

<b>Institution:</b> Institute of Zoology
<b>Unit of Assessment:</b> Panel B, unit 7 - Earth Systems and Environmental Sciences
<b>Title of case study:</b> UK Cetacean Strandings Investigation Programme
<p><b>1. Summary of the impact</b></p> <p>The UK Cetacean Strandings Investigation Programme (CSIP), led by the Institute of Zoology, first identified accidental entrapment in commercial fisheries (by-catch) as the cause of mass mortality of UK common dolphins. Those by-catch diagnostic criteria are still widely used (UK and overseas). CSIP cetacean mass stranding investigations led to a successful ban on naval exercises around the Canary Islands and modification of Royal Navy exercises to reduce harm to cetaceans. CSIP research on brominated flame retardants in porpoises led to an EU-wide ban; follow-up work during the REF period verified the success of the ban by demonstrating declining chemical concentrations.</p>
<p><b>2. Underpinning research</b></p> <p>The publication in 1994 of a study that identified accidental entrapment in commercial fisheries (by-catch) as the cause of mass mortality of common dolphins (<i>Delphinus delphis</i>) provided the first evidence of cetacean by-catch in UK (and European) waters [1]. The investigation was led by Dr Thijs Kuiken of the Institute of Zoology (IOZ).</p> <p>The discovery of “gas and fat embolism” in stranded cetaceans in UK and Spain [2] – analogous to decompression sickness (DCS) or “the bends” in human divers – identified a condition that marine mammals were previously thought not to suffer. The findings helped to renew scientific interest in marine mammal diving physiology. The determination of DCS pathology in a beaked whale mass stranding event (MSE) in Spain provided critical insight into the potential underpinning mechanisms of beaked whale MSEs linked to high-intensity naval sonars globally and continues to inform their mitigation. The work was conducted jointly by Dr Paul Jepson (IOZ) and Professor Antonio Fernandez (University of Las Palmas, Gran Canaria, Spain). Eight gas embolism cases were reported stranded in the UK between 1993 and 2002 and another 10 cases in a mass stranding of beaked whales in September 2002 in Canary Islands, Spain.</p> <p>Other underpinning science includes the investigation into the UK’s largest common dolphin (<i>Delphinus delphis</i>) MSE in 2008 in which at least 26 dolphins died coincident with an international naval exercise [3]. This is one of the very first dolphin (i.e. non-beaked whale) MSEs to be causally linked to naval activities. The CSIP investigation and subsequent peer-reviewed paper was led by Dr Paul Jepson (IOZ) and conducted during 2008-2013.</p> <p>The UK CSIP has a longstanding collaboration with Robin Law at the Centre for Environmental, Fisheries and Aquaculture Science (CEFAS) that has generated probably the largest dataset globally for bio-accumulative chemical contaminants in a marine mammal sentinel species – the UK-stranded harbour porpoise (<i>Phocoena phocoena</i>) [4]. The data enable analysis of trends in a range of pollutants over time, thus assessing compliance with EU bans or on-going EU risk assessments. This underpinning research has shown consistent declines in tissue concentrations of organochlorine pesticides (such as DDTs and dieldrin), brominated diphenyl ethers (BDEs) [4] and hexabromocyclododecane (HBCD) [4,5] since EU bans were imposed. PCBs levels have, however, remained stable from 1997/8 in UK-stranded harbour porpoises (Law et al 2012) where case-control epidemiological studies have found strong links between elevated PCBs levels and infectious disease mortality [6], thus verifying proposed thresholds for toxicity in a free-living marine mammal. Even greater PCB concentrations have been found in apex predators like killer whales (<i>Orcinus orca</i>) and coastal bottlenose dolphins (<i>Tursiops truncatus</i>) [4].</p>
<p><b>3. References to the research (indicative maximum of six references)</b></p> <p>[1] Kuiken, T., Simpson, V. R., Allchin, C. R., Bennett, P. M., Codd, G. A., Harris, E. A., Howes, G. J., Kennedy, S., Kirkwood, J. K., Merrett, N. R. &amp; Phillips, S. (1994) Mass mortality of common dolphins (<i>Delphinus delphis</i>) in south west England due to incidental capture in fishing gear. <i>Veterinary Record</i> <b>134</b>, 81-89. Citations: 69 (Google Scholar) or 52 (Web of Science).</p>

