4.6
<i>E. crystallophias</i>		28.3 \pm 1.8	26.3 \pm 2.1
<i>P. antarcticum</i>		139.1 \pm 16.5	

Location: Davis Station (68°30'S: 77°50'E)

Time: January to February 1986; October 1986 to March 1987; October 1987 to February 1988

Source of material: 10 stomach samples per week obtained by repeated water offloading until empty. 10 samples per 3 weeks in 1987/88 summer. These results present a preliminary analysis of between 25 and 50% of samples.

Reference: Whitehead, Johnstone and Burton (in preparation)

Mean weight of all food (g):

	Posthatch (1985/86)	Prehatch	Posthatch	Prehatch	Posthatch
		(1986/87)		(1987/88)	
	200	20	400	25	450

Diet composition (% by weight):

<i>E. crystallophias</i>	25	38	39	52	55
<i>E. superba</i>	5	3	29	4	0
Fish	24	1	32	3	25
Amphipods	46	58	0	41	0

2.2 Emperor Penguin

Location: Sea ice off Davis Station (68°30'S: 77°50'E)

Time: August to October 1984

Source of material: Faeces collected monthly from sea ice - 51 in August, 61 in September and 39 in October.

Reference: Green (1986d)

Diet composition (% frequency of occurrence):

	Aug	Sept	Oct
Fish	88.2	100	100
Fish eggs		54.1	69.2
Cephalopods	4.0	1.6	5.1
Isopods	7.8	26.2	33.3
Hyperiid	2.0	6.6	15.4
Gammarids		14.8	25.0
Unid. crustaceans	66.7	44.3	48.7

Prey size: Of the 27 fish otoliths recovered, 21 were of *Pleuragramma antarcticum*. Standard lengths calculated from otolith size were between 72 and 183 mm, mean 129.5 ± 23.8 mm.

Location: Amanda Bay (69°19'S: 76°46'E).

Time: 14 August, 15 September and 10 October 1986

Source of material: 15 stomach samples per visit obtained by repeated water offloading until empty, plus 100 faeces collected each visit.

Reference: Gales et al. (in preparation).

Mean weight of all food: Calculated weight of original contents before digestion (mean \pm SD grammes)

Aug	690 \pm 783
Sept	1565 \pm 1013
Oct	1762 \pm 1331

No identifiable material from faeces

Diet composition (% by calculated original weight):

<i>P. antarcticum</i>	78.15
<i>Trematomus/Pagothenia</i> spp	9.50
Channichthyid	7.89
Bathydraconid	1.13
<i>Psychroteuthis glacialis</i>	2.08
Amphipods and euphausiids	0.47

monthly variation, % by number:

	Aug	Sept	Oct
<i>P. antarcticum</i>	78.1	75.6	81.4
Other fish	18.5	3.6	0.3
Cephalopods	2.5	6.5	2.6
Amphipods	0.8	14.2	9.9
Euphausiids	0	0	6.5

Prey size (mean length and weight \pm SD, length range):

<i>P. antarcticum</i>	101.0 \pm 10.3 mm, 7.4 \pm 2.6g, 70-135 mm
<i>Trematomus/Pagothenia</i>	101.4 \pm 155.8 mm, 23.5 to 66.1g
Channichthyids	113.7 \pm 150.8 mm, 25.8 to 68.3g
Bathydraconids	61.9 \pm 116.0 mm, 1.7 to 10.8g
<i>P. glacialis</i>	45.3 \pm 21.5 mm DML, 3.75 \pm 6.17g

2.3 King Penguin

Location: Macquarie Island (54°30'S: 158°57'E), Lusitania Bay.

Time: November 1984 to November 1985

Source of material: At least 10 stomach samples per month obtained by repeated water offloading until empty.

