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Robert L. Dow

John W. Hurst

RENEWABLE RESOURCE PROBLEMS OF HEAVY METAL MINING IN COASTAL MAINE

by
Robert L. Dow and John W. Hurst, Jr.
Maine Department of Sea and Shore Fisheries

Reputedly the only intertidal heavy metal mine in the world, the open pit on Cape Rosier at Harborside where Goose Pond was a tidal cove before a dam was built to exclude seawater, is also unique in other respects: except for copper it has established in clams record Atlantic Coast highs of such toxic metals as manganese, cadmium, chromium, nickel, zinc, lead, iron, and cobalt. All these record high scores came from samples collected after operation of the separation plant (Table 1).

Table 1

Station #	Metal	PPM	Date
1	Manganese	341.20	Sept. 1968
7	Cadmium	1.70	Dec. 1969
8	Chromium	29.5	Feb. 1972
7	Nickel	4.12	Dec. 1969
8	Zinc	195.2	Feb. 1972
8	Lead	55.0	Feb. 1972
14	Iron	2471.50	Sept. 1968
14	Cobalt	1.49	Sept. 1968

The mining operation, together with background levels, has also produced measurable amounts of zinc, copper, lead, cadmium, and nickel in seawater, bottom sediments, and rockweeds in addition to clams. All these metals are, in varying degree, poisonous to humans and to marine worms, fish, shellfish, and plants, although several of them are essential in trace amounts to human as well as to other animal life.

Water samples contaminated by mine effluent discharge and collected for a mile outside Goose Cove were toxic to one-cell algae, an important part of the food base of commercial species; therefore, shellfish which manage to survive the effects of heavy metals may very well starve to death because of the damage done to their food sources by these same metals.

To obtain information on normal background levels, other clam samples from unmined areas of coastal Hancock County have been analyzed (Fig. 1). Results showed that all copper, lead, and zinc samples from Goose Cove exceeded the maximum of all background samples. All but one each of post-milling iron, cobalt, and manganese samples exceeded the maximum background. Two-thirds of all Goose Cove cadmium samples exceeded the maximum background; only chromium and nickel varied little from background.

A study of tidal flow and toxic metal contaminated clams showed that water-borne mine and mill wastes moved closely along the mainland shore east of Holbrook and Ram Islands (Fig. 2). Results of the hydrographic study were later confirmed by the analysis of sediments, rockweeds, and soft clams collected at stations established to monitor the environmental impact of heavy metal mining and ore separation. The relative stability of metal concentrations at Station #9 on the western tip of Goose Cove can be attributed to the outflow of these waters away from this station toward Station #8 on the eastern tip of the cove. This flow is indicated by differences in metal levels in clams from both sides of Goose Cove at its mouth. On the east side, lead scores increased from less than 5 parts per million in December 1967, before ore milling operations, to 55 ppm by February 1972, but on the other side at Station #9 lead increased from 2 to 17 ppm immediately after the mill began ore processing but has declined since to 2 ppm and has remained relatively steady at that level. Increases in heavy metals at Station #8 on the east side of Goose Cove since 1967 are shown in Table 2.

Table 2

GOOSE COVE SOFT CLAM ANALYSES - STATION #8
FOR HEAVY METALS IN PARTS PER MILLION

Metal	Dec. 1967	May 1968	Aug. 1968	Sept. 1968	Jan. 1969	Dec. 1969	Feb. 1972
Copper	4.89	8.41	7.89	4.84	2.92	8.0	58.8
Zinc	18.50	45.20	69.58	35.60	34.74	52.97	195.2
Cadmium	.30	.854	.625	.621	.25	.73	--
Chromium	1.36	3.94	1.340	1.681	3.28	5.88	29.5
Lead	4.94	19.50	5.26	12.42	7.13	27.35	55.0
Average	5.998	15.5808	16.939	11.0324	9.664	18.962	--
Average 4 metals w/out cadmium	7.42	19.26	21.02	13.64	12.02	23.52	84.60

Clams and rockweeds also appear to be selective in their concentration of metals. Zinc concentrations were five times as high in rockweeds as they were in sediments and ten times as high in rockweeds as they were in soft clams. Copper was the same in sediments and in rockweeds, but only half as high in clams.

Water and gravity appear to be the means by which metals are transported. Lead in water samples increased from less than .2 ppm to less than .9 ppm but in bottom sediments from 5 to 273 ppm during the same period. Scores at other sampling stations of Cape Rosier and of other metals appear to support the statement that there is a more direct influence of metals in sediments on levels of contamination in clams than there is of metals in water. The low solubility of copper (and other metals) may account for the lack of correlation between water and clam concentrations and the positive correlation between levels in sediments and clams.

