Chapter 16
Assessing the Welfare of Pinnipeds

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Abstract A recent increase in collaborative and independent studies on sea lions, seals and walruses has advanced our knowledge and interest in pinniped welfare. Nevertheless published discussions of the welfare of pinnipeds, and secondly of potential measures to assess their welfare, are, respectively, very few and non-existent. This chapter aims to make first steps in the discussion on assessing pinniped welfare, with the goal of stimulating future welfare investigations. Pinniped species are able to thrive in two opposing environments, the land/ice margin at the coast and in the sea, and these animals use these two 'domains' for different functions. Welfare measurement is concerned with the outcome of an animal's internal and external responses to its environment, and pinniped species' evolutionary biology may be especially important in this respect, in terms of our understanding of the animals' responses and interactions within their two domains. Pinnipeds are being directly impacted by serious anthropogenic disturbances in the wild, including human interference at established feeding and breeding grounds, hunting, entanglement and climate change, and are also often kept in captive collections. Feasible evaluations of welfare can therefore be assumed to have potential widespread utility, including applications benefitting the animals themselves.

16.1 Introduction

Although the literature on pinnipeds is not as extensive at that of the charismatic megafauna cetacean species, many collaborative as well as independent studies on sea lions, seals and walruses have advanced our knowledge and sustained the interest in these fascinating animals. Nevertheless published discussions of the welfare of pinnipeds, and secondly of potential measures to assess their welfare, are very

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few and non-existent. This chapter aims to make first steps in the discussion on assessing pinniped welfare and hopes to stimulate future welfare investigations. Pinniped species are able to thrive in two opposing environments, the land/ice margin at the coast and in the sea, and these animals use these two 'domains' for different functions. Welfare measurement is concerned with the outcome of an animal's internal and external responses to its environment, and pinniped species' evolutionary biology may be especially important in this respect, in terms of our understanding of the animals' responses and interactions within their two domains. Pinnipeds are being directly impacted by serious anthropogenic disturbances in the wild, including human interference at established feeding and breeding grounds, hunting, entanglement and climate change, and are also often kept in captive collections, so feasible evaluations of welfare could be assumed to have widespread utility, including applications benefitting the animals themselves.

16.2 Tools from Welfare Science Applicable to Pinnipeds

In this chapter, we will discuss the Otariidae (sea lions and fur seals), Phocidae (true seals) and Odobenidae (walruses) separately where possible, as these families have each followed a different evolutionary path to become adapted to both the land and the sea (Renouf 1991) and thus sometimes may merit differential consideration in terms of welfare. However, in many areas of the literature concerning wild and captive pinnipeds, there is a paucity of information on certain topics among the families and species, and in these cases our suggestions for potential welfare measures will be inter-specific and thus remain conservative. As we reviewed in Chap. 12, welfare science has established itself in regard to farm animal species, and scientists working in laboratory, zoo and companion animal welfare are adapting some of the tools and techniques first developed for farm animal assessment, to these species too (Barber 2009; Whitham and Wielebnoswki 2013). One notable disparity between welfare measurement for farm and zoo animals is that the former may, in some cases, have herd-based assessments, whereas the latter are usually afforded individual assessments. Pinnipeds are held in many zoological collections, where individual welfare assessment is logical because often the animals are observable, animals may have detailed discrete records, and come into contact with, and are often known individually by, the keepers (Barber 2009). Measuring the welfare of wild animals such as pinnipeds is possible but has been little investigated (see Chap. 12 for fuller discussion), and we suggest here how this might be accomplished and where measures for captive and wild pinnipeds might overlap. We start by reviewing the existing research on pinniped welfare since this provides context for our suggestions and discussions.

16.3 Existing Pinniped Welfare Research

There are very few studies discussing directly the welfare of pinnipeds in general and none which investigate how it might be measured comprehensively or 'holistically' (i.e. considering a wide range of risk factors and variables which may affect welfare).

Seal welfare has featured in legislative documents and guidance articles relating to the culling of seals for fur or population control practices (e.g. Fitzgerald 2011), but discussions are limited to the ethics of welfare states as perceived by humans. One recent report investigated the welfare implications of seal hunts for individual animals and in particular the qualities of the killing process itself where the authors highlight the poor welfare likely experienced by wounded animals which escape the sealers (Butterworth and Richardson 2013). Butterworth et al. (2012) reviewed how entanglement may impact pinniped welfare at the time of death or through debilitating wounds or increased energetic demands. From available data, the authors calculated that 0.24–2.21% of pinniped populations are currently entangled and discussed how the different species' behaviour and ecology alters the risk for each type of entanglement.

The only published research available which discusses multiple aspects of pinniped welfare (a more holistic approach to welfare assessment, rather than a focus on single welfare impacts) is a report on sea lion welfare in traveling circuses, where opinions on welfare were given by 20 experts (Hopster and de Jong 2014). The experts were in agreement on important risk factors (i.e. input measures) for pinnipeds in this situation (pool dimensions, space, social conditions, food and water quality), but overall there was a large degree of variation in the experts' opinions on the welfare significance, leading the authors to conclude that empirical data is urgently needed on the subject. Two other studies have looked at stereotypic behaviour as a single potential measure of pinniped welfare: Kastelein and Wiepkema (1988) found that conducting training sessions reduced Steller sea lions' (*Eumetopias jubata*) stereotypy frequency, and Smith and Litchfield (2010) showed that enrichment reduced stereotypic behaviour in Australian sea lions (*Neophoca cinerea*). Notably, in contrast to progress in cetology, emotion studies or discussions of affective states in pinnipeds are non-existent (e.g. these are not mentioned in the widely read book on pinniped behaviour by Renouf 1991). As a result and due to the paucity of welfare studies, our proposals for measures in this chapter must be partially based on extrapolation from other species' research and should be regarded conservatively as an initial 'pilot effort' aimed at focussing investigative effort on pinniped emotion and welfare.

