Agenda Item 8.1 Funding of Projects and Activities

Progress of Projects Supported by ASCOBANS

Document Inf.8.1.a

Project Report: Pollutant exposure in coastal top predators: assessing current levels of exposure and toxic effects

Action Requested

- Take note

Submitted by Secretariat / ZSL

NOTE:
DELEGATES ARE KINDLY REMINDED
TO BRING THEIR OWN COPIES OF DOCUMENTS TO THE MEETING

Pollutant exposure in coastal top predators: assessing current levels of exposure and toxic effects

(Small project SSFA2010-3)

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Introduction

Policy Background

1. Project/Programme objectives to which the small-scale funding contributes:

- **ASCOBANS Conservation and Management Plan**
  - **2.** Surveys and research
  - **3.** Use of by-catches and strandings
- **ASCOBANS Triennium Work Plan 2010-2012**
  - 2. Continue to review annually new information on pollution and its effects on small cetaceans that occur in the ASCOBANS area and, on the basis of this review, provide recommendations to Parties and other relevant authorities
  - 4. Review new information, as far as possible in co-operation with EU, ICES and IWC, on cetacean population size, distribution, structure, and causes of any changes in the ASCOBANS area and based on implications for conservation to make appropriate recommendations to Parties and other relevant authorities

Introduction:

Cetaceans and other marine mammals can accumulate high levels of a wide range of persistent organic pollutants (POPs) that are persistent, bioaccumulative and toxic (Aguilar *et al.* 2002). Within this broad group of chemical pollutants, the polychlorinated biphenyls (PCBs) are thought to pose the greatest threat to marine mammals in industrialised regions due to their abundance, chemical persistence and relative toxicity (Safe 1994). Some marine mammal species that are top predators in marine ecosystems, like killer whales (*Orcinus orca*), can bioaccumulate some of the very highest blubber POP concentrations recorded on earth (Aguilar *et al.* 2002). It is thus essential to establish what levels of POP exposure may cause significant adverse physiological and lethal effects to individuals and populations, if the vulnerability of exposed populations is to be robustly evaluated and to help facilitate informed conservation and management plans.

Objectives:

1) Determine PCB levels in existing blubber samples of bottlenose dolphins (*Tursiops truncatus*) and killer whales within the ASCOBANS range.

2) Combine results of these analyses with existing pollutant exposure data for PCBs in cetaceans within the ASCOBANS range.

3) Compare the levels of PCBs in bottlenose dolphins and killer whales with levels of PCBs in healthy and diseased harbour porpoises (*Phocoena phocoena*) in UK waters (Jepson *et al.* 2005; Hall *et al.* 2006) and to a proposed threshold of toxicity for total PCBs of 17mg/kg lipid weight (Kannan *et al.* 2000). PCB levels will also be compared with those associated with reproductive impairment in bottlenose dolphin studies in the US (e.g. Schwacke *et al.* 2002).

4) Undertake a risk assessment for the toxic effects of PCB exposure in bottlenose dolphins and killer whales in European water within the ASCOBANS range.

This project is highly relevant for the attainment of ASCOBANS goals by generating pollutant data in species that – due to their high trophic position in marine food webs - have the capacity to bioaccumulate very high exposures and to assess the likely effects of these pollutant exposures on disease susceptibility/mortality and reproductive function. Such research would clearly comply with the Agreement's Conservation and Management Plan, Resolutions, Activities in the Agreement's Triennium Work Plan and actions recommended by the Advisory Committee.

Outcomes:

A final report will be submitted to the ASCOBANS Advisory Committee, helping to assess the current levels of PCB exposure in UK/European bottlenose dolphins and killer whales and their likely toxicological impacts. The results of the study will also be presented at the next ASCOBANS AC meeting (September 2015). Finally, data from this study is included in a pan-European analysis of PCB levels in a number of dolphin species (Jepson *et al. submitted*).

Methods

Approaches were made to stranding networks within both ASCOBANS Party and Range states to determine how many extant samples of bottlenose dolphins and/or killer whales were available for analysis. Samples were imported under appropriate licensing to IoZ, for subsequent toxicological analysis at the Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory (CEFAS, www.cefas.co.uk). Blubber samples from twenty four stranded bottlenose dolphins were examined at CEFAS under this small project funding, comprising individuals from Spain (n=11), the UK (n=8) and Portugal (n=5).

