REPRODUCTIVE SUCCESS OF HERRING GULLS NESTING NEAR A BLEACHED KRAFT PULP MILL

Shutt, J. L.
National Wildlife Research Centre, Canadian Wildlife Service, Ottawa, Ont. Canada K1A 0H3

INTRODUCTION

Exposure to pulp mill effluents has been shown to have various negative impacts on aquatic biota. In addition, Bellward *et al*[1] noted that a colony of great blue herons (*Ardea herodias*) feeding near the outfall of a bleached kraft pulp mill failed to fledge any young. The kraft pulping process is known to produce dibenzo-p-dioxins (PCDDS) and dibenzofurans (PCDFS) as a byproduct[2]. A suite of effects noted in wild birds, including reduced reproductive success, has been associated with exposure to environmental levels of dioxins[3]. Fish collected from a bay in Lake Superior known to be contaminated with discharge from a bleached kraft pulp mill were found to have lowered circulating sex steroids and increased hepatic mixed function oxygenase (MFO) activity[4]. Herring gulls (*Larus argentatus*) nest on three small islands located directly in the effluent plume at this site. In order to determine if other species of fish-eating birds were also experiencing reduced reproduction as a result of exposure to bleached kraft mill effluents (BKME), a study involving this colony was initiated in 1991.

MATERIALS AND METHODS

In May of 1991 10 eggs were collected from a total of 33 marked apparently occupied herring gull nests in the effluent-contaminated site at Jackfish Bay. An additional 10 eggs were collected from a control colony 10 km to the west. Prior to fledging all young at both colonies were counted. Eggs were analyzed for 23 organochlorine compounds and 42 major PCB congener peaks according to the method of Peakall *et al*[5]. 2,3,7,8-substituted dioxins and furans were analyzed according to the method of Norstrom and Simon[6]. In addition, pooled egg extracts were added to a chic hepatocyte bioassay[7] to measure ethoxyresorufin-O-deethylase (EROD) induction and total intracellular porphyrin accumulation. In 1992 15 unincubated eggs were collected from individual clutches at Jackfish Bay and 17 eggs were collected from the control site for subsequent artificial incubation. The number of apparently occupied nests was counted at both colonies as well as at several other uncontaminated sites on the north shore of Lake Superior. Five incubating adults were collected from both the contaminated and control sites to estimate organochlorine body burdens, hepatic EROD (modified from the method of Pohl and Fouts[8]), hepatic retinol, retinyl palmitate and plasma retinol as well as total highly

carboxylated porphyrins. Daily behavior observations were conducted on selected breeding pairs in Jackfish Bay and the control colony. An estimate of reproductive success was made by counting the number of pre-fledged young as a function of the number of apparently occupied nests.

RESULTS AND DISCUSSION

The 10 eggs collected in Jackfish Bay in 1991 contained relatively low levels of 2,3,7,8 TCDD compared to other sites on the Great Lakes (Fig. 1). Levels of other organochlorines including p,p' DDE, mirex, dieldrin and oxychlordane were also low. The geometric mean of the sum of 42 PCB congeners was 5.0 mg/kg wet weight, below mean egg levels for most Great Lake sites. A pooled extract of eggs collected in Jackfish Bay was added to a chick hepatocyte bioassay. EROD induction was not elevated above background levels indicating the eggs were not significantly contaminated with known inducing compounds including the non-ortho substitute PCBs.

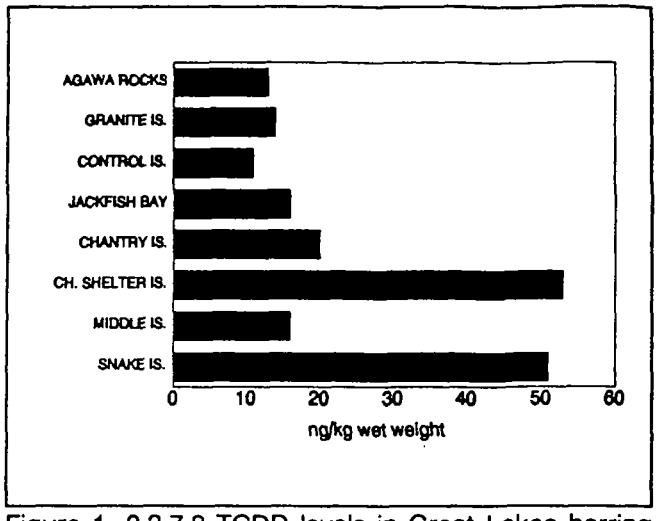

Figure 1. 2,3,7,8 TCDD levels in Great Lakes herring gull eggs collected in 1991.

Of the 33 apparently occupied nests followed in 1991, all failed to produce any young of fledging age. Indications from colony surveys suggest the mortality was occurring primarily from the pipping stage through the first several days post-hatch.

Fresh, unincubated eggs were collected the following spring from both the contaminated and control colonies and artificially incubated to determine if the reproductive failure observed in Jackfish Bay was a result of factors intrinsic or extrinsic to the egg. Results indicate that eggs from both sites hatched equally well (Table 1). Eggs collected concurrently and pooled for organochlorine analysis revealed low levels of all compounds measured.

Table 1. Hatching success of artificially incubated herring gull eggs.

Colony	No. eggs incubated	No. eggs fertile	No. hatched	Hatching success
Control	17	12	8	67%
Jackfish Bay	15	12	9	75%

In 1992 an additional number of herring gull colonies in presumed uncontaminated areas of the north shore of Lake Superior were visited to determine reproductive success (Table 2). As in 1991, the colony in Jackfish Bay failed to fledge any young. The other sites did produce young although at or below the 1 young per nest considered necessary to maintain stable population numbers. Behavior observations conducted on selected pairs at the contaminated and control colonies showed predation by ravens (*Corvus corax*), the main predator, to be equal at both sites. As in the previous year, mortality occurred late in incubation or just after hatch as no young could be located 4 days post hatch.

