Chapter 7
Health Assessment of Weddell Seals, *Leptonychotes weddellii*, in McMurdo Sound, Antarctica

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7.1 Introduction

The demography of Weddell seals in eastern McMurdo Sound, Antarctica, has been well studied during the past three decades (e.g. Stirling 1971; Siniff et al. 1977; Testa and Siniff 1987; Hastings and Testa 1998; Gelatt et al. 2001). Detailed life-history data are available on thousands of seals tagged as pups in McMurdo Sound, making this population a rich resource for wildlife health studies because health parameters can be evaluated in the light of reproductive histories and genetic relationships of several generations of tagged seals.

Recently, evidence of exposure to diseases generally associated with domestic animals and feral wildlife has been detected in Antarctic wildlife (Austin and Webster 1993; Olsen et al. 1996; Gardner et al. 1997; Retamal et al. 2000; Foster et al. 2002) and this has generated concern and debate regarding the risks of disease introduction to Antarctic wildlife. Antibodies to viruses that have caused large die-offs in phocids in other areas of the world have been detected in Weddell seals (Bengtson et al. 1991), and there is a historical report of a mass die-off of crabeater seals that may have had a viral etiology (Laws and Taylor 1957).

We examined and collected biomedical samples from Weddell seals (*Leptonychotes weddellii*) during studies of post-breeding-season foraging behaviour of adults and movements of weaned pups as a complement to ongoing studies on the ecology and population dynamics of the McMurdo seals (Stewart et al. 2000, 2003). Here we report on Weddell seal health assessments conducted during the 1996/97, 1997/98 and 1998/99 breeding seasons at the Delbridge Islands (77.68°S,

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166.50°E), McMurdo Sound, Antarctica. Our objectives were to compile baseline biomedical data for Weddell seals in McMurdo Sound, and to identify infectious and non-infectious diseases affecting the population. Development of such a database, including information on normal background morbidity and mortality, is an important first step in evaluating natural versus anthropogenic impacts on population health (Geraci et al. 1999; Reddy et al. 2001). These data will be integral to international studies of southern ocean pinnipeds that seek to evaluate the influence of biotic and abiotic factors on the ecology of these apex predators.

7.2 Methods

Seals that appeared to be healthy were observed for several minutes while resting prior to initiation of physical restraint (Fig. 7.1). Respiratory rate was obtained by counting chest excursions for 2–5 min; heart rate was obtained, where possible, by observing the left lateral chest wall just behind the fore flipper for the slight movement associated with each heartbeat. The body was scanned for obvious abnormalities such as fresh wounds or nasal discharge. Animals were captured and handled using standard techniques (Stirling 1966; Cline et al. 1969); head bags (Fig. 7.2) were used for all adults (some animals were first captured in a hoop net) and for some larger pups. Seals were examined by a veterinarian and were measured (standard length and axillary girth). Physical examinations included evaluation of the musculoskeletal system (symmetry, lesions) and cardiopulmonary system (heart rate, mucous membrane colour, respiratory rate and character). The integument was examined for evidence of moult, wounds or other lesions. Eyes, ears, nares and oral cavity were inspected for discharges or lesions such as corneal ulcers and broken teeth. Hydration was estimated by visual inspection of mucous membranes, skin turgor and tears. The urogenital and gastrointestinal systems were evaluated opportunistically by examining urine or faeces and by visual inspection for lesions at urogenital openings. Examination of the nervous system consisted of a limited evaluation of animals' vision, hearing, cranial nerve function (e.g. blink reflex) and peripheral nerve function (e.g. flinching when rear flippers were touched) in response to the activities of handlers. Blood samples were collected from the extradural vein or from the interdigital vessels of the rear flippers of all seals; faecal samples were collected opportunistically from a subset of seals (17 adults, 3 weaned pups). Satellite-linked radio-transmitters and other telemetry instruments were glued to the dorsal pelage of some seals (Fig. 7.2). A subset of animals was sedated with intra-vascular injections of diazepam (mean dosage = 0.07 mg kg^{-1}; s.d. = 0.02 mg kg^{-1}) immediately following blood sample collection to facilitate attachment of instruments.