All toxicological analyses were conducted at CEFAS using internationally standardised methodology (Jepson *et al*. 2005; Law *et al*. 2012a). Blubber samples were stored frozen prior to being analysed for summed concentrations of 25 individual chlorobiphenyl (CB) congeners (∑25CBs) mg/kg lipid weight concentrations. Data generated from the 24 individuals examined under this ASCOBANS small project, were then combined with PCB data derived from stranded and biopsied individuals of a number of cetacean species across Europe, to give one of the world's largest datasets on contaminants in cetaceans (n=1081, Jepson *et al. submitted*). All data generated was then analysed to assess the threat posed by PCBs.

To assess the trend in ∑PCBs in UK-stranded harbour porpoises in 1990-2012 we fitted a Generalised Additive Model (GAM) to the natural log (ln) data ∑PCBs (mg/kg lipid) concentrations for all data for 1990-2012 (n=706) using the R (R Development Core Team, 2013) package *mgcv*. We used thin plate regression splines to do the smoothing and the degree of smoothing was determined by generalised cross validation (see Jepson *et al. submitted*).

Concentrations of ∑25CBs (mg/kg lipid) in bottlenose dolphins and killer whales were compared with ∑25CBs in healthy and diseased UK-stranded harbour porpoises (Jepson *et al* 2005; Hall *et al* 2006). These ∑25CBs exposures were also compared to a proposed threshold for onset of mild physiological toxicity endpoints for total PCBs (as *Aroclor 1254*) of

17mg/kg lipid weight (Kannan *et al* 2000), which is equivalent to 9 mg/kg lipid as sum ∑25CBs lipid in this study (Jepson *et al*. *submitted*). The very highest marine mammal toxicity threshold published of 77 mg/kg total PCBs (as *Clophen 50*) (Helle et al 1976) and equivalent to 41 mg/kg lipid as sum ∑25CBs lipid in this study (Jepson *et al*. *submitted*).

The project would be one year in duration for toxicological analysis of samples – although this period was later extended by two years in order to collect further blubber samples and allow extra time for ∑25CBs analyses at CEFAS.

Results

A large dataset on causes of death, pathology and toxicology of UK-stranded harbour porpoises (*Phocoena phocoena*) has also been generated by the Defra funded UK Cetacean Strandings Investigation Programme (CSIP, www.ukstrandings.org) from 1989-2012 using internationally standardised methodologies (Jepson 2005; Jepson *et al.* 2005). Subsets of this data have already enabled rigorous statistical analyses to be conducted that show compelling associations between elevated tissue concentrations of PCBs and indices of immunosuppression (thymic involution) (Yap *et al.* 2012) and death due to infectious disease when compared to a control group that died of physical trauma (e.g. by-catch) using large sample sizes (see Jepson *et al.* 2005; Hall *et al.* 2006; Yap *et al.* 2012).

Collectively, these analyses are highly consistent with PCB-induced immune suppression leading to infectious disease mortality at summed PCB congener concentrations that exceed 15-20mg/kg lipid. Long-term studies show a very gradual temporal decline in PCBs and other organochlorine pollutants in UK-stranded harbour porpoises since 1989, but that decline stopped around 1998 (Law *et al.* 2012a) (**Figure 1**). A similar plateau in mean summed PCBs concentrations has also been identified in striped dolphins (*Stenella coeruleoalba*) in the western Mediterranean Sea since 2003 (Jepson *et al*. *submitted*).

PCB levels in top predators such as UK-stranded bottlenose dolphins and killer whales are around one order of magnitude higher than levels thought to predispose to infectious disease mortality in UK-stranded harbour porpoises and greatly exceed all PCB toxicity thresholds for marine mammals, including the very highest marine mammal toxicity threshold based on Helle *et al.* (1976) and equivalent to 41 mg/kg lipid as sum ∑25CBs lipid in this study (Jepson *et al*. *submitted*) (**Figure 2**). Mean blubber ∑PCB concentrations in male KWs in this study were higher than male "southern resident" KWs off British Columbia (NE Pacific) and were only slightly lower than male (marine mammal eating) "transient" KWs from the same region (Houde *et al*. 2005). Mean ∑PCB concentrations in adult female KWs in this study readily exceeded concentrations in both southern resident and transient female KWs off British Columbia (Houde *et al*. 2005). Only a highly polluted BND population off Brunswick, Georgia (USA) exposed to a major point source of PCB pollution with *Aroclor 1268* (Balmer e*t al.* 2011) had mean exposures similar to many BND groups in this study. These data show very high risk of PCB toxicity for KWs in NE Atlantic and BNDs off SW Iberia (**Fig. 2**). High PCB contamination is a likely causal factor in the death of many of the stranded KWs, BNDs and HPs in this study.