Reference: Hindell (1988a)

Mean weight of all food: Calculated weight of original contents before digestion (mean \pm SD and range)

923g \pm 518.4 range 4.9 - 2342.0

Mean weight increased from 117g in November 1984 to 1186g in April, then decreased to a low in July of 764g and recovered to 1290g in September, remaining \pm steady until November 1985

Diet composition (% by calculated original weight):

<i>Kreftlichthys anderssoni</i>	37.7 (dominant Oct-Apr)
<i>Electrona carlsbergi</i>	53.2 (dominant May-Sept)
Other myctophids	1.3
<i>Magnisudis prionosa</i>	4.5
Other fish	1.2
Cephalopods	2.2

Prey size (mean length and weight):

<i>E. carlsbergi</i>	76 mm, 6.5g 2 classes - small 40-50 mm, 1-2g (Jan-Jul) and large 80-100 mm, 10-15g (Aug-Nov)
<i>K. anderssoni</i>	55 mm, 2.5g
<i>Martialia hyadesi</i>	259.5g
<i>Moroteuthis</i> sp	32.4g

2.4 Royal/Macaroni Penguin

Location: Macquarie Island (54°30'S: 158°57'E), Nuggets Beach

Time: November 1984 to February 1985; September to November 1985

Source of material: 10 stomach samples per week obtained by repeated water offloading until empty

Reference: Hindell (1988b)

Mean weight of all food: Calculated weight of original contents before digestion (mean \pm SD, range grammes)

Overall	249 \pm 238g range 1-973g
Pre hatching	<100g
Guard stage	300-700g
Creche stage	700-300g

Diet composition (% by calculated original weight):

<i>Euphausia vallentini</i>	32.13
<i>Thysanoessa gregaria</i>	10.34
Other euphausiids	8.87
<i>Kreftlichthys anderssoni</i>	23.69
<i>Electrona carlsbergi</i>	9.64
Other myctophids	7.87 (<i>Protomyctophum</i> and <i>Gymnoscopelus</i> spp)
Other fish	4.47 (<i>M. prionosa</i> , <i>P. magellanica</i>)
Cephalopods	2.95 (<i>Martialia hyadesi</i> , <i>Moroteuthis</i> sp)

Seasonal variation:

<i>E. vallentini</i>	dominant Oct-Nov and Feb
<i>T. gregaria</i>	most common Dec-Jan
<i>K. anderssoni</i>	dominant late Nov-early Dec common Dec and Feb
<i>E. carlsbergi</i>	most common Dec

Prey size (mean length, length range and weight \pm SD):

<i>E. vallentini</i>	overall 15.6 mm \pm 4.7, smallest in Nov	
<i>T. gregaria</i>	13.3 \pm 3.8 mm	
<i>K. anderssoni</i>	25.1 (13.9-31.8 mm)	2.1 \pm 0.8g
<i>E. carlsbergi</i>	23.6 (16.2-44.8 mm)	1.62 \pm 1.7g
<i>Moroteuthis spp.</i>		30.5 \pm 47.4g
<i>M. hyadesi</i>		51.6 \pm 54.3g

Location: Heard Island (53°01'S: 73°23'E)

Time: 15 December 1986 to 7 January 1987

Source of material: Total of 66 stomach samples obtained by repeated water offloading until empty

Reference: Klages, Gales and Pemberton (in preparation)

Mean weight of all food: Calculated weight of original contents before digestion of the 48 contents containing food.

mean wt 95.5 \pm 65.4g

Diet composition (% by calculated original weight):

Fish	23.2
Crustacea	76.8

(composition by % frequency of occurrence and size distribution (mm)):

	%F	size range
<i>K. anderssoni</i>	75.0	15-70
<i>Protomyctophum bolini</i>	8.33	
<i>E. carlsbergi</i>	6.25	
<i>Champscephalus gunnari</i>	27.08	100-200
Fish larvae	10.4	
<i>E. vallentini</i>	64.58	11-25
<i>Thysanoessa macrura</i>	87.5	9-23
<i>Parathemisto gaudichaudi</i>	27.1	
Squid	8.33	

2.5 Rockhopper Penguin

Location: Macquarie Island (54°30'S: 158°57'E)

Time: November 1984 to February 1985 and October 1985

Source of material: 8 stomach samples per week obtained by repeated water offloading until empty

