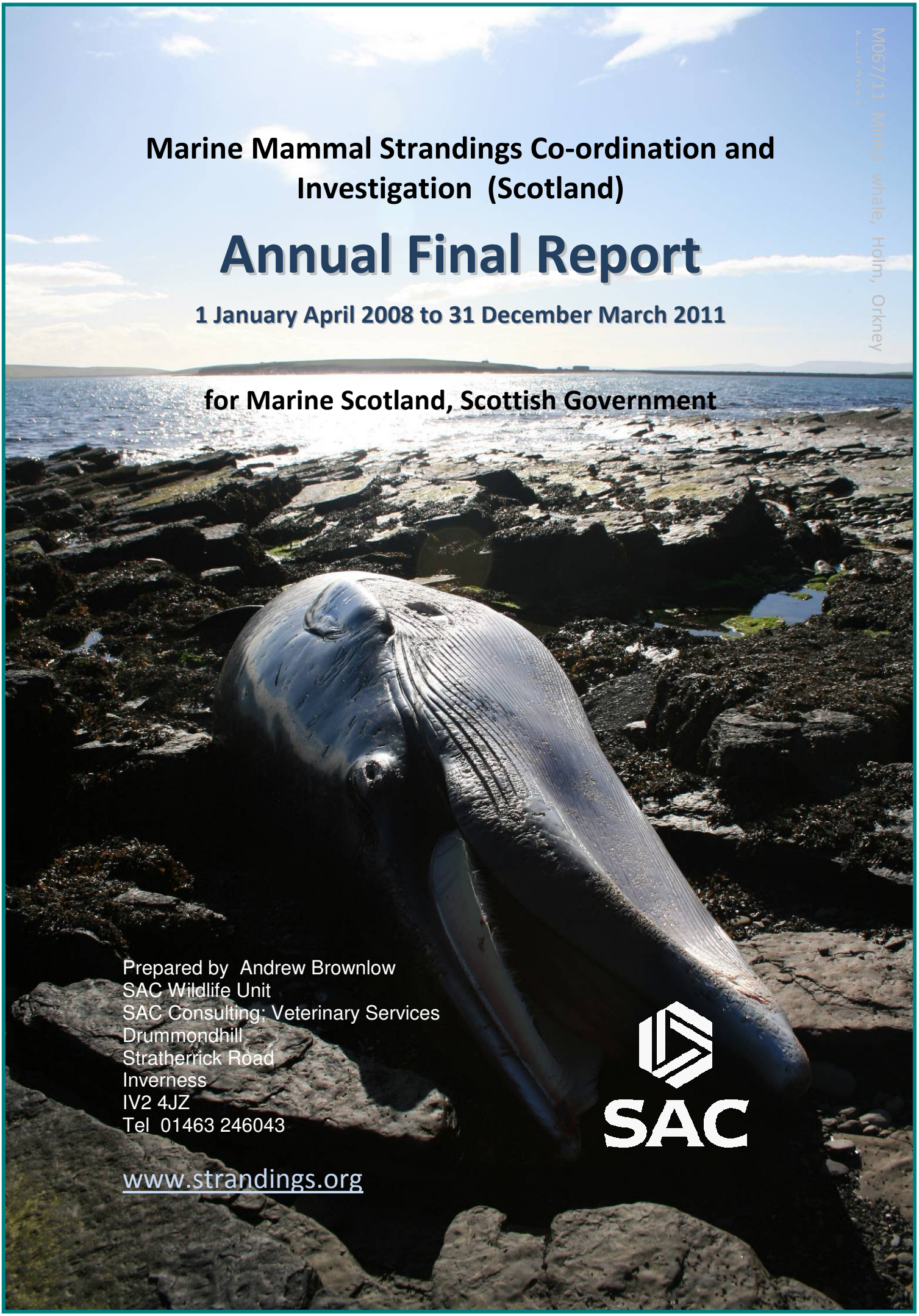
Marine Mammal Strandings Co-ordination and Investigation (Scotland)

Annual Final Report

1 January April 2008 to 31 December March 2011

for Marine Scotland, Scottish Government



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SAC

1 Executive Summary

For the three year period from the 1st April 2008 to 31st March 2011, 789 marine animals were reported to the Scottish Strandings Investigation Programme; 379 seals, 401 cetaceans, 6 basking sharks and 3 marine turtles. Of these, 216 cases (37%), comprising 141 cetaceans, 73 seals, 1 marine turtle and 1 basking shark were necropsied to establish a cause of death.

As in most years, the harbour porpoise, (*Phocoena phocoena)*, was by far the most commonly reported animal, representing 45% of all cetacean strandings. In subsequent decreasing order of prevalence are minke whale (*Balenoptera acutrostrata*) 8.7%, white-beaked dolphin (7.9%) and Atlantic white-sided dolphin (6.0%). In contrast to other UK averages, Scotland sees a significantly higher number of pelagic dolphin and whale species than any other UK region the exception being common dolphins which are show a cluster in south-west of England.

This period saw an increase in seal carcases, attributed to increased reporting effort rather than mortality. Verminous pneumonia remains the single most common cause of death for seals. For cetaceans the picture is more complex as it is species dependent, although live strandings, pneumonia and generalised bacterial infections are commonly diagnosed..

Scanning surveillance for threats to marine mammals has shown a new type of traumatic lesion in seals and one porpoise, characterised by a single, continuous spiral cut running caudally from the head of the animal with associated flensing of the skin and blubber from the underlying musculature. Termed 'corkscrew' lesions, the number of animals exhibiting these lesions have been increasing and represents a serious potential cause of concern.. It is considered that the lesions are caused by the animal becoming drawn through a ducted propeller, although the precise mechanism is not yet clear. Investigations into the cause of these lesions required good collaborations with SMRU, RSPCA, VLA and demonstrated the importance of a integrated and multidiscipline approach to marine mammal research.

Since early 2009, significant effort was put into increasing the availability of strandings data to both the scientific community and members of the public. In 2010 interactive stranding maps were launched (www.strandings.org) and an online database went live in spring 2011.

2 History of project

Information on UK stranded cetaceans has been routinely collected in the UK by the Natural History Museum since 1913. In 1988 a large number of dead or moribund harbour seals were found around the coast of the UK. The Sea Mammal Research Unit (SMRU), then part of the British Antarctic Survey, based at The University of Cambridge led studies into this for the UK. At that time the SAC Veterinary Centre in Inverness was managed by a veterinary surgeon with an interest in marine mammals and became involved in the seal investigation in collaboration with SMRU and the Scottish SPCA.

It became evident that this was the first recorded outbreak of morbillivirus in seals, a virus of similar type to that causing distemper in dogs and rinderpest in cattle, and subsequently termed Phocine Distemper Virus (PDV).

Aberdeen University was concurrently establishing a field centre in Cromarty to study the ecology of common seals and the resident population of bottlenose dolphins in the Moray Firth. This increase in interest in marine mammals in the area led to stranded pinnipeds and cetaceans being reported and taken to SAC for necropsy.

In 1990 The Institute of Zoology in London was awarded a research contract to investigate stranded marine mammals for the UK. It soon became apparent that there needed to be local input to this project in Scotland therefore on 1 January 1992 the SAC were awarded a three-year research contract to coordinate and investigate marine mammal strandings in Scotland.

In 2000, the separate projects were amalgamated into a single UK strandings investigation programme under the aegis of the CSIP (Cetacean Strandings Information programme) In 2001, the investigation of UK stranded marine turtles was formally incorporated into the CSIP remit, followed by the incorporation of stranded basking shark investigations in 2007. A consortium of organisations now collaboratively record information on all cetaceans, marine turtles and basking sharks that are found stranded around UK shores each year and retrieve a proportion of these strandings for examination at post-mortem.

Contiguous 3-4 year long contracts have been awarded since, and currently by Defra, Scottish Government and Welsh Government.

Currently the Scottish Marine Animal stranding scheme undertakes the most extensive marine stranding surveillance in the UK. In addition to the cetacean stranding investigation undertaken as part of the CSIP, Scotland is unique in investigating mortalities and undertaking necropsies on dead or euthanized seals. This work is in strong collaboration with other Scottish marine science institutions and current work adheres to recommendations made in 2008 following a review of the Scottish marine stranding scheme.

3 Policy objectives and project descriptor

The JNCC Surveillance and Monitoring website page for cetaceans (http://jncc.defra.gov.uk/page-1554) states that;

"A variety of conservation issues affect cetaceans in UK waters today, many of which are related to human activity. They include fishing, pollution and the effects of noise from shipping, oil and gas exploration , military activity and tourism. The degree of impact of any human activity, varies considerably between different species and depending on their ecology, distribution and abundance. A range of legislative instruments oblige the UK to support research that has a bearing on the conservation status of cetacean populations. All species are listed on Annex IV of the Habitats Directive (92/43/EEC). It requires regular assessments of the conservation status of all species that cover abundance, distribution and the pressures and threats experienced. In addition, bottlenose dolphin and harbour porpoise are listed on the Directive's Annex II which requires the designation of Special Areas of Conservation where areas can be identified. The Convention on the Conservation of Migratory Species (Bonn Convention) and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), oblige signatories – which include the UK - to apply a range of research and management measures aimed at the conservation of all cetaceans. An objective under ASCOBANS commits signatories to reducing the incidental catch of harbour porpoises in commercial fisheries to 1.7 per cent of the species' abundance, a target specified in the EU Regulation 812/2004."

In addition, elements of strandings research in the UK may also provide data to help inform the implementation of the Marine Strategy Framework Directive in the UK.

3.1 Project overview

Marine mammal surveillance in Scotland is more extensive than in the rest of the UK, with additional funding granted from Marine Scotland to undertake seal disease surveillance, unusual mortality investigations and perform an additional number of seal and cetacean necropsies. Figure 1 shows the stages undertaken when a stranding is reported. The SAC in Inverness currently manage stranding co-ordination, carcase selection and collection for necropsy, sample archiving and data management for all marine mammals reported stranded in Scottish waters.

The principal requirement of this project is to provide a co-ordinated approach to the surveillance of marine species (e.g. cetaceans & seal) strandings and to investigate major causes of death of stranded marine species in Scotland.

This work builds on the work undertaken in Scotland by the UK Cetacean Strandings Investigation Programme (CSIP). Detailed information about the CSIP, including access to stranding records, can be found at ukstrandings.org.

3.2 Details of work

- 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). 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 common seal decline, to determine cause of death and any potential contributing factors.
- To investigate specific cases of strandings/causes of death as requested by Scottish Government.
- Continue to contribute to existing SG funded projects including the minke whale entanglement and the bottlenose dolphin projects
- To provide scientific advice to the Scottish Government as necessary about major causes of death in stranded marine mammals, including any trends or unusual trends.
- To develop a database which brings together data on both strandings and post mortems for seals. All cetacean data should be fed into the database for the "UK Cetacean Strandings Investigation Programme".
- Contribute to the production of strandings training material and workshop events and raise awareness through publicity.
- Standardise the current protocols for necropsies where appropriate
- Review options for specimen storage facility, with a focus on reducing storage demand and consider publicising tissue bank facility.
- Review any papers compiled using SAC free samples as a means of quality control.

3.3 Triage protocol for carcase sampling/recovery

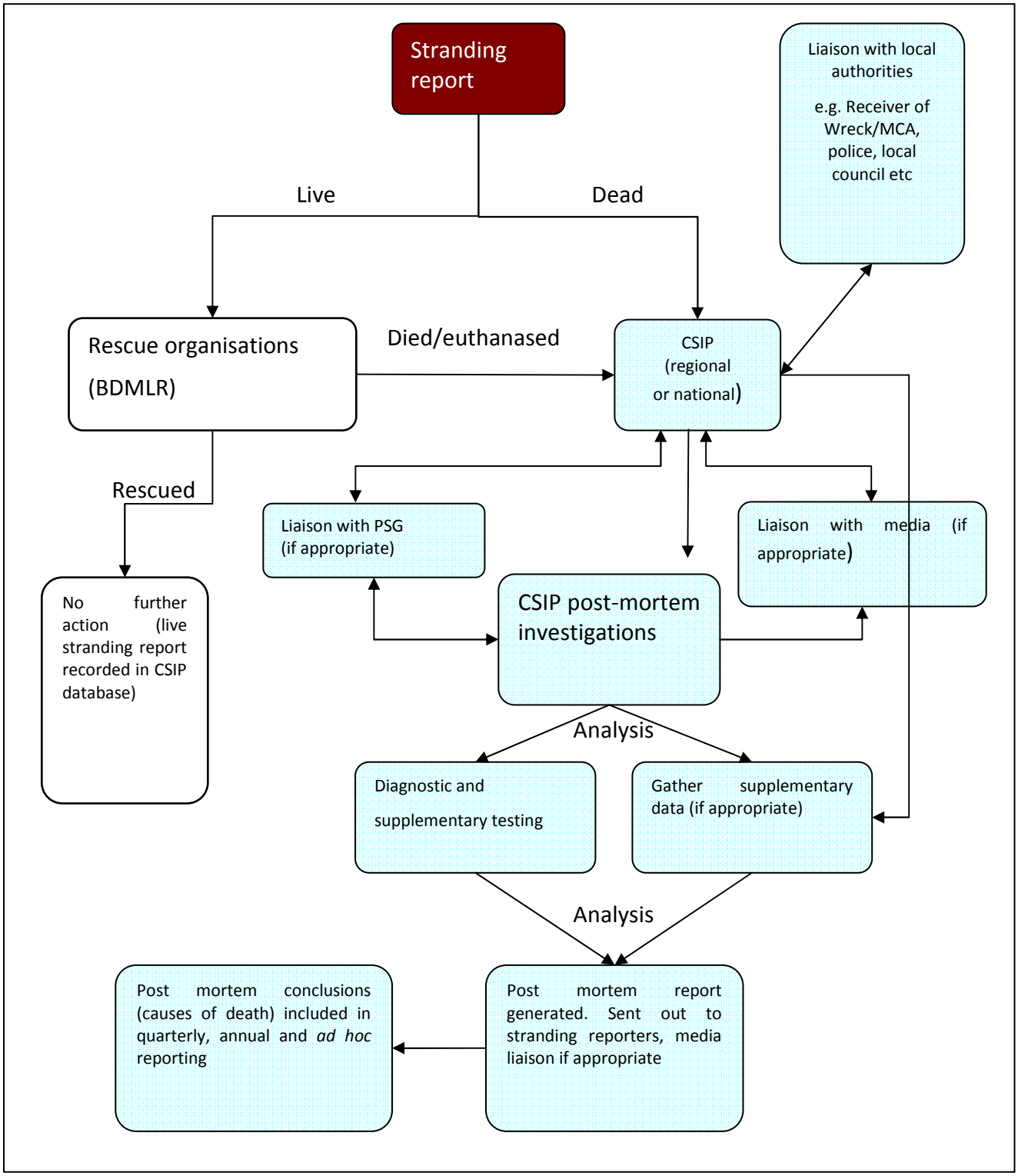


Figure 2 Outline process in strandings reporting and post-mortem examinations in the UK by the CSIP consortium. Blue highlighted sections denote CSIP actions.

Figure 2 shows the triage protocol for carcase sampling and recovery. Work is undertaken according to a UK-wide protocol however implementation of this is facilitated in Scotland by the SAC Wildlife Unit in Inverness taking responsibility for all the stages of carcase recording, selection and recovery. A maximum limit of 25 cetacean necropsies per annum was agreed by DEFRA for Scotland however this is augmented by support from Marine Scotland. Consequently, it has been possible to attempt recovery and necropsy of all carcases in a suitable condition, effectively removing that aspect of selection bias from the dataset. Carcases collected for necropsy are subjected to the range of diagnostic tests necessary to establish a cause of death, however additional samples collected are archived for future work.

4 Marine species strandings around the Scottish coast (2008-2011)

4.1 Strandings overview

For the three year period from the 1st April 2008 to 31st March 2011, 789 marine animals were reported to the Scottish Strandings Investigation Programme, comprising of 379 seals, 401 cetaceans, 6 basking sharks and 3 marine turtles. Of these, 216 cases (37%), comprising 141 cetaceans, 73 seals, 1 marine turtle and 1 basking shark were necropsied to establish a cause of death. (Figure 2 & Table 1)

4.2 Main species found stranded around the coast

The most commonly stranded cetacean in Scotland, and indeed the whole of the UK is the harbour porpoise (*Phocoena phocoena, n=177*). A 1994 study (SCANS) estimated a population of approximately 280,000 harbour porpoises in the North Sea, making it the most numerous cetacean species. Additionally, porpoises are largely coastal animals and most will float if they die at sea hence the high frequency of reported strandings for this species.

Other species commonly found include the minke whale (*Balaenoptera acutorostrata, n=35*), Atlantic white-sided dolphin *(Lagenorhynchus acutus n=34*), white-beaked dolphin *(Lagenorhynchus albirostris n=32),* long-finned pilot whale *(Globicephala melas n=16)* and the short-beaked common dolphin (*Delphinus delphis n=13*) Spatial maps of individual species are shown in Figure 6

The minke whale was extensively hunted in the Antarctic until 1986 but it now appears the population is recovering. Since the beginning of the Scottish strandings scheme in 1992 there is an upward trend in the number of minke whales recorded, which is probably in part due to the population increase. 42% of 7 minke whales examined show some evidence of entanglement, usually in some type of mooring rope.

The Atlantic white-sided dolphin is the species recorded most often as live-stranded in Scotland. Most live stranded animals either die or are euthanased. Bacteriological analysis of tissue taken from 7 necropsied animals showed 42% to have *Brucella* infection in the brain, and it is thought that infection causes disorientation, impaired feeding ability and ultimately live stranding. The white-beaked dolphin is another species reported stranded regularly, mostly in the North of Scotland. This is another species that often strands alive.

Long-finned pilot whales live in tight social groups and are a species commonly associated with mass-strandings in Scotland and in many other countries around the world. In the 1980s there was a spate of mass strandings around the UK with hundreds of animals being involved. Recently a group of around 30 long-finned pilot whales were seen in a sea loch in South Uist and a description of this case is outlined in section 4.7 below

4.3 Stranding process

Clearly, every cetacean will die somewhere at some time and several things can happen then. By far the majority of these deaths will occur at sea and most of these carcases

will never reach the shore. They may float for a time and then sink to the seabed to become food for other organisms or they may be predated upon as they float on the surface.

Many of the stranded cetaceans that we examine either died very close to the coast and were taken ashore by tidal and/or weather influences or actually came ashore alive and died there.

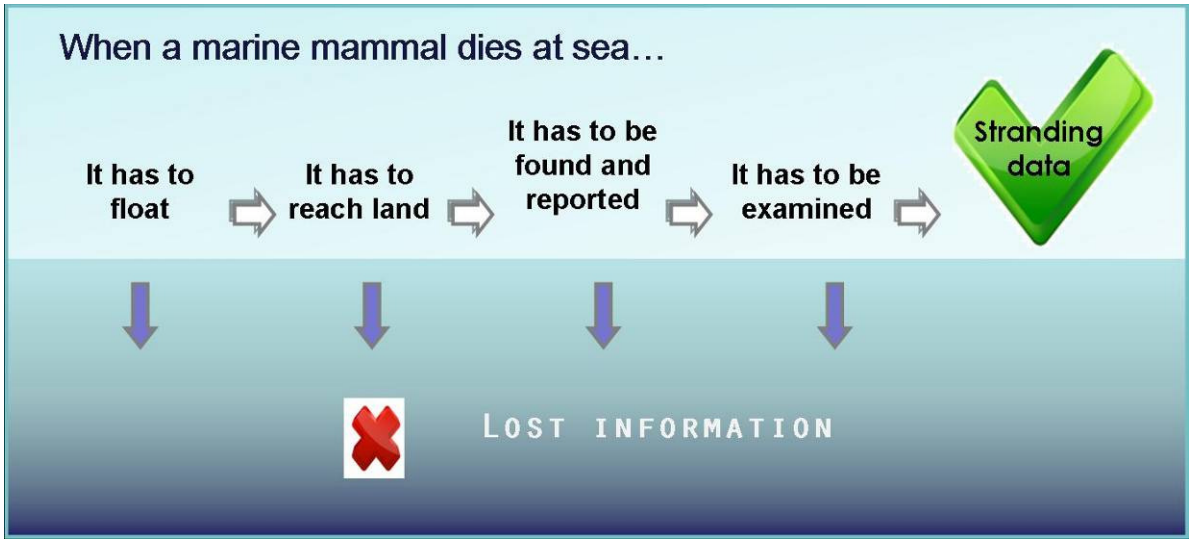


Figure 1: Graphic showing what happens when an animal dies at sea.