16.4 Specific Considerations for Pinnipeds

Welfare measures for pinnipeds may be challenging to develop due to the two environments they inhabit, especially since the time spent in each of these two locations is likely to vary seasonally, interspecifically and also inter- and intra-individually (Riedman 1990; Renouf 1991). In general, pinnipeds use the water for foraging while the land is used for resting and reproduction, with social interactions occurring in both environments. Some species can rest and reproduce in the sea (Gulland et al. 2001; Walsh et al. 2001; Renouf 1991). To establish potential pinniped welfare evaluations, detailed species-specific knowledge of behavioural ecology must be gathered (see reviews by Riedman (1990) and Reynolds and Rommel (1999)). It has been noted that certain pinniped species recently brought into captivity will eat more readily in water than in land (Gulland et al. 2001). Pinnipeds do not

echolocate and have highly developed and sensitive visual, tactile and passive listening systems, which vary among species and individuals depending on their environment (Schusterman et al. 2000). Mating systems differ greatly among species, and breeding seasons are variable, resulting in marked behavioural and physiological adaptations of the different pinniped species, and these are well documented (Boyd 1991; Thompson et al. 1994; Robeck et al. 2001). Understanding of the variability in pinniped behaviours, both in the wild and captivity, is likely to be an important consideration when developing welfare measures for these species.

16.5 Input and Outcome-Based Measures

Input or resource-based measures of welfare are those that assess the resources available to the animal, and outcome or animal-based measures focus on the multidimensional responses of the animal to the environment; outcome measures are considered more accurate measures of welfare (Webster 2005; Veissier et al. 2008). At the present time, legal requirements for baseline requirements for pinniped husbandry and welfare in captivity are based on inputs (resources), and examples of these resource requirements can be found in the Animal Welfare Act (AWA 1966) in the USA and Council Directive 1999/22/EC in Europe.

The pinnipeds' various ecological adaptations suggest that the input-outcome measurement frameworks (see Chap. 12 for full explanation) would be more complex to establish for pinnipeds than for cetaceans, but could nevertheless be useful tools for pinniped welfare research. The input measures of welfare would need to cover both land and water environments and might consider variables such as water quality, topography of the pool surface and haul-out site, diet and social group membership. Potential outcome-based measures might focus on aspects of the animal's behaviour, physiology and cognitive processes (Fig. 16.1).

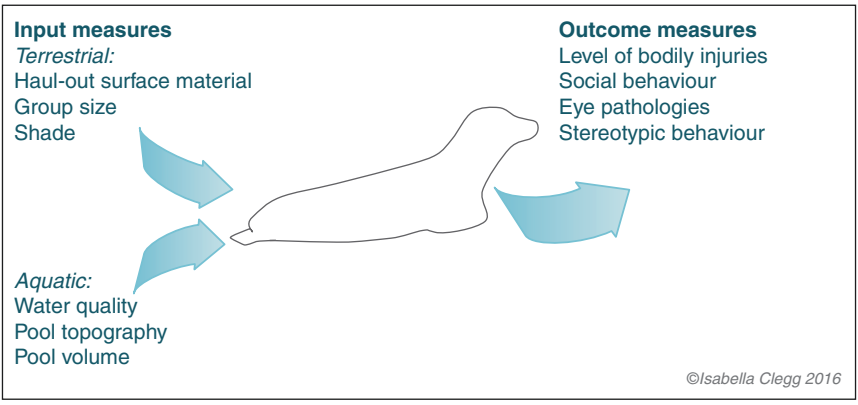

Fig. 16.1 Diagram showing some examples (not an exhaustive list) of potential input (resource-based) and outcome (animal-based) measures of welfare for pinniped species in captivity. (Image credit: Isabella Clegg)

Joseph and Antrim (2010) provide recommendations for the resources which should be provided to captive pinnipeds. In terms of designing observation methods and recording data for outcome, or animal-based, measures, the two concurrent environments inhabited by pinnipeds will mean that extra considerations must be made: for example, during behavioural observations, where animals are generally free to move between land and water, there might have to be two observers present, one watching each environment. Pinnipeds are observed to be 'intelligent' (responsive to their environment in adaptive ways) and easily trained (Schusterman et al. 2002), and so conducting physiological and cognitive measures should be no more difficult than with cetaceans, at least in captive situations. In a similar way to the model for cetacean welfare described in Chap. 12 of this book, the Triangulation principle could be used to study pinniped welfare, where welfare is assessed and the respective measures are validated by correlating against data from behavioural, health and cognitive measures (based on Webster 2005).

16.6 Animal-Based Welfare Measures for Pinnipeds in Captivity

16.6.1 Behavioural Measures of Welfare

Relatively little is known about captive pinniped behaviour, and very few published ethograms (definitions of behavioural repertoires) from the wild exist (Smith and Litchfield 2010). This makes it hard to incorporate information concerning normal behavioural patterns and seasonality of behaviours into welfare measurements (e.g. Fig. 16.2 shows a normal resting position for a wild Steller sea lion).

