Antarctic Science 22(1), 25–29 (2010) © Antarctic Science Ltd 2009 doi:10.1017/S0954102009990447

A preliminary assessment of the impact of disturbance and handling on Weddell seals of McMurdo Sound, Antarctica

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Abstract: There has been growing concern over the impact of increased human disturbance and research effects on Antarctic species. The Weddell seal of McMurdo Sound in particular has been used as a model species for over four decades of research, with some individuals handled multiple times over a single season. Using opportunistic data, we performed an assessment of blood indicators in adult males ($n = 26$) and adult females ($n = 24$) based on high versus low disturbance areas, with results showing no variation in overall seal health. In addition, we performed a preliminary analysis of blood and faecal indicators of inflammation and stress collected from adult, non-lactating females ($n = 13$) handled twice in less than two weeks for research purposes. There was no indication of a change in white blood cells, platelets, globulins or haptoglobins, or faecal corticosteroids (all $P > 0.05$). While based on a small, opportunistic sample size with limited power in some cases, preliminary results indicate there is no acute impact of repeated handling or difference in overall traffic level on adult Weddell seals.

Received 2 June 2009, accepted 31 July 2009

Key words: corticosteroids, Erebus Bay, globulins, haptoglobins, *Leptonychotes weddellii*, platelets

Introduction

The Weddell seal, *Leptonychotes weddellii* (Lesson), is the southernmost breeding mammal, and one of the largest of the phocid seals, with some adult females exceeding 500 kg (Wheatley *et al*. 2006). The estimated total population of 800 000 seals is found only in the circumpolar Antarctic, and is therefore subject to little or no potential impact from commercial fisheries and other anthropogenic influences (Siniff 1991). The Erebus Bay population in McMurdo Sound (*c*. 1000) is one of the most comprehensively monitored groups, with early pup tagging efforts in 1968 leading to ongoing annual surveys since 1978. The proportion of animals tagged at birth and returning to Erebus Bay to breed due to high philopatry approaches 70% (Cameron & Siniff 2004, Cameron *et al*. 2007). These are long-lived mammals (27 years, Proffitt *et al*. 2007) with little to no evidence of reproductive senescence until at least age 17 (Cameron & Siniff 2004). Despite the inherent difficulties of working in the Antarctic, this population has been an ideal model for studies of lactation (e.g. Wheatley *et al*. 2006, 2008), population ecology (e.g. Cameron & Siniff 2004), aging (Proffitt *et al*. 2007, Hindle *et al*. 2009) and diving physiology (e.g. Ponganis *et al*. 1993, Williams *et al*. 2004). Some animals are sampled once in a lifetime, others multiple times in a single season. While the ultimate effects of multiple handling events can only be inferred through determination of lifetime reproductive success or survival rates (e.g. Baker & Johanos 2002, McMahon *et al*. 2008), the potential for short-term, or acute responses to research-related manipulations can be substantial. Well-documented in other mammals, these can include behavioural aversions (Born *et al*. 1999), reduced digestive efficiency (Trevisi *et al*. 2007), increased stress hormones (Fletcher & Boonstra 2006, Petrauskas *et al*. 2008), inflammatory response (Viswanathan & Dhabhar 2005, Mellish *et al*. 2007b) and hyperthermia (Groenink *et al*. 1994, Oka *et al*. 2001). While there is no single accepted method to define impact, efforts to describe and quantify its effects are growing (McMahon *et al*. 2005, Wilson & McMahon 2006). Short-term and long-term responses to capture, handling, blood sampling and tagging have been investigated in only a handful of pinniped species (e.g. Lander *et al*. 2001, Baker & Johanas 2002, Englehard *et al*. 2002a, Littnan *et al*. 2004, McMahon *et al*. 2008).

As part of a larger investigation of aging in Weddell seals, the objective of this study was to document the acute responses of repeated handling within the same season in adult, non-reproductive seals. We specifically identified parameters that may be indicative of negative effects on general body condition (mass, blubber depth) and immune status (white blood cells, platelets, globulins, haptoglobins) rather than immediate stress *per se* (e.g. serum cortisol), such that small scale variations in the timing of sample collection in relation to capture and handling events would not substantially contribute to the variance within the data collected. Where possible, comparisons of low disturbance and high disturbance areas within the Erebus Bay study region are included.