Both the striped and common dolphin are found stranded regularly with the most common cause of death recorded as live-stranded. It is interesting to note that some species of cetacean are more likely than others to float after death. For example, despite the presence of a local population of bottlenose dolphins in the Moray Firth, the only carcases to be found stranded are either animals that have stranded alive and died or very decomposed carcases. It appears that fresh bottlenose dolphin carcasses seldom float but sink to the seabed. Only after the carcase become buoyant due to the gas released during autolysis will they float on the surface, where tidal and weather may act to wash ashore to be found.

4.4 Species found stranded 2008-2011

Table 1 shows the marine species found stranded around Scottish coasts in this period. 401 cetaceans comprising 14 identifiable species were reported, and as in previous years the majority (44%) were harbour porpoise (*Phocoena phocoena*, n=177). 379 seals comprising the two native species of common, or harbour, seal (*Phoca vitulina*), and grey seal (*Halichoerus grypus*) and a single hooded seal (*Cystophora cristata*) were reported. It is likely the 121 unidentifiable seals are native species.

SubClass	Species (common name)	Species (scientific name)	Not necropsied	Necropsied	TOTAL
	Harbour porpoise	Phocoena phocoena	87	90	177
Dolphin	Atlantic white-sided dolphin	Lagenorhynchus acutus	17	7	24
	Bottlenose dolphin	Tursiops truncatus	4	6	10
	Risso's dolphin	Grampus griseus	11	3	14
	Short-beaked common dolphin	Delphinus delphis	9	4	13
	Striped dolphin	Stenella coeruleoalba	8	7	15
	White-beaked dolphin	Lagenorhynchus albirostris	24	8	32
	Dolphin (indeterminate species)	Unknown	4		4
Whale	Cuvier's beaked whale	Ziphius cavirostris	7		7
	Killer whale	Orcinus orca	1		1
	Long-finned pilot whale	Globicephala melas	15	1	16
	Minke whale	Balaenoptera acutorostrata	28	7	35
	Northern bottlenose whale	Hyperoodon ampullatus	5	4	9
	Sowerby's beaked whale	Mesoplodon bidens	2	2	4
	Sperm whale	Physeter catodon	9	1	10
	Basking shark	Cetorhinus maximus	5	1	6
Marine Turtle	Leatherback turtle	Dermochelys coriacea	1		1
	Loggerhead turtle	Caretta caretta	1	1	2
Seal	Grey Seal	Halichoerus grypus	100	27	127
	Harbour Seal (Common Seal)	Phoca vitulina	41	45	86
	Hooded seal	Cystophora cristata		1	1
	Seal (indeterminate species)	Unknown	165		165
	Lagenorhynchus sp. (ind. species)	Unknown	6		6
	Odontocete (indeterminate species)	Unknown	5		5
	Cetacean (indeterminate species)	Unknown	19		19
Grand Total			573	216	789

Table 1: Total number of marine strandings, Scottish waters 2008-2011

4.5 Spatial maps of strandings

Figure 2 shows all strandings for the period April 2008- March 2011, arranged by species class. Figure 3 shows the same data but as a interpolated smoothed density map, with colours showing 'hot-spots' areas of high stranding density (red). Figure 4 & Figure 5 show the spatial distribution of strandings during this period for seals and cetaceans respectively. It can be seen there was an equal spread around the Scottish coastline with notable clusters around Fife, the Forth, Tay and Moray firths, Loch Linnhe and the Clyde. This correlates well with areas of active reporting and beach surveys, for example the hotspot in Fife is probably attributable to seal reporters local to SMRU in St Andrews. The foci around the on the east coast firths is likely to also represent the populations resident around these sites, but may be biased due to increased probability of reporting in areas of higher population density.

Figure 6 shows the spatial distribution of some of the most commonly stranded species The critical importance of effective surveillance and carcase recovery in island communities such as the Western isles, Orkney and Shetland is particularly noticeable when considering oceanic dolphin species and pilot whales. Additionally, given the known high population of seals in Orkney and Shetland, there is a surprising absence of strandings data from this region.