Behavioural measures of welfare are likely to be crucial in welfare evaluations if experience from other species is considered a template for use in pinnipeds. Behaviour can indicate how the surroundings are perceived by the animal (Gonyou 1994; Veasey 2006), which in the case of pinnipeds is their utilisation of two complex and contrasting environments which may be difficult to fully simulate in captivity. Behavioural measures of welfare can provide information about the adequacy of the captive environment and thus whether the animals' needs are likely being fulfilled (Veasey 2006). Recently, partial ethograms of behaviours in captivity were published for two pinniped species (Australian sea lions, Smith and Litchfield 2010; Cape fur seals (*Arctocephalus pusillus*), Wierucka et al. 2016). These ethograms suggest that regular behavioural monitoring for captive pinnipeds would aid in establishing 'normal' baselines (Maple 2007; Wierucka et al. 2016). For example, basic, long-term data on the topography and frequency of play, affiliative and agonistic behaviours in different species, and in varying contexts, would start to reveal the function and applicability of pinniped behaviours for welfare assessment.

There are no behavioural measures of welfare already validated for pinnipeds. Compared to cetaceans there are likely to be fewer potential measures of social

Fig. 16.2 Photo showing chosen resting position of a wild Steller sea lion (*Eumetopias jubata*): published data and observations of wild pinniped behaviour will aid in understanding of 'normal' behaviours in captivity. (Image credit: Isabella Clegg)

behaviour, due to the (generally) less complex social systems seen in pinnipeds when compared to, for example, cetaceans (Schusterman et al. 2002). Using knowledge of other species' welfare and indications from published pinniped research, some 'pilot' behavioural measures can be suggested:

a. **Inappetence** (poor or reduced appetite) has strong potential as a pinniped behavioural measure. Pinnipeds' appetite for food can be lost or diminished in response to a number of infectious and non-infectious diseases (Gulland et al. 2001), but decreases in response to environmental stress (Mellish et al. 2006) and in response to behavioural stressors, e.g. in the breeding season (Kastelein et al. 1995; Petrauskas and Atkinson 2006). Future studies should discriminate between these contexts and associated levels of inappetence before inappetence can be used as an indicator of poor welfare.
b. **Stereotypic behaviours** are perhaps the most studied potential welfare indicators in pinnipeds, although as with other species in captivity, it is not clear whether animals with stereotypies have worse welfare or improved welfare compared to non-stereotyping conspecifics due to the potential that the activity may function as a 'coping mechanism' in challenging environments (Rushen and Mason 2008). Walruses are a species for which stereotypic behaviour is often

reported (Mason 2010; Kastelein and Wiepkema 1989), with repetitive tusk rubbing being repeatedly cited. In addition to the potential detrimental impacts on the animal's affective state, this behaviour can cause secondary health problems such as tusk pulpitis (Walsh et al. 2001) and thus is likely to be valid measure of poor welfare. Other stereotypies include regurgitation, flipper chewing, pattern swimming, weaving and head shaking (Smith and Litchfield 2010; Hopster and de Jong 2014). As with cetaceans, pattern swimming would require meticulous observation before classification as a stereotypy, to be sure that there is really no function (i.e. that the behaviour is not adaptive or offers functional advantages) and that it does not vary (Clegg et al. 2015). Pattern swimming in pinnipeds can reach high frequencies, e.g. 45% of observed time in Smith and Litchfield's (2010) study, and thus may be detrimental to affective state through the prevention of other activities. Broom (1983) stated that an animal performing stereotypic behaviour for more than 10% of waking time has poor welfare, but this statistic may need to be established as having the same significance when applied to the pinnipeds. Multiple studies have found that provision of enrichment is effective in reducing pattern swimming frequency in pinnipeds (e.g. Grindrod and Cleaver 2001; Smith and Litchfield 2010; Hocking et al. 2015). The next step for this area of welfare research could be to record physiological and cognitive data and use it concurrently with data on stereotypy type and frequency, to explore how these behaviours impact emotions and affective states (Rushen and Mason 2008).

c. **Anticipatory behaviour** related to feeding sessions in captive animals has been suggested as an indicator of affective state (Spruijt et al. 2001), and the approach taken by a study with dolphins (Jensen et al. 2013), which involved assessment of recognised anticipatory behaviours, could be applied to captive pinnipeds, who are also likely to perform this behaviour. Anticipatory behaviour may signify positive expectations of the event to come and thus be a positive indicator of welfare (Spruijt et al. 2001), but concurrently high levels of such behaviours might represent prolonged fixation on the event and lack of other stimulation in the environment. More research in pinnipeds and other species is needed to understand how we might use this measure in welfare assessments.
d. **Agonistic behaviour** is used as a welfare measure in farm animal welfare assessment (WelfareQuality 2009a,b,c; Mononen et al. 2012). Aggressive behaviour has been documented in captive pinniped species, especially during the breeding seasons (Miller 1975; Robeck et al. 2001; Wartzok 1991). Due to the effects of seasonality and sexual dimorphism on aggressive behaviour, measurements of the type and frequency of agonistic behaviour may be of limited use as a welfare indicator; however, the secondary effects of aggressive interactions in terms of wounds (discussed in the next section on health) and social isolation from the group could be investigated as outcome measures of welfare.
e. **Affiliative behaviours**: In terms of behaviours which may indicate positive states of welfare, literature from other species indicates that play and affiliative behaviours may be good candidates as welfare assessment tools (Held and Špinka, 2011). As mentioned before, there are few published studies on play frequency in captive pinnipeds (see Wartzok 1991 for a review). Affiliative behaviours and their link to