## Impact case study (REF3b)

- [2] Jepson, P.D., Arbelo, M., Deaville, R., Patterson, I.A.R., Castro, P., Baker, J.R., Degollada, E., Ross, H.M., Herráez, P., Pocknell, A.M., Rodriguez, E., Howie, F.E., Espinosa, A., Reid, R.J., Jaber, J.R., Martin, V., Cunningham, A.A., and Fernandez, A. (2003) Gas-bubble lesions in stranded cetaceans. *Nature*, 425, 575-576. Already cited 247 (Google Scholar) or 128 (Web of Science) times.
- [3] Jepson P.D., Deaville R., Acevedo-Whitehouse K., Barnett, J., Brownlow A., Brownell Jr, R.L., Clare F.C, Davison N.C., Law R.J., Loveridge J., Macgregor S.K., Morris S., Murphy S., Penrose R., Perkins M.W., Pinn E., Seibel, H., Siebert, U., Sierra E., Simpson V., Tasker M.L., Tregenza N., Cunningham A.A. and Fernández A. What caused the UK's largest common dolphin (*Delphinus delphis*) mass stranding event? *PLoS ONE* 8(4): e60953. doi:10.1371/journal.pone.0060953
- [4] Law, R.J., Barry J., Barber J.L., Bersuder, P., Deaville, R., Reid, R.J., Brownlow, A., Penrose, R., Barnett, J., Loveridge, J., Smith, B., Jepson, P.D. (2012) Contaminants in cetaceans from UK waters: status as assessed within the Cetacean Strandings Investigation Programme from 1990 to 2008. *Marine Pollution Bulletin* 64: 1485-1494.
- [5] Law, R.J., Bersuder, P., Barry, J., Wilford, B.H., Allchin, C.R. and Jepson, P.D. (2008) A significant downturn in levels of HBCD in the blubber of harbour porpoises (*Phocoena phocoena*) stranded or bycaught in the UK: an update to 2006 *Environmental Science & Technology* 42, 9104-9109. Already cited: 43 (Google Scholar). Citations: 24 (Web of Science).
- [6] Jepson, P.D., Bennett, P.M., Deaville, R., Allchin, C.R., Baker J.R. & Law, R.J. (2005) Relationships between PCBs and health status in UK-stranded harbour porpoises (*Phocoena phocoena*). *Environmental Toxicology and Chemistry* 24, 238–248. Already cited 108 (Google Scholar) or 73 (Web of Science) times.

Details of the CSIP (formerly UK Marine Mammal Strandings Programme) grants that funded this underpinning research:

- **Grant holder:** Professor James Kirkwood; **Grant title:** Marine mammal strandings investigation (England and Wales); **Funder:** Department of the Environment **Grant period:** September 1990-September 1993; **Grant value:** £276,500 (approximately)
- **Grant holder:** Dr Paul Jepson; **Grant title:** Marine Mammal Strandings Investigation (England and Wales); **Funder:** Department for the Environment, Transport and the Regions; **Grant period:** October 2000 – December 2003; **Grant value:** £470,036
- **Grant holder:** Dr Paul Jepson; **Grant title:** Cetacean Strandings Investigation and Co-ordination in the United Kingdom; **Funder:** Department for Environment, Fisheries and Rural Affairs (Defra); **Grant period:** December 2003 – March 2005; **Grant value:** £219,450
- **Grant holder:** Dr Paul Jepson; **Grant title:** UK Cetacean Strandings Surveillance and Investigation; **Funder:** Defra; **Grant period:** April 2006 – March 2007; **Grant value:** £352,500
- **Grant holder:** Dr Paul Jepson; **Grant title:** UK Cetacean Strandings Surveillance and Investigation; **Funder:** Defra, Scottish Government and the Welsh Assembly Government; **Grant period:** April 2007 – July 2011; **Grant value:** £1,532,355
- **Grant holder:** Dr Paul Jepson; **Grant title:** Emergency funding to investigate a cetacean mass stranding in Cornwall; **Funder:** Defra; **Grant period:** June 2008 – June 2009; **Grant value:** £27,000
- **Grant holder:** Dr Paul Jepson; **Grant title:** One-year extension of UK Cetacean Strandings Investigation Programme (CSIP) with several optional extra modules for stranded cetacean toxicology; **Funder:** Defra; **Grant period:** March 2010 - March 2011; **Grant value:** £327,308
- **Grant holder:** Dr Paul Jepson; **Grant title:** Cetacean Strandings around the UK coasts: UK Cetacean Strandings Investigation Programme (CSIP); **Funder:** Defra, Scottish Government and the Welsh Assembly Government; **Grant period:** April 2011 - July 2014; **Grant value:** £1,113,673