Methods

Biological samples were collected from adult Weddell seals (9–27 yrs) in the McMurdo Sound region (77°53'S 166°40'E) in the breeding seasons of 2006 and 2007 (October–December) as part of a larger study (e.g. Hindle *et al*. 2009) investigating the physiological and behavioural characteristics of aging in this species. A total of 50 seals ($n = 24$ non-reproductive female, $n = 26$ male) were included in a preliminary investigation of the effect of geographic location on physiological measures of stress and body condition, by grouping initial sampling location into low and high disturbance areas. Low disturbance areas ($n = 17$ samples) included: remote McMurdo Sound, Cape Evan's Road, Turk's Head, Tryggve Point, and Inaccessible Island. High disturbance areas ($n = 33$ samples) included: Little Razorback Island, Big Razorback Island, Tent Island and Turtle Rock. For females included in the assessment of multiple handling events (see below), only Event 1 data were included in this comparison. A preliminary assessment of the effect of repeated handling for research purposes included non-reproductive females only ($n = 20$), with two sampling events per individual (e.g. Event 1 & Event 2). Event 1 lasted approximately three hours and included physical restraint, chemical immobilization (described in detail in Mellish *et al*. in press), blood sampling, ultrasound for blubber depth, mass, morphometric measurement (standard dorsal length) and telemetry instrument attachment. Opportunistic faecal samples (e.g. voided by the animal during processing or collected from the rectal thermometer housing) were collected when possible ($n = 14$). Event 2 included physical restraint for telemetry instrument removal, with opportunistic blood sampling only occurring in individuals that required intravenous chemical immobilization ($n = 13$; Table I). Ultrasound blubber depth was collected opportunistically during Event 2 in a smaller subset of animals ($n = 8$, Table I).

Table I. Demographic summary for non-lactating female Weddell seals (*Leptonychotes weddellii*) sampled twice within a two week period in McMurdo Sound, Antarctica. Mass, standard length (ventral recumbancy) and girth were taken on initial sample only. Second event activities are noted (B = blood collection, U = ultrasound blubber depth).

	Mass (kg)	Standard length (cm)	Axillary girth (cm)	Age interval (yr)	Event (d)	Event 2
LW06-12	320	-	-	10	9	B
LW06-14	465	-	-	9	7	B
LW06-15	513	-	-	21	9	B
LW06-16	467	246	189	18	10	B
LW06-19	400	-	-	15	9	B
LW06-20	373	242	188	15	6	B
LW07-12	332	226	183	9	16	B
LW07-13	398	252	191	17	15	B
LW07-16	459	264	194	27	11	B
LW07-17	317	251	181	21	11	B, U
LW07-18	395	242	197	11	13	U
LW07-20	423	247	187	18	10	U
LW07-21	508	259	206	13	11	B, U
LW07-22	446	250	201	23	10	U
LW07-23	422	256	193	25	10	B
LW07-24	461	263	202	24	7	-
LW07-25	427	243	202	13	2	-
LW07-26	420	252	195	12	7	U
LW07-27	422	258	189	18	7	U
LW07-28	428	251	201	14	6	B, U
average	420	250	194	17	9	
s.e.	12.2	2.4	1.8	1.2	0.7	

In all cases, seals were aged prior to handling using uniquely numbered flipper tags in place as part of a long-term population monitoring project (Cameron & Siniff 2004). Animals were initially approached on foot and slowly herded away from others prior to initial restraint via head bag (Stirling 1966). All animals were chemically immobilized to facilitate ease of handling and enhance animal and human safety. An intramuscular injection of 2 mg kg^{-1} ketamine hydrochloride and 0.1 mg kg^{-1} midazolam hydrochloride was utilized for induction, with intravenous or intramuscular administration at a reduced concentration (0.5 mg kg^{-1} ketamine and 0.025 mg kg^{-1} midazolam) as required for extended handling events. There were no measurable effects of multiple anaesthesia events as described in detail in Mellish *et al*. (in press). Animals were weighed only during Event 1 via sling net from a handing tripod scale to the nearest 0.5 kg. Blood samples were collected from the extradural intravertebral vein with a 6 inch 18 g spinal needle. Portable imaging ultrasound (SonoSite Vet180Plus) was used to identify non-pregnant females prior to handling and to determine blubber depth (including skin) at up to eight sites along the body (four lateral, four dorsal). The eight body locations correspond to sites 2–5 as described in Mellish *et al*. (2007a), at roughly four equidistant sites between the axial girth and hip at lateral and dorsal positions. Blubber depth data are presented as both a summary data point and for indicator sites as found in Mellish *et al*. (2007a) as appropriate.