emotional state are also very little studied, but there are some potential behaviours which may yield welfare measures, such as allogrooming and 'facial expressions'. Facial expressions have been linked to emotions in other species (Boissy et al. 2007; Waller and Micheletta 2013), and unlike cetaceans, pinniped species display many different facial expressions, some very canid-like (Miller 1975). Naso-nasal contact and the accompanying facial expression were proposed by Miller (1975) as an affiliative interaction for New Zealand fur seals (*Arctocephalus forsteri*) and Pacific walruses (*Odobenus rosmarus divergens*), and this author also suggested that the degree of erection of vibrissae could be used as an indicator of how relaxed the animals were, since for the New Zealand fur seals the vibrissae seemed to be more erect when naso-nasal contact was made with unfamiliar or more dominant animals. In captivity, where breeding is often controlled, and male-male competition limited or eliminated, the distance maintained between animals over time could be investigated as an indicator for the strength of social bonds (accounting for any temperature and space variations, Baldi et al. 1996).

16.6.2 Health-Related Measures of Welfare

Epidemiological measures of disease or pathology incidence can be used as indicators of health and welfare and can be broadly informative. Such parameters have been published for pinnipeds in captivity. Roberts and Demaster (2001) examined the annual survival rate of six pinniped species in 95 different captive facilities and found it to range from 0.957 (i.e. survival rate of 95.7% of the population per year) for the South American sea lion (*Otaria flavescens*) to 0.884 for the Northern fur seal (*Callorhinus ursinus*). Small and Demaster (1995) highlighted that while mortality rate for California sea lions (*Zalophus californianus*) had improved significantly over the years studied, it was significantly higher in the first 40 days after animals were taken from the wild or transferred between facilities (whether captive or wild born), leading them to conclude that homeostasis was significantly disturbed during this acclimation period and that it was the most stressful time for the animals. Mason (2010) used mortality rates and reproduction success in a captive and wild pinniped species to hypothesise that walruses were more likely to have 'relatively poor welfare' in captivity and grey seals (*Halicheorus gypus*) likely to have 'relatively good welfare'. While this approach provides a starting point for pinniped welfare research based on the blunt indicator of mortality, animal-based indicators measurable in real time are more likely to be accurate in determining day-to-day welfare impacts.

The relationship between health and welfare states is complex (Boissy et al. 2007; Mason and Veasey, 2010), and, as in Chap. 12 of this volume, we consider here how health and disease may cause changes in affective state. In many other species, health status data is used as a welfare measure (concurring with "feelings-based" welfare definitions, e.g. Fraser et al. 1997; Mason and Veasey 2010). Pinnipeds can contract a number of debilitating diseases and health problems in the wild and in captivity (wild, Bossart 2011; captive, Dierauf and Gulland 2001). One of the most

revealing analyses for animals in relation to health status comes from records of haematological sampling, and several studies have published data for captive pinnipeds (Roletto 1993; Mellish et al. 2006; Trumble et al. 2006). Roletto (1993) compared profiles in healthy and "diseased" animals in 395 California sea lions, Northern elephant seals (*Mirounga angustirostris*) and Pacific harbour seals (*Phoca vitulina richardsi*) over 6 years. This author found that the animals experiencing a range of diseases had significantly higher red blood cell counts, haemoglobin values, haematocrit and blood urea nitrogen among others, but that the different white blood cells measured were highly variable and could not always be used to predict health status. The animals studied by Roletto (1993) were those being rehabilitated after stranding, and this is likely to have resulted in variation from 'normal' haematological baseline values. Considering that captive pinnipeds are intelligent, adaptable and trainable (Schusterman et al. 2002) and can, in some cases, voluntarily participate in medical husbandry procedures (Brando 2010), captive facilities could potentially publish the baseline data found in each species to facilitate the use of blood parameters in future welfare assessment of the welfare impact of disease states.

Eye pathologies in captive pinnipeds are common and have been attributed to pool design and water quality (Colitz et al. 2010; Gage 2011) (Fig. 16.3). Although cataracts and lens luxation are common age-related diseases in humans and other animals, additional risk factors for their incidence in captive pinnipeds were identified by Colitz et al. (2010). These risk factors include insufficient access to shade, a history of fighting and previous ocular disease. Access to shade (or deep water) is likely a crucial resource-based measure of welfare for pinnipeds and is stipulated in the AWA (1966), but could be more conservative, i.e. more rigorous, as proposed by Clegg et al. (2015) for dolphins. Although pool colour was not reported to be a significant factor in Colitz et al.'s (2010) study, the authors nevertheless suggest that colour should be considered for inclusion in welfare assessments. Individual clinical measures of eye disease could follow the standardised method suggested by Clegg et al. (2015) in which a photographic scale (reference scale) is used (see Chap. 12). Photographic reference scales of eye opacity and squinting in pinnipeds

Fig. 16.3 Cataracts and lens luxation are commonly seen in pinnipeds in captivity: the photo shows a severe case in a California sea lion *(Zalophus californianus).* (Image credit: Isabella Clegg)

could be developed, and these would allow facilities to assess the severity of eye pathologies. Consequently such data could be pooled between facilities and correlated to other behavioural and physiological data to help to understand how this problem impacts the animals' affective states.

Body condition scoring (BCS) is another useful tool which could be standardised to allow assessments of the deposition of tissue and body fat on an animal, as is widely used in welfare assessments for other species (WelfareQuality 2009a,b,c; Mononen et al. 2012; Clegg et al. 2015). Although the link between BCS and affective state is unclear (Roche et al. 2009), as with eye pathologies, a standardised scoring system could encourage widespread data collection. The pinniped literature provides a strong background for protocols to measure body condition which have been used in number of past health assessments (e.g. Castellini et al. 1993; Guinet et al. 1998; Trites and Donnelly 2003), and ultrasound imaging of tissue and fat reserves could be a useful validation tool for this measure (Mellish et al. 2004).