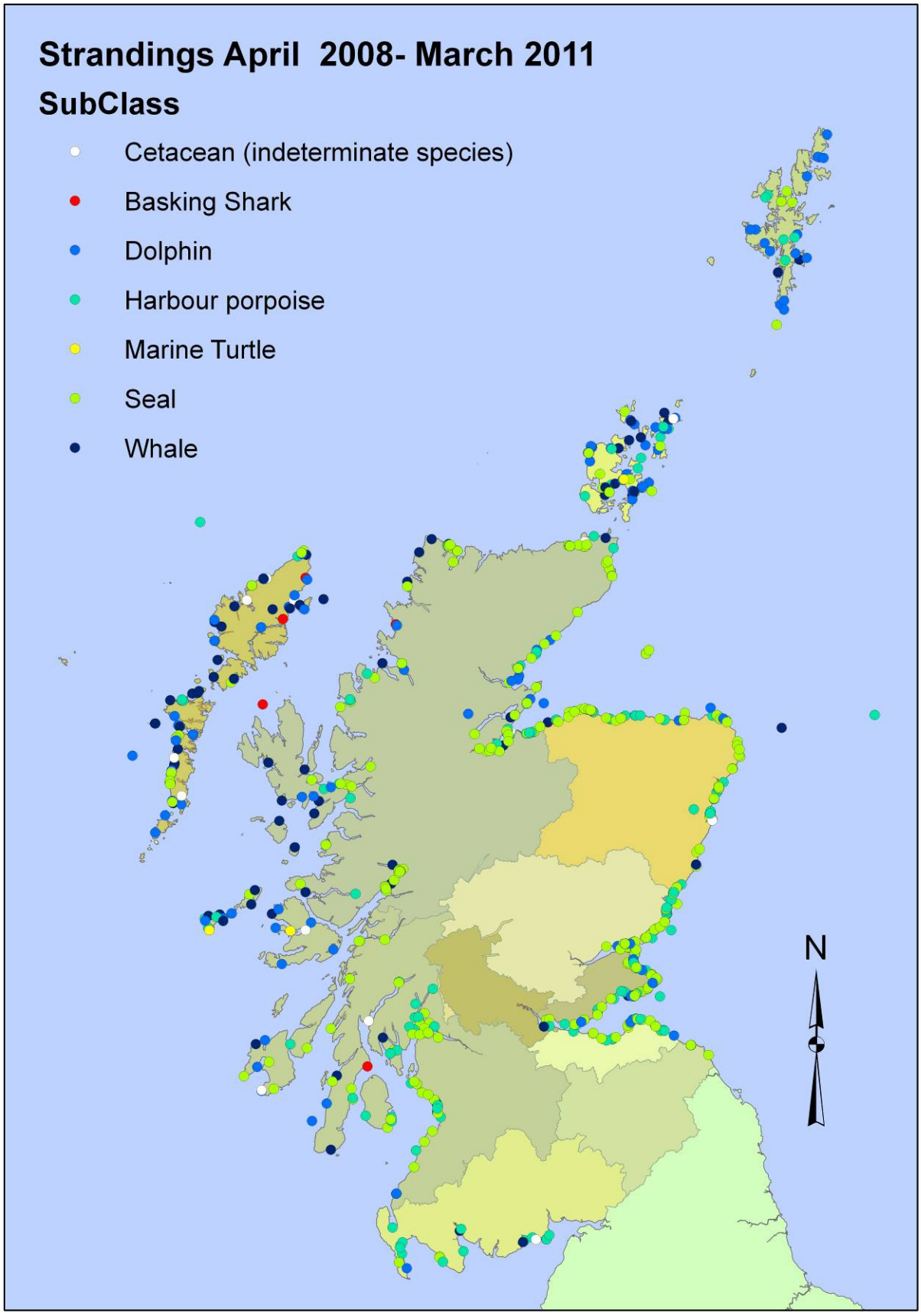


Figure 2: All strandings 2008-2011

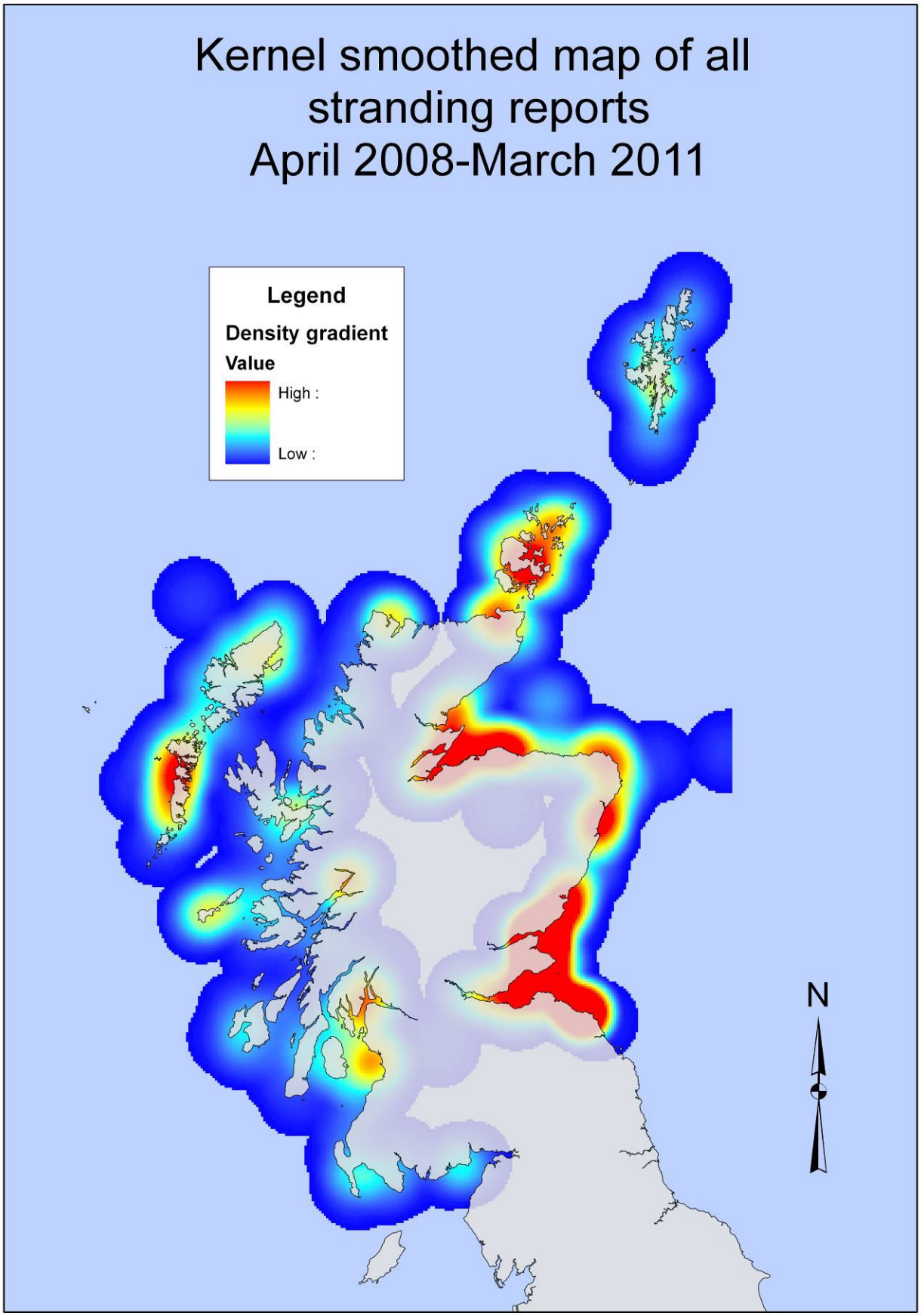


Figure 3: Density map of strandings 2008-2011

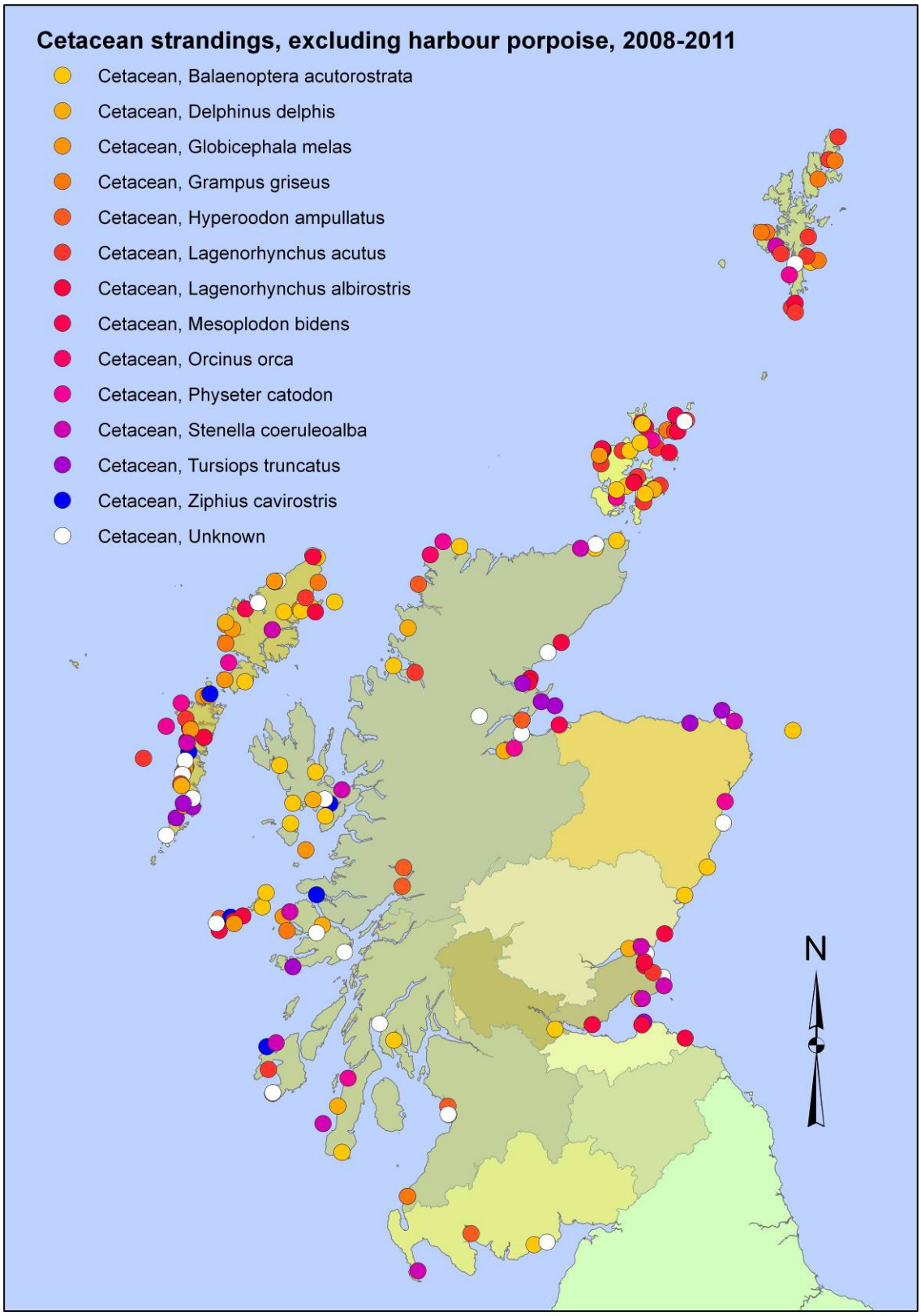


Figure 4: Cetacean strandings April 2008- March 2011

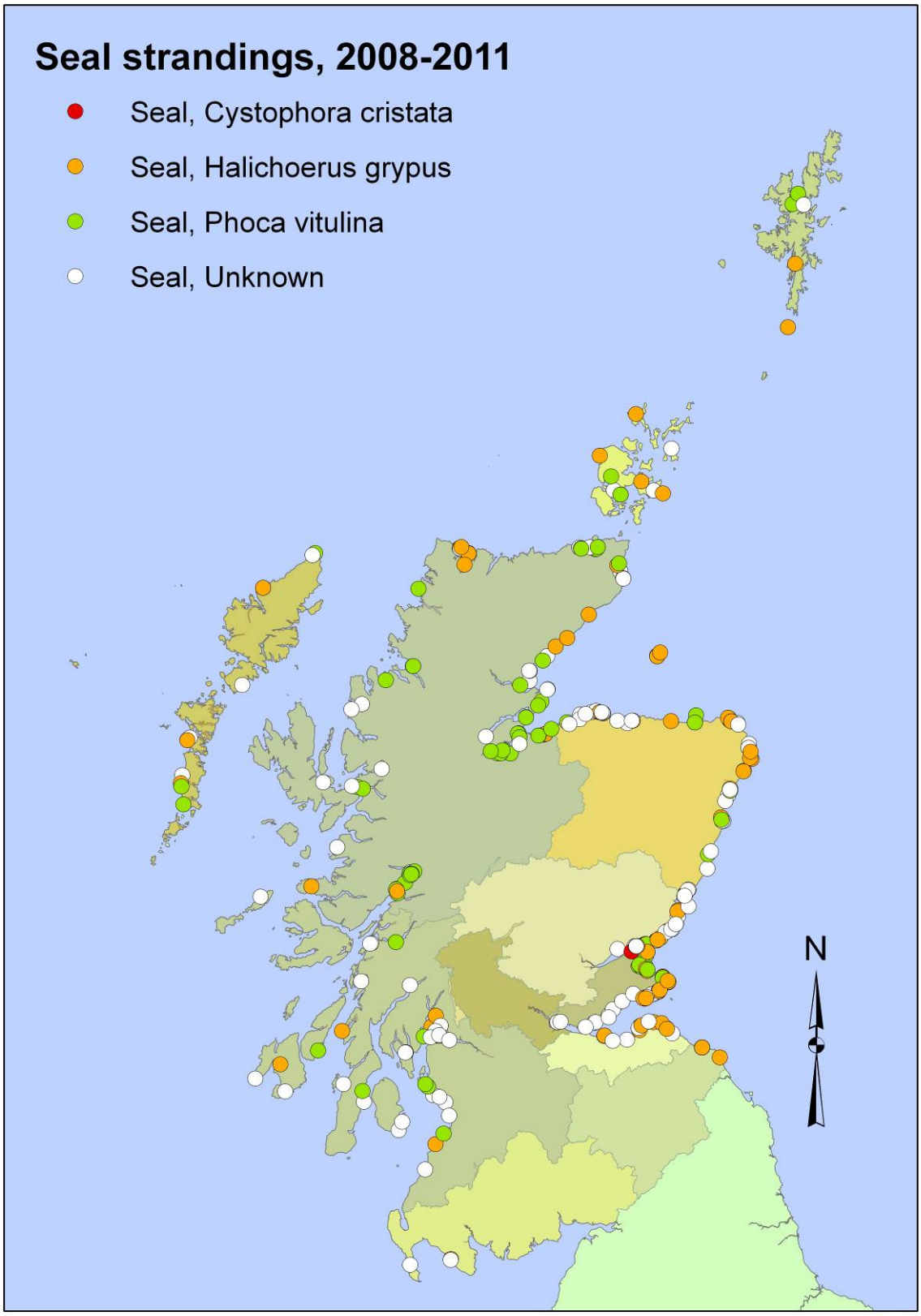
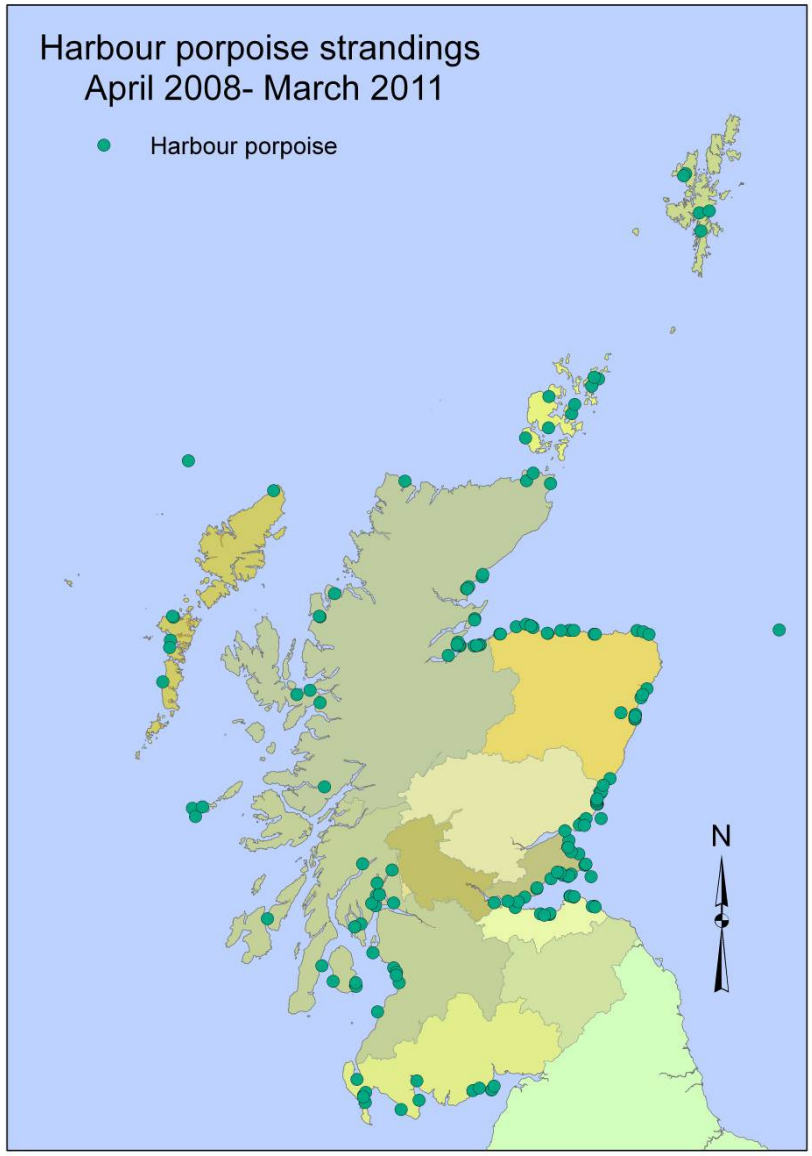
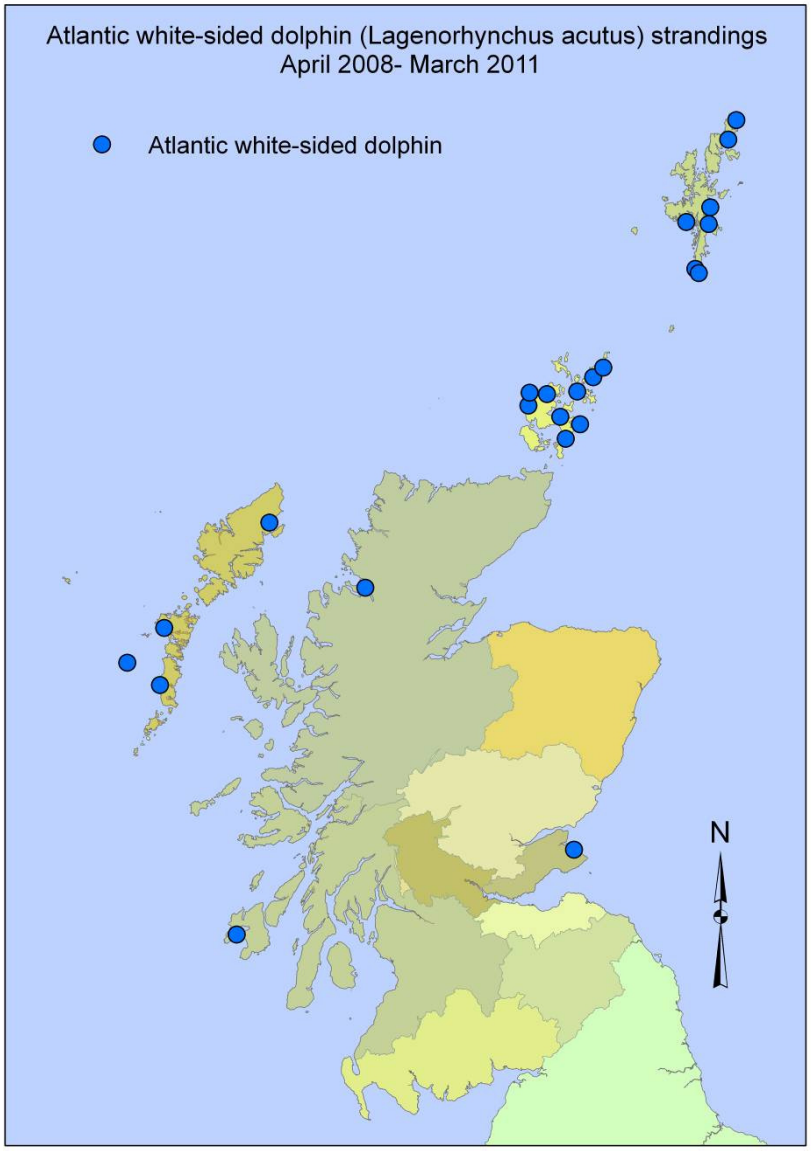
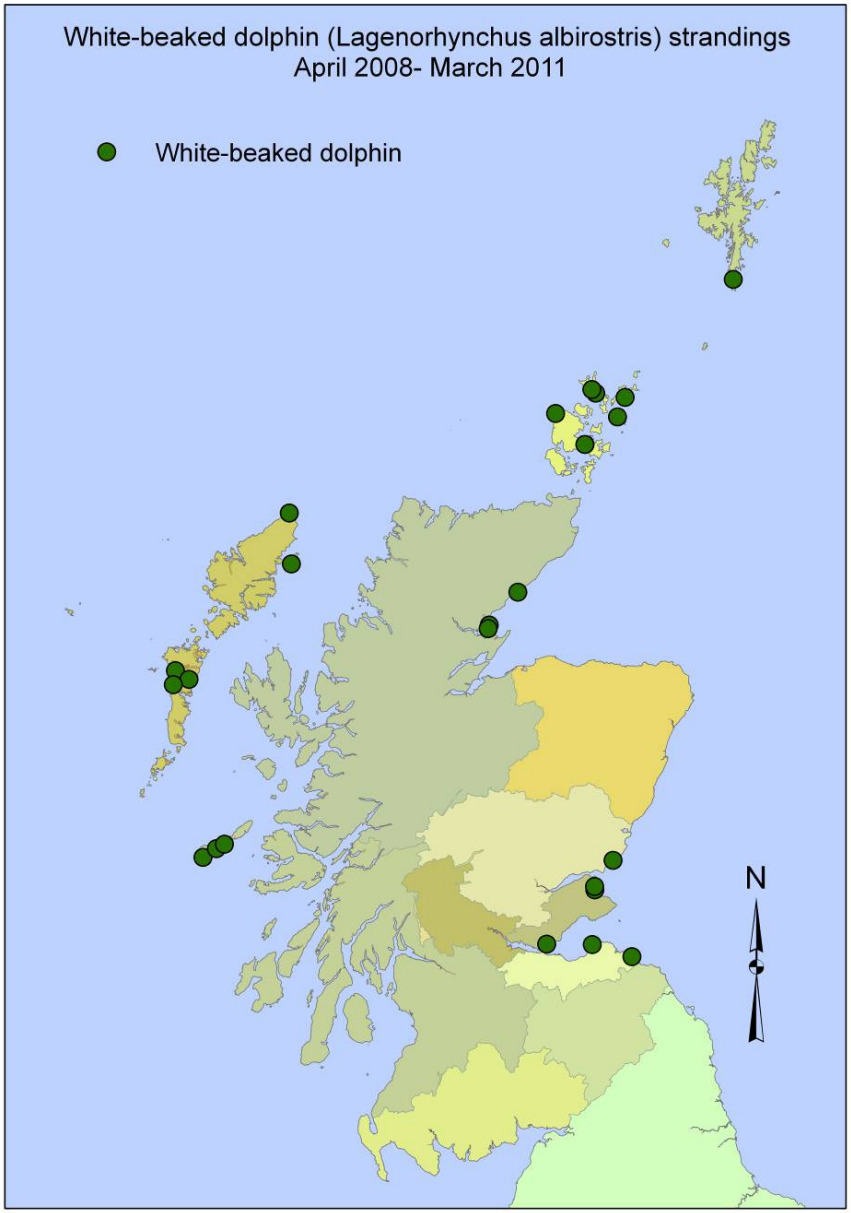
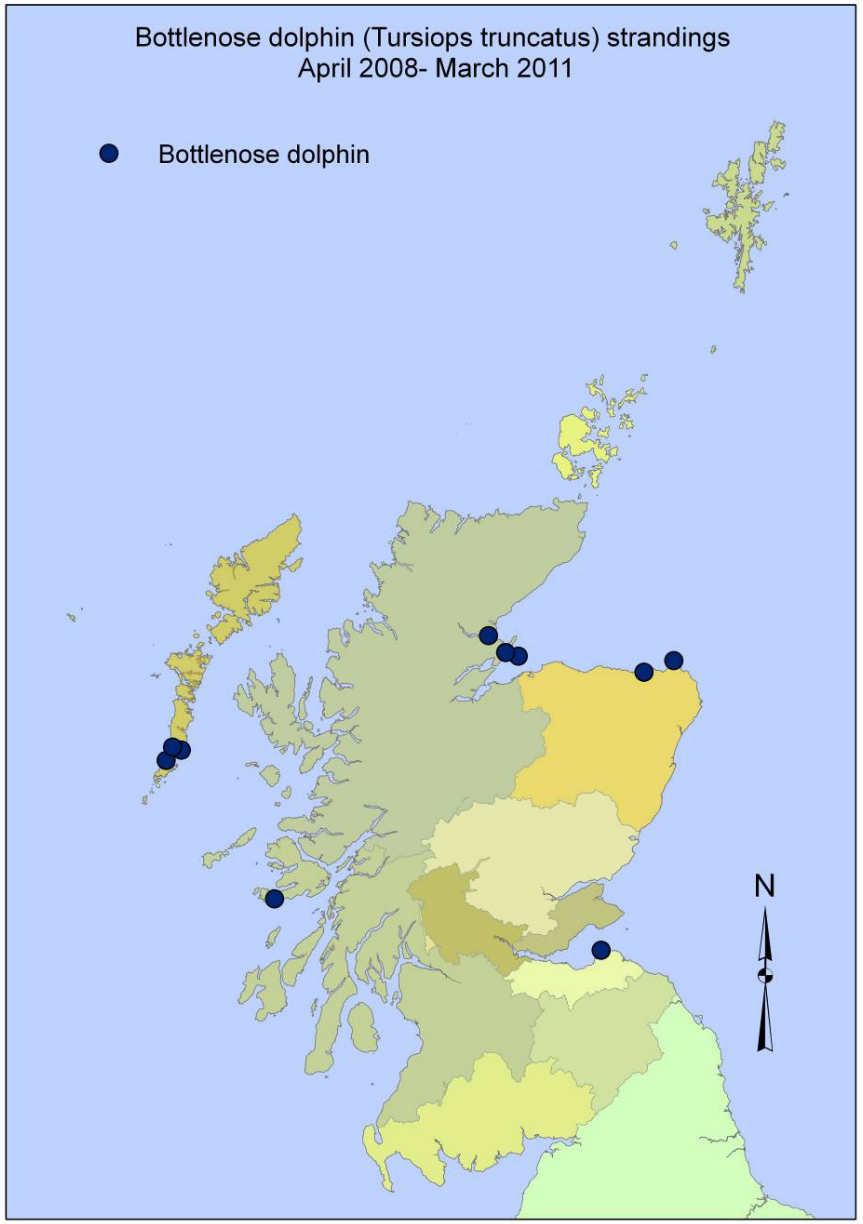


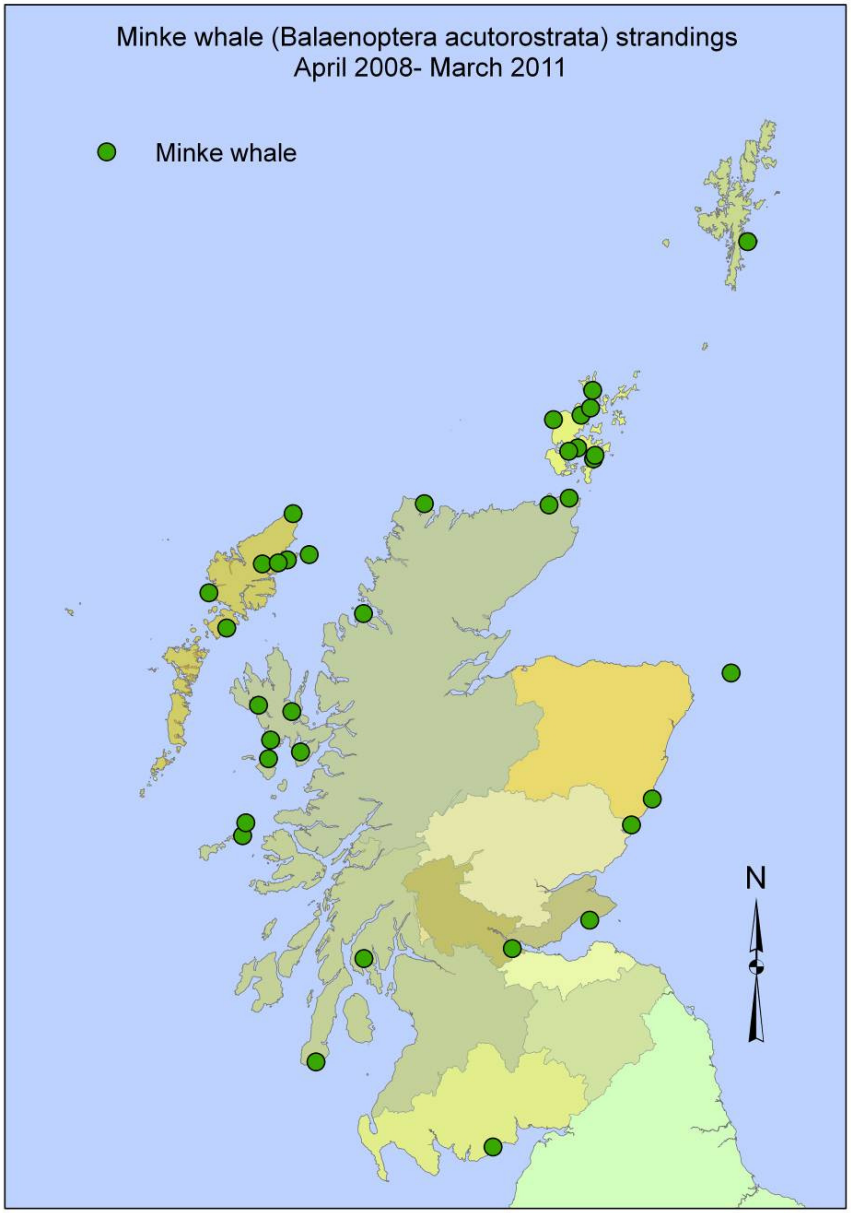
Figure 5: Seal strandings April 2008- March 2011

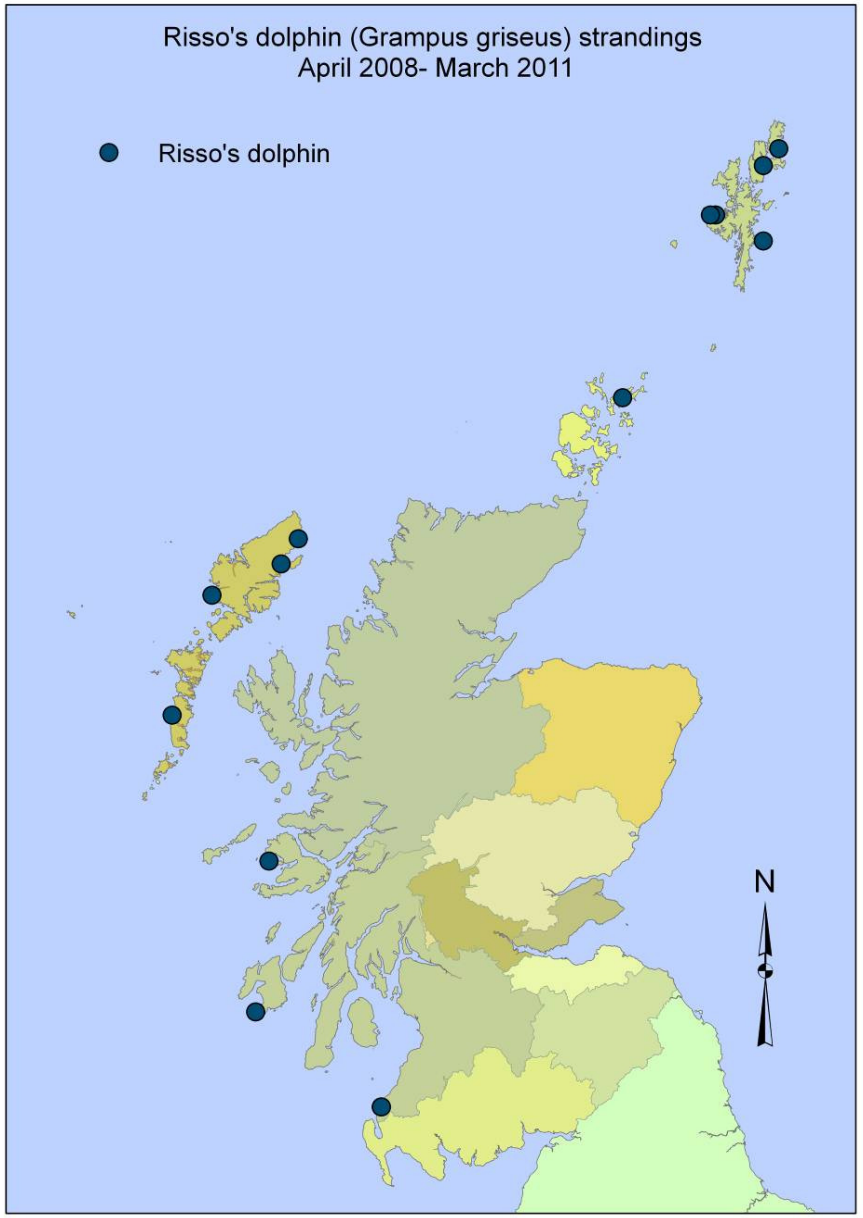

Harbour porpoise strandings
April 2008- March 2011
Harbour porpoise
N

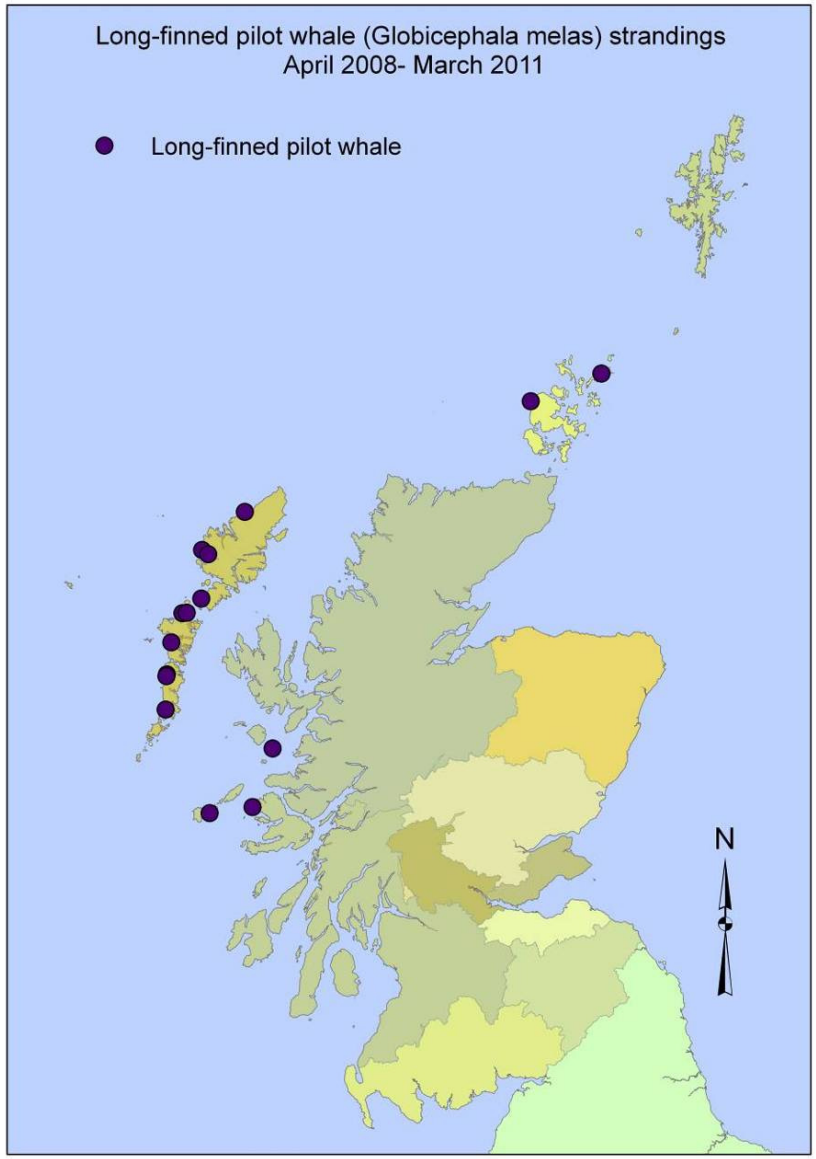

Atlantic white-sided dolphin (Lagenorhynchus acutus) strandings
April 2008- March 2011
Atlantic white-sided dolphin
N