Collected blood was held in a cooler to prevent freezing while in the field. White blood cells and platelets were counted manually (Unopette® system, Becton-Dickenson, Franklin Lakes, NJ). Spun sera were aliquoted and frozen at -80°C until analysis. Globulin concentrations were assayed with a Vetscan® Diagnostic Profile Plus analysis rotor system (Abaxis, Union City, CA). Haptoglobins were analysed with TriDelta diagnostics EIA as per Thomton & Mellish (2007). We specifically did not include serum cortisol as a measure of handling effect due to difficulties in standardizing time of blood collection, known rapid response and individual variation shown in other pinnipeds (e.g. Petrauskas *et al.*

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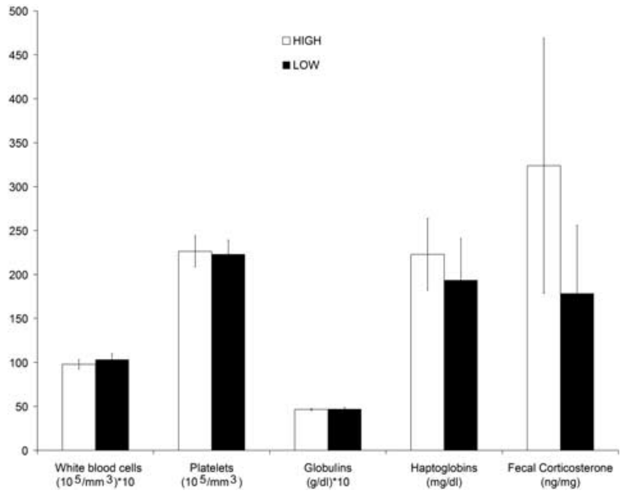

Fig. 1. Trends in white blood cell count, platelets, globulins, haptoglobins and faecal corticosterone between a high and low disturbance location in adult male and non-lactating adult female Weddell seals (*Leptonychotes weddellii*) in McMurdo Sound, Antarctica. There was no significant variation between areas in any parameter ($P > 0.05$).

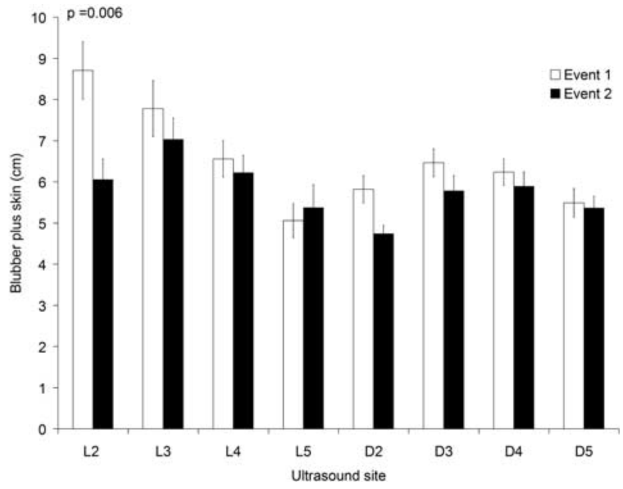

Fig. 2. Blubber depth via imaging ultrasound at eight sites (e.g. Mellish *et al*. 2007a) on non-lactating adult Weddell seals in McMurdo Sound during two capture events in a single season. Paired results showed that three of the eight sites differed between sampling events (L2, D2, D3).

