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Histopathological Alterations in *Mya arenaria* Following a #2 Fuel Oil Spill in the Arthur Kill, Elizabeth, New Jersey

R. P. Brown, A. Cristini[a] & K. R. Cooper

Joint Graduate Program in Toxicology, Rutgers University, Piscataway, New Jersey, and [a]Ramapo College, Mahwah, New Jersey, USA

ABSTRACT

Following a 2 270 000-liter #2 fuel oil spill on 1 January 1990 studies were carried out to evaluate histopathological alterations in a population of Mya arenaria *inhabiting an impacted tidal mud flat in the Arthur Kill, Elizabeth, New Jersey. Approximately 30 clams were collected 1 week after the spill and on a monthly basis thereafter. The lesion incidence found in* M. arenaria *following the spill was compared to a base-line incidence established at the same location during 1988 and 1989. There was an increased incidence of moderate and severe lesions of the digestive gland, gills, and mantle 1 week after the spill, returning to pre-spill levels by 1 month. During the first 3 months post-spill an increase in lesion incidence of the intestines was observed which returned to previous levels by 6 months post-spill. The heart and kidney showed a latent increase in lesion incidence 2 and 3 months following the spill, which by 4 months returned to previous levels. Examination of the gonadal development indicated that ova and sperm development were not adversely affected and spawning occurred both in late spring and late summer. The siphon, gill, stomach, foot muscle, and body epithelium were not found to be adversely affected.*

The rupture of an Exxon oil pipeline on 1 January 1990 near Elizabeth, New Jersey, resulted in the spillage of approximately 2 270 000 liters of #2 fuel oil into the Arthur Kill waterway, a widely used channel linking Raritan Bay and Newark Bay between New Jersey and Staten Island, New York. Located in a heavily industrialized area of New Jersey the Arthur Kill is impacted by landfill leachate, roadway runoff, and industrial effluent on a daily basis. In

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Newark Bay Study Area

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this densely urbanized area this estuary remains a prominent coastal breeding ground for a number of migratory shore birds and supports a complex estuarine ecosystem of crustaceans, molluscs, and fish.

In many previous studies following an oil spill there has been little information on the condition of the impacted species prior to the contamination.[1] Most of these studies have dealt primarily with the kinetics of accumulation and depuration[2,3] or have examined only a few of the organs.[4] Researchers in our laboratory have been evaluating the histopathological condition of the soft-shell clam, *Mya arenaria*, from the Arthur Kill since 1986. Because of the extensive background histopathological database at this site a comparison could be made of lesion incidence following the #2 fuel oil spill with a base-line lesion level established during 1988 and 1989.

The present investigation involved the collection of approximately 30 clams 1 week after the spill and on a monthly basis thereafter. The animals were fixed in 10% neutral buffered formalin, embedded in paraffin, and stained with Harris' hematoxylin and eosin. The clams were evaluated for histopathological lesions of the following organs: siphon, gill, kidney, mantle, heart, intestine, stomach, digestive gland, gonad, foot muscle, and body epithelia. The lesions observed were graded as absent, mild, moderate, or severe. Moderate and severe lesions were considered to indicate impairment of the normal function of the organ and were grouped together as a percentage of the total number of animals examined.

The results (Table 1) showed three distinct patterns of response among the organs examined:

(1) A rapid and transient (1 week) increase in the incidence of moderate-to-severe lesions of the digestive gland (significant at $p < 0.05$, chi-square analysis), consisting of hypertrophy, hyperplasia, metaplasia, and basophilia; of the gills, consisting of focal hyperplasia, leucocyte infiltration, architectural alterations, and debris accumulation; and of the mantle (significant above 1989 incidence at $p < 0.05$, chi-square analysis), consisting of hyperplasia, vacuolization, and mucus cell proliferation.

(2) A rapid and persistent (4 months) increase in the incidence of lesions of the intestine (significant above 1989 incidence at $p < 0.05$, chi-square analysis), consisting of hyperplasia, vacuolization, accumulation of macrophages, and dilation of the digestive tubule.

(3) A latent (2–3 months) increase in lesions of the heart and kidney (significant at $p < 0.05$, chi-square analysis), consisting primarily of bacterial accumulations in the heart and hyperplasia, vacuolization, cell sloughing, and eosinophilia of the kidney.

TABLE 1
Percent of Clams with Moderate and Severe Lesions

		Digestive gland	*Gill*	*Mantle*	*Intestine*	*Kidney*	*Heart*
1988	Jul	—	30	—	11	25	ND
	Sep	32	41	47	17	8	ND
	Dec	35	14	18	71	67	ND
1989	Feb	30	4	28	18	67	8
	Mar	—	—	—	—	—	ND
	Apr	33	24	33	19	60	ND
	May	—	45	--	13	50	ND
	Jul	—	6	ND	ND	7	ND
1990	Jan[b]	88[a]	40	69[a]	77[a]	60	ND
	Feb	45	4	31	52[a]	48	ND
	Mar	33	22	20	25	86	8
	Apr	44	32	28	57[a]	95[a]	20
	May	6	23	23	32	38	—
	Jun	27	8	11	23	36	ND
	Jul	39	50	21	29	59	ND
	Sep	54	17	ND	21	58	ND
	Nov	4	12	9	7	27	12
	Dec	17	11	ND	4	37	ND

[a] Significant difference at $p < 0.05$, chi-square analysis
[b] Rupture of pipeline, 1 January 1990
ND = not detected.

The remaining organs examined did not have an altered incidence of moderate-to-severe lesions when compared with the background incidence.

Histopathological examination of the gonadal follicles during the course of the year indicated that the production of ova and sperm was not adversely affected in terms of morphological appearance. It would appear from monitoring of the gonadal state that the population of *M. arenaria* from this tidal mud flat spawned twice during 1990, late spring and late summer.

The Newark/Raritan Bay estuary system is not a pristine environment. During 1990 there were several oil spills in the Arthur Kill waterway and surrounding channels with an estimated 5 663 000 liters of fuel oil impacting this estuary (Table 2). Although the amount of oil spilled in 1990 is large, it should be noted that over 500 fuel spills were reported in 1989 in various areas of the estuary.

The lesion incidence observed in the Arthur Kill clam population was evident most rapidly in the gill, mantle, and digestive gland, and quickly returned to pre-spill levels. The intestinal lesions also appeared within 1 week but persisted through 3 months after the impact, before returning to

TABLE 2
Newark Bay Area Spills 1990

Date	*Amount (liters)*	*Location*
2 Jan	1 890 000	Arthur Kill
28 Feb	91 000	Kill Van Kull
6 Mar	378 000	Arthur Kill
9 May	38 000	Arthur Kill
7 Jun	983 000	Kill Van Kull
18 Jul	1 512 000	Arthur Kill
27 Sep	151 000	Kill Van Kull
26 Oct	620 000	Hudson River
Total	5 663 000	

pre-spill levels at the 6-month time point. The heart and kidney exhibited a delayed increase in lesion incidence at 2–3 months after the oil impact and then returned to pre-spill levels by 4 months.

Oil spills have resulted in large-scale mortality among marine shellfish.[5] Our field observations at the Arthur Kill site have estimated mortality at greater than 33% during the course of the study. Two possible paths of lesion progression following this #2 fuel oil spill are (1) that the observed lesions resulted in clam mortality, leading to a selection of healthier clams at subsequent time points, or (2) the clams which survived the initial fuel oil impact were able to acclimatize to the contamination and repair the lesions.

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