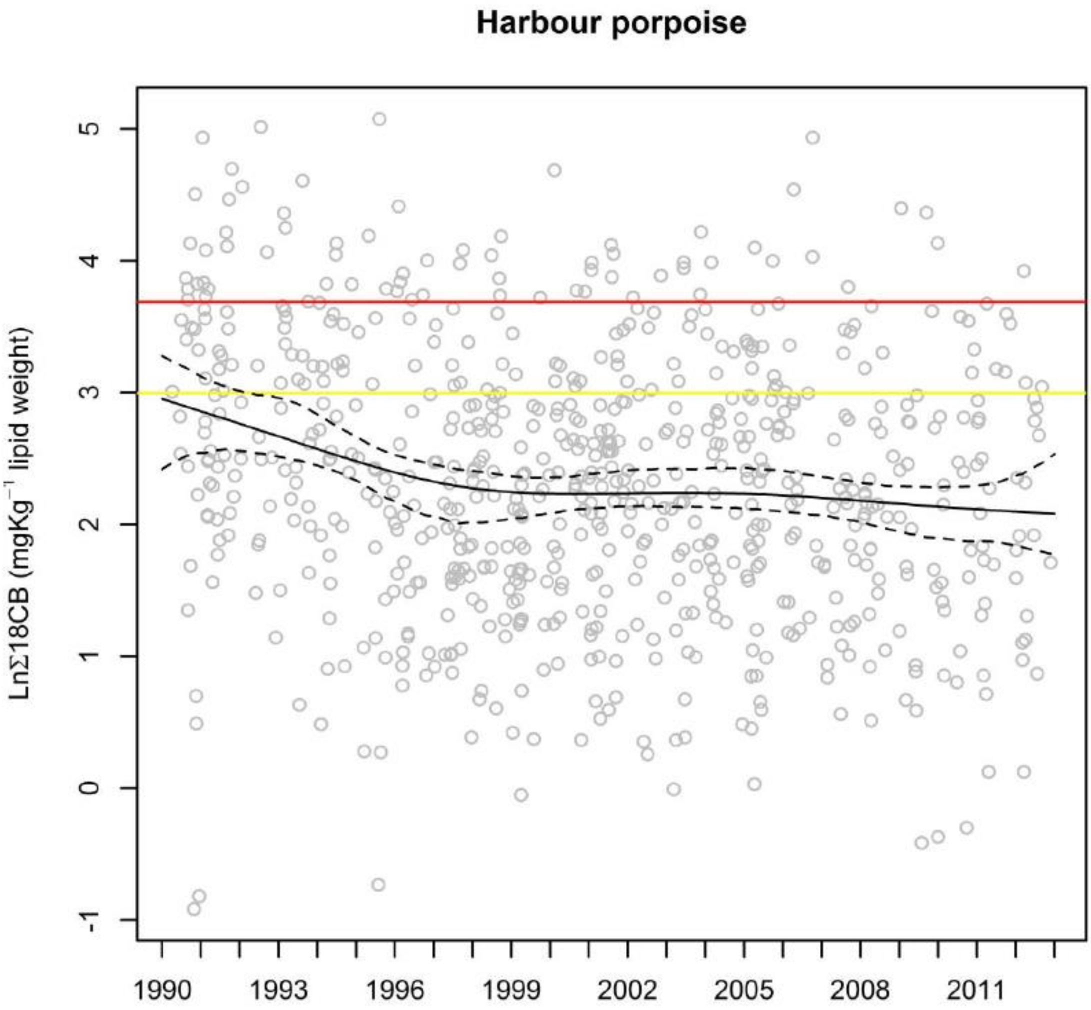

Figure 1 Temporal trend in ∑PCBs in UK-stranded harbour porpoises (*Phocoena phocoena*) (taken from Jepson *et al submitted*). Ln ∑PCBs (sum 18-25CB) mg/kg lipid concentrations in UK harbour porpoise blubber against date for all data for 1990-2012 (n=706). The continuous line represents the smoothed trend from a Generalized Additive Model fitted to the data. The trend is statistically significant ($p<0.001$) against the null hypothesis of no trend. The dashed lines represent the 95% bootstrapped Confidence Intervals. The yellow line represents ln ∑PCBs equivalent to 20.0 mg/kg lipid and the red line 40 mg/kg lipid.