Forty-six adults (14 males, 32 females), 15 weaned pups (8 males, 7 females) and 20 nursing pups (8 males, 12 females) were examined and sampled. In addition, a random sample of 214 seals was surveyed for lesions (as described by McFarlane 1996) without being handled.

Preliminary haematological evaluation was conducted at the Crary Laboratory at McMurdo Station, Antarctica, and included determination of haematocrit and

Fig. 7.1 Resting Weddell seal female and pup being examined prior to capture for biomedical sample collection

description of serum quality. Red and white blood cell counts were obtained using the Unopette system and a haemacytometer. Haemoglobin was evaluated with a BMS haemoglobinometer. Blood smears were air-dried and preserved for transport to the Hubbs-SeaWorld Research Institute laboratory in San Diego, California (USA), where they were stained for microscopic examination and differential count of white blood cells (band neutrophils, mature neutrophils, lymphocytes, monocytes, eosinophils and basophils), morphology of red and white blood cells and subjective evaluation of platelet number. In all, 11 haematological parameters were measured.

Fig. 7.2 Satellite-linked radio-transmitter being glued to the dorsal pelage of a physically restrained Weddell seal

Serum was stored in ultralow freezers (−70 to 80°C) for several weeks and transported on dry ice prior to U.S. laboratory evaluation. Biochemical assays were performed by the SeaWorld San Diego Animal Care Laboratory, San Diego, California. Twenty parameters were measured, including markers for liver, kidney and muscle disease (alanine aminotransferase, aspartate aminotransferase, total bilirubin, gamma glutamyltransferase, blood urea nitrogen, creatine kinase, lactate dehydrogenase), body condition and nutritional status (glucose, cholesterol, triglycerides,

total protein), inflammation/infection (albumin, globulin, alkaline phosphatase, serum iron) and electrolytes (sodium, potassium, chloride) and other ions (calcium, phosphorus). Haematological and serum biochemical parameters were evaluated for age/sex class differences using Kruskal–Wallis ANOVA; differences are reported as significant if $p < 0.05$.

Faecal examinations (consistency, colour, presence of blood or mucous, presence and identity of parasites) by direct smear and faecal flotation were conducted at the Crary Laboratory, McMurdo Station.

Serological assays for antibodies to selected bacterial and viral pathogens were conducted by the California Animal Health and Food Safety Laboratory System, Davis, California (*Brucella* sp., *Leptospira* sp.) and the Okalahoma Animal Disease Diagnostic Laboratory, Stillwater, Oklahoma (canine distemper virus, phocine distemper virus, dolphin morbillivirus, porpoise morbillivirus).

7.3 Results

Abnormal findings from physical examination were recorded for 21 of 81 (26%) animals handled during the course of this study (Table 7.1a); some seals had more than one lesion. Abnormalities included 1 adult that began shivering within 5 min of capture, 8 adults with very worn or broken teeth, 1 pup with an inspiratory wheeze and bilateral nasal discharge, and 11 seals (8 adults, 3 pups) with fresh puncture wounds. Ocular lesions were observed in three adults. There were no significant ($p < 0.05$) differences in serum biochemical parameters between animals with normal versus abnormal physical findings; however, animals with abnormal physical findings had significantly more band neutrophils and mature neutrophils, and fewer lymphocytes than normal seals. Clinically healthy pups were significantly larger (length and girth) than pups that were abnormal on physical examination.

Haematologic and serum chemistry values recorded by age and sex are presented in Table 7.2. Adults differed significantly from pups (weaned and nursing) for 14 parameters. Adults had more band neutrophils and eosinophils, as well as higher creatinine, total bilirubin, alanine aminotransferase, sodium and chloride levels. Pups had more lymphocytes and higher glucose, cholesterol, calcium, phosphorus and serum iron. There was no significant difference in haematocrit between adults and pups, but weaned pups had higher haematocrits than nursing pups. Although there was no significant difference in triglycerides between weaned pups and adults, nursing pups had significantly higher triglyceride levels than either weaned pups or adults. Nursing pups also had higher total protein levels and globulin levels than adults or weaned pups; albumin levels were higher in weaned pups than in either adults or nursing pups.