Five of the six heavy metals under immediate consideration by the Federal Government for control purposes in food and water are present in the mine at Cape Rosier: zinc, copper, cadmium, lead, and chromium. Of 397 clam samples from Cape Rosier, 88 samples or 22% contained levels of lead, zinc, copper, cadmium, or chromium above the standards for heavy metals in shellfish proposed by the U. S. Food and Drug Administration. Although the most consistently high levels (59 samples) came from stations under the influence of the mining operation (Goose Cove and Weir Cove), it is obvious that background levels throughout Cape Rosier and the peninsula area are high. Any increase in these metal levels from mining activity poses a threat both to commercially valuable marine species and to public health. Of 101 samples from Goose Cove itself where the effluent is discharged, 47% exceeded the proposed maximum level recommended by the U. S. Food and Drug Administration.

Although seasonal fluctuations in concentrations of heavy metals by clams are evident, the trend since ore separation was commenced in 1968 is one of significantly higher levels within the area directly influenced by mine effluents.

An interim report on December 1967 sample collections, issued by the Federal Water Pollution Control Administration in April 1968, contained the following comment:

> "Amounts of certain metals -- Fe, Pb, Zn, Cr, and Mn -- approach the upper limit of the range considered normal for clams especially at Stations #8 and #9 in the vicinity of the former Goose Falls. These higher than average amounts may have been caused by the dumping of turbid mine waters seen to take place there on several occasions during the survey."

In the report which the Department of the Interior published, entitled "Effects of Strip-Mine Discharges on the Marine Environment - Cape Rosier, Maine," dated August 1970, there is the following statement on page 55:

> "To point out one possibility of many potential health hazards, let us consider the concentration of lead for Station 8, Phase II (19.5 mg Pb/Kg wet tissue). A reported onset of a case of gastro-enteric plumbism was associated with an alimentary intake of 10 to 15 mg. of lead. An individual consuming a large quantity of clams containing a similar amount of lead could be taken ill, not to mention potential complications from chromium and cadmium."

Since samples collected in February 1972 produced a level of 55.0 ppm (mg/kg) of lead in clams at Station #8 (effluent area), it is obvious that the health hazard has increased over time and that this contribution has come from the mine effluent.

Departmental Scuba biologists collected samples for bioassay in Goose Cove. They reported no scallops, lobsters, or crabs in the cove and only a few mussels, sea urchins, starfish, and sea cucumbers. The soft clam population was also very limited. Their observation was that the cove is virtually a sterile area.

The small number of sandworms (14) in proportion to bloodworms (238) found in sampling the affected area suggests that the normally greater abundance of sandworms has been reduced by the toxic effects of the heavy metals, particularly copper and zinc. Sandworms are much more sensitive to toxic metals than are bloodworms.

Copper bottom paint has been used for many years to paint the exterior hulls of boats to prevent fouling. In a departmental publication entitled "Methods to Reduce Borer Damage to Lobster Traps" we found that the use of copper paint as a lobster trap preservative reduced the catchability nearly 20% as compared with untreated controls.

Marine biologist and former Director of the Department's Extension Service, the late Donald M. Harriman, did extensive evaluation of the effects of heavy metals on the survival of lobsters, both in flow-through and recirculated seawater holding systems. He found that lobsters are extremely sensitive to copper poison.

Results of research elsewhere on the effects of heavy metals are summarized from the literature and contained in Table 3.

Scientists who have investigated heavy metals and their effect on marine plants and animals are in agreement with the need for careful management of mining areas and that the flow of tidal waters into a mined-out area or the discharge of mine wastes should not be permitted until adequate research, monitoring, and corrective measures have shown that no further damage will occur. Damage may come from the metals themselves which are highly toxic or from the deposit of smothering sediments produced by mining and milling operations. In Goose Cove large quantities of silt, rock flour, and other transported sediments have been deposited.

The evidence supports several conclusions:

1. Mining activity has had a major effect on toxic metal levels in seawater, bottom sediments, seaweeds, and clams.

2. Extensive shellfish areas may have to be closed for public health reasons when maximum levels are established by the U. S. Food and Drug Administration.

3. The ability of the area to support commercially important marine species appears to have been greatly reduced by effluent discharges from the mining operation into tidewater.