The conservation implications of such sustained and elevated PCB exposure and (reproductive) toxicity are likely to have severe impacts at the population level in European BNDs and KWs. Many of these populations have experienced major population declines (see Jepson *et al. submitted*). The tuna-feeding KW subpopulation in the Strait of Gibraltar has a very annual female fecundity rate. Although occasional offshore KW sightings occur, no other resident/coastal KW groups remain off the Iberian Peninsula or in the Bay of Biscay. Cetacean stranding records in the Netherlands show that KWs were first recorded on the Dutch North Sea coastline in 1783, observed regularly from 1918 to 1963 and completely ceased thereafter until two single KW strandings in 2009 and 2010. Individuals in a small community of nine marine mammal-eating KWs have also been regularly seen around NW Scotland and Western Ireland over a 19-year period, but no calves have ever been observed within this group (see Jepson *et al. submitted*).

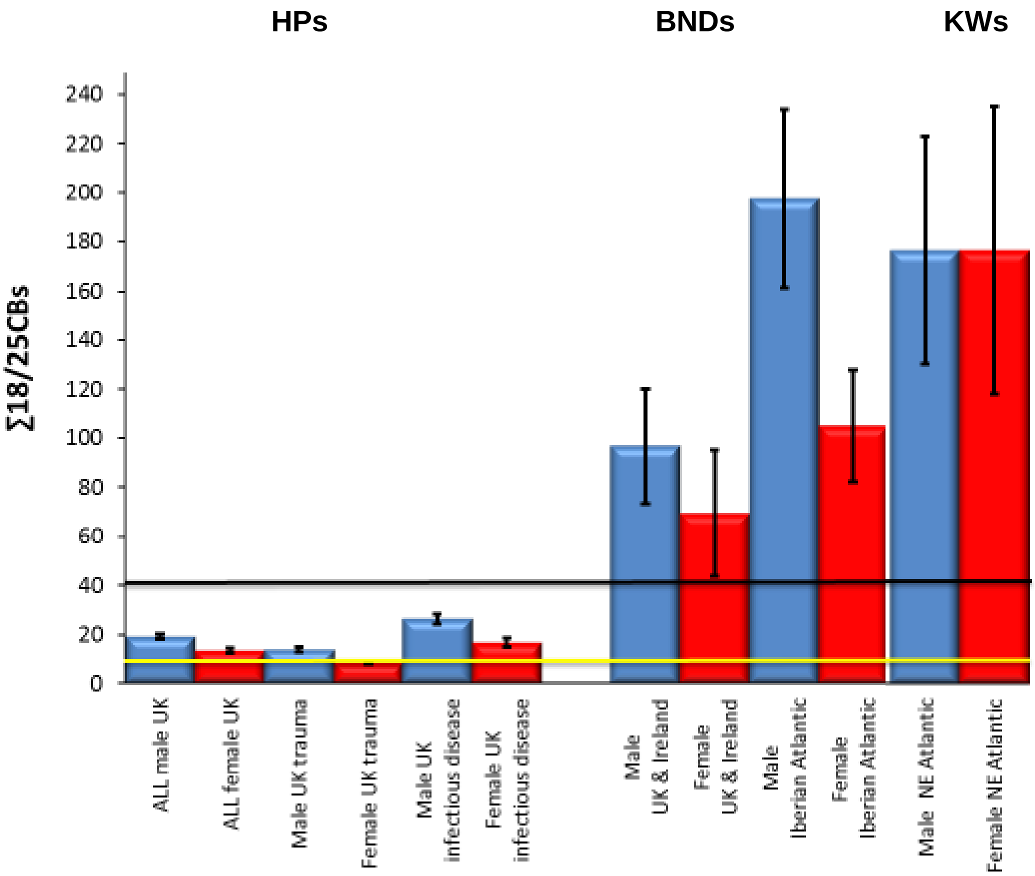

Figure 2 Mean PCB concentrations in male and female cetaceans (harbour porpoises HPs; bottlenose dolphins BNDs; killer whales KWs - all ages). The **blue** bars are males and the **red** bars are females. The lower line is the equivalent ∑PCBs concentrations threshold (mg/kg lipid) for onset of physiological effects in experimental marine mammal studies (Kannan *et al.* 2000). The upper line is the equivalent ∑PCBs concentrations threshold (41mg/kg lipid) for the highest PCB toxicity threshold published for marine mammals based on marked reproductive impairment in ringed seals in the Baltic Sea (Helle *et al.* 1976). Mean ∑PCBs concentrations in male (n=388) and female (n=318) UK-stranded harbour porpoises (HPs) in 1990-2012. Mean blubber ∑PCBs (mg/kg lipid) concentrations in subsets of male (n=201) and female (n=144) UK-stranded HPs that died of acute physical trauma and male (n=120) and female (n=132) HPs that died of infectious disease from the same 1990-2012 period. Mean blubber ∑PCBs (mg/kg lipid) concentrations also shown for stranded/biopsied male (n=29) and female (n=17) bottlenose dolphins (BNDs) from UK and Ireland; male (n=28) and female (n=24) BNDs from Atlantic coast of Spain and Portugal; and male (n=5) and female (n=19) KWs in NE Atlantic.

