A Review of the Scottish Marine Animal Stranding Scheme

Sea Mammal Research Unit
Report to
Marine Scotland, Scottish Government

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Contents

1 Short summary of recommendations

This review is in response to a request from Marine Scotland to assess the current delivery and effectiveness of the stranding scheme in Scotland. A number of recommendations have been made and are summarised below. However, more details on each can be found in Section 11, Specific Recommendations. These are not listed in any order of priority.

1. The importance of monitoring aspects of biology, to address trends in life history parameters, as well as monitoring long term health status and emerging diseases was a recommendation from the previous review that has not yet been fully addressed by the scheme for a number of reasons outlined in the report. This recommendation was also reiterated by some of the stakeholders whose views were invited. It is suggested that, for a number of priority species, a cohort of individuals could be identified each year for more in-depth studies. Species such as harbour porpoises, bottlenose dolphins and harbour seals could be high priorities for these more in-depth studies.
2. Only a small proportion of the seals (e.g. in 2015 approximately < 10% of grey seals and <2% of harbour seals) taken under licence are retrieved and obtained by SMASS for post mortem examination. This is unfortunate as they represent a very useful sample of overtly healthy individuals from the population, providing important baseline health and biological data. However, without the assistance of the licence holders it is difficult to envisage how the recovery rate might be improved, other than increasing awareness of their value.
3. SMASS is currently embedded within the UK CSIP scheme which has advantages. Emerging issues and analyses can be investigated at a UK level. However, the main disadvantage is the complexity and confusion in the management aspects that this causes. In terms of delivery this complexity does not appear to cause any issues, but additional cost savings may be made if the Scottish scheme were to be managed independently, with the funding available going directly to SMASS. Conflicting priorities could also be avoided.
4. There is a backlog of histology samples to be processed. No time schedule is set for the completion of each case. This is understandably due to the fact that the agreement for carrying out this work relies heavily on goodwill and collaboration with the veterinary pathologists working on the samples. It would be worth investigating the current agreement and partnership, with a view to finding out what the bottlenecks and constraints are, and suggesting ways to improve the current turnaround time.
5. The number of seals (particularly harbour seals) examined at post mortem is lower than target (e.g. approximately 30 were necropsied per year between 2012 and 2015; the target being between 40-50). There are a number of reasons for this, which may be insurmountable. However, discussions with Marine Scotland and the Steering Group should be instigated to see if there are ways to increase this, or if there is value in responding to those in poorer states of decomposition.
6. The standard post mortem protocol that is used across virtually all stranding schemes in Europe needs to be updated. Some progress towards this has been made and whilst this is not a priority task that should be driven by the SMASS team, we would encourage them to be closely involved in this process.
7. The freezers used for the storage of the archived tissues will need to be moved as the Veterinary Centre in Inverness, where the SMASS team are currently based, is closing. What tissues and how they should be archived needs to be reviewed regularly. This requires input from the Steering Group, once the future plans for housing the scheme's archive have been agreed and it is clear what the space limitations and the sample storage provisions will be in future.
8. Information about what data and samples exist needs to be much more readily accessible. One option to improve links with other researchers across a wide range of disciplines would be to provide much more detail on what's available and allow access to the sample metadata on the SMASS website. Advertising the holdings in other fora, such as within the Marine Alliance for Science and Technology Scotland (MASTS) community, would also assist in widening access

and the potential for collaboration. The US National Marine Fisheries Service have a National Marine Mammal Tissue Bank which holds samples available for research purposes. It would be worth investigating how this is managed and advertised.

9. The scheme is currently run through a veterinary centre within the SAC Consulting Veterinary Services at Scotland's Rural College (SRUC) which does not give the team ready access to students for projects. Setting up a series of 'standing' student (both undergraduate and postgraduate Masters) projects across Universities would also increase the utility of the samples and data collected. Research meetings could be established on an annual or biennial basis, inviting researchers from the terrestrial and even the human forensic community to attend, could provide further links. Closer links with the Vet Schools in Edinburgh and Glasgow could also facilitate wider research uptake.
10. Other studies which focus on aspects across a broad biological spectrum are not necessarily research topics that could be led by the SMASS team. Long term collaborations could be established with other researchers with the skills and expertise and the track record who could lead these projects. Alternatively, the SMASS team could be expanded to include a biologist whose remit it would be to obtain research funding and carry out projects that would specifically investigate biological questions or conduct other appropriate comparative physiology and genetic studies.

2 Background

Marine mammal strandings schemes, co-funded by Defra, Scottish Government and Welsh Government, have been operating across the UK since the early 1990s and in 2000, these separate schemes were amalgamated into a single programme named the UK Cetacean Strandings and Investigation Programme (CSIP) with the overall aim of monitoring and sampling stranded cetaceans across the country.

The UK CSIP is currently co-ordinated by the Institute of Zoology (IoZ) in London, who subcontract the SAC Consulting Veterinary Services at Scotland's Rural College (SRUC) in Inverness to undertake collection and post-mortem studies of stranded cetaceans, turtles and basking sharks in Scotland. In 2008 Scottish Government initiated a review of Scotland's CSIP and following their recommendations it expanded the original programme to include seals under the Scottish Marine Animal Strandings Scheme (SMASS). This extended programme offers a wider surveillance of marine mammals in Scotland which builds on the work being undertaken within the UK CSIP. The SMASS now undertake the most extensive marine stranding surveillance in the UK. The principal requirement of SMASS is to provide a co-ordinated approach to the surveillance of marine species (e.g. cetaceans, seals, basking sharks and marine turtles) strandings and to investigate the major causes of death of stranded marine animals in Scotland. In addition, the project works towards increasing awareness of the scheme and its research to improve reporting and investigations of strandings in Scotland with the ultimate purpose of further developing a Scotland-wide strandings network.

Whilst it is important to ensure that a coordinated approach to marine mammal research and data collected in response to strandings is maintained throughout the UK, there are regional differences that need to be addressed. In particular, there are obligations in Scotland that differ from those in England and Wales, particularly in relation to seals. Under the Marine (Scotland) Act 2010 seals can only be taken under licence which is not the case in England and Wales under the Conservation of Seals Act 1970 where seals can be taken outside the close season (subject to conservation orders). Thus, in March 2017, Marine Scotland instigated a second review of SMASS, the purpose of which is to re-consider how the scheme operates in Scotland and how well it has been addressing Scottish issues.

The **aims** of the review are to:

- Assess the current delivery of the strandings scheme in Scotland;
- Review how SMASS currently operates and how it has progressed the findings of two focussed workshops which were held in 2012 as part of the strandings scheme 20th Anniversary;
- Explore the value added that can be achieved from the scheme and produce options to develop the research element of the scheme which will utilise the wealth of data collected from stranded marine mammals. This must not compromise the current delivery of the scheme's objectives and continue to address the Scottish government mandatory policy responsibilities;
- Consider how the development of the volunteer network can build on the established scheme.

The **objectives** of the review are to:

a) **Review the effectiveness of the current programme for delivering against the scheme's agreed objectives.**

- Assess the specific Scottish policy drivers and conservation threats and whether the scheme addresses these adequately;
- Review the scheme's ability to contribute to new policy or policy change;
- Consider whether the number of post-mortems undertaken each year are sufficient to fulfil the surveillance core function;
- Review how samples are handled (given the limitations on storage). Are the samples still fit for purpose?

- Where the scheme is not effective in delivery, provide recommendations that can be implemented by Marine Scotland and the current contractors.

b) **Explore the opportunities to utilise the wealth of data collected thorough the scheme and identify further research collaborations and network links (UK, European and further afield).**

- Review the outputs of the project and its active collaborations in terms of whether the data are being utilised to its full potential. Where appropriate, identify organisations in Scotland (and wider) interested in marine mammal conservation issues which can collaborate with SMASS;
- Is the data being effectively managed, backed up and archived so that it will be accessible into the future?
- Provide a series of options on how SMASS can further create links with wider UK research on marine mammals;
- On the basis of outputs from the schemes, develop a series of recommendations for potential future research that SMASS could be leading.

c) **Review and critically reflect on the effectiveness of the complex management and funding arrangements involved in the current scheme.**

- Review links with the UK CSIP and whether these are meeting Marine Scotland's requirements in terms of management/ delivery/outputs. Is an alternative approach required?

d) **Recommend improvements on how to deliver greater value for money (include a cost benefit analysis).**

- Consider how the scheme currently operates and identify whether there are opportunities to reduce cost of operations given its current level of output delivery. If any such opportunities exist, they should be clearly identified along with potential cost savings.

e) **Other information that the review should address includes:**

- Review current protocols for handling Mass Stranding Events (MSEs) in Scotland and whether there are opportunities to improve current practices? Consider current management protocols and whether a need exists for greater management and co-ordination of such events in Scotland?
- Review the volunteer network and whether there are opportunities to further expand and develop this capacity.

2.1 Approach to the review

Meetings with the SMASS team, including a visit to the current laboratory and post mortem facilities in Inverness and email exchanges, provided information for this review. For some of the sub-objectives listed above, further information was also received from the SMASS team in response to specific questions (not obtainable from the 2012 workshop reports and the interim and annual reports submitted to Marine Scotland and the Steering Group that were also referred to) and these are given in separate sections under the relevant sub-objectives.

