Densities of *Anoplarchus purpurescens* in the Intertidal Areas of Howe Sound in relation to the Discharge of Mine Waste Water

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Introduction

This report presents information on the abundance of *Anoplarchus purpurescens* Gill in the intertidal habitats of Howe Sound. Comparisons of the abundance of *A. purpurescens* between stations polluted by mine drainage carrying dissolved copper and unpolluted stations were done to determine the effects of the copper on intertidal fish. The waters near the confluence of Britannia Creek and the Sound contain elevated levels of dissolved copper. This is due to the fact that wastewater from the Anaconda Copper Mine at Britannia Beach is released through portals into this creek. At the time of sampling, the concentration of copper was approximately 1.14 mg/L at the confluence, whereas, at other locations in Howe Sound, less than 0.05 mg/L was detected. The mine water is also highly acidic due to the sulfuric acid, which is dissolved from the ore. About a tonne of dissolved metals escapes from the abandoned mine each day (Bohn, 1997). This study will examine if intertidal fish such as *A. purpurescens* reject the polluted site due to this pollution.

A. purpurescens or High Cockscomb is an eel-like fish, which is commonly found exposed by the receding tides under rocks. This member of the family Stichaeidae is present in the marine waters between Central California and the Pribilof Islands of the Bering Sea. A detailed description of the cockscomb's life history in Southern British Columbia is provided by Peppar (1965).

The ease of observing this species at low tide makes this species an ideal candidate for investigating pollution in the marine foreshore. *A. purpurescens* has previously been used to determine the persistence of petroleum hydrocarbons after the

Exxon Valdez spill (Woodin, Smolowitz and Stegeman, 1997). The foreshore habitat can be very different from that of a completely immersed environment. For instance, constant contact is maintained with the substrate when emmersion takes place. This can effectively expose the moist surface of the cockscomb to metals, particularly if they inhabit the many locales, where mine tailings were dumped.

Little data exists on the consequences of discharged mine waste on the biota in the marine environment (Brothers, 1992). Investigations are currently underway to determine possible effects of the mine seepage. Some of these include studies on the deleterious effects on rockweed seaweed (*Fucus*), juvenile salmon and epibenthic invertebrates.

Materials and Methods

All population studies were performed in Howe Sound, a fjord which is heavily influenced by the Squamish River. Most stations were situated in the vicinity of one of these three similarly sized creeks- Britannia, Furry and Potlatch Creeks. Station nomenclature are the same as those used for other studies in this area. Each station is shown in Figure 10. The reason for two sampling areas at FC6 was to determine if a difference in elevation produced different fish densities. The only station directly affected by the mine waste water is BB3. Sampling areas were defined by the similarity of substrate, relative elevation and algal cover. This explains the variable number of quadrats at each station. All stations included numerous rocks under which cockscombs could possibly inhabit.

The quadrat measured 0.50 m X 0.50 m. It was randomly tossed along the intertidal areas and all rocks with a diameter greater than about 0.10 m were overturned. All fish found inside the quadrats were caught, identified and promptly returned. Photographs were taken of every quadrat so that the percentage of *Fucus* cover could be determined at a later time. Visual analysis of the substrate was conducted at all stations and as well, the approximate sampling elevation was predicted using tidal graphs for Squamish.

Results

A total of ninety-two intertidal fish were discovered from the sampling stations (Figure 1). All except two of these were *A. purpurescens*. The other fish were the Crescent Gunnel (*Pholis laeta*) and Sharpnose Sculpin (*Clinocottus acuticeps*). These two species are known to inhabit the same foreshore areas as *A. purpurescens*; however, they are much less tolerant of desiccation and are only found during the lowest tide.

Fish were only encountered at three of the eight sampling stations. The density of *A. purpurescens* at FC6 (low tide), FC5 and BB1 was 11.2 fish/m^2, 2.0 fish/m^2 and 1.6 fish/m^2 respectively (Figure 2). For the quadrats which contained *A. purpurescens*, a plot of the percentage of *Fucus* per quadrat was constructed to determine if *Fucus* provided better habitat for these fish (Figure 3). The data suggests that most cockscombs from this study were found under rocks with limited or no *Fucus* covering.

Discussion

The lack of any fish at the stations FC6 (high tide), FC4, BB2 and DI4 were likely due to unfavorable terrain, substrate and/or elevation. *A. purpurescens* prefer silt or rocky substratum (Barton, 1982). These substrates retain water under rocks better than more porous materials. *A. purpurescens* are more resistant to water loss than are other Stichaeids because of their lower surface area to weight ratio and thick mucous covering (Horn and Riegle, 1981). Even so, they have not been found in the upper half of the intertidal. During the hot summer days when sampling was taking place, dehydration occurs more rapidly and these fish are found at the lower elevations to minimize the time spent out of the water. It is known that *A. purpurescens* tend to congregate in groups underneath rocks and maintain close contact to minimize evaporative water loss by decreasing their exposed surface area (Horn and Riegle, 1981). This behavioral adaptation was observed in the field on account of most of the quadrats containing more than a single fish. A steep shoreline, such as at BB2 doesn't allow for the retention of water as the tide retreats, hence the scarcity of fish.

The lack of *A. purpurescens* at BB3 cannot be accounted for by any of these previous reasons. Sampling was carried out during a low tide and the substrate keeps water under rocks from draining away rapidly, so in terms of suitability of habitat, this station seems as good as any other. The explanation must be related to the acidic and metal-laden water from the nearby creek. *A. purpurescens* seems to avoid this area either because of the damaging effects of the pollution or because the organisms that they feed upon, such as amphipods, polychaete worms, mussels and green algae are absent.