Induction of EROD was measured for 5 adults from both sites. Results are shown in Figure 2. The adults from the contaminated site showed considerably less induction

Table 2. Reproductive success of Lake Superior herring gull colonies in 1992.

Colony	No. of nests[a]	No. of young[b]	No. of young/nest
Jackfish Bay	99	0	0
Victoria Bay	38	33	0.87
Pump Stn. Is.	90	80	0.56
Terrace Bay	50	49	0.98
Petits Ecrits Is.	110	75	0.68

[a] number of apparently occupied nests counted late in incubation
[b] number of young at approximately 21 to 28 days of age

than the birds from the control colony indicating no significant exposure to halogenated aromatic compounds. Total highly carboxylated porphyrins were also measured in the livers of the same adults. Geometric mean levels of the most prevalent uroporphyrins were 20 and 17 pmol/g for the control and Jackfish Bay sites respectively. These results further indicate that the herring gulls nesting in the pulp mill effluent plume are not exposed to significant levels of halogenated aromatic compounds.

The reproductive failure observed over 2 breeding seasons at Jackfish Bay does

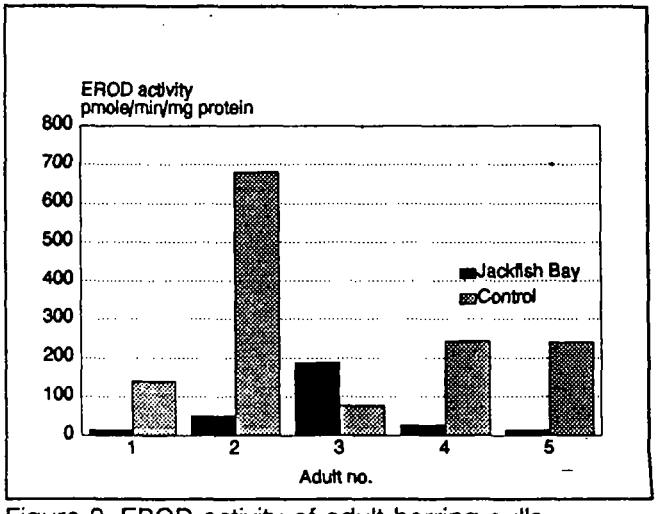

Figure 2. EROD activity of adult herring gulls.

not appear to be the result of exposure of eggs or adults to 2,3,7,8 TCDD or other halogenated aromatic hydrocarbons. Although EROD activity was not elevated in herring gulls, Munkittrick *et al*[9] found that white sucker (*Catostomus commersoni*) collected from the same site exhibited increased liver MFO activity. While Munkittrick *et al*[9] found that fish in Jackfish Bay had higher condition factors compared to a reference site, body condition indices calculated for herring gulls indicated lowered condition in the birds nesting in Jackfish Bay compared to other sites located through the Great Lakes. It is possible that changes in the traditional diet of fish and insects may be playing a role in the effects discussed above.

REFERENCES CITED

1 Bellward GD, Norstrom RJ, Whitehead PE, Elliott JE, Bandiera SM, Dworschak C, Chang T, Forbes S, Candario B. Correlation of polychlorinated dibenzodioxin levels with hepatic mixed function oxidase induction in great blue herons. Chemosphere 1990;20:1087-1090.

2 Kuehl DW, Butterworth BC, De Vita W, Sauer CP. Biomed. Environ. Mass Spect. 1987;14:443-447.

3 Gilbertson M, Kubiak T, Ludwig J, Fox G. Great Lakes embryo mortality, edema, and deformities syndrome (GLEMEDS) in colonial fish-eating birds: Similarity to chick edema disease. J. Toxicol. Environ. Health 1991;33:455-520.

4 McMaster ME, Van der Kraak GJ, Portt CB, Munkittrick KR, Sibley PK, Smith IR, Dixon DG. Changes in hepatic mixed-function oxygenase (MFO) activity, plasma steroid levels, and age at maturity of a white sucker (Catostomus commersoni) population exposed to bleached kraft pulp mill effluent. Aquat. Toxicol. 1991;21:199-218.

5 Peakall DB, Norstrom RJ, Rahimtula AD, Butler RD. Characterization of mixed-function oxidase systems of the nesting herring gull and its implications for bioeffects monitoring. Environ. Toxicol. Chem. 1986;5:379-385.

6 Norstrom RJ, Simon M. Method 5: Determination of specific polychlorinated dibenzo-p-dioxins and dibenzofurans in biological matrices by gel-permeation-carbon chromatography and gas chromatography-mass spectrometry. In: Rappe C, Buser HR, Dodet B, O'Neill IK. eds. Environmental carcinogens methods of analysis and exposure measurement. Vol.11 Polychlorinated dioxins and dibenzofurans. WHO, IARC Scientific Publ. No. 108. 1991:281-297.

7 Kennedy SW, Lorenzen A, James CA, Collins BT. Ethoxyresorufin-O-deethylase and porphyrin analysis in chicken embryo hepatocyte cultures with a fluorescence multiwell plate reader. Anal. Biochem. 1993;211:102-112.

8 Pohl RJ, Fouts JR. A rapid method for assaying the metabolism of 7-ethoxyresorufin by microsomal subcellular fractions. Anal. Biochem. 1980;107:150-155.

9 Munkittrick KR, Van der Kraak GJ, McMaster ME, Portt CB. Response of hepatic MFO activity and plasma sex steroids to secondary treatment of bleached kraft pulp mill effluent and mill shutdown. Environ. Toxicol. Chem. 1992;11:1427-1439.