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Impacts of oil spills on seabirds: Unsustainable impacts of non-renewable energy

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ABSTRACT

Accidental spillage of oil in to the sea from shipping transport and drilling rigs results in spills that cause significant unsustainable mortality of wildlife and destroys marine ecosystem services. External oiling of seabirds causes large scale mortality within days following a spill, while survivors suffercauses long term chronic effects from the exposure to toxic polycyclic aromatic hydrocarbons (PAHs) present in ingested oil. Survival rates for rehabilitated oiled birds are very low despite investment of significant resources. PAHs disturb thyroid homeostasis which plays a vital role in the control of energy metabolism. In this study, plasma PAH and thyroid-stimulating hormone (TSH) were quantified as biomarkers of exposure and endocrine disruption in oiled guillemots (*Uria aalge*). Mean plasma PAH and TSH concentrations, were 98.1 ± 8.3 ng/ml and 0.13 ± 0.02 ng/ml and these parameters were found to be negatively correlated ($p < 0.01$) indicative of PAH-associated thyroid hormone suppression in more heavily oiled birds. Body condition and weight were also lower in birds that died compared with birds that were released. The data also show the value of measuring plasma TSH and PAH to monitor metabolic status and progress of decontamination of oiled birds in a rehabilitation setting.

Introduction

Petroleum continues to be a major source of global energy despite the fact it is a non-renewable resource that has significant adverse impacts on the environment from its extraction, transport and use to its disposal, including resource depletion, habitat destruction, climate change, acid rain, ozone depletion, ecotoxicity and human toxicity [1]. Freight tankers transport large quantities of crude oil to refinery terminals around the world. In addition to regular discharges of refined products from ships, there are also unintentional releases from tankers and drilling rigs, arising from accidents and negligence (environmental conditions, collisions, engineering failures or and/poor maintenance). In 2013, a total of 605 separate discharges of oil from vessels and offshore oil and gas installations were reported in UK waters alone [2]. Worldwide release of petroleum oils in to the marine ecosystem globally, has been estimated to range from 0.5 to 8.4 million tonnes per year,

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with shipping and drilling rigs contributing ~35% to this total [3,4].

Mass mortalities of seabirds are a common in the aftermath of oil spills with tens if not hundreds of thousands of birds stranding dead or dying [5]. Seabird populations are particularly vulnerable due to their distribution, foraging and breeding behaviour. Following a spill, seabirds come in to contact with crude oil floating on the water's surface causing them to become smothered with oil and this can cause immediate mortality via suffocation [6]. Crude oil disrupts feather integrity displacing insulating air between feathers leading to loss of water-proofing, thermal insulation and buoyancy. They become unable to dive or fly so they cannot forage to feed. Relatively quickly fat reserves are depleted and ultimately birds become severely hypothermic and emaciated causing significant mortality [7,8]. The oil that is ingested from preening and feeding results in oral exposure to hydrocarbon chemicals present in crude oil. A significant proportion of these are toxic polycyclic aromatic hydrocarbons (PAHs) which, depending on the type of oil, degree of weathering and water content, can constitute up to 30% of total hydrocarbons present [9]. It has been estimated that ~170,000 metric tons of PAHs are discharged to the aquatic environment per annum as a result of petroleum spillage and natural sources [10]. PAHs enter the circulation leading to tissue and plasma contamination [11]. PAHs are believed to be the cause of the long term chronic effects of oiling which compromise the ability of rehabilitated cleaned seabirds to recover both at the individual, and population level. The subsequent of effects of "internal oiling" on seabirds are numerous and include pathological changes in the intestinal tract, lungs, liver, kidneys and salt gland [12–14] leading to dysfunction, reproductive toxicity [15], haemolytic anaemia [16,17], immunotoxicity [18,19] and endocrine disruption [20,21].