No sex differences were detected for any of the biochemical parameters measured. However, statistically significant differences were noted for some haematological parameters, and these differences were present in both adults and pups: males had lower haematocrits, lower red blood cell counts and more band neutrophils than females.

Table 7.1 Lesions and other sources of morbidity recorded during visual inspections (214 seals) or veterinary medical examinations (81 seals) of Weddell seals in McMurdo Sound

(a) Lesions and other abnormalities detected during veterinary medical examinations of 81 seals handled for biomedical sampling. Abnormalities were recorded from 21 of 81 (26%) seals; some seals had more than one lesion

	Adults		Pups	
Lesion/abnormality	Males (n = 14)	Females (n = 32)	Males (n = 16)	Females (n = 19)
Fresh skin lesion(s), minor (e.g. puncture wound)	5 (36%)	3 (9%)	2 (13%)	1 (5%)
Worn or broken teeth	4 (29%)	4 (13%)	0	0
Ocular pathology (corneal opacity)	2 (14%)	1 (3%)	0	0
Inspiratory wheeze	0	0	0	1 (5%)
Purulent bilateral nasal discharge	0	0	0	1 (5%)
Shivering	1 (7%)	0	0	0

(b) Lesions and other abnormalities recorded during visual surveys of 214 randomly selected Weddell seals. Abnormalities were noted for 75 of 214 (35%) seals; some seals had more than one lesion

Lesion/abnormality	Adult males (n = 42)	Adult females (n = 119)	Weaned pups (n = 53)
Pup ill-health	0	0	13 (25%)
Fresh skin lesion(s), minor	9 (21%)	23 (19%)	2 (4%)
Fresh skin lesion(s), major	10 (24%)	7 (6%)	0
Worn or broken teeth	11 (26%)	9 (8%)	0
Ocular pathology (e.g. corneal opacity, punctured globe)	3 (7%)	7 (6%)	1 (2%)
Respiratory disease	1 (2%)	2 (2%)	3 (6%)
Firm nodule on thorax	0	1 (1%)	0
Healed fracture, foreflipper	1 (2%)	0	0

No parasites were detected during examinations of blood smears or during direct examinations of fresh faecal smears. Faecal floatations revealed ova from both anisakid nematodes and diphyllobothrid cestodes in 11 of 17 (65%) adult seals. Anisakid nematode ova were found in only 3 of 17 (18%) adults. Diphyllobothrid cestode ova were found in only 3 of 17 (18%) adults and 2 of 3 (67%) weaned pups. No parasite ova were detected in 2 of 17 (12%) adults and 1 of 3 (33%) weaned pups.

Visual surveys of 214 randomly selected Weddell seals (42 adult males, 119 adult females, 53 weaned pups; Table 7.7b) revealed the following lesions or other sources of morbidity: pup ill-health (lethargy, malnourishment; 13 animals), fresh skin lesions/wounds (34 minor, 17 major), severely worn or cracked teeth (20 animals), ocular pathology (11 animals), and respiratory disease (6 animals). One animal had a firm nodule on its thorax, and one appeared to have a healed fracture of one foreflipper. Some seals had more than one lesion.

No serum antibodies were found in any seal for *Brucella* sp., *Leptospira* sp. or the four morbilliviruses (canine distemper virus, phocine distemper virus, dolphin morbillivirus, porpoise morbillivirus).

Table 7.2 Haematologic and serum chemistry values for 81 Weddell seals sampled in McMurdo Sound expressed as mean (± standard deviation)