Reference: Hindell (1988c)

Mean weight of all food: Calculated weight of original contents before digestion (mean \pm SD)

Overall	197g \pm 147
Prehatch	<100g
Guard	100-320
Creche	200-300g

Diet composition (% by calculated original weight):

<i>Euphausia vallentini</i>	62.3
Other euphausiids	6.8
<i>Krefflichthys anderssoni</i>	16.0
Other myctophids	7.1
Other fish	5.5
Cephalopods	1.7

seasonal variation:

<i>E. vallentini</i>	Low early Dec, peak early Jan, partial decline to mid Feb then \pm steady
Other euphausiids	Only common after mid Jan
<i>K. anderssoni</i>	Very variable, most common mid Dec and Feb
Other myctophids	More important than inshore fish
Other fish	Minor amounts Jan

Prey size (mean length and weight \pm SD):

<i>E. vallentini</i>	18.1 \pm 5.0 mm,	0.05 \pm 0.01g (largest in Jan-Feb)
<i>T. gregaria</i>	13.5 \pm 3.1 mm,	0.05 \pm 0.01g
<i>K. anderssoni</i>	54.5 \pm 20.5 mm,	3.42 \pm 2.98g
<i>E. carlsbergi</i>	53.0 \pm 5.9 mm,	2.17 \pm 0.78g
<i>Moroteuthis spp</i>		15.66 \pm 8.61g
<i>M. hyadesi</i>		60.77 \pm 39.04g

Location: Heard Island (53°01'S: 73°23'E)

Time: 15 December 1986 to 7 January 1987

Source of material: Total of 58 stomach samples obtained by repeated water offloading until empty

Reference: Klages, Gales and Pemberton (in preparation)

Mean weight of all food (calculated weight of original contents before digestion):

26 stomach contents - mean wt 42.5 \pm 17.4g

Diet composition (% by calculated original weight):

Crustacea	90.8
Fish	8.0
Squid	1.2

(% frequency of occurrence (F%) and size distribution (mm)):

	%F	size range
<i>Krefftichthys anderssoni</i>	46.2	30-80
<i>Protomyctophum bolini</i>	3.9	
<i>Notothenia cyanobranca</i>	3.9	
Fish larvae	11.5	
<i>Euphausia vallentini</i>	92.3	15-26
<i>Thysanoessa macrura</i>	80.8	9-29
<i>Parathemisto gaudichaudi</i>	23.1	
Squid	23.1	

2.6 Gentoo Penguins

Location: Macquarie Island (54°30'S: 158°57'E), Bauer Bay

Time: April to November 1985

Source of material: 12 stomach samples obtained per month by repeated water offloading until empty.

Reference: Hindell (in press)

Mean weight of all food (calculated weight of original contents before digestion):

Overall	240.3g±188.9g
Apr-Jun	<200g
Jun-Nov	ca. 350g regardless of breeding stage

Diet composition (% by calculated original weight) and seasonal variation (periods of dominance in diet underlined):

<i>Krefftichthys anderssoni</i>	15.1	<u>May-June</u> , <u>Sept</u> , Oct-Nov
<i>Electrona carlsbergi</i>	27.5	<u>Apr and July</u>
<i>Gymnoscopelus sp</i>	15.7	<u>Nov</u> (Apr, Aug)
<i>Paranotothenia magellanica</i>	18.4	<u>Aug</u>

Prey size (mean length and weight ±SD):

<i>K. anderssoni</i>	37.5±15.2 mm,	1.3±1.9g
<i>E. carlsbergi</i>	45.9±11.6 mm,	1.7±2.4g
<i>Gymnoscopelus sp</i>	88.2±33.4 mm,	6.7±8.4g
<i>P. magellanica</i>	84.8±50.6 mm,	23.8±27.9g
<i>Moroteuthis spp</i>		27.9±88.8g
<i>Martialia hyadesi</i>		229.3±117.0g

Comments:

K. anderssoni small (<1g) Apr-July, and larger (2-3g) Aug-Nov.
E. carlsbergi increased from 1g to 11g July-Oct.

2.7 Cape Petrel

Location: Vicinity Davis Station (68°30'S: 77°50'E), Bluff Island and Rauer Islands

Time: 26 January to 20 February 1984

Source of material: Vomit samples (63 from Bluff, 10 from Rauer Islands)

Reference: Green (1986a)

Diet composition (% by weight):

Fish	23.4	
Euphausiids	75.9	Frequency of occurrence:
		<i>E. superba</i> 60.7%
		<i>E. crystallophias</i> 7.1%
Others	0.7	

Location: Vicinity Davis Station (68°30'S: 77°50'E), Rauer Islands

Time: 16 January to 12 February 1988

Source of material: About 10 stomach samples per week by repeated water offloading until empty

Reference: Arnould and Whitehead (in preparation)

Mean weight of all food: 8.3±3.55g no significant variation during study period

Diet composition (% by weight):

<i>Pleuragramma antarcticum</i>	13.8
<i>Euphausia superba</i>	85.5
Cephalopods	0.5
Others	0.2

P. antarcticum comprised 50% of the diet in the first week after chick hatch, but declined to 10% by the 4th week and never subsequently exceeded this proportion.

Prey size:

<i>P. antarcticum</i>	144.5±12.1 mm
<i>E. superba</i>	46.6±4.3 mm

2.8 Antarctic Petrel

Location: Prydz Bay (67°31'S: 74°39'E)

Time: 16 December 1982

Source of material: Stomach contents of 17 birds shot at sea

Reference: Montague (1984)

Mean weight of all food: 31g, range 2-72g

Diet composition (% frequency of occurrence):

<i>Pleuragramma antarcticum</i>	6
<i>Euphausia superba</i>	100
Cephalopods	18

E. superba were 100% of contents in all but one stomach, and the mean number per stomach was 42, range 1-117. Two specimens of *P. antarcticum* were found in one stomach, constituting 95% of the contents.

Prey size:

<i>E. superba</i>	48 mm, range 41-55 mm
<i>P. antarcticum</i>	160 mm

Location: Vicinity Davis Station (68°30'S: 77°50'E), Rauer Islands

Time: 16 January to 12 February 1988

Source of material: About 10 stomach samples per week by repeated water offloading until empty

Reference: Arnould and Whitehead (in preparation)

Mean weight of all food: 49.3±37.5g no significant variation during study period

Diet composition (% by weight):

<i>Pleuragramma antarcticum</i>	77.5
<i>Euphausia superba</i>	22.3
Cephalopods	0
Others	0.2

Generally no significant differences with time, but *P. antarcticum* tended to increase slightly through the study period, with a consequent slight decrease in *E. superba*.

Prey size:

<i>P. antarcticum</i>	125.4±35.2 mm
<i>E. superba</i>	46.6±4.1 mm

2.9 Antarctic Fulmar

Location: Vicinity Davis Station (68°30'S: 77°50'E), Rauer Islands

Time: 16 January to 12 February 1988

Source of material: About 10 stomach samples per week by repeated water offloading until empty.

Reference: Arnould and Whitehead (in preparation)

Mean weight of all food: 72.7±32.35g no significant variation during study period

Diet composition (% by weight):

<i>Pleuragramma antarcticum</i>	63.2
<i>Euphausia superba</i>	36.2
Cephalopods	0.4
Others	0.2

P. antarcticum decreased from >80% in week 2 to about 55% by week 5 after chick hatch. *E. superba* increased from about 15% to about 45% in the same period.

Prey size:

<i>P. antarcticum</i>	142.1±33.4 mm
<i>E. superba</i>	47.0±3.8 mm

2.10 Weddell Seal

Location: Sea ice off Davis Station (68°30'S: 77°0'E), Mawson, and McMurdo Stations

Time: 1983 to 1984

Source of material: Stomachs (Mawson 5, McMurdo 20), vomits (Mawson 2, Davis 14) and faeces (unknown age Mawson 18 1984, Davis 150 1983 and Jan 84) and known age Jan 84-Jan 85 from near shore (423) and offshore (422).