White-beaked dolphin (Lagenorhynchus albirostris) strandings
April 2008- March 2011
White-beaked dolphin
N


Bottlenose dolphin (Tursiops truncatus) strandings
April 2008- March 2011
Bottlenose dolphin
N


Minke whale (Balaenoptera acutorostrata) strandings
April 2008- March 2011
Minke whale
N


Risso's dolphin (Grampus griseus) strandings
April 2008- March 2011
Risso's dolphin
N



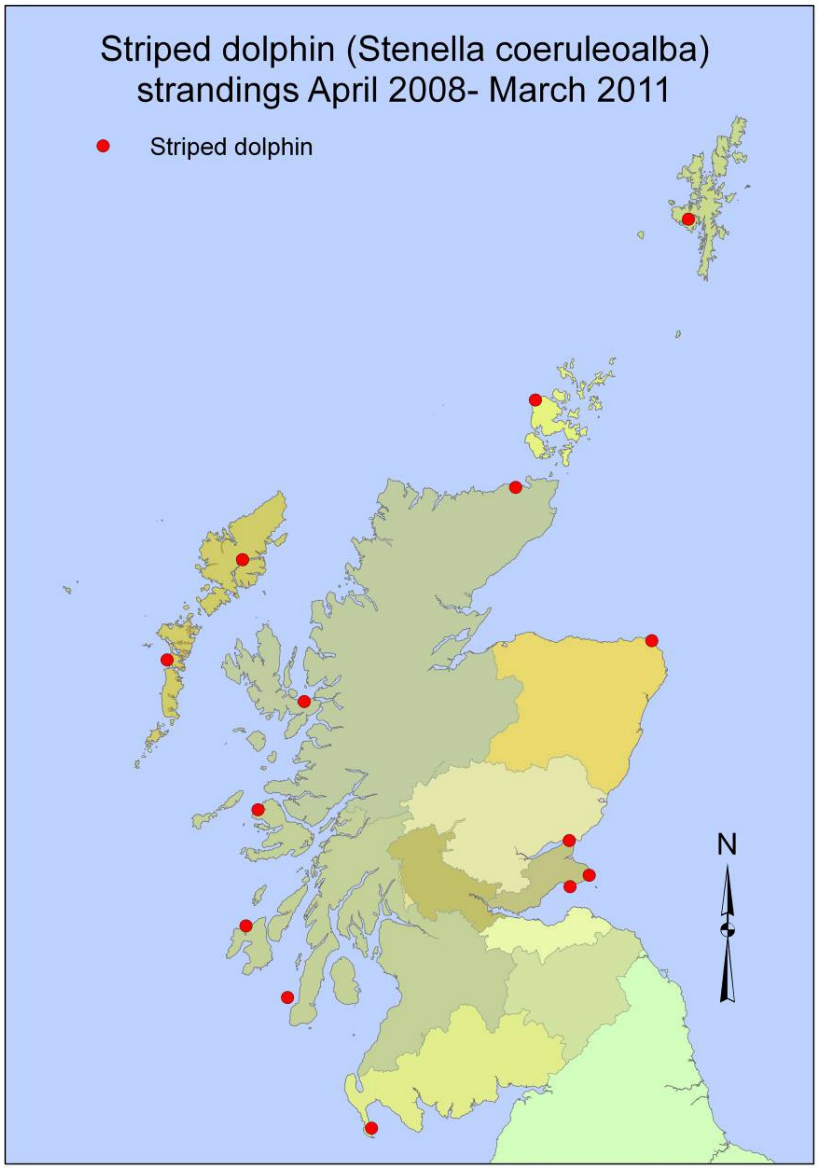
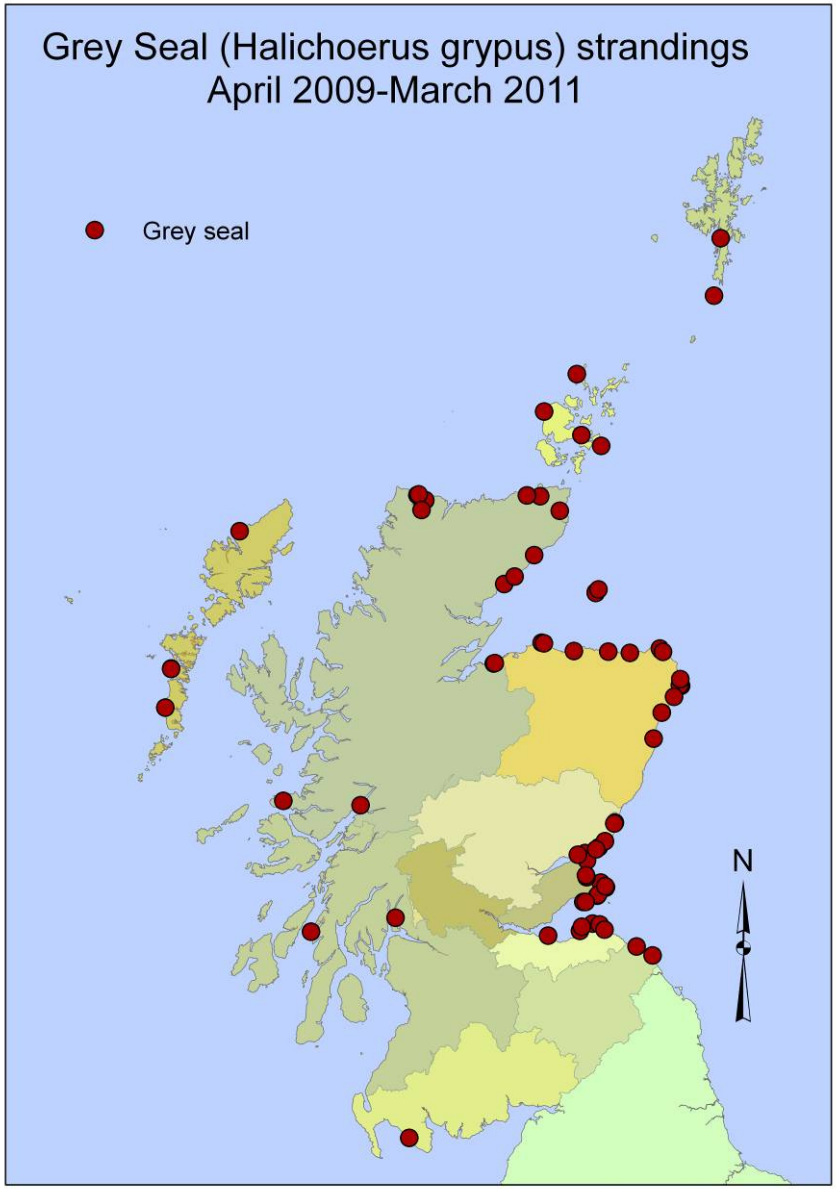


Figure 6: Individual cetacean species strandings



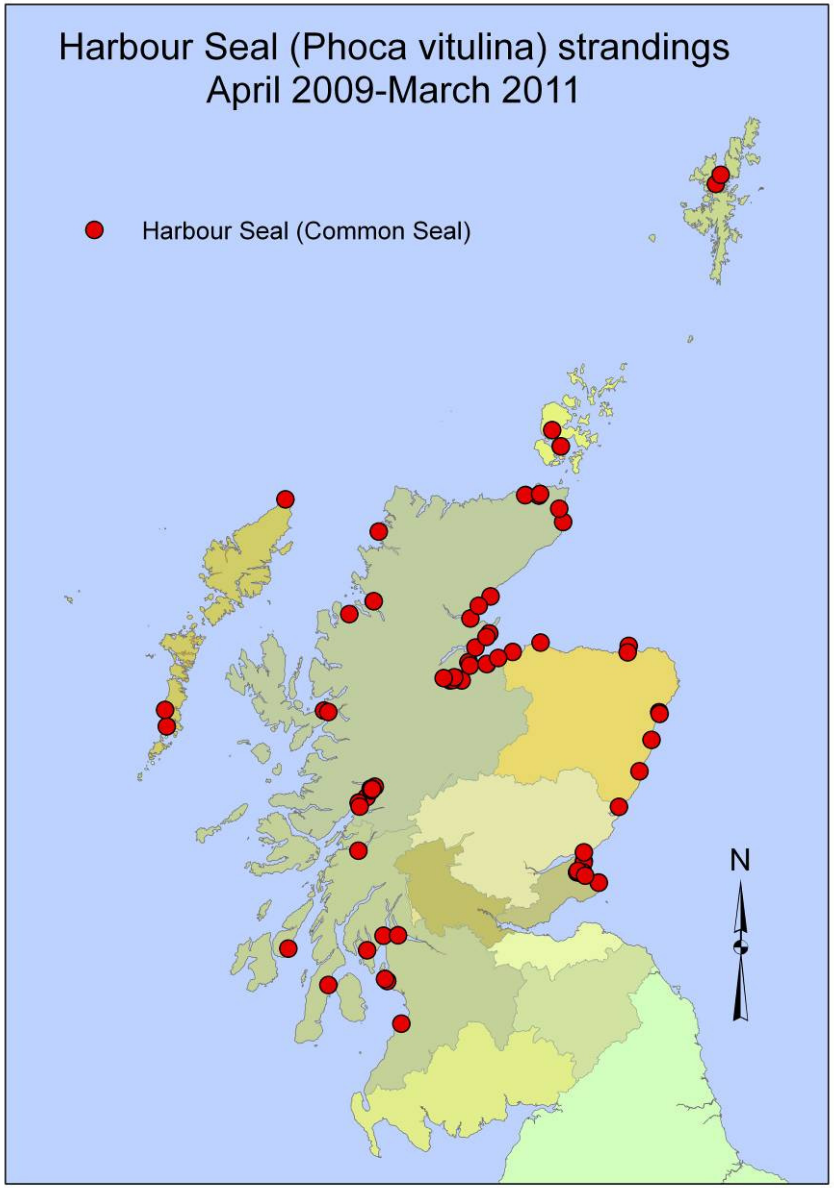


Figure 7: Seal species strandings

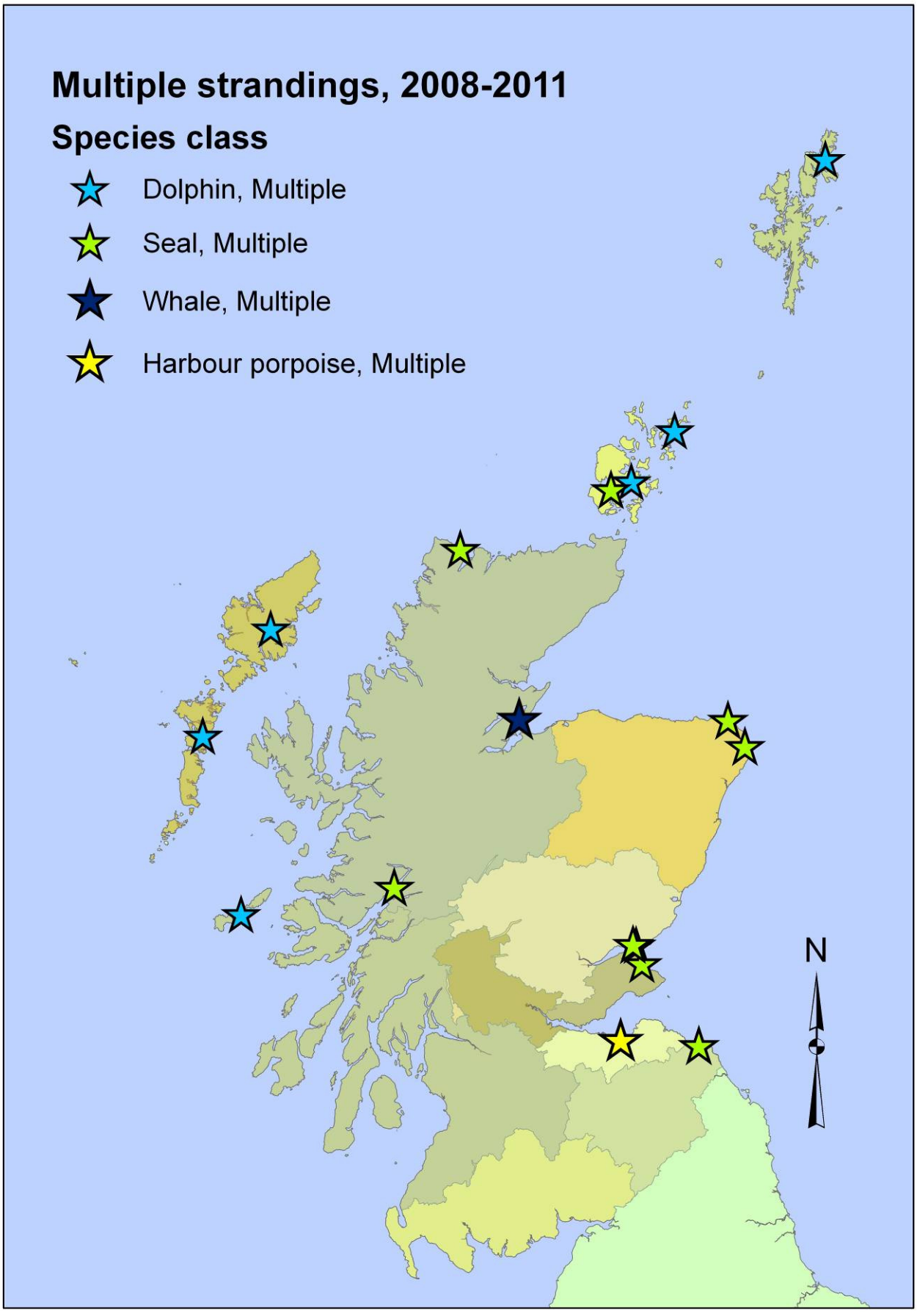


Figure 8: Locations for multiple strandings 2008-2011

4.6 Trends in marine strandings 2008-2011

Figure 10 shows the total number of Scottish strandings reported 2008-2011. Figure 11 shows the same data but as a proportion of all strandings. The number of seals reported during this period has increased in both absolute numbers and relative to all strandings and is attributable to increased public awareness to report seal carcases rather than increased mortality. Cetacean strandings do not show any clear trends in numbers.

4.6.1 Strandings by month

Figure 9 shows the number of strandings by month. July and August, November and January show the highest number of strandings, with May showing a particularly low level of reports The cause of these monthly variations is not clear, however factors such as observer effort (highest during summer), weather, neonate mortality and food availability are all likely to play a role. Further investigation of this trend is underway.

4.7 Mass strandings incidents 2008-2011

On 26th October 2010 there a pod of pilot whales sighted in Loch Carnan, Uist. (57.3'N,7.2'W) On the 31st October, they left the area however a week later, on the 6th November, there was a mass stranding of pilot whales in Rutland Island, Donegal in the Republic of Ireland. (55.0'N,8.4'W) 33 animals initially stranded and a further two carcasses subsequently washed in. Detailed carcase examination was not possible , however minimal sampling and morphometric data was collected by volunteers from the Irish Whale and Dolphin Group. Photo-identification made a positive link between the group seen in Uist and those stranding in Ireland, however further information about the cause of stranding is unknown.