Table 3

EFFECTS OF HEAVY METALS ON HUMANS AND MARINE RESOURCES

Metal	Effects on Humans	Effects on Marine Plants and Animals
Cadmium	High blood pressure, sterility, flu-like disorders, depletes bone calcium.	Extremely toxic to oysters, less toxic to hard clams, and moderately to all other animals. Damage to intestinal tract, kidney, and gills of marine fish. It increases the toxicity of other metals.
Lead	Colic, brain damage, convulsions	Toxic to oyster gonads; also adversely affects hard and soft clam reproduction. Toxic to most enzyme systems.
Copper	Not toxic except in large concentrations.	100% mortality of lobsters in tanks Inhibits one-cell algal growth. .5 ppm in water 100% lethal to sand worms in 7 days. Oyster larvae killed by 3 ppm levels. Extremely toxic to soft clams above .02 ppm in water.
Zinc	Emetic at concentrations of 675-2280 ppm. 6 grams of zinc chloride reported to be fatal. 45 grams of zinc sulfate reported to be fatal.	Damage to gills of fish. Toxic to oysters in very small amounts.
Copper-Zinc	Emetic	Toxic to most marine animals. Interferes with Atlantic salmon spawning migration. Mussel mortality at .55 ppm.
Nickel	Dermatitis, cancer. Hazardous to human health.	No information
Cobalt	Respiratory and skin changes.	Not toxic except in large concentrations.
Chromium	Skin disorders, lung cancer, liver damage.	Not toxic except in large concentrations.
Iron	Not toxic except in large concentrations	
Manganese	Not toxic except in large concentrations	