There are considerable efforts to recover, clean and rehabilitate stranded oiled sea birds and re-introduce them to the wild. Unfortunately, post-release survival of oiled sea birds is extremely low (<1%) in common guillemots, which tend to be most severely affected species following oil spills reaching the British coast [22]. Lack of weight gain and chronic toxicity of PAHs are invariably believed to be the major cause of mortality [23,24]. Thyroid hormones, under the control of the hypothalamus-pituitary-thyroid (HPT) axis, are critical to metabolism, weight gain, thermoregulation, reproduction and development in birds [25]. Any disruption of the HPT axis by oil exposure may exacerbate emaciation, hypophagia and hypothermia in oiled birds. There is good body of evidence that polyaromatic hydrocarbon chemicals such as PAHs, and halogenated varieties (e.g. polychlorinated biphenyls (PCBs), dioxins, organochlorine pesticides) disrupt thyroid hormone homoeostasis by altering the synthesis, secretion and transport of thyroid hormones in avian wildlife [20,26–31]. New monitoring approaches are required in wildlife rehabilitation to improve practice and improve post-release survival of rehabilitated oiled seabirds. The methods must address the diverse logistics and issues affecting wildlife centres practices such as technical and financial resource limitations, ethical constraints, crowding during oil spill events. Furthermore, only small blood plasma sample volumes are feasible from severely emaciated, dehydrated and hypothermic oiled birds, especially from guillemots. Plasma thyroid-stimulating hormone (TSH) concentration can be used to diagnose HPT status where sample volumes are insufficient for T3 (tri-iodothyroxine) & T4 (thyroxine) testing, since TSH is their precursor and vital to thyroid homoeostasis. The monitoring of plasma PAH concentrations provides good evidence of internal exposure status [11]. Here, a scoping study was undertaken to quantify PAH and TSH concentrations in plasma samples from guillemots oiled by the *MV Tricolour* spill in the French Channel. The relationship between these two parameters would be assessed as a means of monitoring PAH-mediated thyroid hormone disruption. The testing methods were selected and adapted for use with micro-volume plasma samples, to suit a rehabilitation setting.

Materials and methods

RaPID® carcinogenic PAH test kit was obtained from *Strategic Diagnostics Inc.* (Delaware, USA). Certified high-purity PAH standards were obtained from *Sigma–Aldrich Inc.* (Missouri, USA): acenaphthene, phenanthrene, acenaphthalene, pyrene, fluorene, chrysene, naphthalene, anthracene, benzo(a) anthracene, fluoranthene, benzo(a)pyrene (BaP) and phenanthrene-D_{10} (internal standard; IS). Solvents were of high-purity glass distilled grade. All other chemicals were purchased from *Sigma–Aldrich Inc.*

Sampling

The birds in this study were common adult guillemots (*Uria aalge*) stranded live on the South coast and East Coast of England in the winter of 2002–03, as a result of oiling following the *MV Tricolor* oil spill. The spill occurred as a result of a shipping lane collision involving the *MV Tricolor* with other vessels causing 170 tonnes of crude oil to be released in to the French Channel [32]. Approximately 19,000 seabirds were oiled and subsequently stranded (alive or dead) along the French, Belgian, Dutch and English coastlines, of which nearly 90% were common guillemots (*U. aalge*) [33,34].

Only samples from stranded guillemots admitted to East Winch Wildlife Centre (RSPCA) were available for this study and samples from healthy guillemots for use as "controls" were unavailable. Blood samples were collected from 50 birds. Information on exact age and sex of the bird was only available for a handful of the birds studied as there were insufficient resources to undertake the detailed examinations required to age and sex individuals of this species. Body weights were recorded on admission and eventual outcome recorded (dead, euthanized or released). Overall body condition was determined by of examination of the fat reserves and scored as follows; emaciated (0), lean (1), fair (2) and good (3). External oil coverage of plumage was determined by examination of the feathers and scored as follows; unoiled (0), lightly oiled (1), moderately oiled (2) and severely oiled (3). Prior to blood sampling all birds were washed according to

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