Photo 1: Pilot whales mass stranded on a Donegal beach. Photo courtesy of IWDG

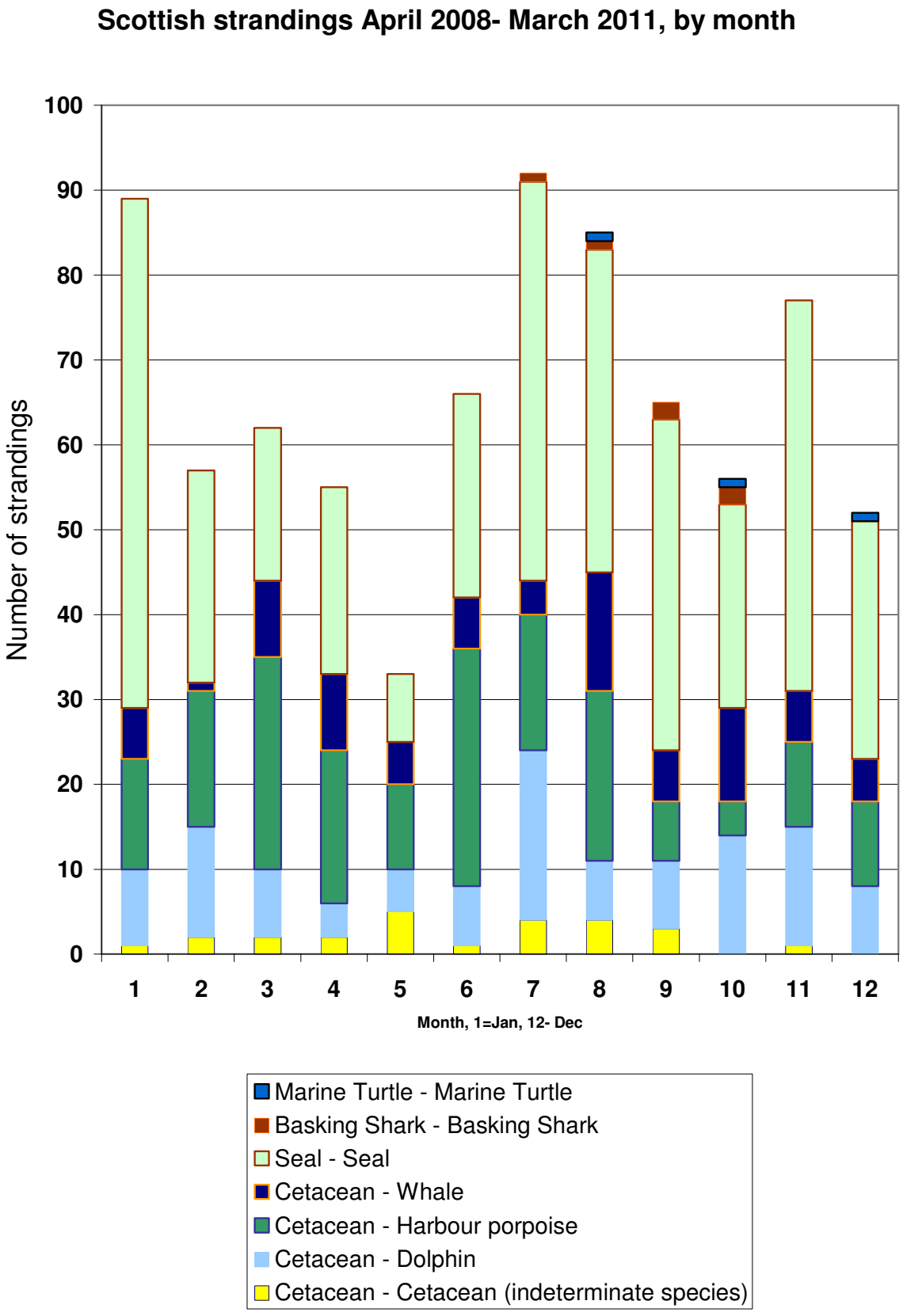


Figure 9: Scottish strandings by subclass and month

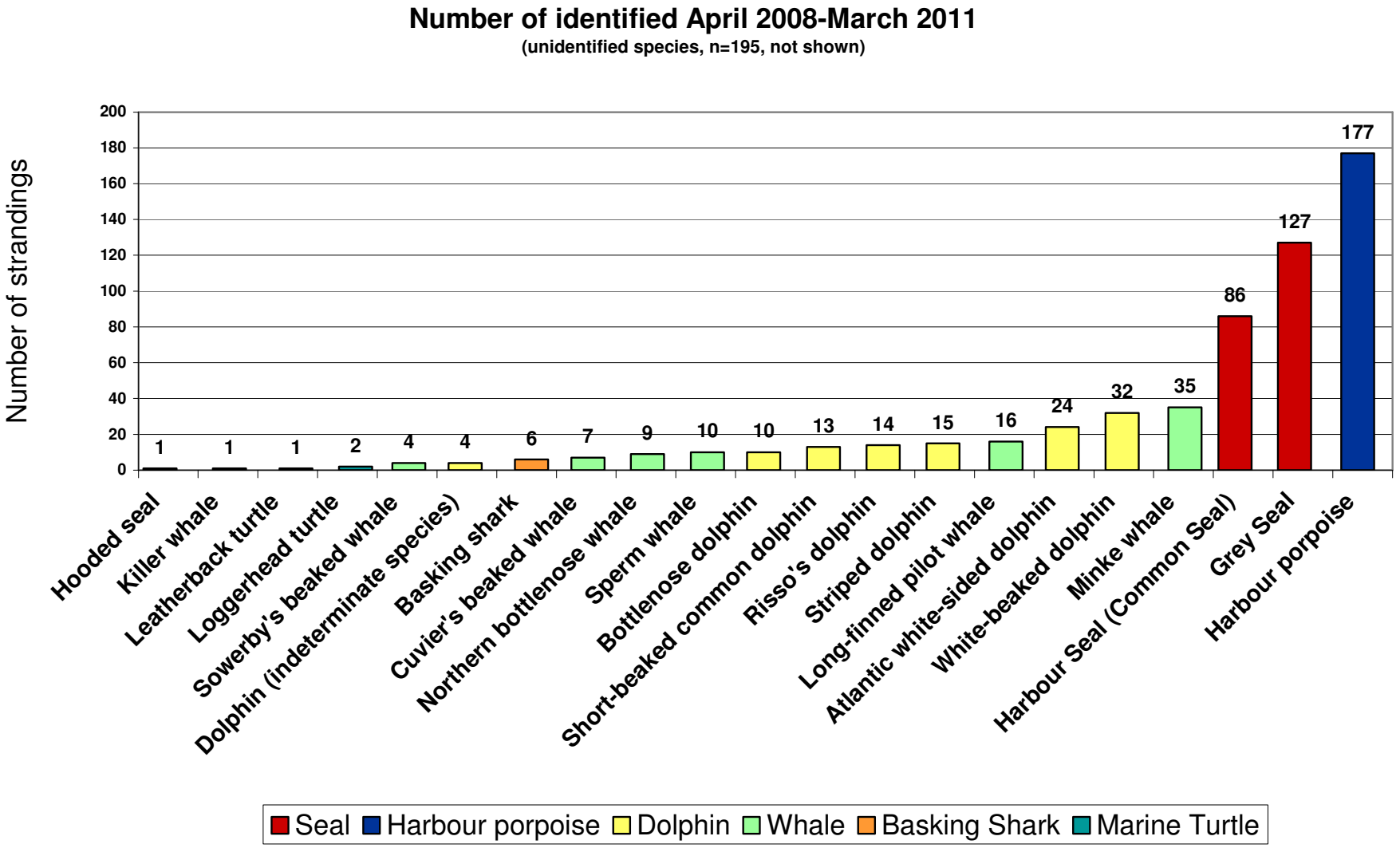


Figure 10: Plot of total number of marine strandings, Scottish waters

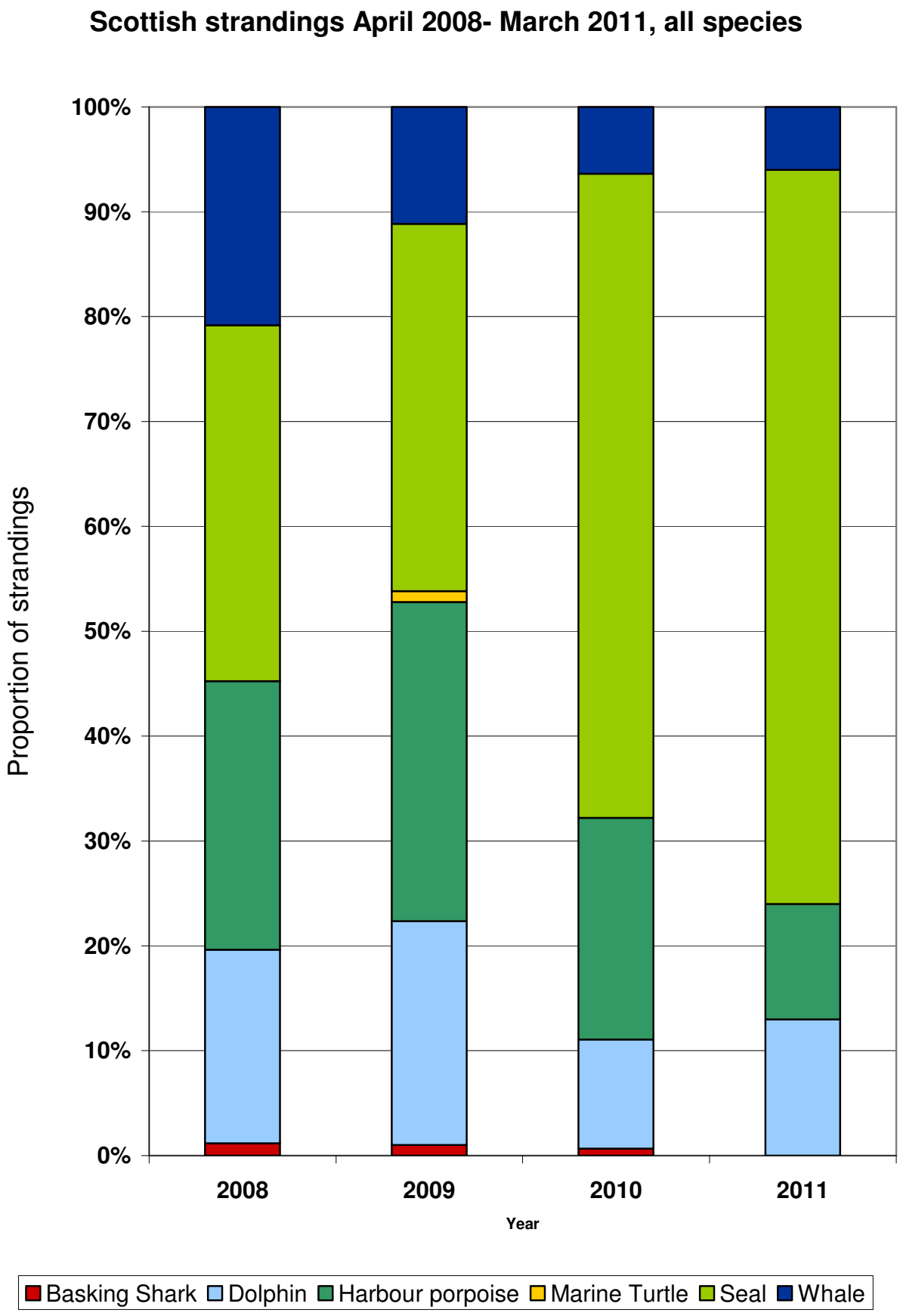


Figure 11: Proportion of Scottish strandings 2008-2010, all species

5 Necropsies

5.1.1 Selection of samples for necropsy

Figure 12 shows the spatial distribution of strandings, of all species, which were taken for necropsy. Figure 13 & Figure 14 are density maps showing regions where, in relation to the total number, there are respectively high densities of either necropsied, or non necropsied strandings. Figure 16 shows the number of strandings by administrative region.

Strandings are collected for necropsy based on a number of factors; condition of the carcase being the most significant. Carcases with condition score 3 or greater, indicating a significant amount of autolysis, carcase bloating and skin peeling are not routinely collected as the additional value added from necropsy is considered to be limited. Whilst significant effort is made to minimise the bias to the data of convenience sampling those carcases easy to collect on account of location or logistics, it can be seen there are regions of the country where less necropsies have been undertaken.

Regions with a good proportion of cetacean recoveries include Highland, Fife, Strathclyde and Fife. Not surprisingly, more inaccessible regions fare less well, in specific the west coast, Orkney and the Uists. Seal necropsy tends to be lower than cetaceans and this can be attributable to a greater number of reports of autolysed carcases unsuitable for necropsy rather than logistical constraints. Figure 17 shows the condition as reported of carcases collected and not collected for necropsy, by region and species class.

It should be noted that this data shows strandings reported; obviously many strandings go unreported and it is likely this underreporting also exhibits the same spatial heterogeneity.