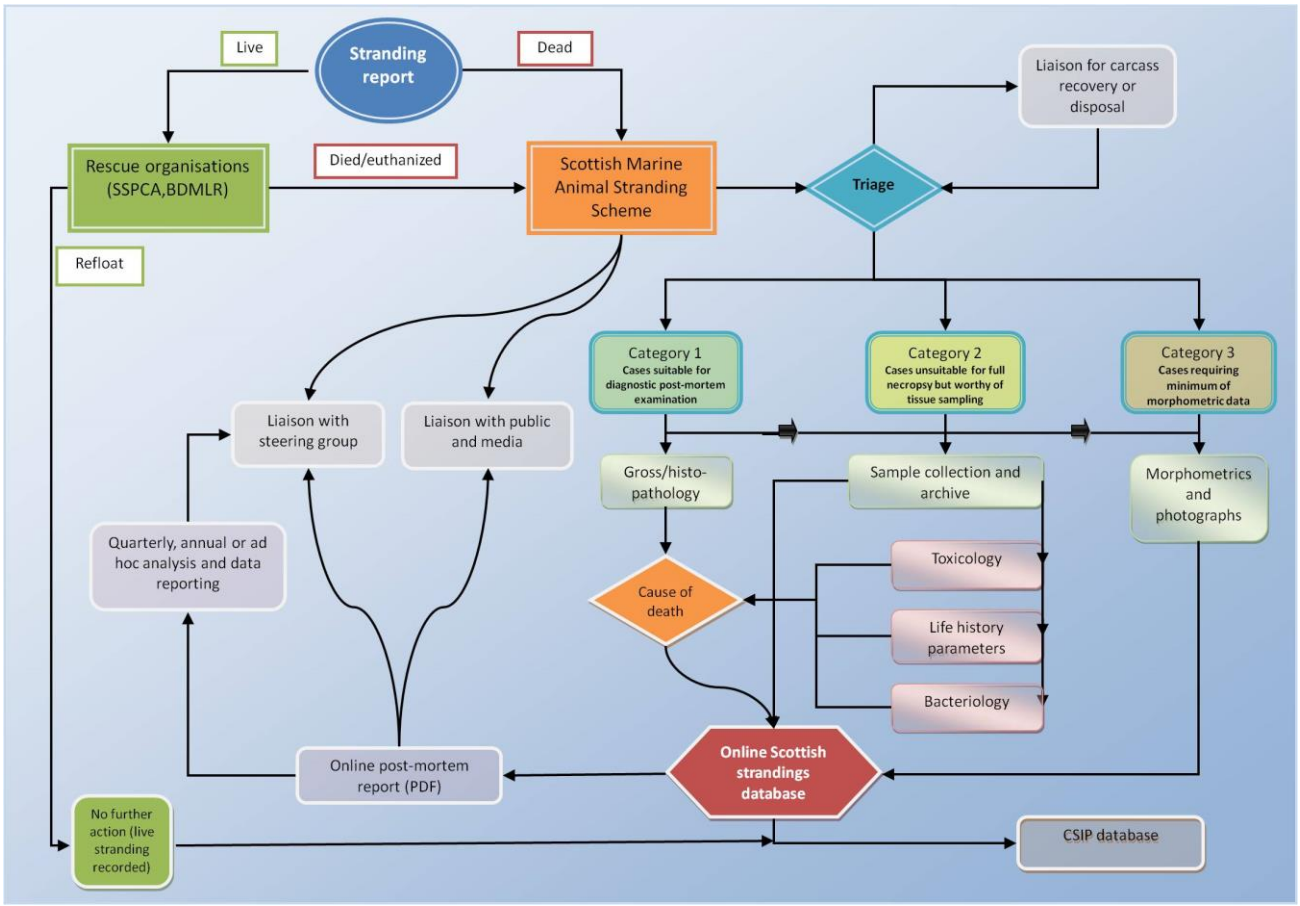
Two anonymous online questionnaires were circulated, one to the stakeholders and partners in the scheme; Joint Nature Conservation Committee (JNCC), Scottish Natural Heritage (SNH), the Moredun Research Institute, Scottish Association for Marine Science (SAMS) and University of Highlands and Islands (UHI) and Marine Scotland, and the second to a selection of identified research groups and Universities that may or may not currently collaborate with SMASS but who, from their research portfolios, have an interest in marine mammal research.

3 An overview of the Scottish Marine Animal Stranding Scheme

The SAC Consulting Veterinary Services at Scotland's Rural College (SRUC) in Inverness currently holds a sub-contract via the Institute of Zoology for the UK CSIP to investigate and respond to cetacean, turtle and basking shark strandings in Scotland. All data are then integrated across the UK by the coordinators. Not all stranded cetaceans are responded to and an assessment about whether to go out into the field to carry out a limited examination and collect samples (which can be either members of the SMASS team or trained volunteers), or whether to collect the carcass and return it to Inverness for full post mortem examination, is carried out by the strandings co-ordinator. This decision is made on the basis of various criteria, including location, reliability of report, state of carcass and current scheme priorities. SMASS employs a full-time technical assistant/strandings co-ordinator and a veterinary pathologist to respond to stranding reports. A stranding assistant on a short-term contract is also currently part of the team.

A schematic showing the processes involved is given in Figure 1 below. The data (strandings, causes of death and associated information collected at post mortem) are held by SMASS but are also fed into a central database held by the UK coordinators at CSIP. The details of the objectives and work programme for the current SMASS project are given in Appendix 1

Figure 1. Schematic showing the processes involved in SMASS (courtesy of A. Brownlow).



4 Effectiveness of current programme

4.1 Policy and Other Drivers

A marine mammal strandings scheme has the ability to address several objectives. These include concerns about animal and human health, conservation policy and scientific endeavour. The SMASS can assist in

all these areas, as well as providing the key biological information on feeding habits, mortality and reproduction for many species that cannot be studied directly.

Marine mammals, and cetaceans in particular, have a high public profile, and animals that are found on beaches often initiate interest from the press and public. Sampling stranded animals may therefore help to engage and inform the public about wider marine issues, while understanding the cause of death of such animals addresses a public need for information, and serves to inform policy makers of any epidemic or endemic diseases that may have a population level consequence, or human health implications.

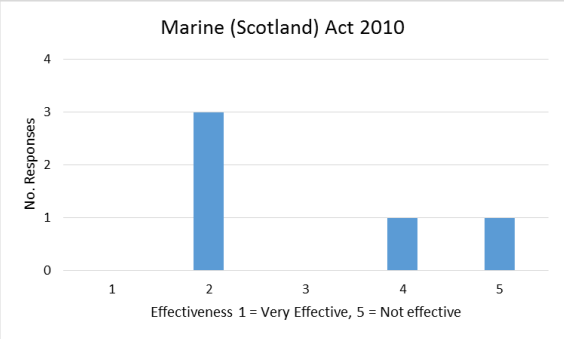
Information from SMASS contributes towards fulfilling the requirements and obligations set out in a number of national legislative drivers and international conservation agreements. The priority policy drivers and the ability of a Scottish strandings scheme to satisfy their different requirements are listed below. The responses and assessment against each driver are *not* criticisms of SMASS itself but reflects the ability of *any* strandings scheme to contribute to the requirements of each.

4.1.1 Marine (Scotland) Act, 2010

The Marine (Scotland) Act 2010 (Section 6) prohibits the taking of any seals except under licence and licences can be granted for the protection of fisheries, for scientific and welfare reasons and for the protection of aquaculture activities. Seals taken under licence should be retrieved and delivered to or collected by the SMASS staff if logistically possible; this will assist in the collection of life history samples providing 'baseline' data from overtly healthy animals. These carcasses are also useful in understanding the prevalence of covert and emerging diseases. However, recent reports from SMASS to Marine Scotland suggest that only a small proportion of the carcasses from the seals taken under licence are recovered and obtained for post mortem examination.

Responses from Stakeholders:-
How effective do you think SMASS is at addressing the Marine (Scotland) Act, 2010

The figure below summarises the responses from the stakeholders



4.1.2 Bern Convention and the Habitats Directive

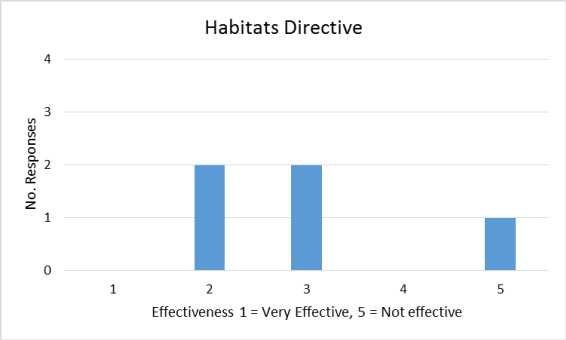
All cetaceans are listed in Annex IVa of the EC Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) as species of Community Interest. Under Article 12 deliberate capture, killing or disturbance is prohibited. Article 12 also requires Member States to monitor the incidental capture and killing of cetaceans, clearly an objective that the work of SMASS contributes to. Under Article 11 of the Habitats Directive, Member States are also obliged to undertake surveillance of the conservation status of the species of wild fauna of community interest.