Interspecific aggression which leads to injuries is a prominent and common wild behaviour (Bartholomew 1970; Chilvers et al. 2005; Wartzok 1991) and in terms of captive animal welfare represents an interesting dilemma in so far that it warrants the question whether wild welfare states are the sole sought-after standard. Pinnipeds species are generally sexually dimorphic and some of the most polygynous of all animals (Riedman 1990): males fight during and around breeding seasons, subadult males practice fighting and mating skills and females defend their resources and pups, and as a result interspecific injuries are common, often debilitating, and sometimes fatal (Fig. 16.4). For example, 84% of females had permanent interspecific-injury scars in a New Zealand sea lion population (*Phocarctos hookeri*), 0.5% of the

Fig. 16.4 Two male Northern elephant seals (*Mirounga angustirostris*) fighting, a behaviour which is often linked to high rates of morbidity and mortality. (Image credit: Ari Friedlaender)

breeding females were killed by males each year (Chilvers et al. 2005) and around 6% of pups born each year in a northern elephant seal population were killed by males (Le Boeuf 1974). Body injuries are a valid assessment of welfare due to their direct and indirect effects on affective state (Broom 1991; Welfare Quality® 2009a,b,c; Mononen et al. 2012). Furthermore, injuries are evidence of interactions that are not always observable and thus are a proxy indicator of aggression (Scott et al. 2005). For these reasons cetologists have taken steps to try to quantify bodily injuries (Scott et al. 2005; Clegg et al. 2015). For pinnipeds, systematic reviews of past research are needed, since behavioural data and mortality rates are sometimes available concurrently, which might enable the creation of methods to quantify the level of injuries on the body and set thresholds for poor welfare. This method could be a simple accumulation of systematic estimations, such as that described for cetaceans in Clegg et al. (2015), in which old scars and new injuries were quantified separately. The data might then be correlated with levels of aggressive behaviour and inappetence. Monitoring of aggression levels in captivity will help us to understand if there is a threshold level of injuries above which welfare decreases rapidly.

Physiological welfare measures for captive pinnipeds provide information on animal emotions and thus can support and validate other measures (Boissy et al. 2007). Faecal glucocorticoid levels were measured in Steller sea lions in response to season (Petrauskas and Atkinson 2006) and medical and restraint procedures (Petrauskas et al. 2008). No significant differences resulted from these variables, but there was much individual variation found between the experimental groups. Kershaw and Hall (2016) found that wild harbour seal (*Phoca vitulina*) plasma cortisol spiked in response to a capture procedure, but that blubber cortisol did not, instead varying significantly with season and sex. Myers et al. (2010) investigated variance in serum cortisol levels in wild and captive Steller sea lions, which was elevated in breeding and annual moult months. Risk factors associated with stress at sampling could be significantly reduced if the most stressful elements of the procedure were understood, and of course could be removed entirely with the use of positive reinforcement training techniques. More theoretical and practical data is required to 'make sense' of the welfare picture as described by glucocorticoids measures, including accounting for the likely physiological differences between the action of terrestrial and marine mammal stress hormone (Atkinson et al. 2015).

16.6.3 Cognitive Measures of Welfare

Cognitive measures of welfare aim to assess the appraisal of emotions, whether conscious or unconscious (Mendl and Paul 2004; Paul et al. 2005). They are the least explored of the 'welfare assessment methods', when compared to the behavioural and health components of the Triangulation approach (Webster 2005), but there are promising new techniques derived from human and other species research (Mendl and Paul 2004; Rogers 2010) which could be applicable to pinnipeds.

Measures may be easier to apply to pinnipeds in captivity than their wild counterparts (Rosen 2009), and since cognitive tests are often based on experimental psychology and require repeated measures, past data and training of the animals, researchers in captive facilities could take the lead in this area of pinniped welfare.

Similar to our assertions for cetaceans in Chap. 12 of this volume, we suggest one of the most promising cognitive measures of pinniped welfare might be cognitive bias testing. Cognitive bias describes an individual's appraisal of ambiguous stimuli, which the individual animal may interpret positively or negatively, and has been shown with other animals to be closely linked to welfare. For example, animals kept in impoverished environments, with anxious dispositions, or subject to physical examinations, i.e. situations likely to induce poor welfare, judge the ambiguous stimuli more negatively (Mendl et al. 2009). The design of tasks created to test this has, in the past, included Go/No-Go or active response operant discrimination tasks, using spatial, visual or auditory cues, and these sorts of tests would certainly be feasible with captive pinnipeds. Schusterman et al. (2002) share their experiences of training cognitive tasks with sea lions, which could be used when designing such future studies. They found that animals retained language-representative signals for short periods of time when other distracting stimuli were present, but were able to successfully compare sample stimuli for extended periods, and thus seem to demonstrate easily disrupted short-term memory but a reliable, accurate long-term memory (Schusterman et al. 2002). If a condition of supposed poor or enhanced (e.g. addition of enrichment) welfare is imposed, cognitive bias results may confirm that these resources have impacts on welfare. Furthermore these results could be correlated to other animal-based measures of welfare to validate them.