#### 4. Details of the impact

The UK CSIP is coordinated by IOZ and primarily funded by the UK Government to comply with specific national and international conservation agreements (e.g. ASCOBANS and OSPAR) and European legislation (including EC Habitats Directives and the Marine Strategy Framework

## Impact case study (REF3b)

Directive). The first identification of by-catch in UK-stranded common dolphins led to realisation of the need among scientists and policy makers better to understand and quantify the population level impact of the phenomenon in exposed species in UK and European waters. For example, it resulted in numerous UK Government and EU-funded independent observer-based studies to quantify cetacean by-catch in commercial fisheries and develop mitigation measures to reduce unsustainable cetacean by-catch rates in specific European fisheries [a]. Diagnostic criteria for cetacean by-catch developed by CSIP are still widely used today in UK [b] and overseas [c,d].

As a result of our work on gas embolism, the Spanish Government imposed a ban on high powered naval sonars in the vicinity of the Canary Islands. This ban was recently hailed as a major conservation success since no further mass stranding events (MSEs) occurred since the ban was imposed (including 2008-2013 period) [e]. The Canary Islands were formerly a “global hotspot” for beaked whale MSEs so the ban is likely to have prevented several MSEs during the REF period. The European Parliament also issued a non-binding resolution to stop the deployment of high-intensity sonars within the EU until the completion of a global assessment of its cumulative effects on marine life following initial publication of our gas embolism findings [e].

The IOZ-led CSIP investigation into the 2008 common dolphin mass stranding event (MSE) in Cornwall concluded that concurrent naval exercises in the area were the most probable cause, led to specific revisions to the mitigation of Royal Navy activities including a direct role for CSIP scientists in early reporting of near-shore groups of pelagic cetaceans to Royal Naval Command in Portsmouth [f,g]. The 2008 MSE investigation also led to the establishment of the Marine Underwater Sound Stakeholders Forum (MUSSF) convened by the UK Government (Defra and Ministry of Defence) to specifically discuss and improve the environmental mitigation of naval activities and of which IOZ continues to form an integral part. The MUSSF was later subsumed into the Underwater Sound Forum with additional input from the oil and gas industry [g].

In relation to chemical contaminants, the CSIP and CEFAS (under Robin Law) were specifically funded to monitor long-term trends in chemical contaminant exposure in direct compliance with several conservation agreements/legislation. This CSIP-CEFAS underpinning research utilises a sentinel marine mammal apex predator – the UK-stranded harbour porpoise (*Phocoena phocoena*). CSIP-CEFAS data on accumulating levels of brominated flame retardants in UK-stranded porpoise blubber in the 1990s contributed directly to the EU-wide ban of the commercial penta- and octa-mix polybrominated diphenyl ether (PBDE) products in 2004 [h]. Following that PBDE ban, CSIP underpinning science showed statistically significant and consistent declines in porpoise tissue concentrations of brominated diphenyl ethers (BDEs) including the 2008-2012 period [h]. For organochlorine pesticides, CSIP-CEFAS data shows statistically significant and consistent declines in organochlorine pesticide concentrations (such as DDTs and dieldrin) including 2008-2012 [h]. CSIP-CEFAS underpinning studies again show a decline in HBCD concentrations in UK-stranded porpoises including the 2008-2012 period [h]. Collectively, these long-term studies show that the EU bans (or ongoing risk assessment for HBCD) resulting from CSIP underpinning science have been highly effective in reducing the bioaccumulation of several classes of chemical pollutants (including organochlorine pesticides and brominated flame retardants) in a sentinel marine top predator and in the wider European marine environment [h].

In contrast, and despite being banned for over three decades, underpinning scientific studies for PCBs have shown that concentrations in UK-stranded harbour porpoises have remained stable since 1997 and regularly exceed established thresholds for mammalian toxicity including the REF period [i]. The impact of our research on PCBs in marine top predators is that urgent scientific, policy and management steps are urgently needed to try to reduce their concentrations and associated impacts [h,i].

##### 5. Sources to corroborate the impact (indicative maximum of 10 references)

###### Corroborating references

[a] Dawson, S, Northridge, SP, Waples, D & Read, A (2013) To ping or not to ping: the use of active acoustic devices in mitigating interactions between small cetaceans and gillnet fisheries. *Endangered Species Research* 19: 201-221.