Both grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) are listed on Annexes II and V of the Directive. The UK has designated 16 Special Areas of Conservation (SACs) specifically for seals, seven for grey seals and nine for harbour seals. Seals are 'features of qualifying interest' at a number of additional SACs. . In the last assessment of ' conservation status' (2007 to 2012) grey seal status was favourable and harbour seal was unfavourable-bad (having declined from unfavourable inadequate in the

previous round). SMASS provides input into this assessment by monitoring and reporting the causes of death and identifying the pressures and threats (such as predation, condition and disease occurrence), particularly to the declining population of harbour seals on the North and East coasts.

Responses from stakeholders
How effective do you think SMASS is in addressing the Habitats Directive?

The figure below summarises the responses from the stakeholders



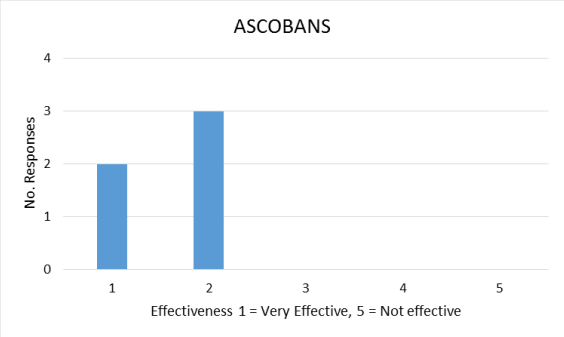
4.1.3 The Bonn Convention (CMS) and the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)

Under the Convention on Migratory Species (CMS (2012) or Bonn Convention), certain cetacean species are protected, which includes the prevention, reduction and control of "endangering factors". Appendix I lists species that are considered endangered and the commitments of Parties to conserve and/restore species habitats, manage pressures that impede/prevent migration and strictly control other factors likely to further endanger the species. Appendix II includes species which have an unfavourable conservation status and which require international agreements for their conservation and management, as well as those which have a conservation status which would significantly benefit from this international agreement. All marine turtles and the basking shark are also listed on Appendices I and II of the Bonn Convention.

A system for monitoring cetacean strandings is required by Parties to 'ASCOBANS', the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (New York, 1992: A Regional Agreement under the Bonn Convention). The Agreement states that *"Each Party shall endeavour to establish an efficient system for reporting and retrieving by-catches and stranded specimens and to carry out, in the framework of the studies mentioned above, full autopsies in order to collect tissues for further studies and to reveal possible causes of death and to document food composition. The information collected shall be made available in an international database."* The reasons for maintaining a stranding scheme under ASCOBANS are therefore focused on determining causes of death and to document feeding habits. ASCOBANS also includes a concise Conservation and Management Plan (CMP) that outlines the measures to be implemented by signatories. This states that research "shall be conducted in order to (a) assess the status and seasonal movements of the populations and stocks concerned, (b) locate areas of special importance to their survival, and (c) identify present and potential threats to the different species." Again, SMASS is particularly able to provide information in relation to the last of these aims. A number of resolutions have also been developed by Parties to ASCOBANS. These relate to requests to support further work to determine cetacean distribution, abundance and effects of chemical contaminants; to reduce bycatch below the threshold for unacceptable interactions; and to produce guidance to minimise risk and mitigate against the potential impacts of noise on cetaceans from offshore renewable energy activities. SMASS can also provide input into these conservation and management objectives (see also Section 5 below).

Responses from stakeholders
How effective do you think SMASS is in addressing ASCOBANS?

The figure below summarises the responses from the stakeholders



4.1.4 Convention on Biological Diversity

Under the Convention on Biological Diversity (CBD) parties agree to develop national strategies, plans or programmes for conservation and sustainable use of living resources, and to promote research, training, education and awareness. The CBD was also the first treaty to provide a legal framework for biodiversity conservation and called for the creation of national strategies and action plans to conserve, protect and enhance biological diversity. 'Biodiversity: the UK Action Plan', required the preparation of action plans with quantifiable targets for the most threatened species, which included cetaceans.

There are currently four UK biodiversity action plans for cetaceans. Under the Grouped Plan for baleen whales, the Grouped Plan for toothed whales and the Species Action Plan for harbour porpoises, a commitment is made to "continue to publicise stranding and sighting schemes". Under the Grouped Plan for small dolphins, there is also a commitment to "maintain and develop national strandings schemes and integrate with post mortem studies and analyses of important biological data (life history parameters, genetics, diet, pollutant burdens, and pathogens)." There is also a commitment to "ensure that samples are analysed". Scotland's response to its obligations under CBD has produced a targeted Scottish strategy which covers the period up to 2020. This was updated in 2013 (The 2020 Challenge for Scotland's Biodiversity, http://www.biodiversityscotland.gov.uk).

The basking shark has its own species action plan under the BAP process in the UK, which includes a commitment to commission research into the life cycle and to monitor population dynamics; both of these proposed actions are facilitated by the inclusion of basking sharks in the strandings scheme.

Similarly, a grouped plan for marine turtles under the UK BAP makes a commitment to establish and support of a system for undertaking post mortem examinations on dead turtles and distributing biological material to specialists, including those working abroad, in order to determine causes of death, and to improve knowledge of marine turtle biology and the threats to turtles in UK waters. There is also a call to promote a system for monitoring and reporting incidental capture and killing of marine turtles. Turtles have therefore been included in the strandings scheme since 2001.

4.1.5 The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)

The Convention for the Protection of the Marine Environment of the Northeast Atlantic provides a comprehensive and simplified approach to addressing issues associated with maritime pollution. Additionally, OSPAR provides for the '*protection and conservation of the ecosystem and biological diversity of the maritime area*' in Annex IV and lays down 'criteria for identifying human activities for the purpose of Annex V' in Appendix 3. In 2004, OSPAR agreed a list of threatened and declining species that included the harbour porpoise. As part of this revision, the harbour porpoise background document now includes a recommended list of monitoring requirements for the OSPAR area. Monitoring

is required that includes visual surveys of abundance and distribution, reporting strandings and bycatch. A stranding scheme is therefore required to undertake some of this work.

4.1.6 Marine Strategy Framework Directive (MSFD) and Good Environmental Status (GES)

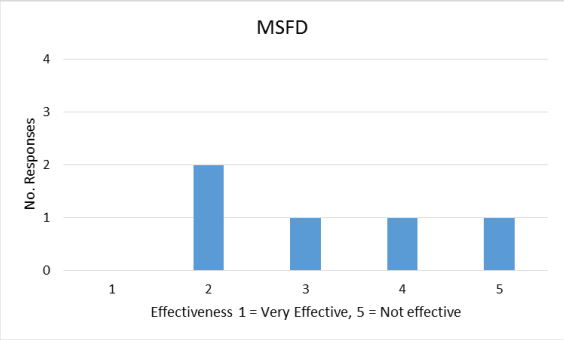
The Marine Strategy Framework Directive (MSFD (2012)) requires Member States to develop marine strategies that apply 'an ecosystem-based approach to the management of human activities while enabling a sustainable use of marine goods and services, priority should be given to achieving or maintaining good environmental status in the Community's marine environment, to continuing its protection and preservation, and to preventing subsequent deterioration. This approach should include protected areas and should address all human activities that have an impact on the marine environment'.

In order to determine Good Environmental Status (GES), eleven qualitative descriptors have been selected. These cover: biological diversity, non-indigenous species, population of commercial fish/shell fish, elements of marine food webs, eutrophication, sea floor integrity, alteration of hydrographical conditions, contaminants, contaminants in fish and seafood for human consumption, marine litter, and introduction of energy, including underwater noise.

OSPAR has been leading the international development of indicators and targets for determining GES in the relevant subregions. In November 2011, OSPAR brought together its Contracting Parties to discuss proposed indicators and targets of GES for Descriptor 1: Biodiversity. The majority of relevant Member States proposed cetacean indicators and targets associated with abundance and distribution, and also bycatch. These were developed through the auspices of ICG-COBAM's expert group on Marine Mammals and Reptiles with support from the ICES Working Group on Marine Mammal Ecology. At the national level, indicators and targets have been proposed that generally align with the needs of the Habitats Directive. The one possible exception to this is the explicit need to monitor contaminant levels in harbour porpoises.

Responses from stakeholders
How effective do you think SMASS is in addressing MSFD?

The figure below summarises the responses from the stakeholders



4.1.7 UK Small Cetacean Bycatch Response Strategy

Bycatch, the incidental capture of cetaceans during fishing activities, is thought to be the major threat to the conservation of small cetaceans, not only in Europe, but throughout the World. The UK Small Cetacean Bycatch Response Strategy (Defra, SG, WAG, DARDNI, 2003) includes a recommendation to undertake research into the population structure of small cetaceans around the UK, utilising material from the strandings programme.

4.2 Ability of SMASS to address conservation threats

4.2.1 Conservation threats

The main conservation pressures and threats for marine mammals were summarised and discussed in the previous review of options for a Scottish strandings scheme (Hall and Northridge, 2009) and these are listed in Table 1. Each of these threats represents a potential immediate or indirect cause of death, and therefore a potential conservation and management issue. Identifying causes of death allows us to identify those issues likely to be most important in determining population dynamics and thereby to inform the Scottish Government on conservation and management policy. The list remains largely unchanged and no additional threats to reproduction or survival have been identified since 2009, with the exception of the risk of collision with underwater tidal turbines. The ability of a stranding scheme to address each of these threats is also summarised in Table 1.