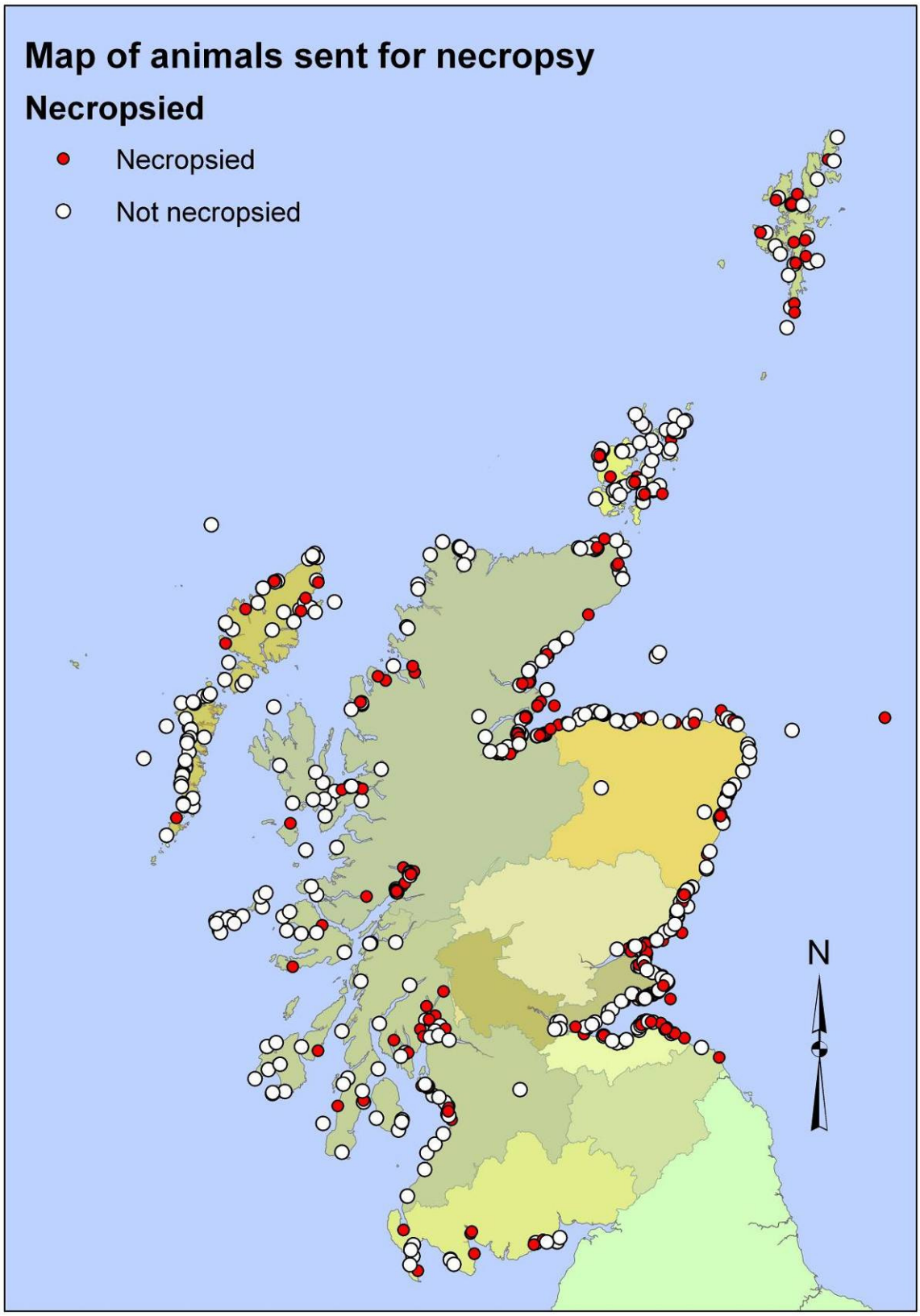


Figure 12: Strandings sent to necropsy 2008-2011

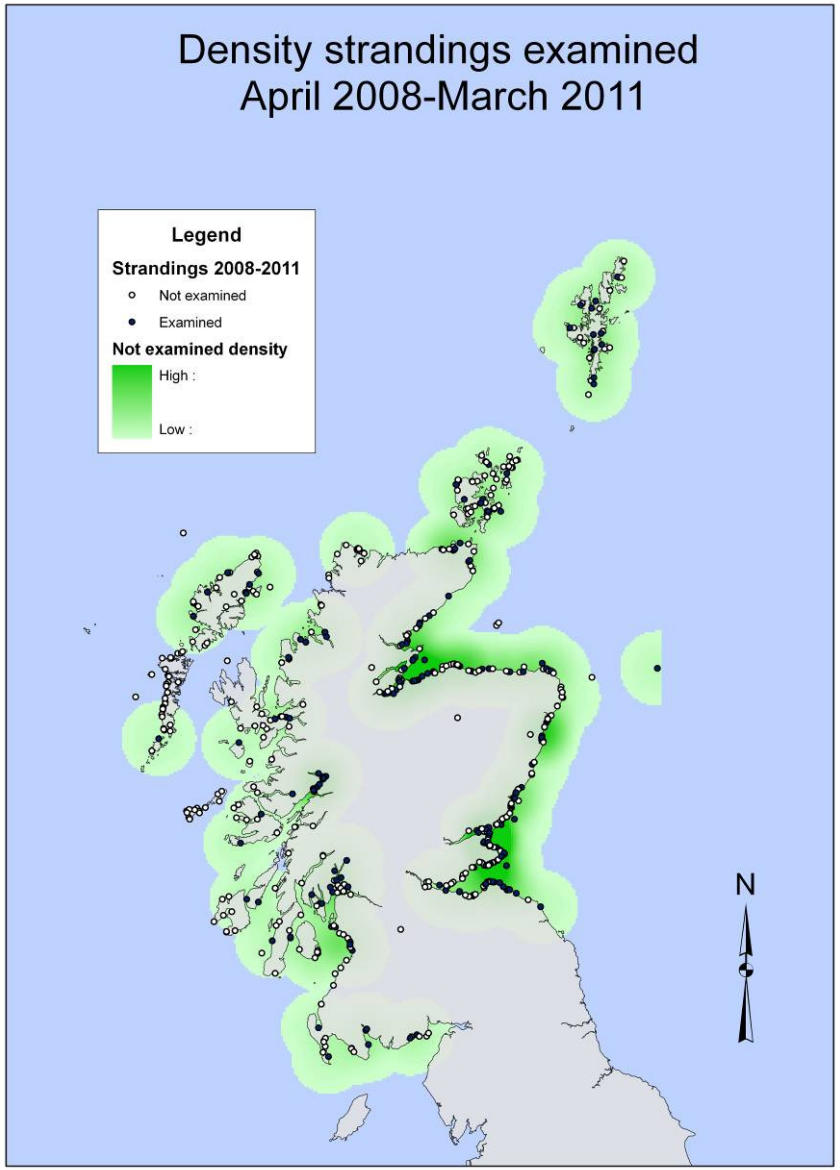


Figure 13: Density map of strandings necropsied or sampled

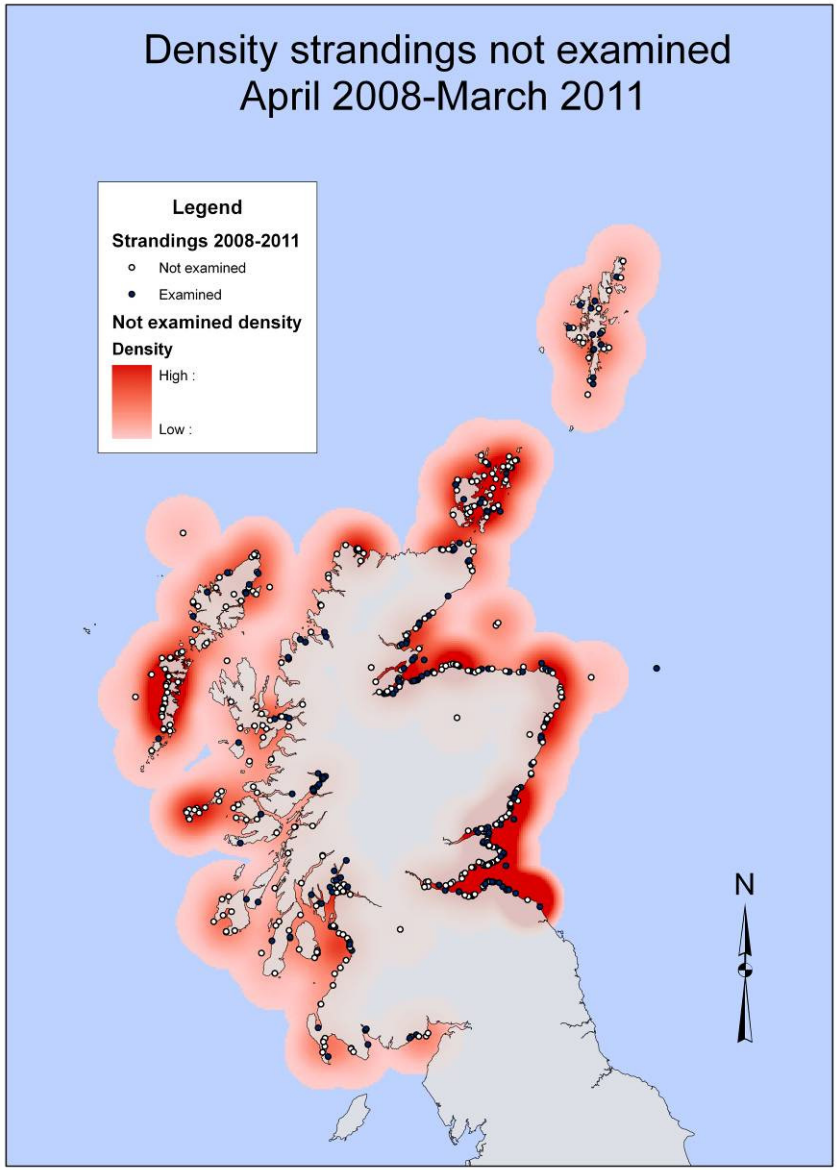


Figure 14: Density map of strandings not further examined

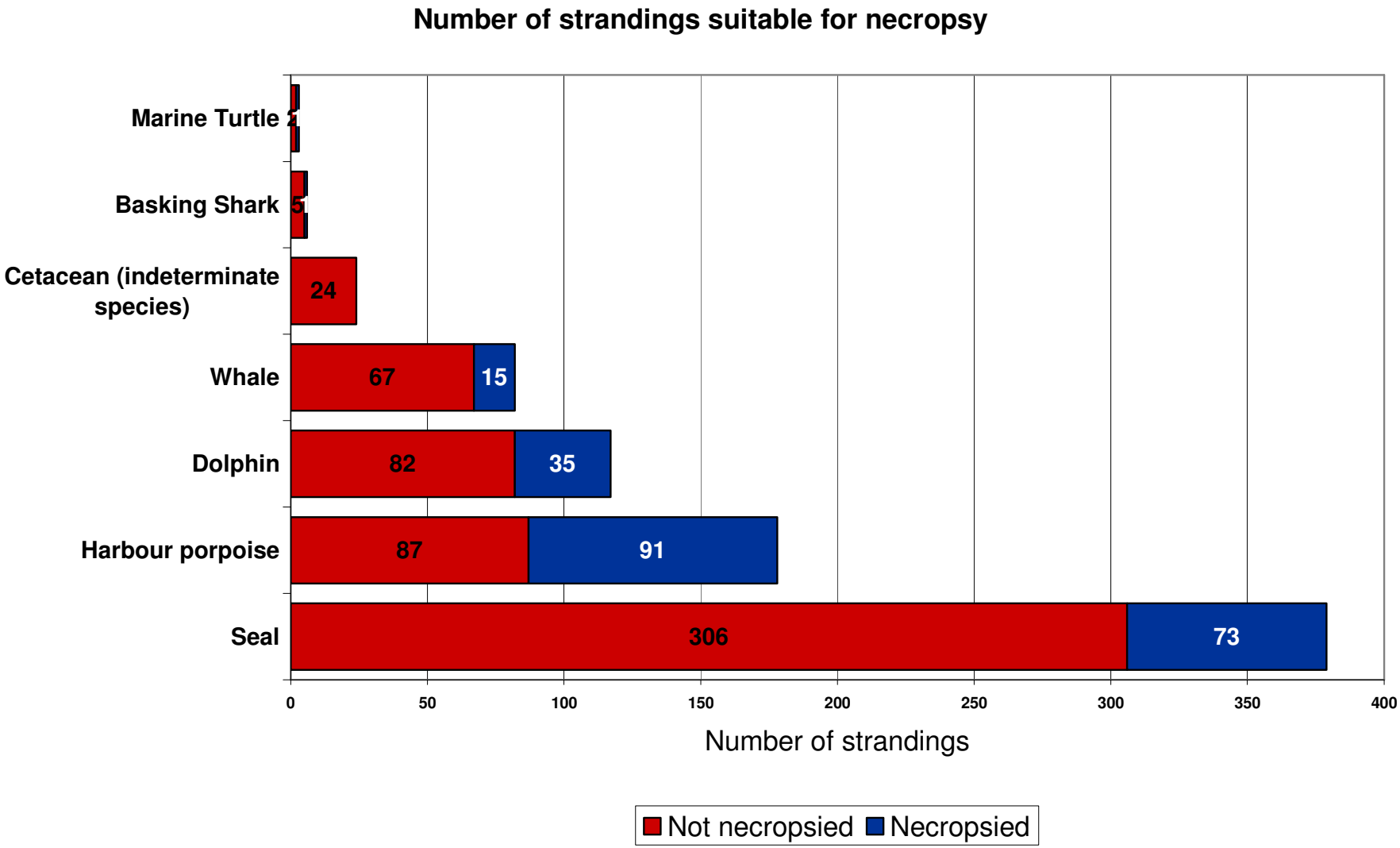


Figure 15: Number of strandings suitable for necropsy

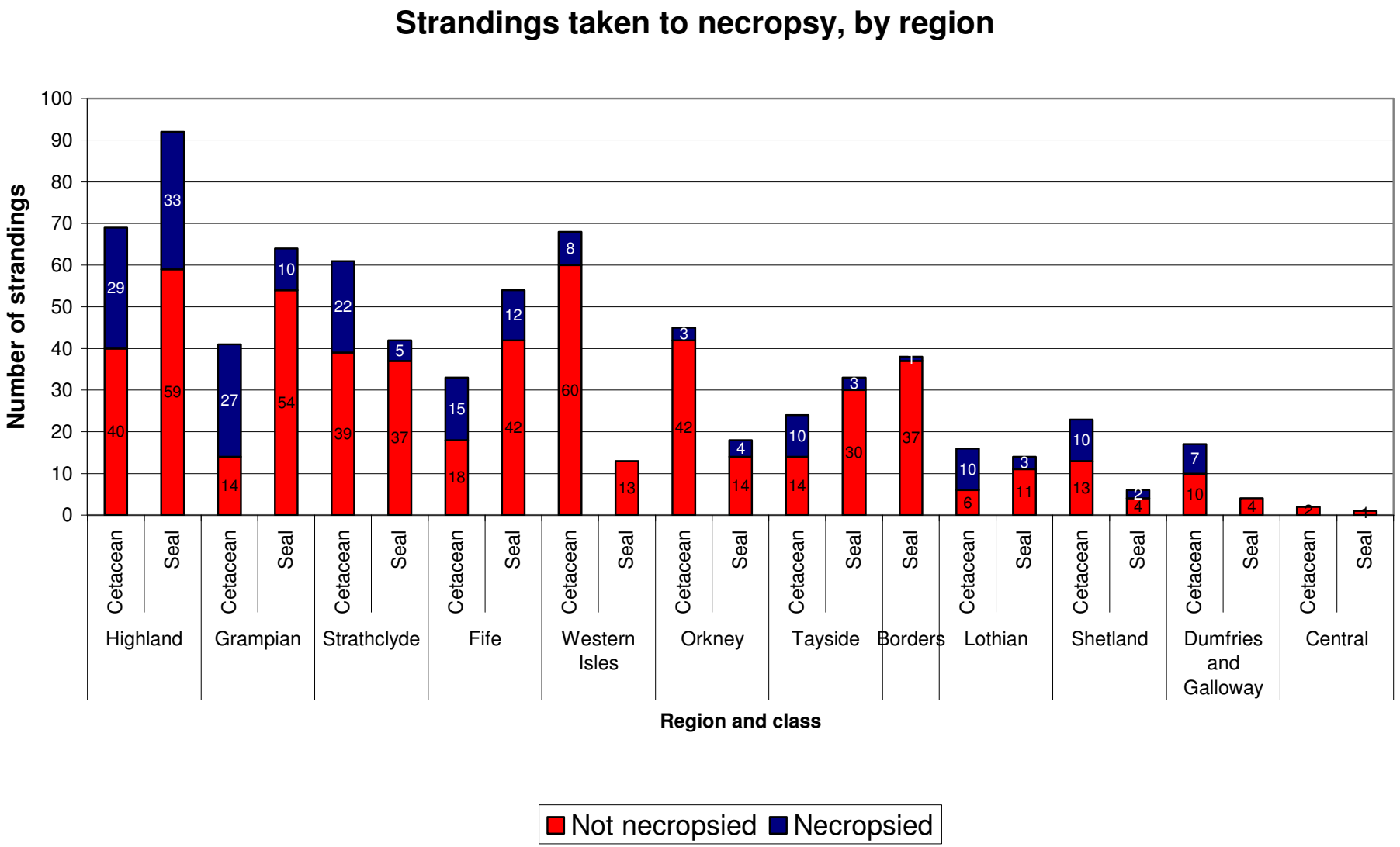
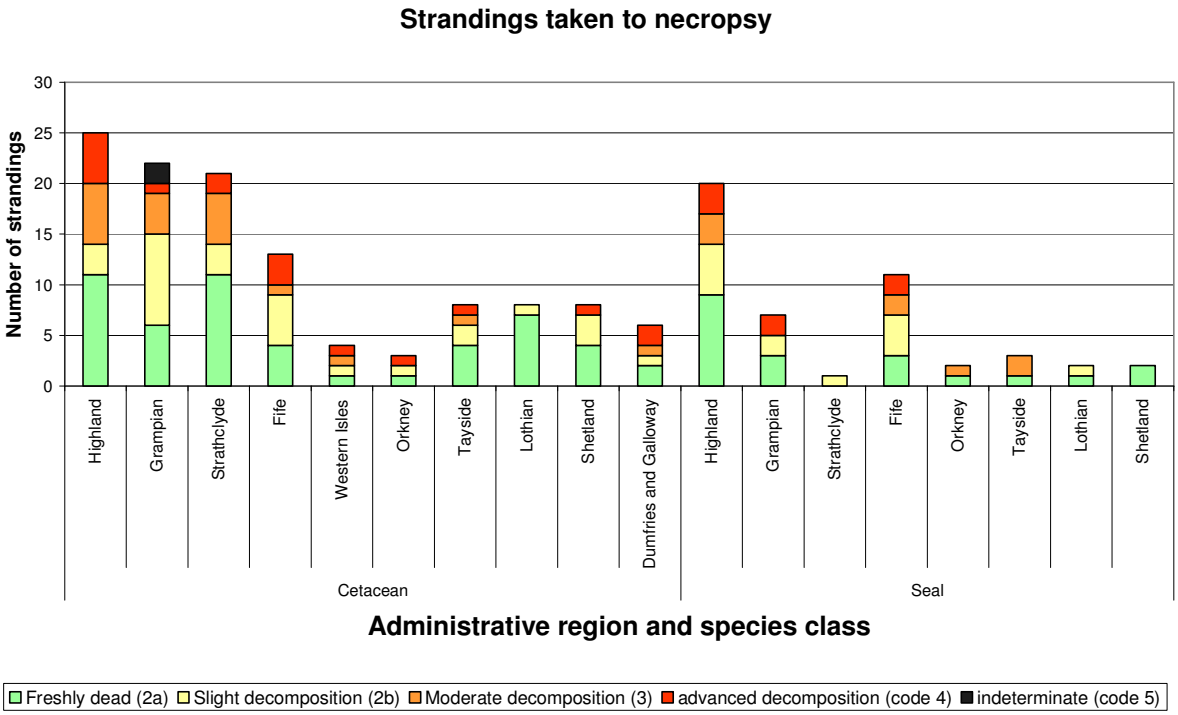


Figure 16: Strandings taken to necropsy, by administrative region



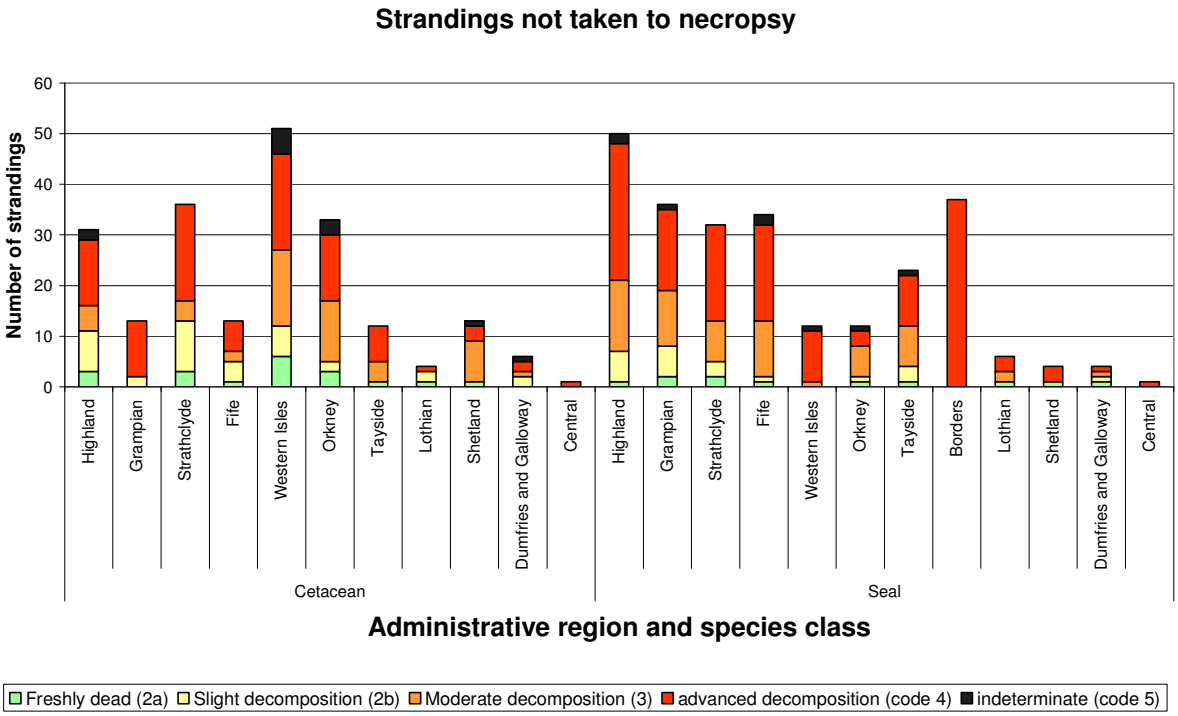


Figure 17: Strandings necropsied, by condition of carcase

5.2 Necropsy protocol

Examination of all cetacean or seal carcases was conducted to a standardized protocol (link) and the results can be seen in Table 2, Figure 18 & Figure 19.

Establishing a cause of death is attempted on every case taken to necropsy. The final diagnosis is made by a veterinary surgeon with experience of marine pathology and is based on the findings of gross necropsy supported in most cases by ancillary serological, bacteriological and histopathological tests.

The necropsy provides the gross pathology data used to establish a cause of death and quantify burden of disease and various additional samples are collected as part of the protocol. In addition to tissues taken for bacteriology and histopathology, a standardised array of tissue samples are archived at -20^{0}C. Gonadal tissues, teeth (for age determination) and stomach contents are collected and used by other research projects, for example investigating the ecological impacts of cetacean by-catch in UK and European waters. Skeletal material from all marine carcases necropsied in Scotland is donated to National Museums of Scotland for inclusion in the research collection. This all supports a broad range of multidisciplinary scientific research activities and collaborations, maximising the information gained from each stranding incident.

5.3 Necropsy overview 2008-2011

Between April 2008 and March 2011, 216 cases underwent necropsy to establish a cause of death. This comprised 141 cetacean strandings (11 species) and 73 seals (45 common seals, 27 grey seals and 1 hooded seal). In addition, 4 severely autolysed carcases were examined for signs of trauma but were too decomposed to allow accurate speciation on morphology alone. Figure 15 shows the number of strandings necropsied by species class. Harbour porpoise were again over-represented in this regard, with 91/178 (51%) of porpoise strandings undergoing necropsy, compared to 50/144 (35%) of all cetaceans. This is attributable to the longer time window available for meaningful necropsy of small cetaceans, compared to larger species which decompose very rapidly.

5.4 Cause of death categories

5.4.1 Bycatch

Death due to incidental entanglement in fishing gear. Pathology usually characterised by healthy animals in good condition, evidence of recent feeding with lung pathology consistent with anoxic drowning. Sometimes net marks visible on fins, flukes or flank.

5.4.2 Entanglement

Results of entanglement in fishing equipment or linear marine debris, acute cases similar to bycatch, sub acute cases result in exhaustion and impaired feeding. Chronic cases often very thin and debilitated and show chronic wounds caused by abrasion and pressure from entangled equipment.

5.4.3 Live stranding

Evidence from clinical history or pathology suggesting the animal was alive when it stranded. Stranding and loss of buoyancy confers a range of pathological changes including impaired respiration, tissue trauma, hyperthermia and metabolic acidosis. Lung congestion and hyperinflation, muscle bruising and necrosis, metabolic acidosis and renal failure are usual indicators.

5.4.4 Bottlenose Dolphin (BND) attack

Usually seen in porpoise from in regions with sympatric *Tursiops truncatus,* characterised by extensive trauma, rake marks on epidermis, fractured ribs or axial skeleton or internal injuries. Also documented in juvenile BND

5.4.5 Pneumonia

A broad diagnosis that death was predominantly caused by severe lung pathology and consequent respiratory compromise. as a result of one or several respiratory pathogens. Either one or several bacterial, fungal, or parasitic (verminous) respiratory pathogens can be involved.

5.4.6 Starvation

Evidence that recent feeding activity or fat stores were insufficient to provide sufficient available energy, resulting in physiological compromise and death. Fat stores also essential for buoyancy, thermoregulation and hormone physiology so starvation also includes cases where impairment of these factors appear to have been significant in the death.

5.4.7 Not established

Insufficient data to reliably come to a single diagnosis, reasons include an incomplete sample range, carcase autolysis, inconclusive test results or simply the case did not display known patterns of pathology.

5.5 Cause of death results

Figure 18 & Figure 19 show the cause of death established by necropsy, arranged by species class, and show the categorisation of causes of death.

Table 2 shows the cause of death as diagnosed, arranged by species class. Infectious diseases accounted for the primary cause of death in 40/141 (29%) of cetaceans and 34/73 (47%) of seals. Of the 40 cetacean cases diagnosed with an infectious disease, pneumonia (50%) meningio-encephalitis (18%) and generalised bacterial infection (28%) are the most prevalent. Of pneumonias, parasitic pneumonia is the most prevalent. In comparison to terrestrial species, marine mammals have a high tolerance for parasite burdens, especially lung nematodes, with most adult animals presenting with some evidence of infection. It is hypothesised the main infection challenge occurs as the animal is weaned and begins to ingest nematode eggs vectored by their prey. There is usually some degree of infection and subsequent mounting of an immune response in the host, with disease severity peaking in juvenile animals and decreasing with age. The greatest pathology is associated with migrating

larvae, rather than adult parasites, and consequently is more severe in juvenile animals. Pathology will be exacerbated in cases with immunosuppression or debilitation from other causes, e.g. starvation, concurrent bacterial infection or pregnancy.

Trauma cases accounted for 27/141 (19%) and 18/73 (25%) of cetacean and seal deaths respectively. 6 cases were confirmed as having pathology consistent with the spiral "corkscrew" lesions. Other causes of death, including live strandings, metabolic, physiological or behavioural causes, accounted for 72/141 (51%) and 9/73 (12%) of cetacean and seal deaths respectively.

There are geographic differences in cause of death due to both species and disease variation over space. For example, the most common diagnosis for animals reported from the Western Isles is live stranding, whereas infectious disease is the most common cause of death throughout the rest of mainland Scotland. This in part can be explained by the species distribution of strandings, with the Western Isles having a larger proportion of non-coastal species where live stranding is a likely diagnosis.

	Harbour porpoise	Percentage of total for species class	Seal	Percentage of total for species class	Dolphin	Percentage of total for species class	Whale	Percentage of total for species class	Basking Shark	Percentage of total for species class	Marine Turtle		Grand Total
Bycatch or entanglement	6	7%	1	1%		0%	2	13%		0%		0%	9
Dystocia & Stillborn	1	1%		0%	1	3%		0%		0%		0%	2
Generalised infectious disease	8	9%	15	21%	3	9%		0%		0%		0%	26
Live Stranding	6	7%		0%	15	43%	10	67%	1	100%		0%	32
Meningoencephalitis	2	2%	1	1%	5	14%		0%		0%		0%	8
Physical Trauma Boat/Ship Strike	1	1%		0%	1	3%	1	7%		0%		0%	3
Physical Trauma: Bottlenose Dolphin Attack	13	14%		0%		0%		0%		0%		0%	13
Physical Trauma: Other		0%	6	8%		0%		0%		0%		0%	6
Physical Trauma: Shot		0%	5	7%		0%		0%		0%		0%	5
Physical Trauma: Spiral "Corkscrew" lesions	1	1%	6	8%		0%		0%		0%		0%	7
Pneumonia	19	21%	18	25%	2	6%		0%		0%		0%	39
Starvation	23	25%	4	5%	1	3%		0%		0%		0%	28
Not Established	3	3%	8	11%	2	6%	1	7%		0%		0%	14
Pending		0%	5	7%		0%		0%		0%		0%	5
Others	8	9%	4	5%	5	14%	1	7%		0%	1	100%	19
Grand Total	91	100%	73	100%	35	100%	15	100%	1	100%	1	100%	216