2008). As a longer-term cumulative measure of stress effect, faecal samples were extracted and assayed for corticosterone concentration as described and validated for pinnipeds in Petrauskas *et al*. (2008). All data are shown as mean ± standard error. Data were analysed for differences between repeat handling events by paired *t*-test, and unpaired *t*-test for differences between high and low disturbance regions. Given the small sample sizes throughout, an estimate of power for each test is also shown at alpha 0.05, two tailed 95% statistical analyses were performed using InStat 3.0b for Macintosh.

Results

In comparing differences between low ($n = 17$) and high disturbance ($n = 33$) areas, there was no variation in animal demographic (mass $P = 0.658$ or age $P = 0.905$) that might influence interpretation of physiological data. However, body condition did vary by location for summed blubber depth (low $n = 12$, 50.8 ± 1.94 cm; high $n = 22$, 44.3 ± 1.57 cm, $P = 0.016$) and at two indicator sites (L2 low 8.1 ± 0.51 cm, high 6.9 ± 0.33 cm, $P = 0.047$; D2 low 6.2 ± 0.38 cm, high 5.1 ± 0.12 cm, $P = 0.002$). White blood cells, platelets, globulins, haptoglobins and faecal corticosterone showed no difference between the two groupings ($P > 0.05$, Fig. 1). Our current sample size should detect the following differences as significant at a 95% power: white blood cells 3.3 m mm^{-3}, platelets 109 m mm^{-3}, globulins 0.8 mg dl^{-1}, haptoglobins 257 mg dl^{-1}, and faecal corticosterone 815 ng mg^{-1}. Of these, the current amount of variation noted in haptoglobins and faecal corticosterone suggests that we would require a much larger sample size than currently available to determine a statistical difference between these means ($n = 1000$ haptoglobins, and $n = 50$ faecal corticosterone).

A subset of twenty females aged 17 ± 1.2 yrs were handled twice in 9 ± 0.7 d intervals. On Event 1, animals averaged 419 ± 12.2 kg (Table I). Seals were not reweighed during Event 2 processing. Although mass and morphometrics were only taken on the initial event, blubber depth measured via ultrasound ($n = 8$) did decline on a site-specific basis by Event 2 (Fig. 2). This effect was masked when all data were pooled as a single blubber measure

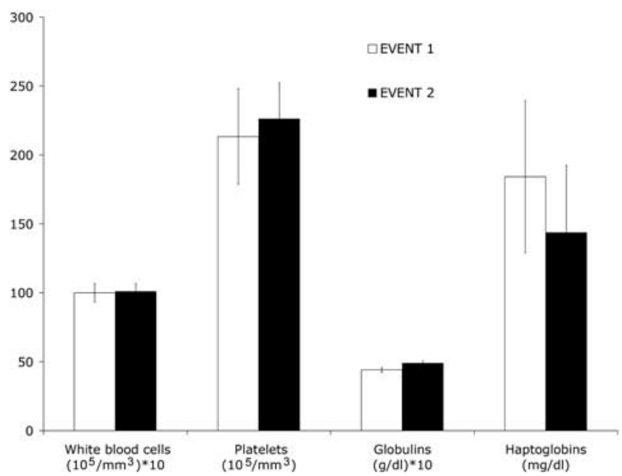

Fig. 3. Trends in white blood cell count, platelets, globulins and haptoglobins over two repeated sampling events in non-lactating adult female Weddell seals (*Leptonychotes weddellii*) in McMurdo Sound, Antarctica. There was no significant variation between events ($P > 0.05$).

https://doi.org/10.1017/S0954102009990447 Published online by Cambridge University Press

(Event 1 50.3 ± 2.66 cm, Event 2 46.5 ± 2.4, $P = 0.139$). Blood samples were collected twice from thirteen females (10 ± 0.8 d interval). Of the five primary serum indicators measured, none changed between handling Event 1 and Event 2 ($P > 0.05$; Fig. 3). Based on the difference in standard deviations, our sample size of 13 would be able to detect, at a 95% power, differences of the following: white blood cells 2.0 m mm^{-3}, platelets 106 m mm^{-3}, globulins 0.3 mg dl^{-1} and haptoglobins 126 mg dl^{-1}. As with our location comparison, our low power with the existing haptoglobin measures suggests that we would need a much greater sample size to determine a significant difference between the current data ($n = 500$).