The focus of the scheme remains the identification of causes of death and the occurrence of disease. The required associated analyses (e.g. histopathology and bacteriology) to determine disease status and assign cause of death is undertaken by SMASS and its long- term partners, including the routine histopathology conducted by the veterinary pathologist at the Moredun Research Institute in Edinburgh. However, many of the other potential threats requiring additional analytical approaches (such as stomach contents analysis, contaminant and biotoxin exposure assessment) are highly reliant on collaborations with other research groups. Apart from the persistent organic pollutant analysis, which has been supported since the 1990s by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) laboratory in Lowestoft (Law et al. 2012), long term studies and the analysis of datasets with sufficient temporal and spatial scale to be reasonably robust continue to be limited in their scope and duration.

4.2.2 The ability of the scheme to contribute to new policy or policy change

The ability of the scheme to contribute to new policy or policy change, depends on how close any new policy driver is to the current remit of the project and thus whether a new focus and prioritisation would be needed. This requires the scheme to be flexible enough to change direction. Additional capacity may be necessary (such as staff or other logistical support) if Marine Scotland felt that the new policy driver should take precedence over the current work triage and prioritisation, again depending on the nature of the work involved. The project work programme is agreed annually and discussions with Marine Scotland (and the Steering Group) are regular enough such that should additional or new policy drivers need to be accommodated, the work programme could be changed as necessary. The current contract and project management structure, with input and oversight from the Steering Group, does appear to allow for such changes.

At the time of reviewing the programme and as far as we were able to judge, the SMASS team are fully occupied with their current work programme. Over the last three years or so the team have made additional efforts to train volunteers to collect samples in order to improve on the scope and geographical spread of the scheme. This has been very successful and welcomed by the Steering Group (see also Section 9 below).

One new policy area that perhaps may be assisted by SMASS is the USA ruling on the import of fisheries products that require importing nations to adhere to the same provisions at the US Marine Mammal Protection Act. This question was posed to stakeholders:

The USA has recently ruled on import provisions of the Marine Mammal Protection Act for fisheries products, establishing marine mammal bycatch criteria for U.S. imports. Do you think SMASS in its current form will contribute to the delivery scientific evidence in support of this policy?

60% responded 'maybe' and 40% 'no' (5 responses, details below).

- *Not as good as observers on boats but suitable monitoring for the small boat fleets and detecting rare conflicts (e.g. creel entanglements)*

- *Cannot see how this could be relevant; the scheme does not quantify bycatch risk, can only rarely pinpoint specific fisheries, and says nothing about sustainability or management strategies to minimise risk to MM populations*
- *Bycatch is now diagnosed much more effectively than before. There is the obvious constraint of the animals being found and reported*
- *PME can diagnose cause of death as bycatch. However, these import provisions will, I believe, require knowledge of which specific fisheries cause bycatch and would be subject to conditions of import or in fact subject to a ban. Some work was initiated by the CSIP with Simon Northridge to see if the net marks & injuries on stranded animals could be confidently identified to gears; but the preliminary results were inconclusive. The entanglement of minke whales is a cause of death in stranded minke whales (although rarely) and this is associated with creel lines which limits the scope of "fish"/fish products that might be affected*
- *As far as we are aware there is currently little cetacean bycatch (in its most typical form) in Scotland - however more evidence in support of conservation of whales from entanglement in e.g. static gear would be valuable*

Stakeholders were also asked for details of any new policies or policy changes relevant to SMASS. Two respondents included the following:

- *None in the short term. The implications of Brexit and transfer of EU laws to UK law will bring about changes in the long term.*
- *Installation of tidal turbines, and a growing industry.*

4.2.3 Are the number of post mortems carried out sufficient to fulfil the surveillance core function?

The number of post mortems currently targeted for Scotland under the UK CSIP contract is 25 per year. In total the target set in the work programme for SMASS under the Marine Scotland contract is an additional 70 per year, approximately 20-30 cetaceans and 40-50 seals (predominantly adults with a small number of pups and juveniles). Thus the total within the programme as a whole is 95 necropsies per year. A wide geographical spread is also a requirement, unless specified otherwise by Marine Scotland and the Steering Group.

This would qualitatively appear to be a sufficient target number to achieve a core surveillance function. However, a formal power analysis would need to be carried out to determine if it was possible to detect particular trends of interest, in, for example, changes in the prevalence of specific diseases or causes of death or in the concentration of contaminants in the blubber. A limited exploration of the power to detect a trend was carried out in the previous review (Hall and Northridge, 2009) but other considerations, particularly how many animals can realistically be sampled, the cost and logistics etc. need to be included in any final decision. The number of seals being examined post-mortem is lower than the target (29 harbour seals and 59 grey seals in the three year period 2012 to 2015, an average of ~30 per year).

The protocol currently used by virtually all the major European strandings schemes was produced at a workshop organised by the European Cetacean Society (ECS) in 1992 (Kuiken and Hartmann 1991). It was recommended in the previous review that this be updated, with particular attention to sample collection and archiving using more recently developed methods. Some progress has been made to do this across the European Stranding groups during the ECS meetings but this still needs to be completed.

Further Background Information from SMASS
What disease surveillance work is undertaken on a regular basis? (e.g. bacteriology, histology, virology, serology) and how is this information analysed/reviewed?

Where carcass suitability and gross pathology indicate, bacteriology is routinely carried out through culture and phenotypic identification up to Category 3 organisms. Further molecular characterisation is

carried out through collaboration with the Animal Health and Veterinary laboratory in Weybridge on a case by case basis.

Similarly, where indicated by gross necropsy, histopathology, including neurohistopathology is routinely carried out as a subcontract by the Moredun Research Institute. Virology in the form of electron microscopy is done on an ad hoc basis through the Weybridge laboratory. Serology is routinely carried out for Brucella sp. and samples stored for any further analysis required, but no other routine serological screening is undertaken.

Results from the ancillary tests contribute to a diagnosis of the cause of death for each individual case, where appropriate partitioned into proximal and ultimate cause. In addition patterns or trends in causes of death are reviewed, at least on an annual basis, and any further diagnostic or epidemiological work scheduled. This follow-up component however could be further developed, for example by making use of student projects to follow up specific syndromes.

Responses from stakeholders
SMASS currently aims to undertake approximately 70 post mortems on cetaceans and seals stranded around the Scottish coast (approximately 20-30 cetaceans and 40-50 seals). Do you think this number is sufficient to fulfil the objectives of the scheme?

20% responded 'No', 40% responded 'Yes' and 40% responded 'Maybe'

- *For a country that has 27 different marine mammals either resident or passing through its waters this number is too low. Also, it should be species dependent, there are plenty of grey seals, but declining numbers of harbour seals. So approx. 70 cetaceans and 50 seals.*
- *What are the objectives of the scheme? At the UK scale, to monitor changes in the cause of death of harbour porpoise you need to PME ~60 a year based on power analysis of the 2012-2016 (80% power, 0.05 alpha) and fewer for the other species. Such an analysis should be carried out for the SMASS data if detecting change is an objective.*
- *It is probably sufficient under "normal" conditions. Perhaps in the event of another seal epidemic or unusual mortality events, then these numbers should be revised*

4.2.4 How are samples handled and are they fit for purpose?

A baseline set of samples are collected from each animal that is subject to a full post mortem examination. This includes various tissue samples for histology, gonads for reproductive status, blubber and skin, foetus or placenta, kidney, liver, milk, muscle, rib, scapula, serum, skull, teeth (baleen plates) and food remains. Parasites are also collected as required. A set of standard samples are stored for future analysis (blubber, skin, muscle and liver) and others are sent to collaborators and partners for current research projects using agreed sampling protocols and storage requirements. A two-tier system is in place for the provision of samples to external groups, depending on the project's goals. In particular those involving pathology or bacteriology studies usually require the close participation of the SMASS team with the expectation that they will also provide intellectual input and be co-authors on any resulting publications.

Sample storage, archiving and tracking has been an issue in the past but samples are now well collated, labelled and recorded. However, the freezers used to store the archived tissues will need to be moved as the Veterinary Centre in Inverness, where the SMASS team are currently based, is closing. Relocation plans have yet to be finalised but due consideration needs to be given to a long-term storage and archiving strategy. How long should the samples be stored for? Proteins denature eventually when stored at -20^{o}C, so although this is very good for many studies (for example contaminant analyses and genetic studies) it is not ideal for long-term storage. What should be archived and how needs to be reviewed regularly, with input from the Steering Group, once the future plans for housing the scheme have been agreed and it is clear what the space limitations and the sample storage provisions will be in future. Other options, such as freeze drying samples for long term storage should also be considered.

4.2.5 Recommendations to improve delivery

Some issues have been raised regarding the points highlighted in this section that would be worth further consideration in future.

1. Only a small proportion of the seals taken under licence are retrieved and obtained by SMASS for post mortem examination (e.g. <10% of grey seals and < 2% of harbour seals reported in 2015). These management cases provide useful baseline data and are clearly important evidence to ensure compliance with the conditions of the licences. However, without the assistance of the licence holders it is difficult to envisage how the recovery rate might be improved other than engaging further with fishermen to ensure they are aware of the value of these carcasses.

2. There is a backlog of histology samples, with currently about 36 cases awaiting completion. There is an agreement with the Moredun Institute to provide this service to the scheme, but with no time schedule set for the completion of each case. This is understandably due to the fact that this agreement relies heavily on goodwill and collaboration with the veterinary pathologists working up the tissues and reading the slides. This partnership has been extremely successful and is important in supporting the disease surveillance work of SMASS and should continue into the future. However, it would be worth investigating the current agreement and partnership, with a view to finding out what the bottlenecks and constraints are in order to improve the turnaround time.