Historic stranding data suggest that multiple BND resident/coastal groups in Europe became depleted or locally extinct in the late-1960s to mid-1970s, including those in the UK (e.g. Morecambe Bay; East coast of England) and the North Sea Dutch coast (Jepson *et al. submitted*). The last member of a resident BND population at Archachon, France, died in 2003 and a small resident BND group (current census n=24) in the Sado Estuary, Portugal, has been declining due to low calf survival over several decades (Jepson *et al. submitted*). Blubber PCB levels for two females and one male BND (1995-1997) from the area ranged from 37.1 to 114 mg/kg lipid weight.

Discussion

Current threats from persistent organic pollutants (POPs) in Europe appear restricted to PCBs. Marked and ongoing declines in tissue concentrations of organochlorine pesticides (e.g. DDTs) have occurred in UK-stranded HPs and brominated flame retardants following a 2004 EU-ban (Law *et al.* 2012a). Similar marked declines have occurred in UK HPs for butyltins in recent decades (Law *et al.* 2012b). Many European seas (e.g. Baltic; Mediterranean; North Sea) are surrounded by highly industrialised land masses with high human population densities - which partly explain their high PCB loads (Aguilar *et al.* 2002; Law *et al.* 2012a). Particular “PCB hotspots” in this study include the SW Iberia, specifically the Gulf of Cadiz (BNDs) and the Strait of Gibraltar (BNDs and KWs), though others may exist. PCB concentrations have now stopped declining in European cetaceans, reaching a “steady state” between environmental input and degradation. EU regulations to mitigate PCB pollution currently appear insufficient to protect KWs, coastal BNDs in the NE Atlantic region.

Monitoring cetacean top predator PCB concentrations should be considered during future development of the monitoring programmes for inclusion as an indicator under descriptor 8 within the *European Marine Strategy Framework Directive* (Directive 2008/56/EC). PCB toxicity thresholds indicate that some cetacean populations in European waters are unlikely to meet Good Environmental Status (under Directive 2008/56/EC) or to achieve Favourable Conservation Status under *EC Habitats Directive* (Council Directive 92/43/EEC). Further steps to reduce PCB inputs into European marine environment should include stricter controls on disposal of buildings with PCBs added to sealants to increase durability (Law *et al.* 2012a; Kohler *et al.* 2005) and measures to limit PCB bioavailability to marine food webs, such as improved management of dredging of harbours/ports, as well as control of PCB contamination in industrial buildings/equipment and domestic waste disposal (e.g. landfill).

Conclusions

- **Very high PCB concentrations still found in stranded/biopsied bottlenose dolphins and killer whales in Europe (global PCB “hotspots”).**
- **Declines in cetacean PCB concentrations following an EU ban have now stopped in UK harbour porpoises.**
- **High and stable PCB exposures are associated with population declines in some BNDs and KWs in European waters** (see Jepson *et al. submitted*)**.**
- **Legacy pollutants (PCBs) continue to pose a major health and conservation threat to marine top predators in Europe today**

References

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Annex 1 Small project "SSFA2010-3" Financial Report

Project Document / Implementation Plan

Date	Milestone
January 2011-June 2013	Collating and despatching of archived blubber samples available for analysis to CEFAS Burnham Laboratory
July 2013-December 2013	Toxicological analysis of samples
January-June 2014	Analysis of all data generated to assess the threat posed by PCBs
22nd December 2014	Delivery of final report to Secretariat

The project was initially intended to be one year in duration for collation of available samples and analyses of contaminant levels and 6 months for data analysis and report writing. Following consultation with the ASCOBANS Secretariat, this period was later extended by two years in order to collect further blubber samples and allow extra time for ∑25CBs analyses at CEFAS.

Budget

Cost/animal (PCBs and OC pesticides) €317 = Analysis of blubber samples from 24 bottlenose dolphins (PCBs)	€7,600
Teeth ageing (Univ. of Aberdeen)	€1,000
Funding for sample transfer/storage and data analysis	€150
Data analysis/final report (IoZ/CEFAS)	€1,000
Total	**€9,750**

Schedule of payments	Date
1st Instalment (75%)	upon initial signature of the SSFA
2nd Instalment (25%)	upon receipt of final technical and financial reports

Invoices

1st instalment (75% of project total, invoiced January 2012)	€7312.50
2nd instalment (25% of project total, pending successful production and sign off of project report)	€2437.50