	Adults		Weaned pups		Nursing pups	
(a) Haematology	Males	Females	Males	Females	Males	Females
Haematocrit (%)	60.0 (4.4)	63.0 (2.5)	62.0 (3.0)	63.4 (3.1)	59.7 (4.2)	58.3 (1.0)
Red blood cells (no. × 10^6)	4.5 (0.7)	4.7 (0.5)	4.5 (0.5)	4.7 (0.6)	4.4 (0.8)	5.0 (0.6)
White blood cells (no.)	10,235.0 (2,752.1)	8,275.0 (1,052.3)	7,956.3 (1,429.6)	8,371.4 (1,326.3)	7,800.0 (2,271.6)	6,362.5 (1,949.1)
Band neutrophils (no.)	297.9 (344.1)	67.1 (101.9)	12.5 (35.4)	26.1 (44.9)	90.0 (106.8)	13.5 (27.0)
Neutrophils (no.)	5,353.4 (2347.7)	4,486.1 (719.2)	3,969.9 (812.8)	4,557.9 (896.6)	4,390.0 (1561.3)	3,555.5 (1140.8)
Lymphocytes (no.)	2,051.1 (417.9)	1,887.8 (514.6)	1,976.8 (425.5)	2,276.6 (693.9)	1,602.7 (1,426.3)	1,789.3 (1,030.4)
Monocytes (no.)	1,124.5 (714.3)	879.2 (216.3)	938.0 (491.5)	975.1 (664.4)	642.7 (359.7)	514.0 (205.4)
Eosinophils (no.)	1,237.1 (778.6)	1,008.3 (461.9)	1,052.3 (529.1)	536.4 (223.7)	505.3 (250.3)	489.0 (135.4)
Basophils (no.)	33.0 (72.0)	8.8 (27.8)	6.8 (19.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
(b) Serum chemistry (SI	Adults		Weaned pups		Nursing pups	
Units)	Males	Females	Males	Females	Males	Females
Glucose (mmol L^{-1})	5.8 (0.7)	5.5 (1.0)	6.6 (0.5)	6.9 (0.5)	6.9 (0.3)	7.6 (0.8)
Blood urea nitrogen (mmol L^{-1})	6.7 (2.7)	7.9 (2.4)	4.7 (1.7)	5.5 (1.5)	5.8 (0.7)	5.3 (1.4)
Creatinine (mmol L^{-1})	114.9 (26.5)	123.8 (26.5)	88.4 (17.7)	79.6 (17.7)	79.6 (8.8)	70.7 (44.2)
Total bilirubin (mmol L^{-1})	8.6 (5.1)	10.3 (5.1)	5.1 (1.7)	3.4 (1.7)	5.1 (1.7)	5.1 (1.7)
Cholesterol (mmol L^{-1})	5.7 (1.5)	7.9 (2.2)	15.2 (1.9)	14.1 (2.6)	13.4 (0.8)	12.6 (1.5)
Triglycerides (mmol L^{-1})	1.0 (0.5)	0.9 (0.6)	1.4 (1.0)	1.0 (0.4)	4.3 (1.2)	2.3 (1.7)
Total protein (g L^{-1})	80.0 (10.0)	74.0 (8.0)	73.0 (10.0)	70.0 (5.0)	87.0 (9.0)	76.0 (14.0)
Albumin (g L^{-1})	25.0 (2.0)	25.0 (3.0)	28.0 (2.0)	28.0 (1.0)	25.0 (1.0)	23.0 (2.0)
Globulin (g L^{-1})	58.0 (10.0)	49.0 (6.0)	45.0 (11.0)	42.0 (11.0)	62.0 (9.0)	53.0 (12.0)

(continued)

Table 7.2 (continued)