3. The surveillance function of SMASS is currently quite broad in its remit (e.g. to undertake a set number of necropsies per year; to provide scientific advice about the major causes of death, including trends or unusual events) with a necessarily limited number of necropsies being carried out annually. This is not a major criticism of the current scheme and is necessary to address the range of issues that may arise. However, in terms of surveillance, it might be worth considering options that allow for more in-depth work to be carried out on a specified number of animals of a given species each year. In the previous review (Hall and Northridge, 2009) a rationale was proposed for prioritising species and this suggestion does not replace the current triage but reinforces the recommendation that priority species should be monitored in the context of their life history.

The project is directly concerned with determining causes of death in marine mammals but it is often difficult to assess how certain disease states relate to the threats and drivers of population change without additional life history information on the individual cases. Consideration could be given to establishing a core surveillance programme that focuses on certain key species (such as harbour porpoise, bottlenose dolphin, minke whale and harbour seal) and examines, for example, not only the pathology but also age, diet, contaminant and toxin exposure and reproductive state in a set number of individuals each year. This could take the form of a case-control type of study in which individuals are chosen to be part of the study based on their sex and age, to control for the effect of confounding factors. Obviously, how the study is designed will depend on the specific question being posed but a targeted study or studies might better address the scientific advice function requirements of Marine Scotland.

How such a programme would fit within the current scheme and how it would be funded clearly need to be considered and a detailed proposal would need to be drafted but with such a long time series of data now available since the inception of the scheme this could be a timely point to consider other, perhaps slightly radical approaches, for fulfilling the surveillance aspect of the scheme, thus providing a more focussed and detailed response.

Origin of Threat	Type of Threat	Specific Issue	Ability of SMASS to address
Anthropogenic causes	Fisheries Interactions	Bycatch	Only minimum estimate provided, net marks and entanglement may identify specific fishery involved
		Indirect interactions	Diet information may indicate indirect interactions but stomach contents not routinely analysed
	Direct Human Interaction	Deliberate killing (seals)	Can identify occurrence of local or illegal deliberate killing but maybe only in isolated cases.
		Disturbance	Not directly addressed from strandings data
	Pollutants	Organohalogenated compounds / Persistent Organic Pollutants	Spatial and temporal trends in pollutant exposure and potential impacts have been addressed
		Heavy metals	Spatial and temporal trends in pollutant exposure and potential impacts have been addressed
		Pharmaceuticals / Personal Care Products	Not routinely analysed in samples collected
	Acoustic Trauma	Navy sonar	May be possible to identify effects, particularly in cases of mass strandings or identification of gas bubble lesions but difficult to prove.
		Seismic operations	Not directly addressed from strandings data
		Construction noise (e.g. pile driving)	Not directly addressed from strandings data
	Marine Renewable Energy Developments	Collision risk (e.g. turbine blades)	Can identify cases likely attributable to collisions
	Global Climate Change	Change in water temperature	Not directly addressed from strandings data
		Change in prey distribution/abundance	Diet information may indicate changes over time but stomach contents not routinely analysed
	Coastal Urbanisation	Habitat encroachment	Not directly addressed from strandings data
		Disturbance	Not directly addressed from strandings data
Natural causes	Infectious Disease	Epidemic disease	Can identify epidemics and their causes
		Endemic disease	Can determine prevalence and changes in occurrence of endemic and parasitic disease
	Unusual Mortality Events of Unknown Cause	Unknown natural agent	Can identify causes of unusual mortality events
	Biotoxins	Saxitoxin	Spatial and temporal trends in saxitoxin exposure and potential impacts have been addressed
		Domoic acid	Spatial and temporal trends in domoic acid exposure and potential impacts have been addressed
	Inter and Intra-Specific Interactions	Increased competition with conspecifics	Potential to identify changes in morphology or pathology associated with increased competitive interactions.
		Increased predation or inter-species aggression	Can identify changes in predation (e.g. spiral seals)

Table 1: Summary Table of Main Potential Threats and ability of SMASS to address these

5 Opportunities to utilise the data collected by SMASS and identify further research collaborations and network links

5.1 Review project outputs

5.1.1 Publications and presentations

The project outputs as detailed in the SMASS Final Contract Report 2012-2015 (Brownlow et al., 2016) were reviewed. The list included 26 peer reviewed publications, two mass stranding event reports, two other reports (a briefing paper to the Special Committee on Seals and a report on predation by grey seals as the cause of the 'spiral' seal cases), 19 conference presentations, 12 conference posters and attendance at 50 other meetings, workshops, symposia or conferences. This is an impressive output and shows the knowledge exchange that the project is achieving, particularly within the marine mammal community. Data and samples collected through the scheme are being utilised across a range of disciplines including pathology, bacteriology, virology, genetics, diet, and biotoxin and contaminant exposure. This clearly reflects the main direction of SMASS and the long- standing collaborators and partners it has fostered over the years.

Other samples have been provided for smaller and pilot projects which have not necessarily resulted in publications that members of the SMASS team as co-authors. However, presumably acknowledgement of the source of samples and data should be included in any outputs (student project theses for example) from these smaller studies.

5.1.2 Media and social media

An impressive list of interactions with the media and through social media (Facebook and Twitter) is given in the Final Contract Report 2012-2015 (Brownlow et al., 2016). This has ranged from dealing with the media during the mass stranding events and in relation to the 'spiral' seal phenomenon, to keeping the public and social media feeds updated with new cases and findings. This is clearly a critical role for the scheme and ensures that awareness of the scheme itself is high to increase the likelihood that stranded marine animals, particularly in remoter regions of Scotland, are reported and to increase awareness of marine animal conservation and management issues in general. These interactions and any developments that will enable strandings to be easily and reliably reported (e.g. development of a marine animal stranding app for mobile phones and supporting the volunteer scheme, see Section 9) should continue to be an important part of the project.

Responses from Stakeholders

Have you ever interacted with the SMASS website?

80% of the 5 respondents said 'Yes', 20% said 'No'

Have you ever interacted with the SMASS Facebook site?

60% of the 5 respondents said 'Yes', 40% said 'No'

Do you think SMASS engages appropriately with the media (e.g. during mass stranding events)?

100% of the 5 respondents said 'Yes'.

Do you think SMASS engagement with the public is effective?

100% of the 5 respondents said 'Yes'.

5.2 **Is the data being effectively managed, backed up and archived?**

All data is stored on the cloud and a dedicated server. SMASS do not use the CSIP database as their primary backup although this would provide a secondary backup for a subset of the data in an extreme emergency. The database is kept up to date although not all the historical information has been digitised as yet. All primary data from 2005 to 2016 is up to date, including the cause of death assignments and the SMASS post mortem findings. The team are happy with the MySQL relational database that is used. CSIP work in a similar way but use a different, non-relational database. The strategy for the retention and maintenance of the tissue sample archive is an ongoing and is not likely to be resolved until the relocation of the scheme from its current premises in Inverness has been resolved.

Further background information from SMASS

Digital data is stored on a Dropbox cloud server with access shared and synced between all three SMASS laptops in addition to a stand-alone hard drive server. SRUC computing infrastructure is used only for internet access and mail client.

Routine toxicology and DNA archive samples (skin, muscle, blubber, liver and kidney) are indexed and stored at -20^{O}C in upright or chest freezers. Serum samples are also stored in this way. Virology samples are stored at -80^{O}C along with any significant bacteriological isolates (on beads).

5.3 **Provide a series of options on how SMASS can further create links with wider UK research on marine mammals**

In order to begin to address this sub-objective, the reviewers sent an online anonymous questionnaire to a number of marine mammal researchers in the UK to determine where and perhaps how further links with the wider UK academic community could be created.

Of the 8 respondents (a list of the organisations is given in Appendix 2), none currently collaborate with SMASS. However, 75% indicated that their future research priorities could utilise SMASS. The *current* outputs that would be most valuable to their different research interests were:

- Long term records of infectious disease
- Trends in numbers of various species
- Access to tissue samples, information about cause of death
- Location, age of individuals, diet and relatedness to other individuals

The *potential* outputs from SMASS that would be valuable included:

- Long term records of infectious disease
- Information on cause of death mainly in harbour seals, as well as morphology and age
- Access to tissue samples and histology; information about cause of death
- Physiology of captive marine mammals
- Location, age of individuals, diet, relatedness to other individuals

In response to the question of what could be done to facilitate future research links, the following answers were given:

- Occasional workshops
- Web information - metadata and contact details
- Ease of contact; building network; clear way to request access to tissues
- Knowledge of what research SMASS actually conduct
- It is good now

In response to the question, what are your research interests that do (or could) overlap with SMASS? The following answers were given:

25% disease
25% population dynamics
25% physiology
12.5% diet
12.5% genetics

Further background information from SMASS
Currently we publicise the availability of the data and sample archive during any outreach work, emphasising the data was collected using public funds and therefore is there to be used. An overview of data and cases is available on our website at www.strandings.org and potential collaborators are asked to contact us should more detailed data or sample lists be required. Data and samples are provided free of charge although we ask for a brief paragraph outlining the purpose of the proposed work and request that, should it lead to any significant outputs, e.g. reports or publications, that SMASS are acknowledged or offered co-authorship as appropriate. We also ask for the results to be provided in digital form and will soon be able to load these up directly into the database.