Table 2: Cause of death of species necropsied

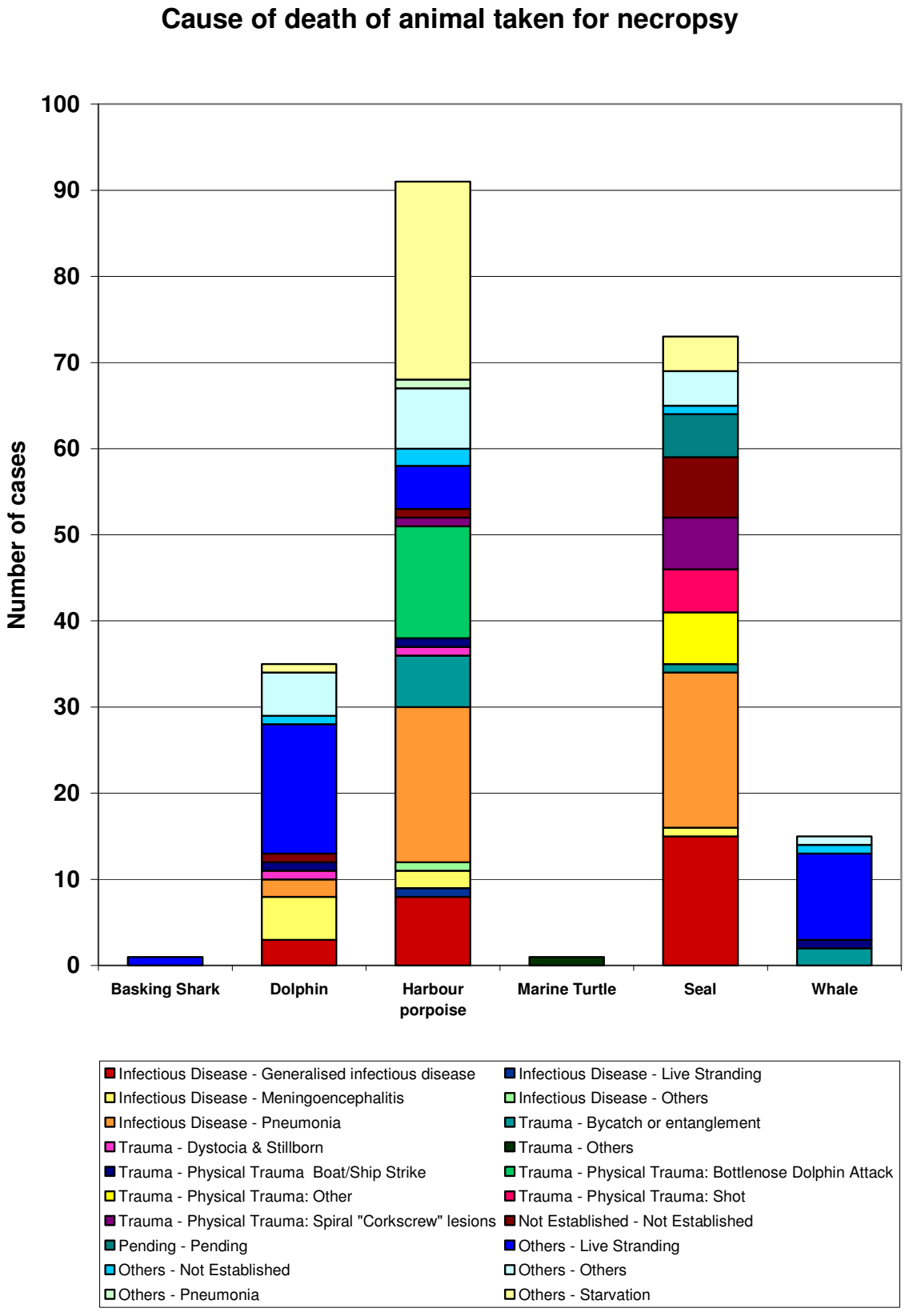


Figure 18: Chart of cause of death of species necropsied, by species class

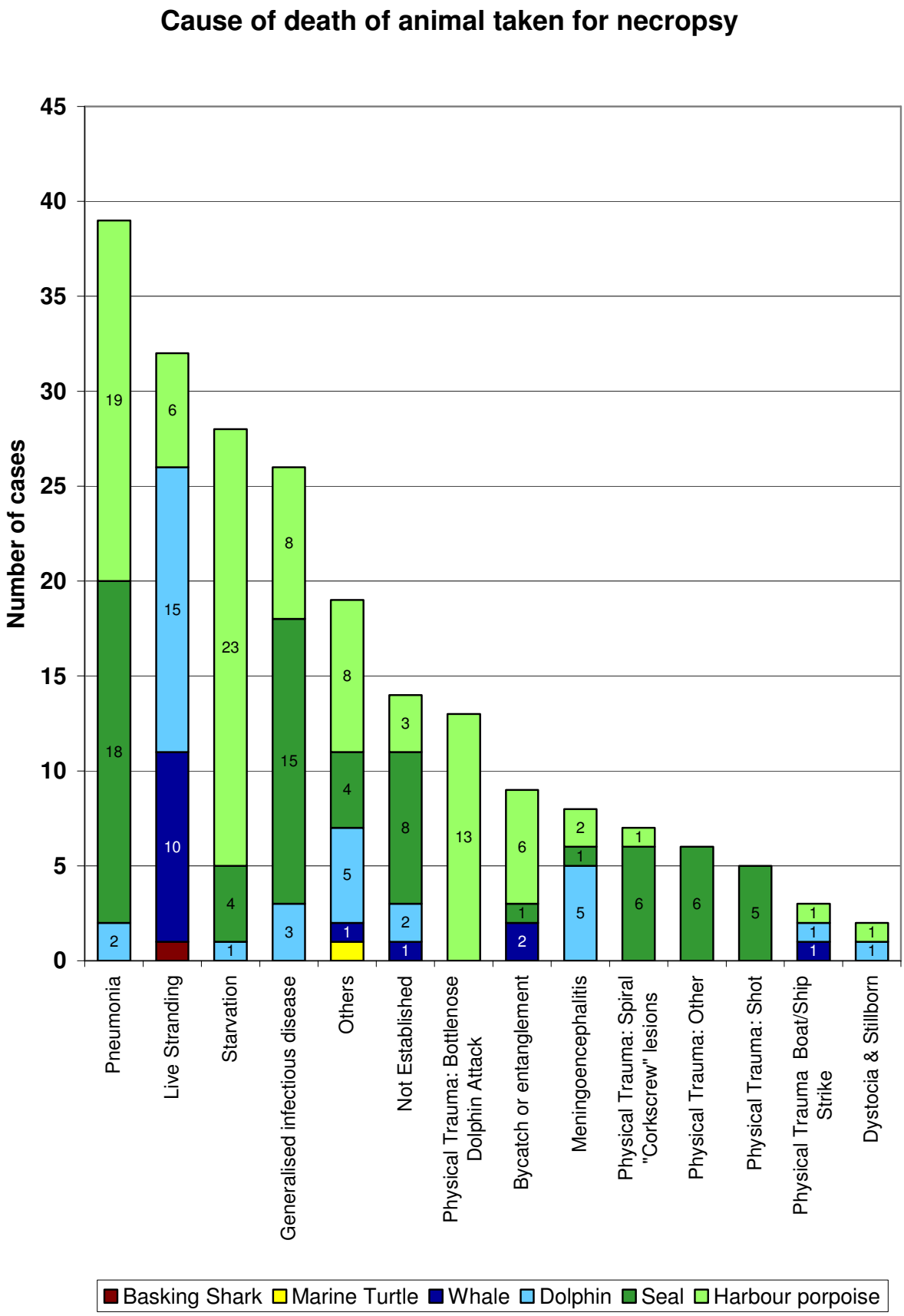


Figure 19: Chart of cause of death of species necropsied

6 Notable strandings

The following are strandings that are notable for reasons either of species, pathology or because they highlight a particular issue.

M89/09: Five white-beaked dolphins Grimsay, south Uist, Western Isles, 22/07/2009 – Significant effort was made by marine life rescuers to refloat these animals. Initially successful, however unconfirmed reports that several dead dolphins had been seen on beaches in the area during the following week. Not necropsied.

M103/09: Three Northern bottlenose whales, Cromarty harbour on 02/08/2009. Reports on one adult (7-8meters) and two juvenile whales. Large whale reported as injured in harbour, haemorrhaging and in or close to Cromarty harbour, however seen to swim back out to the open sea. Two juveniles found to live strand on a stretch of rocky coastline 2 miles upstream on the south side of Nigg bay. An attempt was made to euthanize however insufficient euthanasia solution was available for administration. One animal refloated on the rising tide and swam back to deep water. A dead NBW of similar proportions to this animal was seen floating three days later but could not be recovered. The second animal remained close to shore and was found dead the following morning. This specimen was taken to SAC Inverness where a diagnosis of starvation and subsequent live stranding was made. It is likely these juvenile animals had strayed from their deep oceanic feeding grounds for some time and were in a weakened state. Confused by the topography of the coastline, they live stranded and this generated pathology sufficient to cause the death of both animals.

In July 2009, the first two cases of 'corkscrew' seals were necropsied; two common seals from the Eden estuary reported by SMRU. These patterns matched cases seen in England at Blakeney point, Norfolk, in Strangford Lough Northern Ireland and, most interestingly, a pattern of unusual trauma reported from Orkney in the summer of 1985. Since July 2008, a total of 27 Scottish cases have been identified by either photographs or physical examination, most too autolysed for meaningful necropsy.

M127/09: A male Northern bottlenose whale Wigton bay, Dumfries & Galloway 24/08/2009 – A juvenile male stranded and was necropsied on site. In similar circumstances to the cases described earlier in the month at Cromarty, this animal appeared to have socially separated, had insufficient feeding and live stranded.

M145/09: A male Northern bottlenose whale Loch Eil Fort William, Highland 09/10/2009 – had been seen in the area for over a week. Various techniques were employed to encourage the animal to swim out of the narrow bottleneck of the Loch Eil and into deeper water. Although initially successful, and seen swimming in Loch Linnhe, the animal was seen dead the following day.

M154/09: A young basking shark was found at Lossiemouth, Grampian 25/10/2009 – Attempts were made to refloat the shark but it kept coming back to the beach. Necropsy of a similar sized shark last year had revealed brain pathology, however this specimen had been euthanized with a shotgun which effectively destroyed any meaningful neurological examination.

M160/09: A sperm whale Balmedie, Aberdeen, Grampian 30/10/2009. The animal live-stranded and died but was not examined due to logistical issues. I The decision not to carry out an examination was taken on the basis that, if the carcase was opened for examination, significant environmental contamination was likely by the time a plan for disposal was in place several days later.

M036/10: 20/02/2010. Harbour porpoise – Fraserburgh, Grampian – found with vaginal prolapse and euthanized on site. Necropsy findings: severe generalised parasitism and debilitation. Degree of parasitism was large for an adult and it is possible increased stress and reduced feeding ability during pregnancy may have immunologically compromised the animal, allowing parasitism to develop to such severity.

M045/10: 07/03/2010. Striped dolphin, Drummore, Stranraer – refloated but found dead later. Necropsy findings: Meningioencephalitis, attributed to *Brucella ceti* and subsequent live stranding.

M106/10: 10/06/2010. Minke whale, Tighnabruiach, Argyll. Died on site. Necropsy findings showed that animal had most likely died as a result of previous entanglement. The lesions are shown in photos 2 & 3 below. It can be seen that the wounds are resolving but sufficient damage had been done by the duration and severity of the entanglement process that subsequent infection and mandibular fracture led to the death of this animal.

Photo 2: Lateral view of entangled minke whale M106-10

Photo 3: M106-10 mouth lesions.

M157/10: 30/07/2010 Young minke whale, Horse Isles Bay, Nr Dalbeattie. Seen alive at several locations in the estuary, extensive bruising to blubber and subcuticular muscle from multiple live strandings in estuarine region.

Photo 4: Ventral view of case M157-10 showing bruising associated with successive strandings and tidal refloat in estuary.

M202/10 06/09/2010 An aged male bottlenose dolphin was found in moderate state of autolysis at Hilton of Cadboll. Despite the condition of the carcase, it was possible for to the animal to be positively identify through dorsal fin and flank photographs. Their photo ID work in conjunction with teeth aging suggests the animal had been largely resident in the Moray Firth for at least two decades. This type of data offers huge benefits to subsequent disease burden work or contaminant analysis in these populations.

M206/10: 08/09/2010 Risso's dolphin, Tolsta beach, Lewis. Euthanased. Necropsy findings: Juvenile male Risso's dolphin. No evidence of any traumatic or disease process. The cardiac stomach contained evidence of very recent feeding, It is likely that this animal became socially separated and subsequently live stranded. This illustrates that Risso dolphins are successfully feeding off the Western Isles, supporting findings made by recent survey work.

Photo 5a & b: Food remains found in stomach of M206-10

M210/10: Harbour porpoise, Hillswick, Shetland. Refloated but found dead next day. 11/09/2010 Necropsy findings: The sub-adult male porpoise found live stranded, the liver showed profound jaundice and fatty change and the kidneys were also jaundiced. Samples were sent for agrochemical analysis to investigate if the pathology could have been a result of off-licence use of organophosphates in the marine environment around Shetland. These all tested negative, and the cause of stranding remains unknown.

M209-10, Hooded seal (Cystophora cristata) found Newport, Tayside: This hooded seal pup was seen alive but died before it could be taken to rehab. 10/09/2010: Necropsy findings: Large (3.3kg) mass of rocks and gravel of various sizes ranging from 1-2mm to 5cm diameter in the stomach, alongside some leaf matter and some small plastic debris. It is probable, given this pup was well south of its normal foraging range, that the pica

(deranged appetite) was a response to hypoglycaemia following a period of inadequate feeding.

7 Investigation into 'corkscrew' lesions

Seal carcases, with similar distinctive injuries, have been recovered around the UK in 2009 and 2010. The main finding has been a continuous laceration that spiralled down and around the body in a "corkscrew" spiral. Six cases have been necropsied at SAC and additional 5 more at SMRU. Photo 6 and Photo 7 show the similarity between geographically distinct clusters of cases in Norfolk and Fife.

Photo 6: Typical appearance of a corkscrew Injury in Norfolk cases. Photo courtesy of Steve Bexton, RSPCA Wildlife Hospital Norfolk.

Photo 7: Typical appearance of a corkscrew Injury in a case from eastern Scotland

In collaboration with SMRU, Steve Bexton at the RSPCA wildlife hospital in Norfolk and Tony Patterson at AFBI Stormont Veterinary Laboratory we are continuing to investigate the cause of characteristic spiral cuts seen on seals found dead along the east coast of Scotland, Norfolk and in Strangford Lough, Northern Ireland.

Current theories point to the animals becoming drawn into a ducted or cowled propeller, possibly similar to the type used by vessels employing dynamic positioning systems. Further work is needed to confirm if such mechanical devices are capable of causing these spiral lesions, and also to quantify the impact at a population level. It is possible that the cases seen represent only a small fraction of the total. In particular, the number of animals involved in these trauma incidents, and the mechanism of trauma, has to be understood in order to quantify the severity of this problem and develop measures to mitigate the effect.

In addition, a adult male harbour porpoise was recovered from Gairloch beach, Highland (NG799770, Case M216-10) which was found freshly dead on the beach in good body condition. There were a series of two sets of inclined spiralling cuts, clockwise and anticlockwise, beginning at the head with avulsion of the blubber layer from the musculature. The cuts were not as continuous as seen in some of the 'corkscrew' seal cases, but shared the oblique angle if incision and lack of underlying tissue damage seen in the seal cases. This is the first case we have seen this year reported in cetaceans or from west coast of Scotland. There were also multiple punctate rip marks around the head and jaw. The lungs and liver showed evidence of chronic parasitism with fibrosis and there was stable foam in the airways. The lungs were symmetrical and did not show hyperinflation or congestion. There was little nematode burden in the lung parenchyma. It is difficult to be certain, but a lack of congestion or blood clots seen in the arteries could indicate exsanguination, Food remains in the stomach and a good blubber thickness also suggested this animal was healthy prior to death and propeller trauma is most likely.

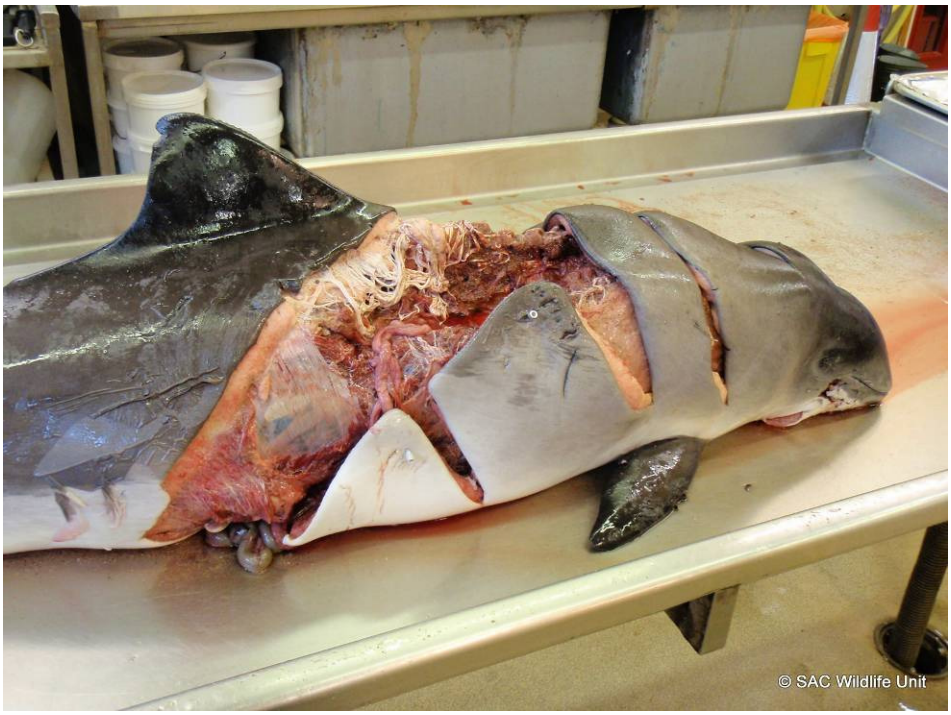


Photo 8: 'Spiral' lesions in case M216-10. The cut was not the same as those seen in the seals, and comprises two cuts perpendicular to each other from, it is assumed, two cutting surfaces.

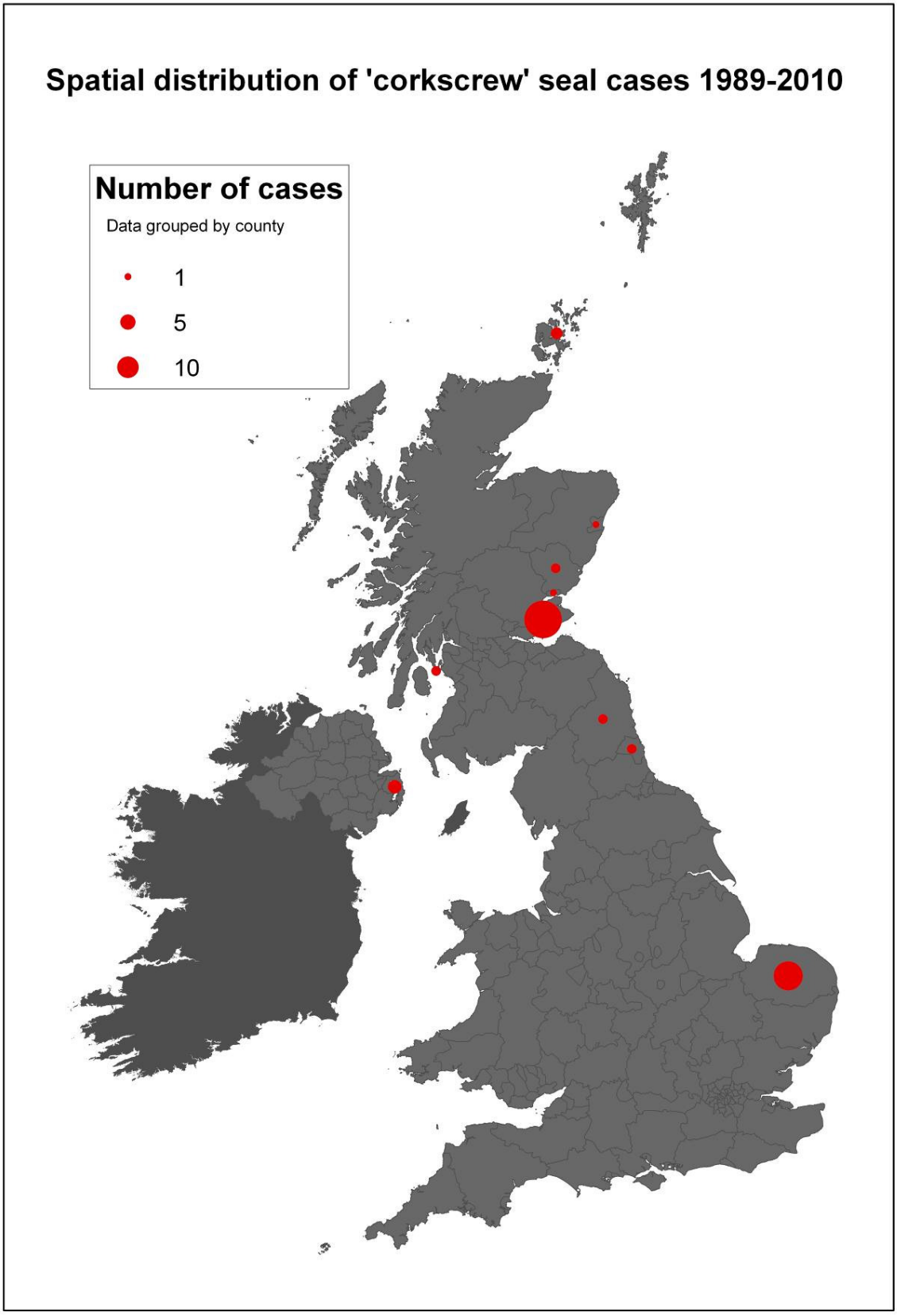


Figure 20: Map of UK locations of spiral 'corkscrew' seals

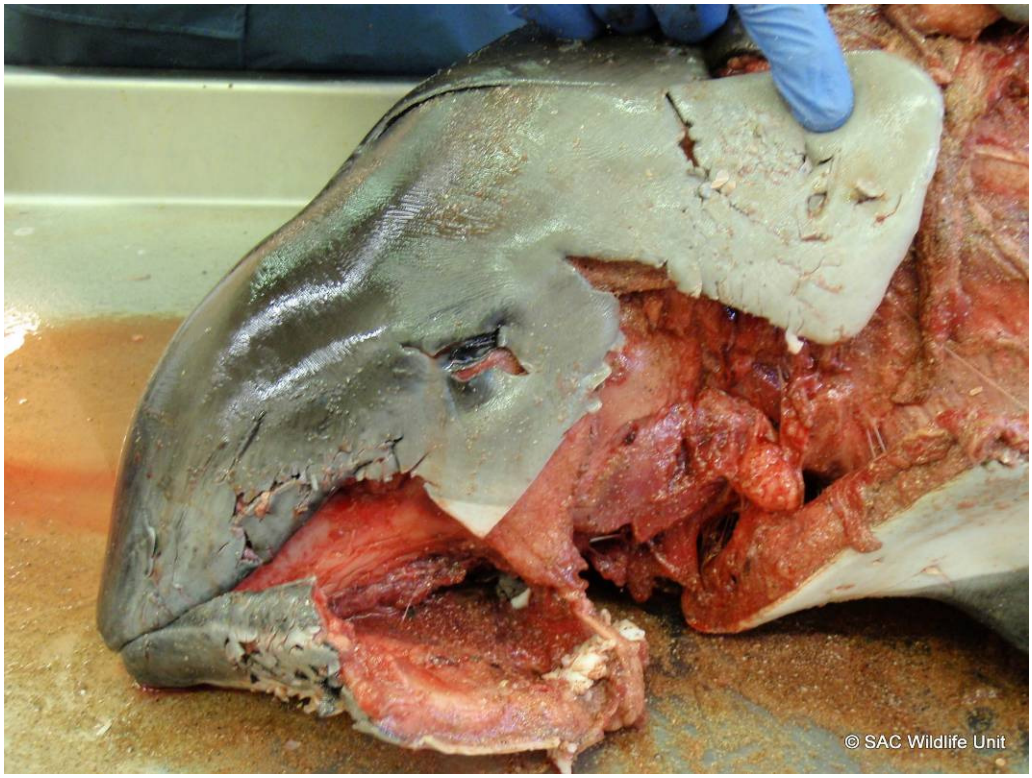


Photo 9:- close up of head trauma to case M216-10

8 Outputs

8.1 Additional research:

Data collected from this project has fed into collaborative research projects with national and international organisations. Notable ongoing collaborations include:

- Sea Mammal Research Unit (SMRU) who run several projects on seal and cetacean physiology, including screening for domoic acid levels and life history and diet analysis using seal teeth and stomach contents.
- Graham Pierce, University of Aberdeen, who undertakes much of the life history and diet analysis on the cetacean samples.
- Paul Thompson, Lighthouse Field Station, University of Aberdeen. A long term BND study, including morphometrics to help calibrate length measurement of live animals.
- Andy Foote, Centre for GeoGenetics, Natural History Museum of Denmark. Work on killer whales and bottlenose whale genetics.
- Scottish Association for Marine Science (SAMS) Feeding ecology studies
- Skeletal material archived at National Museums of Scotland.
- Toxicology samples for CEFAS for persistent organic pollutant assay, notably PCB, DDT, PBB and PBDE levels in porpoise.