Reference: Green and Burton (1987)

Diet composition (% frequency of occurrence for faeces, % by weight for vomit):

	vomit	faeces		
		(1984)	(1-4/84)	(5/84-1/85)
Fish	77.1	69.4	58.2	73.5
Prawns	20.6	54.5	69.8	49.4
Cephalopods	2.0	10.5	6.8	11.0
Amphipods		16.5	15.9	16.6
Isopods		18.7	20.6	18.7
Other crusts		11.5	18.0	22.3
Others	0.6			

During January-April prawns (69.8%) were more common than fish (58.2%) when the inshore areas were ice free, then fish were more common (73.5%) than prawns (49.4%) until January 1985 when sea ice was present. Crustaceans were *Chorismus antarcticus* and *Notocrangon antarcticus* in approximately a 3:1 ratio.

Fish were *P. antarcticum* and a range of benthic nototheniids. The latter dominated in faeces from the inner zone, but in the outer zone both types fluctuated.

Prey size: Average carapace length of *Chorismus* was steady through year at 13.3±1.4 mm, but longer (14.2±1.9 mm) in the outer zone than in the inner (13.1±1.2 mm): *Notocrangon* carapace length was 14.1±1.7 mm. The length of *P. antarcticum* was similar in faeces from the inner and outer zones (146.9±11.8 and 145.1±13.4 mm respectively) and there was little difference between sites although Mawson fish were smaller (116±23.3 mm).

2.11 Leopard Seals

Location: Sea ice off Davis Station (68°30'S: 77°50'E)

Time: August to October 1984

Source of material: Total of 15 faeces

Reference: Green and Williams (1986)

Diet composition (% frequency of occurrence):

<i>Pleuragramma antarcticum</i>	73.3
<i>Trematomus</i> sp	20.0
Decapods	6.7
Amphipods	20.0
Unid. crustaceans	13.3

P. antarcticum length range was 88-175 mm. After October, Adelie penguin remains were common in faeces. No krill were observed - the most common crustacean was gammarid amphipods.

3. DISCUSSION

It is not the intention of this paper to discuss the above results in detail, as this is a task already accomplished in the individual publications. The aim of this paper is rather to bring to CCAMLR's attention the large body of data already obtained on vertebrate predator diets and to summarise briefly the important conclusions relevant to ecosystem monitoring.

3.1 Prydz Bay Area

Most predator species have a rather low dependence on *E. superba* for food, and in many cases on euphausiids in general. Conversely fish, and in particular *Pleuragramma antarcticum*, are important in most diets. This is summarised Table 1.

Thus utilising any of these species to monitor the state of *E. superba* populations would be unreliable. Indeed in the Adelie penguin, breeding success is inversely correlated with the amount of *E. superba* in the diet, except in the disastrous 1985/6 season when all the usual diet components had low occurrences, as shown in Table 2.

Table 2 also shows the extent to which prey switching can occur in Adelie penguins, with high levels of *P. antarcticum* and *E. crystallophias* alternating with dominance of the diet by *E. superba*. Whitehead et al. (in press) discuss fully the possible causes for reduced breeding success and diet changes, and for the Adelie penguin suggest that the extent of sea ice is important. In "bad" years, extensive sea ice forces the penguins to forage further away from the breeding colonies, thus lengthening the intervals between chick feeding and hence the amount of food the chick receives. Much of this inter annual variation may, however, be due to more general oceanographic conditions, as in the 1985/6 season the petrel species, which have much easier access to foraging grounds and which feed much more heavily on other organisms such as fish (eg. Antarctic Fulmar), also had very low reproductive success. Although none of the species studied (with the possible exception of the Cape Petrel) seems to be a reliable indicator of the state of local *E. superba* stocks because of prey switching and/or low dietary importance, such studies are valuable to indicate the underlying variability of the ecosystem.