Options

1. From these responses, it could be argued that the scope for wider collaboration is there but information about what data and samples exists needs to be much more readily accessible. One option to improve these links would be to provide much more detail on the metadata available on the SMASS website. This could include limited access to the database, as is currently the case with the mapping function, but with more details on the sex and age classes of the animals and perhaps a method to query the database in a limited way so researchers could find out how many samples for a particular species might be available for research purposes. It is our understanding that further funding is needed to add sample archiving and indexing of frozen samples to the database (as outlined in the update on progress following recommendations from the 2012 SMASS Workshops) but that sample tracking and collation of results is a target for the developing the next phase of the database.

Advertising the holdings in other fora, such as within the Marine Alliance for Science and Technology Scotland (MASTS) community would also assist in widening access and the potential for collaboration. The US Marine Fisheries Service have a National Marine Mammal Tissue Bank which was set up under their Marine Mammal Health and Stranding Response Act. It would be worth the SMASS team investigating how they manage and more importantly advertise their archive for use by researchers on request. More information can be found at http://www.nmfs.noaa.gov/pr/health/tissue/

2. In addition, the scheme is currently run through a veterinary centre within SAC Consulting which does not give the team ready access to students for projects. Setting up a series of 'standing' student (both undergraduate and postgraduate Masters) projects across Universities, particularly in Scotland, could also increase the utility of the samples and data collected. Embedding the scheme or creating specific research agreements within the academic community would also assist. A Research Day was held at the Sea Mammal Research (SMRU) in June 2015 which brought together some of the researchers collaborating with SMASS to develop research ideas and identify funding opportunities. These meetings could be continued on an annual or biennial basis which would assist in broadening the utilisation of samples and data from SMASS. Inviting researchers from the terrestrial and the human forensic community could provide further links.

5.4 **On the basis of the outputs from the scheme, develop a series of recommendations for potential future research that SMASS could be leading**

1. Potential research that SMASS could be leading would have to fall within the area of expertise that currently exists within the scheme. With a basis in veterinary, research projects would need to

continue to focus on pathology and disease. Closer links with the Vet Schools in Edinburgh and Glasgow could facilitate this but time and effort would be needed to establish appropriate research projects and willing project partners.

2. Large whale entanglement is a particular problem in Scottish waters, an issue which is not a priority for other regions of the UK. Additional EU Funding for this research is currently being pursued as a collaborative effort which includes the SMASS team; this should be encouraged and supported.

3. Other studies which focus on aspects across a broad biological spectrum including life history, comparative physiology, nutritional condition, age determination, diet and contaminant and biotoxin exposure are not necessarily research topics that could be led by the SMASS team. Long term collaborations with other researchers with the skills and expertise and track record who could lead these projects is required. Alternatively, the SMASS team could be expanded to include a biologist whose remit it would be to obtain research funding and to lead projects, again in conjunction with other researchers, to specifically investigate broader biological questions or conduct other appropriate comparative physiology and genetic studies.

6 Review and critical reflection? on the effectiveness of the complex management and funding arrangements involved in the current scheme.

6.1 Review links with the UK CSIP and whether these are meeting Marine Scotland's requirements in terms of management / delivery / outputs.

The current arrangements with the wider Defra funded UK CSIP are complex as funding for the CSIP includes an allocation for Scotland to deliver 25 annual post mortem examinations. The remainder of the funding for the project and the additional 70 post mortem examinations comes directly through Marine Scotland via the SMASS, but the two contracts (Defra and Marine Scotland) are not always temporally aligned. Defra have recently also been unable to commit more than annual funding to the CSIP which has caused a great deal of uncertainty within the scheme as a whole. Whilst the Defra subcontract is for a small proportion of the total number of post mortem examinations carried out by SMASS, all the data collected, regardless of funding stream, is entered into the UK CSIP database. This co-funding model has caused conflicting jurisdictions at times and whilst Marine Scotland sit on the Steering Group for the CSIP, they may be excluded from any direct interactions that occur between Defra and the CSIP team in England.

The advantage of being embedded within the UK CSIP scheme in this way is, however, that some analyses, particularly the contaminant work, is funded through Cefas and Scotland benefits from the results of these studies. Other emerging issues that arise can easily be investigated at a UK level, giving a broad perspective on specific problems (an example being the occurrence of gas bubble lesions in stranded cetaceans).

However, the main disadvantage is the complexity and confusion in the management aspects that having a Scottish scheme within a UK framework necessarily causes. In terms of delivery, there does not seem to be any issues among the two teams with staff are in contact to ensure that communication, and recognition for various aspects of the combined work, are maintained. However, as the scheme in England, Wales and NI has been established for longer, internationally there often seems to be less engagement with the team in Scotland, even though for some aspects they may have more relevant experience (such as studying large whales).

There may be additional cost savings to be made if the Scottish scheme were to be managed independently, with all funding going directly to SMASS. However, to ensure the UK wide picture and current collaborations with the other partners in CSIP were not lost, a Memorandum of Agreement would need to be drawn up to maintain the joint database. This may also have cost implications as staff time would be required to continue the data integration. Further discussion on the cost savings are given in Section 7.

Further background information from SMASS
SMASS is part of the CSIP but operates largely autonomously, mainly because of additional work delivered under SMASS contracts. All strandings records in Scotland, including pinnipeds are however entered into the CSIP database and post mortem records of all cetacean post-mortems, both those funded through CSIP and SMASS are uploaded to the CSIP database. CSIP staff assisted SMASS with necropsies during the 2011, 2012 and 2015 Long Finned Pilot Whale Mass Stranding Events with their costs for this being covered by additional funding from Scottish Government.

Responses from stakeholders
Do you think links between SMASS and the UK CSIP help to meet Scotland's requirements?

60% of the stakeholders responded 'Yes' to this question, 20% 'No' and 20% 'Maybe'

7 Recommend improvements on how to deliver great value for money

7.1 Consider how the scheme currently operates and identify whether there are opportunities to reduce the cost of operations

1. Within the current remit the cost of any comprehensive scheme is dominated by staff costs and overheads. It is difficult to see how the former could be reduced unless the priorities for the scheme were reduced or changed. However, savings may be possible with a reduction in overhead costs, which is potentially an area for negotiation on renewal of the contract.

2. With the complex management of the scheme within the UK CSIP it may be that cost savings or added value could be gained from having SMASS completely financially autonomous from the UK scheme. The disadvantage of running the scheme outwith the CSIP would be that any combined projects and analyses could be lost. However, a Memorandum of Agreement could be drawn up to ensure that collaboration between the teams continues and that data and tissue samples are shared, as is currently the case.

3. The volunteer scheme has been hugely successful and should continue into the future as this will provide further savings, particularly as the long term volunteers become more skilled and accomplished (see Section 9).

8 Review current protocol for Mass Stranding Events

The Mass Stranding Events protocol has been reviewed by the Steering Group and they felt it was a good document that covered all the relevant aspects that need to be considered during such an event. Additional points to consider include:

1. The importance of dealing with the media at these events is highlighted in the protocol and a CSIP Resource Register is being prepared as an up to date list of relevant contacts that could assist at these events, particularly in dealing with the media. Presumably the Scottish contacts in this register would be drawn up by the SMASS team and other groups in Scotland with an interest in marine mammals, identifying those who could help at short notice. Perhaps a register, maintained by SMASS but integrated with the CSIP register would be especially useful. This could also include all marine mammal experts in Scotland who might be able to assist in dealing with the media at short notice. The Sea Mammal Research Unit at the University of St Andrews and the Department of Zoology at the University of Aberdeen have trained many MSc and PhD students over the years, many who have gone on to take up positions in consultancy firms and other related posts but who have retained an interest in marine mammals. Their basic knowledge would be useful in assisting the responding team to talk, at a broad level, to the media. However, they should be thoroughly briefed by the SMASS team before talking to the media.

2. Linked to the above would be the provision of a basic two page fact sheet about mass strandings, including a Question and Answer section specifically for the media and other interested onlookers. This could deal with the obvious questions that arise regarding the event, such as how often mass strandings occur in Scotland, some of the reasons why they occur and what the team are currently doing with the carcasses.

3. This current protocol deals only with what to do in the event of a large cetacean mass stranding. However, it is possible that a pinniped or mixed species mass stranding (e.g. at the onset of an epidemic or following a major toxic algal bloom as is regularly seen in the US and the Gulf of St Lawrence) could also hit Scottish waters. As a future objective should be a protocol to deal with these events, using the large cetacean protocol as a guide.

9 Review the volunteer network

A network of trained volunteers is now in place to assist the SMASS team in their response. These individuals respond to reported strandings in their area (as directed by the SMASS team) to take photographs, measurements and samples if, after consultation with SMASS, the carcasses are not suitable for full post mortem examination. This has increased the geographical spread of the scheme and has improved the number of strandings that are reported to SMASS annually. Whilst there has been a time investment in training required and this will continue into the future as volunteers leave and join the scheme, overall it has been very successful on a number of levels. Firstly, to provide a wide temporal and spatial coverage, secondly to improve knowledge of the scheme with the wider public and thirdly to increase the number of seals that are reported and investigated by SMASS. Maintaining or even increasing this scheme, with additional developments such as a mobile phone App that would ease the reporting of strandings, is recommended. Expanding and developing this capacity is likely to require additional resources but maintaining the current level of training time that the team devote to this activity has been very beneficial.