Other cognitive measures with possible links to welfare include laterality and tests of preference and motivation. Brain and behavioural lateralisation is the differential processing of stimuli by the brain's left and right hemispheres, which can then translate into lateralised behaviours (Rogers 2010). A study of pinniped lateralised behaviour in the wild was conducted, with walruses seeming to prefer the right flipper for feeding (Levermann et al. 2003). A small number of studies were carried out in captivity: California sea lion populations showed directional swimming dependent on sex (Wells et al. 2006) and a right-ear preference for adults listening to conspecific calls (Böye et al. 2005), and directional swimming was recently reported in northern fur seals (Pryaslova et al. 2009). The link between lateralisation and animal welfare has been reviewed by Rogers (2010), and it appears that the left hemisphere deals with non-stressful and the right deals with stressful emotions (Leliveld et al. 2013). Although there exist examples of lateralisation in certain contexts, these traits have not been explored widely as species-specific welfare measures. Nevertheless further studies are encouraged in pinnipeds, and lateralisation data could be collected alongside other experimental data, as laterality can be relatively simple to measure. Preference and motivational tests can indicate which resources the animal seeks and how hard it is willing to work for them, and when different conditions are imposed, the internal appraisal of the resource in relation to external factors can be revealed (Gonyou 1994; Paul et al. 2005; Boissy et al. 2007). In terms of welfare, this can indicate those resources which the animals covet most, and as a next step, the provision of these resources could be used to test potential behavioural and physiological indicators of positive welfare.

16.7 Animal-Based Welfare Measures for Pinnipeds in the Wild

16.7.1 Behavioural Measures of Welfare

Pinniped species divide their time variably between land and sea and can spend from days to months at sea on foraging trips (Riedman 1990; Renouf 1991). Due to the difficulties of underwater observations of these highly mobile animals, behavioural measurements of wild pinnipeds have traditionally been on land (Renouf and Lawson 1987). Therefore we must remain conservative in our suggestions for animal-based welfare measures, since these are likely to be based on limited knowledge of the full behavioural repertoire of the animals.

First we discuss those behavioural measures proposed in the captive pinniped section which also merit investigation in wild populations. Examples of measures which may assess positive affective states include naso-nasal contacts, allogrooming, play and the level of contact between individuals. Renouf and Lawson (1987) found patterns of play over time in harbour seals, showing that adults played almost as much as juveniles, that solitary play was far more frequent than social play and that there were sex differences in frequency and type of play. These authors suggested that the high levels of adult play may represent reduced foraging and energetic pressures and thus would be an indicator for other needs having been satisfied. Wartzok (1991) pointed out that play behaviour may, to one of the participants, be stressful and injurious and still function as play for another, as is the case with older males play fighting or during sexual play with younger animals. Quantifying and defining play is the first step towards its use in welfare assessment but definition of what constitutes play is recognised as a difficult challenge (Held and Špinka, 2011). A recent study proposed an intensity index for play in captive elephants (Vicino and Marcacci 2015), an approach which could be applied to wild and captive pinnipeds. Miller (1975) and Renouf and Lawson (1987) among others have expressed the opinion that a significant amount of pinniped play occurs underwater, and thus future efforts could aim to document this important part of the behavioural repertoire. The distance between individuals could also be a measure of positive (or negative) welfare but would need much investigation first, as the effects of temperature and space available would have to be tested, and 'distance adoption behaviour' may only be a measure applicable outside of the breeding season. Nevertheless, Baldi et al.'s (1996) study on southern elephant seals (*Mirounga leonine*) inhabiting a stretch of coastline with an unusually large amount of available space showed that the females tended to keep a distance of between one and two body length from each other. Smaller-scale differences within this range of 'distance maintained' could be measured to explore whether this may be used as a sign of affiliation (and thus positive affective state), since existing research supports the positive aspects of social recognition and long-term bonds which are seen in pinnipeds (Wartzok 1991; Schusterman et al. 2002; Insley et al. 2003).

Aggression is common within wild pinniped groups and should be considered a potential welfare measure. Excessive levels of aggression have often been used as an indicator for poor welfare states (Swaisgood 2007; Welfare Quality® 2009b), whether caused directly by social interactions or as result of displaced aggression (Broom 1991; Gonyou 1994). Although the frequency of aggressive behaviours per se could not be used alone as an accurate welfare indicator without consideration of other factors, including seasonality and space available, measures such as position in the hierarchy and vigilance behaviour could indicate the level of social stress experienced by individuals. The literature on other species shows that the most stressful hierarchical position in a group can either be the most dominant or the most subordinate individuals and varies between species, with possibilities for intraspecific variability (Abbott et al. 2003; De Vries et al. 2003; Sapolsky 2005). Pinniped species differentially engage in territorial defence or dominance hierarchies to maintain harems of females, with phocid species especially favouring a hierarchical system (Riedman 1990). The dominance hierarchies of male grey seals (*Halichoerus grypus*) in three populations were quantified (Twiss et al. 1998), and further work in this species suggests that levels of aggression are more related to proximity and familiarity of the closest neighbour than to dominance (Bishop et al. 2015). Therefore the chronic social stress in such systems might result from disturbances to social stability and as a result of space restrictions (Bishop et al. 2015). Future studies might control these factors and enable measurement of the frequency of aggression indicators and other physiological indicators to reveal the effect on welfare.