The current database does not yet have the facility to incorporate the data from external research, however collating this data is vital and we aim to try to build in this functionality over the next year.

8.2 Conferences and meetings:

- Bob Reid and Andrew Brownlow were invited speakers at a seminar in Galway, Republic of Ireland in June 2009 that was organised by the Irish Whale and Dolphin Group with a view to having more necropsies carried out on stranded cetaceans.
- Andrew Brownlow attended the European Cetacean Society meeting in Istanbul and the biennial meeting of the Society for Marine Mammology in Quebec. At the latter he presented a poster outlining approaches for analysis of stranding data. A copy of the presentation has been included in Appendix 1.
- Andrew Brownlow gave an oral presentation at the European Wildlife Disease Association conference 'Healthy wildlife, healthy people', 13-16 September 2010 on Vlieland, the Netherlands.
- Bob Reid and Andrew Brownlow presented at the 20 year CSIP conference at London Zoo in November 2010
- Andrew Brownlow gave an oral presentation at the European Cetacean Society meeting in Cadiz March 2011, summarizing the long term harbour porpoise dataset and highlighting some of the patterns and conclusions it has been possible to draw about the health of, and threats to, cetacean populations around the UK coastline.
- Andrew Brownlow was invited speaker to a local Rotary group in March 2011.

8.3 Marine strandings poster:

The new strandings poster continues to be distributed to relevant stakeholders, e.g. marine welfare charities, coastal communities, countryside wardens. A copy of the poster has been included in the appendix.

8.4 Website and database:

A key part of the work has been designing robust methods to hold and search data collected on strandings and any subsequent sampling, necropsy or diagnostics. While a website and database exist for the UK CSIP, it was agreed that there was a need to make information more accessible to members of the public who were interested in strandings data. To this end SAC designed and built an online database with the following key attributes:

1. Provide a repository for seal data collected as part of non-DEFRA funded work.
2. Provide the ability to record necropsy findings, in specific the difference between 'normal' 'abnormal' and 'not examined' for all organ systems to enable valid epidemiological inference.
3. Record of samples taken and location stored to improve use of, and data generated by, the frozen tissue archive.

4. Link to website map and charting function to enable members of the public to access a limited data set of strandings findings in a easy to use graphical format.

The website outlining the Scottish Marine Stranding scheme provides a interface for mapping and displaying the Scottish strandings data. This site is now live and can be seen here: www.strandings.orgThe site enables members of the public to access parts of the marine stranding database using an interactive map to find the location, species and cause of death of all strandings since 1992. It also produces user-specified dynamically generated charts showing the trend in stranding numbers over time by both year and species (Figure 21).

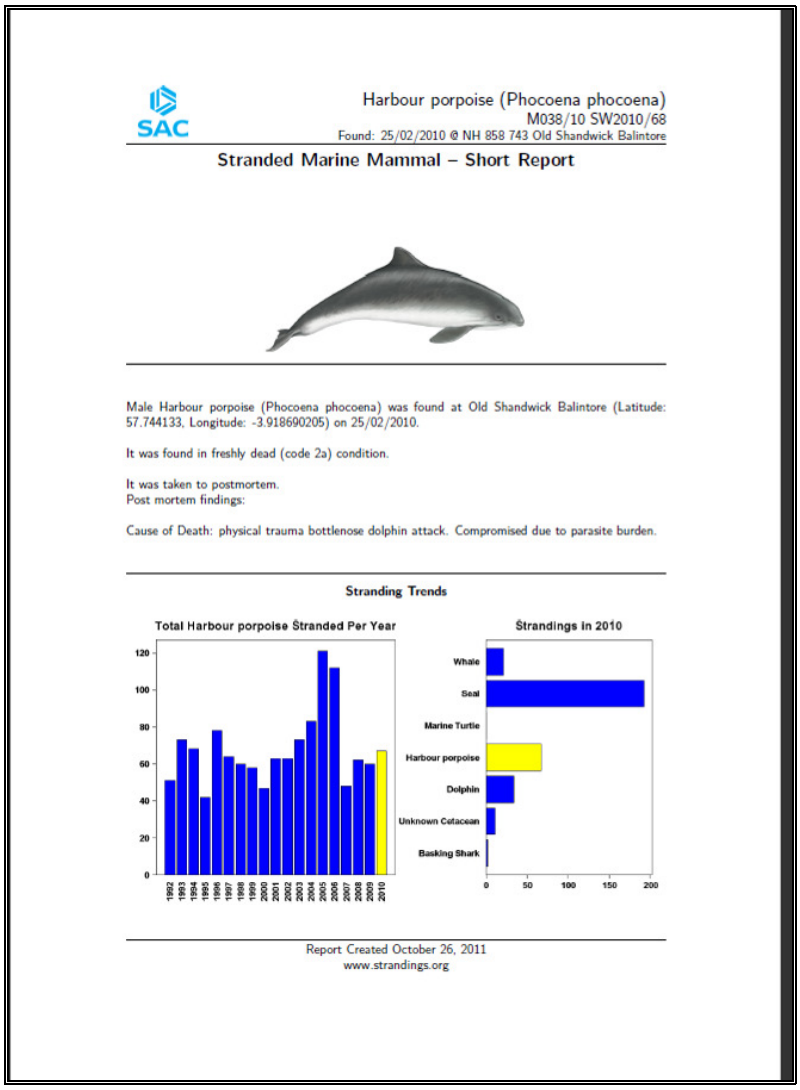


Figure 21: Example of dynamic generated PDF from strandings.org website

8.5 Radio and Media

Feature on the strandings scheme for BBC Radio Scotland 'Out of Doors' broadcast August 2009

A BBC film crew filmed a bottlenose dolphin necropsy in August 2010 for inclusion in a forthcoming BBC2 documentary 'Britain's Secret Seas'. Broadcast in April 2011

9 Tissue storage archive

Since 1992, tissue samples from animals brought for necropsy or sampled in situ prior to disposal have been archived in freezers at the SAC in Inverness at -20^{o}C. These tissue samples have been stored and have enabled subsequent analysis to be undertaken in a range of fields including phylogenetics, molecular epidemiology, toxicology and life history analysis. We now have many thousands of samples and are in the process of archiving exactly what is stored where and assessing the condition of each sample. It is clear however that this is both a unique resource and that space for future storage is finite. A decision regarding the future storage of samples and review of what samples are collected is required and we are aim to have suggestions from this by end 2011.

10 Discussion

Arguably the main achievement of the project is the collection of a large data set to assist with monitoring cetacean populations. Compared to studies of live animals, investigations of strandings are relatively cheap and international bodies such as IWC and ASCOBANS have strongly recommended comprehensive and coordinated stranding investigation programmes such as has been done by the UK CSIP and the Scottish Marine Mammal Investigation Programme.

10.1 Future research questions

The harbour porpoise dataset is unique amongst stranding species in that it is large enough to enable valid inference about the traumatic, toxic, metabolic and infectious processes at work on both this species and, potentially, coastal marine species in general. In this regard the use of porpoise as disease sentinels of marine health is potentially very valuable. Initial data inspection shows a clear spatial heterogeneity of cause of death, although much less of a temporal tend over time. This is being analysed in more detail and collaborations developed to incorporate the strandings data, pathology and disease burden analysis with life history and ecological parameters to investigate trends in more detail.

It is clear that the strandings dataset and tissue archive is has a important role in answering both specific questions on cetacean and seal biology but also questions about general ecosystem health, new and emerging diseases and the impact of climate change. We are therefore committed to building collaborations with institutions working in these fields.

10.2 Knowledge exchange

Since 2009, effort was put in to improving public awareness of the stranding project through the design and distribution of a new poster and the launch of a website (www.strandings.org). This provides users with the opportunity to view strandings data in a graphical or tabulated format, or spatially using Google Maps. The website also provides users with a method for reporting strandings online, in specific an upload function to send digital images which has proved very useful. Use of new media such as Twitter and Facebook has also been explored, and the project profile has been helped by recent radio and television programmes featuring our work.

11 Improvements for the future

The current system for monitoring stranded marine species (seals, cetaceans, turtles and basking sharks) relies on the passive reporting of discovered carcases to the Scottish strandings co-ordinator based in Inverness. The information about each stranding is logged on a national database and the carcase is either sampled or, if suitable, collected for necropsy to establish a cause of death. Strandings are reported via a network of public bodies, charitable groups, academic institutions and members of the public who are aware of the stranding scheme and are prepared to call in a report.

This system has worked well for the past two decades however it is increasingly apparent that in some regions there is both a significant underreporting of strandings and a lack of data from strandings reported (Figure 13 & Figure 14). In particular, despite improved coverage and a much higher reporting rate for seals in 2010, it is still likely that seal strandings are underreported in many areas; often for simple reasons of population, geography and logistics: The length of the Scottish coastline is of the order of about 12,000 km; this is about 8% of the total coastline of Europe, and in many areas strandings are just unlikely to be spotted, let alone reported.

Given this extent, it is inevitable a number of strandings will be missed, however some regions suffer particularly from this bias due to a combination of both geographical and socio-cultural factors. Areas with a local, proactive person or group enable strandings to be reported efficiently; regions without this network tend to have poorer reporting rates. Orkney, for example, has a large seal population yet we receive very few reports of seal carcases from these islands.

Improved awareness and coordination in areas such as this may significantly improve the reporting level, and strategies to achieve this are currently being explored. This is of particular importance when taking into account surveillance for potential new threats to marine species, such as the corkscrew lesions seen on seals during the last couple of years, or acquiring baseline data for assessing the impact of installations/activities by marine users .

Local awareness of, and interest in, reporting strandings is key to both cross-sectional and trend surveillance of stranding patterns. It is becoming clear that establishing and maintaining a network of local interest to the level and consistency necessary for effective monitoring demands a level of input difficult to provide from a single co-ordinator position in Inverness. It is proposed therefore that efforts are made to recruit and train a network of regional strandings co-ordinators to work within the marine strandings surveillance programme but be based in their respective region. They would be responsible for developing and sustaining a local reporting network, e.g. by encouraging local volunteers to cover particular areas of beach and report found strandings. They would collate data arising from these searches and ensure that any records are added to the new online strandings database. Additionally they would assist with collecting fresh carcases for necropsy and appropriate samples and morphometrics from animals unsuitable for a full post-mortem.

SAC has a network around Scotland of farm advisory and veterinary diagnostic centres which could provide the required desk space, clerical and IT support for these roles. Vehicles and equipment for carcase collection could also be arranged through these centres. These posts could be either full or part time positions and the possibility exists to have some of these posts part filled by new SAC staff based in the regional centres. It is also advised that stronger collaborations are formed between other research institutions, in specific SMRU, SAMS and

Aberdeen University who already volunteer staff and expertise in reporting, recording and sampling strandings. The launch of the online database which permits users authorised access to read and update strandings records is expected to facilitate a more regional approach to reporting strandings whilst maintaining data integrity.

12 Appendix

12.1 Publications 2008-2010

The following publications in peer-reviewed scientific journals have been generated using data or tissue samples derived wholly or in part from the Scottish Marine Stranding Scheme between 2008 and 2010. A full list of all CSIP publications produced between 1990 and 2010 can be found at http://ukstrandings.org/CSIP_publications.pdf .

• Banguera-Hinestroza, E., Bjorge, A., Reid, R.J., Jepson, P. and Hoelzel, A.R. (2010) The influence of glacial epochs and habitat dependence on the diversity and phylogeography of a coastal dolphin species: *Lagenorhynchus albirostris*. *Conservation Genetics* **11**: 1823-1836. DOI: 10.1007/s10592-010-0075-y

• Canning, S.J., Begona Santos, M., Reid, R.J., Evans, P.G.H., Sabin, R.C., Bailey, N., Pierce, G.J. (2008) Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. Journal of the Marine Biological Association of the United Kingdom, 2008, **88**(6), 1159-1166.

• Dagleish, M., Barley, J., Finlayson, J., Reid, R. J. and Foster, G. (2008) *Brucella ceti* associated pathology in the testicle of a harbour porpoise (Phocoena phocoena). Journal of Comparative Pathology **139:**54-59

• Dagleish, M., Foster, G., Howie, F. E., Reid, R. J. and Barley, J (2008) Fatal mycotic encephalitis in a Northern bottlenose whale (Hyperoodon ampullatus) caused by Aspergillus fumigatus. Veterinary Record **163:**602-604

• Dagleish, M.P., Baily, J.L., Reid, R.J. and Barley, J. (2010) The first report of disease in a basking shark (*Cetorhinus*

maximus). J. Comp. Path. **143**, 284-288

• Dolman, Sarah J., Eunice Pinn, Robert J. Reid, Jason P. Barley, Rob Deaville, Paul D. Jepson, Mick O'Connel Simon Berrow, Rod S. Penrose, Peter T. Stevick, Susannah Calderan, Kevin P. Robinson, Robert L. Brownell, Jr Mark P. Simmonds (2010) A note on the unprecedented strandings of 56 deep-diving whales along the UK and

Irish coast. *Marine Biodiversity Records*, **3: 1-8. doi**:10.1017/S175526720999114X; Vol. 3; e16.

• Foote, A.D., Newton, J., Piertny, S.B., Willerslev, E. and Gilbert, M.T.P. (2009) Ecological, morphological and genetic divergence of sympatric North Atlantic killer whale populations. Molecular Ecology **18(24)**:5207-5217.

• Foote, A.D., Vilstrup, J.T., de Stepahnis, R., Verborgh, P., Abel Nielsen, S.C., Deaville, R., Kleivane, L., Martín, V., Miller, P.J.O., Øien, N., Perez-Gil, M., Rasmussen, M., Reid, R.J., Robertson, K.M., Rogan, E., Similä, T., Tejedor, M.L., Vester, H., Víkingsson, G.A., Willerslev, E., Gilbert, M.T.P. and Piertney, S.B. (2010) Genetic differentiation among North Atlantic killer whale populations. *Molecular Ecology* doi: 10.1111/j.1365-294X.2010.04957.x

• Law, R.J., Bersuder, P., Barry, J., Deaville, R., Reid, R.J., Jepson, P.D. (2010a) Chlorobiphenyls in the blubber of harbour porpoises (*Phocoena phocoena*) from the UK: levels and trends 1991-2005. *Marine Pollution Bulletin* **60**, 470-473.

• Law, R.J., Barry, J., Bersuder, P., Barber, J., Deaville, R., Reid, R.J. and Jepson, P.D. (2010b) Levels and trends of BDEs in blubber of harbour porpoises (*Phocoena phocoena*) from the UK, 1992 – 2008 *Environmental Science & Technology* **44**, 4447-4451

• Luque, P.L., Pierce, G.J., Learmonth, J.A., Santos, M.B., Ieno, E., Lopez, A., Reid, R.J., Rogan, E., Gonzalez, A.F., Boon, J., Law, R.J. and Lockyer, C.H. (2009) Dentinal anomalies in teeth of harbour porpoises (Phocoena phocoena) from Scottish waters: Are they linked to sexual maturation and environmental events? *Journal of the* Marine Biological Association of the UK 89(5):893-902. 2009

• Luque, P.L., Learmonth, J.A., Santos, M.B., Ieno, E. & Pierce, G.J., (2009). Comparison of two histological techniques for age determination in small cetaceans. *Marine Mammal Science* **25**, 902-919.

• Maquart, M., Le Fleche, P., Foster, G., Tryland, M., Ramisse, F., Djonne, B., Al Dahouk, S., Jacques, I., Neubauer, H., Walravens, K., Godfroid, J., Cloeckaert, A. and Vergnaud, G. (2009) MLVA-16 typing of 295 marine mammal *Brucella* isolates from different animal and geographic origins identifies 7 major groups within *Brucella ceti* and *Brucella pinnipedialis*. BMC Microbiology 9:145

• Murphy, S., Winship, A., Dabin, W., Jepson, P.D., Deaville, R., Reid, B., Spurrier, C., Rogan, E., López, A., González, A., Read, F., Addink, M., Silva, M., Ridoux, V., Learmonth, J.A., Pierce, G.J. and Northridge, S. (2009)

Importance of biological parameters in assessing the current status the short-beaked common dolphin *Delphinus delphis* in the eastern North Atlantic. *Marine Ecology Progress Series* **388**:273-291.

• Murphy, S.**,** G.J. Pierce, R.J. Law, P. Bersuder, P.D. Jepson, J.A. Learmonth, M. Addink, W. Dabin, M.B. Santos, R. Deaville, A.F. Zuur, B.N. Zegers, A. Mets, E. Rogan, V. Ridoux, R.J. Reid, C. Smeenk, T. Jauniaux, A. López, J.M. Alonso Farré, A.F. González, A. Guerra, M. García-Hartmann, S.P. Northridge, C. Lockyer & J.P. Boon (2010) Assessing the effect of persistent organic pollutants on reproductive parameters in small cetaceans in the eastern North Atlantic. *J. Northw. Atl. Fish. Sci.*, **42**: 153–173

• Murphy, S., Deaville, R., Monies, R.J., Davison, N. and Jepson, P.D. (2010) True hermaphroditism: First evidence of an ovotestis in a cetacean species. *Journal of Comparative Pathology* doi:10.1016/j.jcpa.2010.06.001

• Pierce, G.J., Santos, M.B., Murphy, S., Learmonth, J.A., Zuur, A.F., Rogan, E., Bustamante, P., Caurant, F., Lahaye, V., Ridoux, V., Zegers, B.N., Mets, A., Addink, M., Smeenk, C., Jauniaux, T., Law, R.J., Dabin, W., López, A., Alonso Farré, J.M., González, A.F., Guerra, A., García-Hartmann, M., Reid, R.J., Moffat, C.F., Lockyer, C. & Boon, J.P., (2008). Bioaccumulation of persistent

organic pollutants in female common dolphins (*Delphinus delphis*) and harbour porpoises (*Phocoena phocoena*) from western European seas: geographical trends, causal factors and effects on reproduction and mortality. *Environmental Pollution* **153**, 401-415.

• Santos, M.B., Pierce, G.J., Learmonth, J.A., Reid, R.J., Patterson, I.A.P. & Ross, H.M., (2008). Strandings of striped dolphin *Stenella coeruleoalba* in Scottish waters (1992–2003) with notes on the diet of this species. *Journal of the* Marine Biological Association of the United Kingdom **88**, 1175-1183.

12.2 Strandings poster