(b) (serum chemistry (SI Units)	Adults		Weaned pups		Nursing pups	
	Males	Females	Males	Females	Males	Females
Alkaline phosphatase (IU L^{-1})	278.6 (140.2)	480.8 (302.6)	478.8 (110.9)	506.7 (116.1)	869.3 (207.6)	484.3 (345.8)
Alanine amino transferase (IU L^{-1})	26.5 (6.3)	25.7 (6.7)	18.8 (5.8)	19.3 (9.4)	22.0 (3.5)	27.3 (7.2)
Aspartate amino transferase (IU L^{-1})	42.1 (14.3)	46.4 (26.4)	38.3 (20.8)	39.6 (16.5)	34.3 (8.0)	57.8 (10.7)
Gamma glutamyl transferase (IU L^{-1})	3.9 (2.1)	7.8 (15.1)	5.3 (5.3)	3.0 (2.4)	4.5 (3.8)	3.9 (4.2)
Creatine kinase (IU L^{-1})	343.4 (494.9)	501.6 (397.9)	509.5 (558.4)	450.4 (264.6)	393.3 (178.0)	718.3 (239.0)
Lactate dehydrogenase (IU L^{-1})	500.8 (138.2)	608.0 (375.0)	611.3 (139.2)	696.4 (329.7)	639.3 (113.1)	855.5 (243.0)
Calcium (mmol L^{-1})	4.8 (0.4)	4.9 (0.6)	5.2 (0.3)	5.1 (0.3)	5.4 (0.3)	4.9 (1.2)
Phosphorus (mmol L^{-1})	2.0 (0.6)	1.9 (0.5)	2.7 (0.4)	2.5 (0.5)	3.2 (0.1)	2.8 (0.2)
Sodium (mmol L^{-1})	155.7 (3.6)	154.4 (4.9)	152.0 (1.7)	151.4 (1.6)	152.0 (1.5)	152.0 (2.8)
Chloride (mmol L^{-1})	111.2 (4.7)	109.6 (3.3)	107.7 (2.8)	108.4 (2.2)	111.0 (2.5)	106.5 (0.7)
Potassium (mmol L^{-1})	5.3 (0.6)	5.1 (0.5)	4.8 (0.3)	4.7 (0.5)	4.6 (0.5)	4.7 (0.9)
Iron (mmol L^{-1})	34.7 (14.6)	39.2 (13.1)	40.1 (13.1)	55.7 (22.0)	59.1 (35.3)	74.5 (13.8)

7.4 Discussion

7.4.1 Haematology and Serum Chemistry

Seal et al. (1971) and Schumacher et al. (1992) have presented data for a number of biochemical parameters in Weddell seal blood; the values we measured were consistent with those reported by these authors (exceptions noted below) and were generally within reference ranges known for other phocid seals. Variability in haematology and serum or plasma biochemistry in pinnipeds, including Weddell seals, has been correlated with many factors, including age (Bryden and Lim 1969; Seal et al. 1971; Lane et al. 1972; Horning and Trillmich 1997; Hall 1998; Sepulveda et al. 1999; Lewis et al. 2001; Nordøy and Thoreson 2002), sex (Poulin et al. 1994; Lewis et al. 2001), diet (Kuiken 1985; Thompson et al. 1997), habitat (e.g. coastal vs. offshore dolphins, Duffield et al. 1983), diving ability (e.g. deep-diving vs. shallow-diving species; Vallyathan et al. 1969; Hedrick and Duffield 1991), air temperature (Poulin et al. 1994), physiologic state (e.g. pregnancy, lactation, malt, fasting vs. feeding; Worthy and Lavigne 1982; Poulin et al. 1994; Lewis et al. 2001; Englehard et al. 2002), handling (St Aubin et al. 1979) and condition (Geraci et al. 1979; Roletto 1993).

Some of the age and sex class differences in haematological and serum biochemical parameters we observed in Weddell seals have been reported previously in Weddell seals or other pinnipeds. Seal et al. (1971) also measured higher creatinine levels in adult versus young Weddell seals. Nordøy and Thoresen (2002) reported higher sodium levels and lower calcium levels in harp seal adults than in pups; we observed the same differences in Weddell seals. Although Hall (1998) did not sample adults, she did report higher glucose levels in pups than in yearling grey seals; we observed higher glucose levels in pups than in adults. We observed higher haematocrits in weaned than in nursing pups; this has been reported by other researchers for Galapagos fur seals (Horning and Trillmich 1997) and southern elephant seals (Lewis et al. 2001). Packed cell volume is often used interchangeably with haematocrit (Willard et al. 1999); Sepulveda et al. (1999) reported higher packed cell volume in juveniles than in pups (Juan Fernandez fur seals). Although we did not detect significant differences in haematocrits between adults and pups, others have reported conflicting data on these differences: Sepulveda et al. (1999) found that packed cell volumes of adult females were lower than those of juveniles (Juan Fernandez fur seals), whereas Bryden and Lim (1969) and Lane et al. (1972) found higher haematocrits in adults than in pups.

The nursing Weddell seal pups we sampled had higher total protein levels and globulin levels than adults or weaned pups. Seal et al. (1971) and Nordøy and Thoresen (2002), however, reported higher globulin levels in adults than pups for Weddell seals and harp seals, respectively. Sepulveda et al. (1999) reported higher plasma proteins in juveniles than pups for Juan Fernandez fur seals.