Figure 1

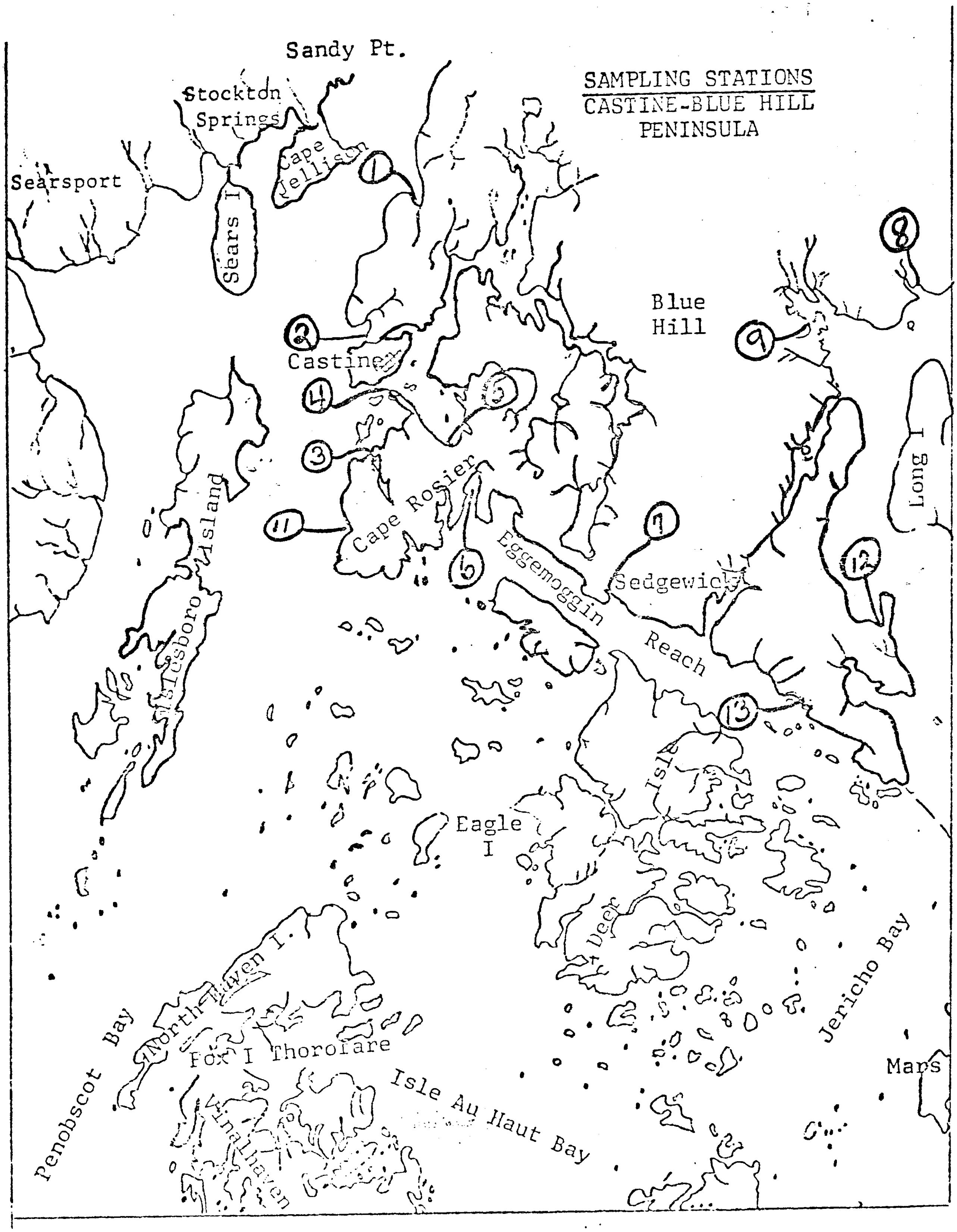
SAMPLING STATIONS
CASTINE-BLUE HILL
PENINSULA
Sandy Pt.
Stockton
Springs
Searsport
Sears I
Cape Jellison
Castine
Blue
Hill
Cape Rosier
Islesboro
Island
Eggemoggin
Reach
Sedgewick
Long I
Isle
Eagle
I
Deer
North Haven I.
Fox I
Thorofare
Vinalhaven
Isle Au Haut Bay
Penobscot Bay
Jericho Bay
Maps
1
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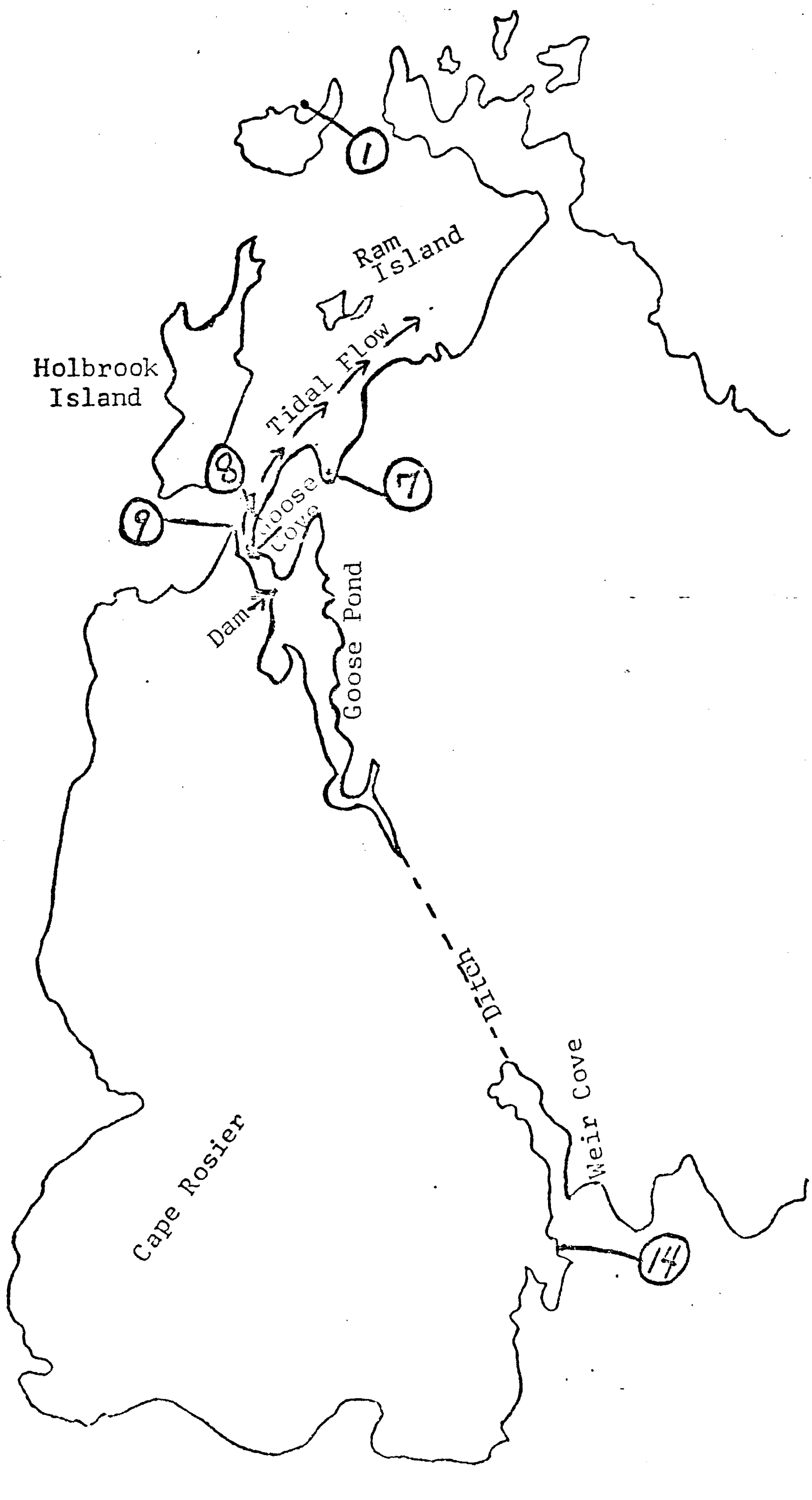
Figure 2


1
Ram Island
Holbrook Island
Tidal Flow
8
7
9
Goose Cove
Dam
Goose Pond
Ditch
Weir Cove
Cape Rosier
14