– **verify** that cetacean by-catch is still a very important conservation issue in UK and Europe.

[b] Deaville, R. & Jepson, P.D. (compilers) (2011) CSIP Final Report for the period 1<sup>st</sup> Jan. 2005-

## Impact case study (REF3b)

31<sup>st</sup> Dec. 2010. [http://randd.defra.gov.uk/Document.aspx?Document=FinalCSIPReport2005-2010\\_finalversion061211released\[1\].pdf](http://randd.defra.gov.uk/Document.aspx?Document=FinalCSIPReport2005-2010_finalversion061211released[1].pdf)

– **verify** CSIP-derived criteria for the diagnosis of cetacean by-catch still used today in UK.

[c] Braulik, G., Savadkouhi, O.S., Fadakari, S., Mohammadi, H., Brownell, R.L.(Jr), Reeves, R.R., Bagher Nabavi, M., Fernandez, A. (2010) A retrospective investigation of two dolphin mass mortality events in Iran, Autumn 2007. *Zoology in the Middle East* 49:

– **verify** CSIP-derived criteria for the diagnosis of cetacean by-catch are still used to investigate overseas cetacean mass mortality events.

[d] Wang Y. and We L. (2012) Strandings, bycatches and injuries of aquatic mammals in China: a review based on national official documents. *Integrative Zoology* doi: 10.1111/j.1749-4877.2012.292.x

– **verify** CSIP-derived criteria for the diagnosis of cetacean by-catch still used today overseas.

[e] Fernandez, A., Arbelo M., Martin, V. (2013) No mass strandings since sonar ban. *Nature* 497:317

- **verify** that the 2004 ban on high powered sonars in the Canary Islands following the 2002 beaked whale MSE reported in Jepson et al (*Nature* 425, 575–576; 2003) was a conservation success and also led to a non-binding European parliament resolution to stop the deployment of high-intensity sonar until the completion of a global assessment of its cumulative effects on marine life.

[f] JNCC (2013) 3rd UK Report on Implementation of the Habitats Directive.

<http://jncc.defra.gov.uk/page-6387>

- **verify** that the IoZ-led CSIP investigation into the 2008 common dolphin mass stranding event in Cornwall led to specific revisions to the mitigation of Royal Navy activities including a direct role for CSIP scientists in early reporting of near-shore groups of pelagic cetaceans to Royal Naval Command in Portsmouth.

[g] Can be verified by a contact at Navy Command, SO2 Environmental Protection (maritime), Chief Environment and Safety Officer (Royal Navy), Navy Command Headquarters, MP4-3, Leach Building, Whale Island, Portsmouth, Hampshire, England, PO2 8BY, UK

- **verify** that the IoZ-led CSIP investigation into the 2008 common dolphin mass stranding event in Cornwall led to specific revisions to the mitigation of Royal Navy activities including a direct role for CSIP scientists in early reporting of near-shore groups of pelagic cetaceans to Royal Naval Command in Portsmouth. Also **verify** that the 2008 MSE investigation led to the UK Government (Defra and Ministry of Defence) establishing the *Marine Underwater Sound Stakeholders Forum* (later subsumed into the *Underwater Sound Forum*) to specifically discuss the environmental mitigation of naval activities, of which IoZ still forms an integral part.

[h] Law RJ, Barry J; Barber JL; Bersuder P; Deaville R; Reid RJ; Brownlow A; Penrose R; Barnett J; Loveridge J; Smith B; Jepson PD. (2012) Contaminants in cetaceans from UK waters: status as assessed within the Cetacean Strandings Investigation Programme from 1990 to 2008. *Marine Pollution Bulletin* 64: 1485-1494

– **verify** declines in BDEs, OCs declines but show that PCBs remain stable in UK-stranded harbour porpoises.

[i] International Council for Exploration of the Seas (ICES)(2010) Report of the Working Group on Marine Mammal Ecology 12-15 April 2010, Horta, The Azores. ICES CM 2010/ACOM: 24.212pp.

– **verify** that UK CSIP-CEFAS contaminant data and research fed into large ICES scientific review of contaminants in marine mammals within the NE Atlantic region in 2010. Report also verifies that many banned contaminants are declining in UK porpoises but PCBs are stable and regularly exceed proposed thresholds for mammalian toxicity in some highly exposed cetacean species – including killer whales and coastal bottlenose dolphins.