No sex differences were detected for any of the biochemical parameters we measured. However, we did find statistically significant differences for some haematological parameters, and these differences were present in both adults and pups:

males had lower haematocrits, lower red blood cell counts, and more band neutrophils than females. Although male Weddell seals had more neutrophils than females, there was no significant difference between the sexes in the total white blood cell count. Poulin et al. (1994), however, did report higher white blood cell counts in males than in females. Lewis et al. (2001) reported lower haemoglobin levels in males than in females. While there was no significant difference in haemoglobin levels in the males and females we sampled, males did have lower values for two other measures of oxygen-carrying capacity of the blood, haematocrit and red blood cell count.

7.4.2 Macroparasites

A wide variety of endoparasites and ectoparasites have been reported in Weddell seals and other Antarctic phocids (Beverley-Burton 1971; Drozda 1987; Orecchia et al. 1994; Wojciechowska and Zdzitowiecki 1995; Mehlhorn et al. 2002). We did not detect any previously unreported nematodes or cestodes in the Weddell seals we examined, and none of these animals had clinical signs consistent with gastrointestinal or respiratory parasitism (e.g. diarrhea, cough). Parasite infections in marine mammals, even when infestations are heavy, often do not have a significant impact on otherwise healthy hosts and may be considered incidental or secondary findings (Baker 1989; Duszynski et al. 1998 cited in Dailey 2001; Geraci et al. 1999; Dailey 2001; Gulland et al. 2001). Parasites may cause morbidity and even mortality in some cases (Gerber et al. 1993; Roletto 1993; Geraci et al. 1999; Dailey 2001), although this may be due primarily to concurrent secondary bacterial infection (as in verminous pneumonia, Dailey 2001). Gastrointestinal protozoa have been reported in Antarctic and sub-Antarctic pinnipeds (Drozda 1987; Duszynski et al. 1998 cited in Dailey 2001), but we did not detect them in the fresh faecal smears we examined. However, protozoal parasite ova and cysts are frequently missed with a single faecal smear (Willard et al. 1999); examination of multiple samples, collected 1–2 weeks apart, is generally recommended before an animal is considered negative for protozoal parasites.

7.4.3 Bacteria and Viruses

As with macroparasites (nematodes, cestodes, trematodes), the presence of bacteria and viruses is not always correlated with clinical disease. However, bacteria and viruses may have been responsible for mass die-offs, particularly where large populations of social or seasonally gregarious species have been exposed to new pathogens to which they have no herd immunity. Although no Weddell seals tested positive for *Brucella* sp. or morbillivirus in our study, others have reported the presence of antibodies to these and other pathogens in Antarctic phocids

(Bengtson et al. 1991; Stenvers et al. 1992; Retamal et al. 2000). We did not detect leptospirosis in any of the Weddell seals we tested. Although leptospirosis has not been reported to date in pinnipeds in the Southern Hemisphere, it has caused epizootics among pinnipeds in other areas (Vedros et al. 1971). Other serosurveys have demonstrated little exposure to other viruses in Weddell seals and other Antarctic phocids. Truyen et al. (1995) surveyed over 200 adult and 10 juvenile Weddell seals for influenza viruses and paramyxovirus but found no positives. Stenvers et al. (1992) reported no antibodies against phocine distemper virus in Weddell seals, although they did detect high neutralizing titres to seal and feline herpes virus. No antibodies to either herpes virus or distemper virus were detected in crabeater seals by Stenvers et al. (1992).