Almost all the diet studies show that the predators are feeding exclusively on the continental shelf, because all the major diet components (*E. crystallophias*, *P. antarcticum* and amphipods) are exclusively shelf species. Although *E. superba* occurs both on and off the shelf, it is likely that most have been taken near the shelf margin, where they are usually abundant. Typically off-shelf species, such as myctophid fish, almost never occur. There seems little partitioning by size within a prey species. All predators studied take adult *E. superba* (36-48 mm length) and sub-adult *P. antarcticum*, between 90 and

160 mm SL, with Emperor penguins taking generally smaller fish than Adelie penguins or petrels! Some rather surprising food items were the high proportion of decapods (especially near shore) in the Weddell seal diet, and the dependence on amphipods by Adelie penguins before laying.

Most diet work to date has been done in the South Atlantic region, from South Georgia to the Antarctic Peninsula and Weddell Sea. The Prydz Bay work summarised here shows consistent differences in diets of vertebrate predators from those in the South Atlantic sector. Chief among these is the virtual absence of cephalopods in diets of all species, and the much lower dependence on *E. superba*, with other euphausiids and *P. antarcticum* replacing it. Results from Adelie Land and McMurdo tend to resemble those from Prydz Bay, which underlines the importance of assessing ecological relationships from a series of widely spaced localities. In East Antarctic coastal sites at least, it is also important to study the ecology of the other major prey species such as *E. crystallophias* and *P. antarcticum*.

3.2 Sub-Antarctic Islands

The diets of the four species of penguins at Heard and Macquarie Islands again stresses the differences between areas. Macaroni and Gentoo penguins feed largely on *E. superba*, and King penguins on cephalopods in the South Atlantic sector, whereas at Macquarie and Heard Islands Royal/Macaroni penguins take other euphausiids (*E. vallentini* and *T. gregaria*) and fish, and King and Gentoo penguins feed almost entirely on fish. Penguin diets at these islands generally resemble those at Marion Island, but a feature of the diets, especially at Macquarie Island is the dominance of myctophid fish, probably reflecting the very narrow shelf area and proximity to deep water feeding grounds.

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Table 1: Summary of mean % composition by weight of euphausiids and fish from all sources.

	<i>E. superba</i>	<i>E. crystallophias</i>	Fish
Adelie Penguin*	35.1	33.8	23.7
Emperor Penguin	<1		96.7
Cape petrel	80.7 (nearly all <i>E. superba</i>)		18.6
Antarctic petrel	22.3		77.5
Antarctic fulmar	36.2		63.2
Weddell Seal			77.1

*Post hatch period only

Table 2: Annual variability in diet during posthatch period and breeding success* of Adelie penguins (by split year).

	81/82	82/83	83/84	84/85	85/86	86/87	87/88
Overall weight(g)	450	141	202	114	200	400	450
<i>E. crystallophias</i> (%wt)	44	42	18	13	25	39	55
<i>E. superba</i> (%wt)	24	25	77	66	5	29	20
Fish (%wt)	28	32	5	20	24	32	25
Amphipods(%wt)	4	1	0.1	0.5	46	0	0
Chicks hatched in reference colonies	502	692	398	395	240	600	630

*Data from Whitehead et al. (in press)



Légendes des tableaux

- Tableau 1 Résumé du pourcentage moyen de composition par poids des euphausiacés et des poissons de toutes les origines.
- Tableau 2 Variabilité annuelle du régime alimentaire pendant la période suivant l'éclosion, et réussite de la reproduction des manchots Adélie (par année fractionnée).

Заголовки к таблицам

- Таблица 1 Сводка среднего процентного состава антарктического криля и рыбы по весу на основании данных, полученных из всех источников.
- Таблица 2 Годовая изменчивость в диете в течение постынкубационного периода и репродуктивный успех пингвинов Адели.

Encabezamientos de las Tablas

- Tabla 1 Resumen de la composición media % por peso de euphausidos y peces de todos los orígenes.
- Tabla 2 Variabilidad anual en la dieta durante el período posterior a la incubación y éxito de reproducción de los pingüinos Adelia (por año dividido).