10 Other information

In the online survey for stakeholders, the following question was also asked:

What is the most valuable output from SMASS for your own work / research?

The 5 responses received were:

- *Follow up on strandings to unlock stories such as the corkscrew seals, dolphin-porpoise interactions and disease outbreaks. Access to diet samples has been key too*
- *Occasional biological samples*
- *The data generated by SMASS is invaluable to me for formulating the correct questions for hypothesis driven research and also the material upon which to perform this work.*
- *Indication of range of pressures affecting cetaceans and seals. Early warning of novel threats. Samples could be used more widely (funding allowing!) and analyses of these does give more information on key pressures, including contaminants, and potentially demographic parameters.*
- *From a MSS perspective, most important to us is knowing more about causes of population change of protected species, specifically bottlenose dolphin, harbour porpoise and harbour seal.*

11 Specific recommendations

From the synthesis of those comments received from the various organisations, reference to the 2012 workshops, the 2009 review and our own analyses we have drawn up the following list of recommendations (not in any particular order).

- The importance of monitoring aspects of biology to address trends in life history parameters as well as monitoring the long-term health status and emerging diseases was a recommendation from the previous review that has not yet been fully addressed. This is not surprising given the limitations of the scheme and funding such studies. However, it is suggested that, for the priority species, a cohort of individuals be identified each year for more in-depth studies. The results of this research would provide important information for identifying conservation threats in a wider context. In view of the need to address policy issues that are primarily focused on the conservation status of the species concerned, it is recommended that species should be ranked according to the need to address aspects of their conservation. To this end we suggest that the species such as harbour porpoises, bottlenose dolphins and harbour seals should be given a high priority for any in-depth studies.
- Only a small proportion (e.g. in 2015 approximately < 10% of grey seals and < 2% of harbour seals) of the seals taken under licence are retrieved and obtained by SMASS for post mortem examination. These management cases provide useful baseline data and are clearly important evidence to ensure compliance with the conditions of the licences. However, without the assistance of the licence holders it is difficult to envisage how the recovery rate might be improved other than engaging further with fishermen to ensure they are aware of the value of these carcasses.
- SMASS is currently embedded within the UK CSIP scheme which has advantages that emerging issues can be investigated at a UK level, giving a broad perspective on specific problems and some analyses, particularly the contaminant work, is funded through the Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Scotland benefits from the results of these studies. However, the main disadvantage is the complexity and confusion in the management aspects that this necessarily causes. In terms of delivery there does not seem to be any issues among the two teams and staff are in contact to ensure that communication, and recognition for various aspects of the combined work, are maintained. However, as the scheme in England has been established for longer, internationally there often seems to be less engagement with the team in Scotland, even though for some aspects they may have more relevant experience (such as studying large whales). There may be additional cost savings to be made if the Scottish scheme were to be managed independently, with all funding going directly to SMASS. However, to ensure the UK wide picture and current collaborations with the other partners in CSIP were not lost, a Memorandum of Agreement would need to be drawn up to maintain the joint database. This may also have cost implications as staff time would be required to continue the data integration.
- There is a backlog of histology samples, with currently about 36 cases awaiting completion. There is an agreement with the Moredun Institute to provide this service to the scheme, but with no time schedule set for the completion of each case. This is understandably due to the fact that this agreement relies heavily on goodwill and collaboration with the veterinary pathologists working up the tissues and reading the slides. This partnership has been extremely successful and is important in supporting the disease surveillance work of SMASS and should continue into the future. However, it would be worth investigating the current agreement and partnership, with a view to finding out what the bottlenecks and constraints are in order to improve the turnaround time.
- The number of seals (particularly harbour seals) examined at post mortem is lower than target (approximately 30 per year between 2012 and 2015 compared to a target of 40-50). This could be for a number of reasons, particularly the decomposition status of most of those reported to the scheme. However, discussions with Marine Scotland and the Steering Group should be instigated to see if this can be improved at all or if there is value in responding to those in poorer states of decomposition.
- The standard post mortem protocol that is used across virtually all stranding schemes in Europe needs to be updated. Some progress towards this has been made and whilst this is not a priority task that should be driven by the SMASS team, we would encourage them to be closely involved in this process.

- The freezers used to store the archived tissues will need to be moved as the Veterinary Centre in Inverness, where the SMASS team are currently based, is closing. Relocation plans have yet to be finalised but due consideration needs to be given to a long term storage and archiving strategy. What should be archived and how needs to be reviewed regularly, with input from the Steering Group, once the future plans for housing the scheme have been agreed and it is clear what the space limitations and the sample storage provisions will be in future.
- Information about what data and samples exists needs to be much more readily accessible. One option to improve links with other researchers across a wide range of disciplines would be to provide much more detail on what is available and allow access to the metadata on the SMASS website. Advertising the holdings in other fora, such as within the Marine Alliance for Science and Technology Scotland (MASTS) community would also assist in widening access and the potential for collaboration. The US National Marine Fisheries Service have a National Marine Mammal Tissue Bank which holds samples available for research purposes. It would be worth investigating how this is managed and advertised.
- The scheme is currently run through a veterinary centre within SAC Consulting which does not give the team ready access to students for projects. Setting up a series of 'standing' student (both undergraduate and postgraduate Masters) projects across Universities, particularly in Scotland, could also increase the utility of the samples and data collected. Embedding the scheme or creating specific research agreements within the academic community would also assist. Research meetings could be established on an annual or biennial basis, inviting researchers from the terrestrial and even the human forensic community could provide further links. Closer links with the Vet Schools in Edinburgh and Glasgow could facilitate this but time and effort would be needed to establish appropriate research projects and willing project partners.
- Other studies which focus on aspects across a broad biological spectrum are not necessarily research topics that could be led by the SMASS team. Long term collaborations with other researchers with the skills and expertise and track record that could lead these projects is required. Alternatively, the SMASS team could be expanded to include a biologist whose remit it would be to obtain research funding and carry out projects, again in conjunction with other researchers, that would specifically investigate biological questions or conduct other appropriate comparative physiology and genetic studies.

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13 Appendix 1 – SMASS Objectives and Work Programme

- To continue to collate, analyse and report data for all cetacean, seal, basking shark and marine turtle strandings across the Scottish coast. This will include determination of cause of death and surveillance of the incidence of disease. To undertake approximately 70 post mortems on cetaceans and seals stranded around the Scottish coast (approx. 20-30 cetaceans and 40-50 seals) to determine major causes of death, including by-catch, physical trauma and the incidence of disease. A wide geographical spread of post mortems should be achieved unless specified otherwise.

- To provide an overall Scottish sample of both species of seal, including areas of harbour seal decline, to determine cause of death and any potential contributing factors.
- Continue to support relevant research organisations (e.g., SMRU, SAMS, University of Aberdeen) and ongoing research to investigate the occurrence of seals exhibiting spiral seal lacerations. This will involve, but not be limited to, undertaking necropsies (in accordance with established criteria), working with SMRU on field trials, and scrutinising the current scheme in terms of its ability to effectively locate, monitor and respond to strandings of seals exhibiting spiral lesions across Scotland.
- Continue to expand and maintain a Scotland-wide volunteer network to assist with identification, triage and possible measurement and sampling of cases reported to the stranding scheme and include a range of individuals and organisations. This should allow for improved depth, accuracy and efficiency in the information recoverable from strandings.
- Continue to provide training courses and post mortem demonstrations to teach volunteers how to accurately and safely collect skin and blubber tissue samples from cases otherwise unsuitable for recovery. In addition to samples, volunteers will be trained to collect morphometric and locational data and a series of digital photographs.
- Continue working towards developing a monitoring protocol for targeted areas of marine renewable activity, (e.g., Pentland Firth) which will aim to collect baseline data on marine animal strandings in the region. This should incorporate partnerships and volunteers developed in the current contract, as well as industry and conservation advisors (e.g., SNH, JNCC).
- To investigate specific cases of strandings/causes of death as requested by Scottish Government.
- To provide scientific advice to the Scottish Government as necessary about major causes of death in stranded marine mammals, including any trends or unusual events.
- To maintain a standard Scottish database for seal strandings which brings together accurate and geo-reference data on both strandings and necropsy data. Any cetacean data should be fed into the cetacean database for the "UK Cetacean Strandings Investigation Programme" which is held by the Institute of Zoology (IoZ). Contribute to the production of strandings training material and workshop events and raise awareness through publicity.
- Ongoing review of techniques used to determine the causes of death aimed at improving their accuracy, efficiency and cost-effectiveness.
- Review options for developing an online, secure searchable archive for data derived from the necropsies and ancillary tests
- Maintain a public-facing website to provide relevant information about reported cases back to the public to maintain interest.

14 Appendix 2 – List of academic research groups contacted

University of Bangor
University of Aberdeen (2 groups)
University of Durham (2 groups)
University of St Andrews (2 groups)
University of Swansea
University of Plymouth (2 groups)
University of Cork
Abertay University
Royal (Dick) Vet School Edinburgh
Glasgow Vet School

Of the 14 contacted, 8 responded to the questionnaire.