Our seroprevalence data suggest that the McMurdo Weddell seal population is relatively naïve with respect to pathogen exposure, suggesting that it may be vulnerable to disease outbreaks such as those that have caused large die-offs of marine mammals in other regions. The die-off of crabeater seals reported by Laws and Taylor (1957) affected over 85% of the local population (over 1,500 seals in the Antarctic Peninsula region). Barrett (1999) noted that the population size of Antarctic crabeater seals (several million) would be adequate to maintain a morbillivirus in circulation once introduced; it has been estimated that at least 300,000 individuals are necessary to maintain the human morbillivirus, measles, in the population (Black 1991). Such large numbers are needed because the virus is maintained by infecting new susceptible hosts. Grenfell et al. (1992), examining the long-term consequences of the 1988 morbillivirus epizootic in North Atlantic phocids, stated that the seal population would have to recover for at least 10 years before another outbreak was likely; it appears that this was an accurate calculation, as the most recent (2002) outbreak occurred 13–14 years after the previous one. Jensen et al. (2002) noted that testing in the 10 years leading up to the 2002 phocine distemper outbreak in Europe demonstrated 95% seronegativity in the harbour seal population; all positives were newly-weaned pups, suggesting that these were passive/maternal antibodies. The authors noted that this was an indication that the virus had not been circulating in the population and that the recent (2002) reappearance of phocine distemper virus into this largely susceptible population could allow rapid spread with devastating consequences, as was observed during the 1988 outbreak that killed over 18,000 animals. Van Bressem et al. (2001) noted that decreased seroprevalence to morbillivirus detected over time in two species of odontocete cetaceans made them susceptible to new epizootics, as the virus was not becoming endemic in the population and animals were losing their humoral immunity.

Harwood and Hall (1990) reviewed marine mammal epizootics and their population effects. The factors responsible for emergence or resurgence of a viral disease are often difficult to determine (Miller et al. 2001); often a change in host range is implicated (Truyen et al. 1995). Innate differences among species in immune response (and therefore resistance) to morbilliviruses have been reported in phocids (Duignan et al. 1997). Duignan et al. (1995) proposed that enzootic infection may become established in one species (grey seals), facilitated by factors such as large population size, high annual recruitment, and innate resistance to the virus, and

then be maintained in another less abundant and/or less resistant species (harbour seals) through casual contact with the first species.

7.4.4 Starvation and Physical Injury

Common and important causes of morbidity and mortality in pinnipeds include starvation and malnourishment (particularly of neonates and newly weaned pups), conspecific trauma, and predation (Tierney 1977; Baker and McCann 1989; Steiger et al. 1989; Banish and Gilmartin 1992; Cooper 1996; McFarlane 1996; Baker et al. 1998; Geraci et al. 1999; Gulland et al. 2001; Lucas et al. 2003). Physical injury caused by inter-specific and intra-specific interactions has long been recognised as an important source of non-infectious disease in free-ranging wildlife, including marine mammals (Cooper 1996). The clinical significance of a physical injury to an individual animal depends upon the severity of the injury (including the area of the body affected) and the presence or absence of secondary conditions (e.g. haemorrhage, infection; Cooper 1996; Gulland et al. 2001). Cooper (1996, p. 163) noted that '…clinical signs [of trauma] can range from coma to an almost complete absence of abnormalities.' In the Weddell seals we examined, pup ill health (lethargy, malnourishment) and physical trauma were the most common findings. However, most of the wounds we examined in Weddell seals appeared to be the result of interactions with conspecifics (e.g. male fighting) rather than inter-specific or predatory wounds. The Delbridge Islands in McMurdo Sound are surrounded by fast-ice during the breeding season, when our disease surveys were made. Predators such as leopard seals and killer whales generally do not move into the area until the ice begins to break up and/or icebreakers have opened up a channel into McMurdo Station several months after the peak of the breeding season. Ocular pathology (e.g. corneal oedema, cataracts) was observed in 5% of the seals we examined, and is commonly reported in other stranded and free-ranging pinnipeds (Stoskopf et al. 1985; Schoon and Schoon 1992; Gerber et al. 1993). Severely worn or cracked teeth were observed in 6% of the seals we examined (all adults), and this has been identified as a mortality factor in Weddell seals (Stirling 1969); Weddell seals' teeth are important for maintaining breathing holes in the ice.

7.5 Conclusions

Baseline biomedical data such as those reported here, combined with information on life history and behaviour (e.g. migratory behaviour), are important for elucidating patterns of infection and risk within and between populations and for interpreting toxicological data (Duignan et al. 1995; Gelatt et al. 1999; Geraci et al. 1999). Geraci et al. (1999, p. 368) noted that 'only by understanding the causes and patterns of normal mortality can we recognise unusual events and determine their cause and impacts on a population….'

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