Pinnipeds are one of the most vocal mammalian taxa (Schusterman et al. 2001). Vocal behaviour in other species is used as a measure of welfare, since vocalisation is likely to accompany a particular mood or emotion. However, in order for the emotional state to be indicated, there must be well-established understanding of the 'meaning' of the vocalisations (Manteuffel et al. 2004). Schusterman et al. (2001) concluded in their review paper that pinnipeds have consistent calls (some similar between species) for mothers reuniting with pups and during threats, alarm and aggressive behaviour. Miller (1975) noted that 'whimpering' in male New Zealand fur seals occurred in 'mild distress' situations: during territorial swimming, accompanying mild threat displays, and in interactions with females. Vocalisations linked to these contexts could be tested in relation to affective state (i.e. alongside other potential welfare measures), and more work is needed to define the vocal nuances for each species before welfare states can be assumed or alluded to. Captive pinniped research teams could focus their research efforts in this area (mapping of vocalisations), as data collection could build on the results of current studies (Schusterman et al. 2001) and through collaborations with wild animal studies.

16.7.2 Health-Related Measures of Welfare

Like cetaceans, pinnipeds are considered sentinels of ocean health since they are high in the food chain and mobile, gregarious animals, thereby able to provide us with biomarkers of the state of the environment (Bossart 2011). Reviews of the pathologies in pinniped diseases are found elsewhere (Dierauf and Gulland 2001; Bossart 2011), but here

we are concerned with measures which correspond to the animals' affective state. Our suggestions discussed for captive pinnipeds (Sec. 16.3) for how blood analyses and cortisol measurement might relate to welfare which are potentially applicable to wild pinnipeds. Bringing together findings from both wild and captive studies could increase the efficiency of data use, adopting the 'three Rs' principles (refine, reduce, replace) and so lessen the stressors to wild and possible endangered animals (Nolen and Bishop 2001). 'Sickness behaviours' are caused by disease impact on affective state and include anorexia, lethargy, depression and antisocial behaviours (Broom 1991; Sneddon et al. 2014). Documentation recording the frequency of these behaviours and of any changes in accompanying behaviours or physiology in wild pinnipeds would greatly assist work in this area. Millman (2007) suggests that these sickness behaviours should be included within welfare assessments and explores the theory that sickness behaviour is a motivational state which competes with other needs dependent on the context.

In addition to contracting diseases, wild pinniped populations have been observed to undergo severe nutritional stress (Trites and Donnelly 2003; Rosen 2009). The health and physiological changes in pinnipeds resulting from starvation or shortage of food include metabolic depression, poor body condition, immunosuppression and a blood profile typical of the sequential starvation process: elevated blood glucose (carbohydrate utilisation), followed by elevated ketone and non-esterified fatty acid levels (fat utilisation), followed by elevated blood urea nitrogen which signifies protein metabolism in the last stage of starvation (Trites and Donnelly 2003). Epidemiological measures during times of nutritional stress in pinnipeds include reduced growth rate, reduced pup survivability, increased mortality rate and reduced reproduction success rate; these data can reveal the early stages of food deficiencies and could be used to select populations for validation of other animal-based welfare indicators. Rosen (2009) reviewed the results of captive studies conducted on nutritional stress and emphasised how collaborative efforts between researchers focusing on either the wild or captivity can help to identify the tangible and measurable effects of a lack of, or a reduction in, available food.

A standardised body condition scoring protocol and method of wound quantification, as discussed in the captive pinniped section (Sect. 16.6), would also aid welfare measurement of wild pinnipeds for the same reasons. The assessment of wounds on wild animals may sometimes be hindered by visibility issues, and a potential tool could be the use of thermal imaging cameras as presented in Walsh and Gaynor (2001), used by these authors to assess infection in conspecific wounds in captive California sea lions and walruses. This technique could be validated in captivity where the severity of wounds assessed through thermograms could be correlated with external appearance, haematology and behavioural indices and then used in wild pinniped studies.

16.7.3 Cognitive Measures of Welfare

Experimental cognitive studies are logistically harder to conduct in wild animals, and in the past, simple 'counts of cognition' per taxonomic species have been used as an indicator of intelligence level (Lefebvre 2010). Schusterman et al. (2002)

hypothesised that pinnipeds have advanced problem-solving abilities, as demonstrated by their raiding of fisherman's catches, and these authors' captive cognition studies showed that California sea lions classify stimuli successfully and can recall elements easily from long-term memory, skills useful for social interactions, foraging and vigilance behaviour in the wild. However, when looking for cognitive measures of welfare, the focus is more on how the animals process emotional experiences and how this affects the treatment of other information (Paul et al. 2005): for these topics, there are very few studies yet concerning any wild animal species.

Earlier in this chapter, we presented the advantages of cognitive bias tests as non-invasive measures of welfare which are capable of drawing together other multidimensional indicators. Although cognitive bias studies have previously not been conducted with any wild animals, there may be potential to assess such biases in a passive way (without the operant conditioning step) through using salient stimuli in the animals' environment which are already associated with positive or negative outcomes (Brilot et al. 2009). In addition to cognitive bias, Paul et al. (2005) also suggest attention and judgement biases as welfare measures, where affective state is shown to impact decision-making or attention to a task, and again such experiments could be possible with wild pinnipeds. With captive three-spined sticklebacks (*Gasterosteus aculeatus*), Purser and Radford (2011) show how such tests may reveal impacts on affective state which were being missed before: they found that although their imposed condition (noise) only induced a mild fear response, there were significant increases in food-handling errors and decreased food to non-food discrimination which led to overall reduced foraging efficiency. These studies could be attempted with wild pinnipeds, for which anthropogenic noise and disturbances might be good candidates for an assumed deleterious condition. Lastly, as reviewed earlier in this chapter, behavioural lateralisation could potentially reveal aspects of affective states and thus welfare which are otherwise not accessible (Rogers 2010). Studies could continue to build on existing laterality findings with pinnipeds (Levermann et al. 2003; Böye et al. 2005; Wells et al. 2006; Pryaslova et al. 2009), perhaps with more focus on collecting multidimensional data on potential emotional states at the same time.