Discussion

Concern over the impact of research and human disturbance effects has grown in the past decade, particularly in the few remaining 'pristine' environments such as the Antarctic (e.g. Tin *et al*. 2009). The Weddell seal is one of the most-studied species due to its large size, extreme diving capabilities, low aggression and relative accessibility. Due to changes in the polar ice patterns, it is very likely that Weddell seals may become even more heavily researched as models for Arctic species, as the more northern animals are extremely difficult to access.

Behavioural studies in the McMurdo Sound region have shown that adult, lactating Weddell seals will respond to over-snow vehicles, but that this response was largely mediated by the distance between the vehicle and the animal (van Polanen Petel *et al*. 2007). Similarly, lactating southern elephant seal females of Macquarie Island display modified behaviour patterns during and immediately after human presence (increased alertness, reduced vocalizations; Engelhard *et al*. 2002a). In McMurdo Sound, varied levels of human foot traffic within a two-hour window resulted in habituation of Weddell seals, but repeated exposure over a longer period of three weeks had the opposite result of sensitization (van Polanen Petel *et al*. 2006). This suggests there is a potential for increased stress among individuals repeatedly disturbed over a single season due to general traffic and/or research activities. This effect clearly needs to be investigated to assist in conservation measures and to allow individual researchers to account for the potential of acute stress due to their experimental protocol, including whenever possible overall traffic levels and individual-specific repeated disturbance.

General classification of Weddell seal location into low and high traffic areas was associated with some variation in body condition, but the immediate cause is unclear. Measured blood indicators were not found to vary based on human activity level at the seal's location, similar to lactating southern elephant seals (Engelhard *et al*. 2002c). Individual seals in our study (e.g. Hindle *et al*. 2009) were handled twice within a two-week period. Despite our repeated handling, there was no evidence of a generalized immune response (white blood cells, platelets, globulins) or an acute phase reaction (haptoglobins) in Weddell seals, a finding similar to that observed in other Antarctic phocids (Engelhard *et al*. 2002b), but contrary to other pinniped species in response to various traumas (e.g. Mellish *et al*. 2007b, 2007c, Thomton & Mellish 2007). This suggests that our level of disturbance was much lower than required to elicit a mounted or protracted physiological effect, but our statistical power was poor for serum haptoglobins, which warrants further investigation in a longitudinal study. The importance of suitable statistical power is highlighted by the individual variability of an acute stress response. For example, immediate adrenal response in elephant seals (e.g. serum cortisol) to disturbance appears to vary with age and level of disturbance (Engelhard *et al*. 2002b).

While there was some evidence of reduced body condition (e.g. blubber depth) between the first and second handling events, this most probably reflects the typical changes in condition with season and altered foraging habits due to breeding behaviour. In the absence of a control set, we cannot distinguish between the effects due to seasonality and the potential effects of handling. Indeed, one of the largest constraints associated with the study of wild pinnipeds is the ability to include a true control in the study design, such that few investigators are able to truly perform a meaningful comparison (e.g. Baker & Johanas 2002). In a long-term study of southern elephant seals, McMahon *et al*. (2008) were able to show no impact to individual mass or survival on individual seals that participated in up to eight telemetry device deployments. Combined with our current data, this suggests that Antarctic species may be generally tolerant to some types of research activities. In summary, although there are no clear indicators of negative physiological effect in this preliminary assessment, it is imperative that appropriate biological samples be collected whenever possible to gain a clearer picture of the impact of general disturbance and research activities on the species.

Acknowledgements

We would like to recognize the field efforts of M. Gray, R. Hill, S. Hill, J. Nienaber, J. Thomton, P. Tuomi and the support of the Crary Science Laboratory Staff. All work was conducted under Marine Mammal Protection Act 1034-1854, Antarctic Conservation Act 2007-007, ASLC Animal Use Protocol 05-004 and OSU Animal Use Protocol 3454. This project was funded by the National Science Foundation Polar Programs Antarctic Organisms and Ecosystems (Awards 0649609 and 0440715).

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