15 Appendix 3 - Publications June 2107-May 2017

1. James Barnett, Akbar Dastjerdi, **Nick Davison**, Rob Deaville, David Everest, Julie Peake, Christopher Finnegan, Paul Jepson, Falko Steinbach. 2015. Identification of Novel Cetacean Poxviruses in Cetaceans Stranded in South West England PLoS ONE 10(6): e0124315.(Barnett et al. 2015)

2. Sinéad Murphy, Jonathan L Barber, Jennifer A. Learmonth, Fiona L. Read,Robert Deaville, Matthew W. Perkins, **Andrew Brownlow, Nick Davison,** Rod Penrose, Graham J. Pierce, Robin J. Law, Paul D. Jepson. 2015 Reproductive Failure in UK Harbour Porpoises Phocoena phocoena: Legacy of Pollutant Exposure? PLOS ONE | DOI:10.1371/journal.pone.0131085 July 22, 2015. (Murphy et al. 2015)

3. **Geoffrey Foster**, Adrian M. Whatmore, Mark P. Dagleish, Johanna L. Baily, Rob Deaville, **Nicholas J. Davison**, Mark S. Koylass, Lorraine L. Perrett, Emma J. Stubberfield, Robert J. Reid, and **Andrew C. Brownlow**. 2015 Isolation of Brucella ceti from a Long-finned Pilot Whale (Globicephala melas) and a Sowerby's Beaked Whale (Mesoploden bidens) DOI: 10.7589/2014-04-112 Journal of Wildlife Diseases, 51(4). (**Foster** et al. 2015)

4. Sílvia S. Monteiro1, Paula Méndez-Fernandez, Stuart Piertney, Colin F. Moffat,Marisa Ferreira, José V. Vingada, Alfredo López, **Andrew Brownlow**, Paul Jepson, Bjarni Mikkelsen, Misty Niemeyer, José Carlos Carvalho, Graham J. Pierce. 2015 Long-finned pilot whale population diversity and structure in Atlantic waters assessed through biogeochemical and genetic markers. Marine Ecology Progress Series Vol. 536: 243–257 doi: 10.3354/meps11455 (S. Monteiro et al. 2015)

5. **Nicholas J. Davison, Andrew Brownlow, Barry McGovern**, Mark P. Dagleish, Lorraine L. Perrett, Emma-Jane Dale, Mark Koylass, **Geoffrey Foster**. 2015 First report of Brucella ceti-associated meningoencephalitis in a long-finned pilot whale *Globicephala melas.* Diseases of Aquatic Organisms 116;237-241 doi:10.3354/dao02926 27/10/15 (**Davison** et al. 2015)

6. Zuzana Gajdosechova, **Andrew Brownlow**, Nicolas T. Cottin, Mariana Fernandes, Fiona L. Read, Dagmar S. Urgast, Andrea Raab, Jörg Feldmann, Eva M. Krupp 2016. Possible link between Hg and Cd accumulation in the brain of long-finned pilot whales *(Globicephala melas)* in Science of the Total Environment 545-546:407-413.(Gajdosechova, **Brownlow**, et al. 2016)

7. **Nicholas J. Davison, Mariel T. I. ten Doeschate,** Mark P. Dagleish, Fiona L. Read, **Robert J. Reid, Geoffrey Foster, Andrew Brownlow and Jason Barley**. (2016) Twin foetuses in an Atlantic white-sided dolphin (Lagenorhynchus acutus) stranded on the coast of Scotland, UK. Journal of the Marine Biological Association of the United Kingdom doi:10.1017/S0025315415002246 (**Davison** et al. 2016)

8. Johanna L. Baily, **Geoffrey Foster**, Derek Brown, **Nicholas J. Davison**, John E Coia, Eleanor Watson, Romain Pizzi, Kim Willoughby, Ailsa J. Hall and Mark P. Dagleish (2016) Salmonella infection in grey seals (Halichoerus grypus), a marine mammal sentinel species: Pathogenicity and molecular typing of Salmonella strains compared with human and livestock isolates. Environmental Microbiology DOI: 10.1111/1462-2920.13219 (Baily et al. 2016)
9. Paul D. Jepson, Rob Deaville, Jonathan L. Barber, Àlex Aguilar, Asunción Borrell, Sinéad Murphy, Jon Barry, **Andrew Brownlow**, James Barnett, Simon Berrow, Andrew A. Cunningham, **Nicholas J. Davison, Mariel ten Doeschate**, Ruth Esteban, Marisa Ferreira, Andrew D. Foote, Tilen Genov, Joan Giménez, Jan Loveridge, Ángela Llavona, Vidal Martin, David L. Maxwell, Alexandra Papachlimitzou, Rod Penrose, Matthew W. Perkins, Brian Smith, Renaud de Stephanis, Nick Tregenza, Philippe Verborgh, Antonio Fernandez & Robin J. Law. (2016) PCB pollution continues to impact populations of orcas and other dolphins in European waters. Nature Scientific Reports 6:18573 DOI: 10.1038/srep18573 Published 14 January 2016 (Jepson et al. 2016)

10. Zuzana Gajdosechova, **Andrew Brownlow**, Nicolas T. Cottin, Mariana Fernandes, Fiona L. Read, Dagmar S. Urgast, Andrea Raab, Jörg Feldmann, Eva M. Krupp. (2016) Possible link between Hg and Cd accumulation in the brain of long-finned pilot whales (Globicephala melas). Science of The Total Environment Volumes 545–546, Pages 407–413. Published 1 March 2016:

11. **Andrew Brownlow**, Joseph Onoufriou, Amanda Bishop, **Nicholas Davison**, Dave Thompson (2016) Corkscrew Seals: Grey Seal (Halichoerus grypus) Infanticide and Cannibalism May Indicate the Cause of Spiral Lacerations in Seals. PLoS ONE 11(6): e0156464. doi:10.1371/journal.pone.0156464 (**Brownlow** et al. 2016)

12. Sílvia S. Monteiro , José V. Vingada , Alfredo López , Graham J. Pierce , Marisa Ferreira , **Andrew Brownlow**, Bjarni Mikkelsen, Misty Niemeyer, Robert J. Deaville, Catarina Eira, Stuart Piertney (2016). Major Histocompatibility Complex (MHC) class II sequence polymorphism in long-finned pilot whale (Globicephala melas) from the North Atlantic. Marine Biology Research doi: 10.1080/17451000.2016.1174266 (S. S. Monteiro et al. 2016)

13. Zuzana Gajdosechova, Mohammed M. Lawan, Dagmar S. Urgast, Andrea Raab, Kirk G. Scheckel, Enzo Lombi, Peter M. Kopittke, Katrin Loeschner, Erik H. Larsen, Glenn Woods, **Andrew Brownlow**, Fiona L. Read, Jörg Feldmann & Eva M. Krupp (2016) In vivo formation of natural HgSe nanoparticles in the liver and brain of pilot whales. Nature Scientific Reports 6, 34361; doi: 10.1038/srep34361 (Gajdosechova, Lawan, et al. 2016)

14. Maria Morell, **Andrew Brownlow**, **Barry McGovern**, Stephen A. Raverty, Robert E. Shadwick, and Michel André. 2017. "Implementation of a Method to Visualize Noise-Induced Hearing Loss in Mass Stranded Cetaceans." Scientific Reports 7 (February). Nature Publishing Group: 41848. doi:10.1038/srep41848. (Morell et al. 2017)

15. Michaël C. Fontaine, Oliver Thatcher, Nicolas Ray, Sylvain Piry**, Andrew Brownlow, Nicholas J. Davison,** Paul Jepson, Rob Deaville, Simon J. Goodman. (2017) Mixing of porpoise ecotypes in south western UK waters revealed by genetic profiling. Royal Society Open Science. 4: 160992. http://dx.doi.org/10.1098/rsos.160992 (Fontaine et al. 2017)

16. Norbert van de Velde, Brecht Devleesschauwer, Mardik Leopoldd, Lineke Begeman, Lonneke IJsseldijk, Sjoukje Hiemstra, Jooske IJzer, **Andrew Brownlow, Nicholas Davison,** Jan Haelters, Thierry Jauniaux, Ursula Siebert, Pierre Dorny, Stéphane De Craeye (2016) Toxoplasma gondii in stranded marine mammals from the North Sea and Eastern Atlantic Ocean: Findings and diagnostic difficulties. Veterinary Parasitology 230 25–32 (Van de Velde et al)

17. **Nicholas J. Davison**, Lorraine L. Perrett, Claire Dawson, Mark P. Dagleish, Gary Haskins, Jakub Muchowski, Adrian M. Whatmore. Brucella ceti infection in a common minke whale (Balaenoptera acutorostrata) with associated pathology. On line ahead of print Journal of Wildlife Diseases http://www.jwildlifedis.org/doi/abs/10.7589/2016-08-200 (Davison et al. 2017)

18. Kershaw JL, Sherrill M, **Davison NJ, Brownlow A**, Hall AJ. Evaluating morphometric and metabolic markers of body condition in a small cetacean, the harbor porpoise (*Phocoena phocoena*). Ecol Evol. 2017;7:3494–3506. (Kershaw et al. 2017)

19. Mariel T.I. ten Doeschate, Andrew C. Brownlow, Nicholas J. Davison and Paul M. Thompson (2017) Dead useful; methods for quantifying baseline variability in stranding rates to improve the ecological value of the strandings record as a monitoring tool. Journal of the Marine Biological Association of the United Kingdom doi:10.1017/S0025315417000698 (ten Doeshate et al 2017)