16.8 Recommendations for Developing Measures of Pinniped Welfare

Although only one study thus far has explicitly aimed to assess pinniped welfare (Hopster and de Jong 2014), the literature reviewed in this chapter shows that there is enough reported knowledge to support initial investigations. There is very little 'emotion' research in pinnipeds, and since welfare is a balance of affective states made up of moods and emotions (Spruijt et al. 2001; Mendl et al. 2010), this topic should be established further in order to facilitate welfare research. Other species' emotion research can contribute to the foundations of measures applicable to pinnipeds: Mendl et al. (2010) offer theoretical and practical advice for advancing

animal emotion research, and Boissy et al. (2007) present robust indicators of positive emotions in terrestrial mammals, e.g. play, inter-animal distance, and allogrooming. Désiré et al. (2002) stipulated that to investigate emotions (in their case with farm animals), fine-scale behaviours such as posture and body position must be studied as opposed to only the more obvious actions, and this is likely to also be true for pinnipeds.

With cetaceans, a welfare assessment has been proposed for bottlenose dolphins (*Tursiops truncatus*) since they are one of the most studied species and the most commonly kept in captivity (Clegg et al. 2015). The same approach could be used with pinnipeds, where California sea lions, Steller sea lions, northern fur seals and harbour seals might be the first to be assessed for the welfare impact of captivity. Welfare studies should always be conducted in situ in the environment the animals are inhabiting (Dawkins 2006). Initial welfare research on baseline behaviours for these well-studied species would be best conducted outside of the breeding season, since marked behavioural and physiological changes often occur (Riedman 1990; Robeck et al. 2001; Kershaw and Hall 2016) which may distort the data collected and mask the welfare significance from the parameters assessed. However, clearly these periods should not be ignored, as they are often the source of high levels of stress and injury for the animals (Le Boeuf 1974; Chilvers et al. 2005; Fig. 16.4), and thus could be used in the context of validation of measures used to assess 'poor welfare' (discussed earlier in this chapter, e.g. injury extent, excessive aggression, body condition).

Other contexts for validation of measures can be used, and for wild and captive pinnipeds, this could involve situations in which there is human interaction. Similar to our discussion in Chap. 12 for cetaceans, welfare data could be gathered during interactions and used to explore correlations among sets of measures. For example, a recent phenomenon has been the stranding of California sea lions along the central Californian coast, where the causes listed include leptospirosis (*Leptospira interrogans*) infection, domoic acid poisoning, malnutrition (sometimes with gastric ulcers) and human interactions (Greig et al. 2005). Data on measures such as body condition scoring, inappetence and play/vocalisation/activity level could be taken from animals with chronic infections and compared with those which stranded, but were clinically healthy (as occurred in 0.7% of strandings from 1991 to 2001, Greig et al. 2005). In wild pinnipeds, entanglement in marine debris can cause significant injury and debilitation and affect a measurable proportion of some pinniped populations (Butterworth et al. 2012) (also see Chap. 13 this volume): the proposed welfare measures discussed in this chapter could be applied to these animals as part of the assessment of the poor welfare caused by marine debris.

In captivity, pinnipeds usually receive their food within multiple training sessions, and thus there is potential for the human-animal relationship (HAR) to be a factor in enhancing or reducing welfare (as with other captive species, Waiblinger et al. 2006; Whitham and Wielebnowski 2013). California sea lions can use the pointing gestures of their trainers as referential cues, suggesting that through their habituation to humans, they have learned to exploit human body language (Malassis and Delfour 2015). Captive pinnipeds' behaviour towards trainers during training

sessions could be measured to indicate whether they find this interaction aversive, neutral or positive. For example, vocalisations have been proposed as an emotional indicator in pinnipeds (Schusterman et al. 2001), and approach/avoidance tests could also be applied, as they have with dolphins (Clegg et al. 2015). Once basic indicators of pinniped emotional state are established, different human interactions in captivity might be used as either a situation where good welfare is likely (e.g. cognitively enriching training sessions, Clark 2013) or where poor welfare is likely (e.g. some travelling circuses, Hopster and de Jong 2014; when being transported between facilities, as with cetaceans, Castellote and Fossa 2006).

16.9 Conclusions

Past research has described the behaviour, health and cognition of captive and wild pinnipeds, and this foundation of published material can be used to progress the application of welfare research and welfare assessment methods for pinnipeds. There are no existing established pinniped welfare measures per se as yet, but proposals for indicators in cetaceans and other terrestrial mammals show some significant potential for creation of pinniped species-specific tests, tools and measures. There is very little emotion research thus far in pinnipeds, and this topic should be established further in order to facilitate welfare research and could include development of indicators of positive emotions—play, inter-animal distance, allogrooming and the use of fine-scale behaviours such as posture and body position. The breeding season should be carefully defined as a context but not ignored, as this is often a period of high levels of stress and injury for the animals. The first pinniped welfare investigations might benefit from focussing on those species most well studied and commonly kept in captivity. Human interaction with both captive and wild pinnipeds is likely to be important to their welfare: captive pinnipeds' behaviour towards trainers during training sessions could be measured to indicate whether they find this interaction aversive, neutral or positive. In wild pinniped populations, entanglement in marine debris negatively impacts many animals, and measures discussed in this chapter could be applied to these animals to assess the welfare impact of debris, as well as validating objective welfare indicators for use in other contexts.

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