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Appendix
Table 1

Numbers of *Anoplarchus purpurescens* found in each quadrat at the eight sampling sites in Howe Sound

Station: FC6 (low tide)
Date: July 22, 1997
Intertidal Elevation: 0.9 metres
Substrate: silt

Quadrat Number	Anoplarchus purpurescens
1	14
2	-
3	2
4	10
5	2
6	2
7	-
8	-
9	5
10	-
11	1
12	7
13	-
14	2
15	-
16	-
17	-
18	3
19	4
20	-
21	1
22	3
23	7
24	5
25	2
Total	**70**

Station: FC6 (high tide)
Date: July 17, 1997
Intertidal Elevation: 3.3 metres
Substrate: silt and sand

Quadrat Number	Anoplarchus purpurescens
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	-
9	-
10	-
Total	**0**

Station: FC5
Date: July 23, 1997
Intertidal Elevation: 1.2 metres
Substrate: silt and sand

Quadrat Number	Anoplarchus purpurescens
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	3
9	-
10	1
11	-
12	-
13	-
14	-
15	-
16	-
17	5
18	-
19	1
20	-
Total	**10**

Station: FC4
Date: July 17, 1997
Intertidal Elevation: 2.4 metres
Substrate: silt and sand

Quadrat Number	Anoplarchus purpurescens
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	-
9	-
10	-
Total	**0**

Station: DI4
Date: July 16, 1997
Intertidal Elevation: 2.0 metres
Substrate: sand

Quadrat Number	Anoplarchus purpurescens
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	-
9	-
10	-
11	-
12	-
13	-
14	-
15	-
16	-
17	-
18	-
19	-
20	-
Total	**0**

Station: BB1
Date: July 17, 1997
Intertidal Elevation: 1.5 metres
Substrate: sand

Quadrat Number	Anoplarchus purpurescens
1	-
2	-
3	2
4	-
5	-
6	1
7	1
8	-
9	-
10	-
11	-
12	-
13	3
14	-
15	1
16	-
17	-
18	-
19	2
20	-
21	-
22	-
23	-
24	-
25	-
Total	**10**

Station: BB2
Date: July 18, 1997
Intertidal Elevation: 1.2 metres
Substrate: sand

Quadrat Number	Anoplarchus purpurescens
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	-
9	-
10	-
Total	**0**

Station: BB3
Date: August 19, 1997
Intertidal Elevation: 1.0 metres
Substrate: clay-like precipitate

Quadrat Number	Anoplarchus purpurescens
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	-
9	-
10	-
11	-
12	-
13	-
14	-
15	-
16	-
17	-
18	-
19	-
20	-
21	-
22	-
23	-
24	-
25	-
Total	**0**

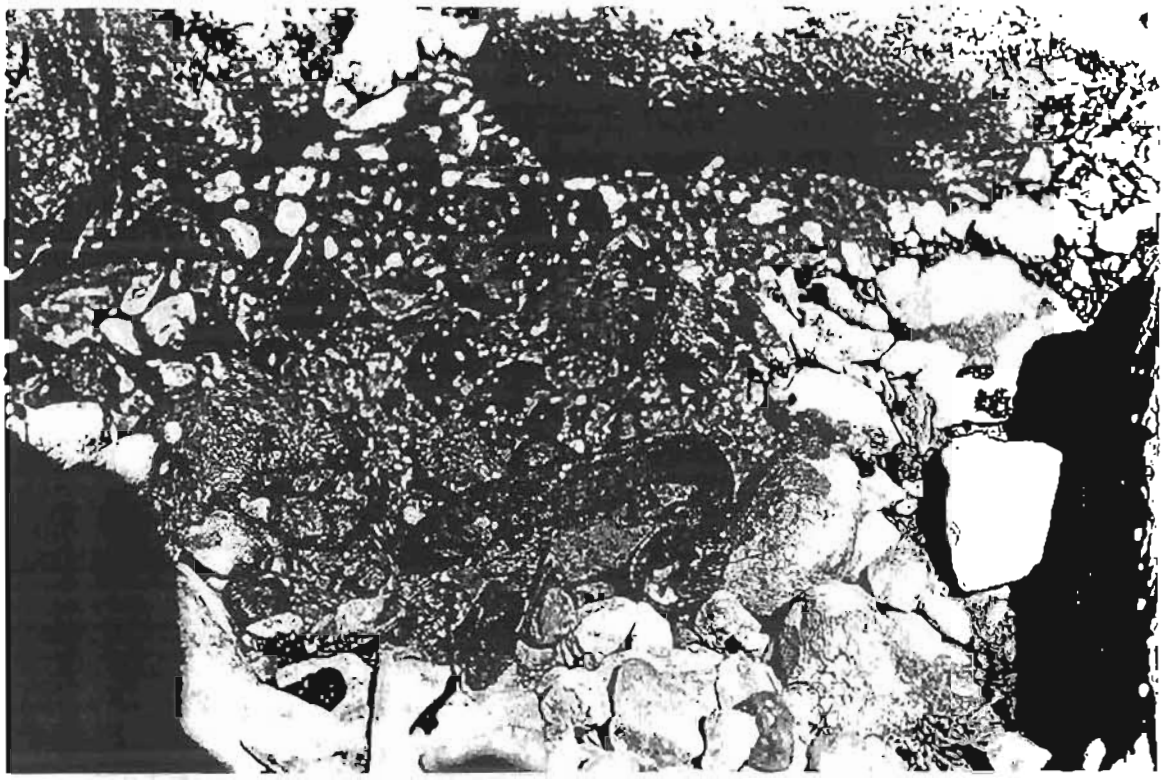

Figure 4- High Cockscomb (*Anoplarchus purpurescens*)

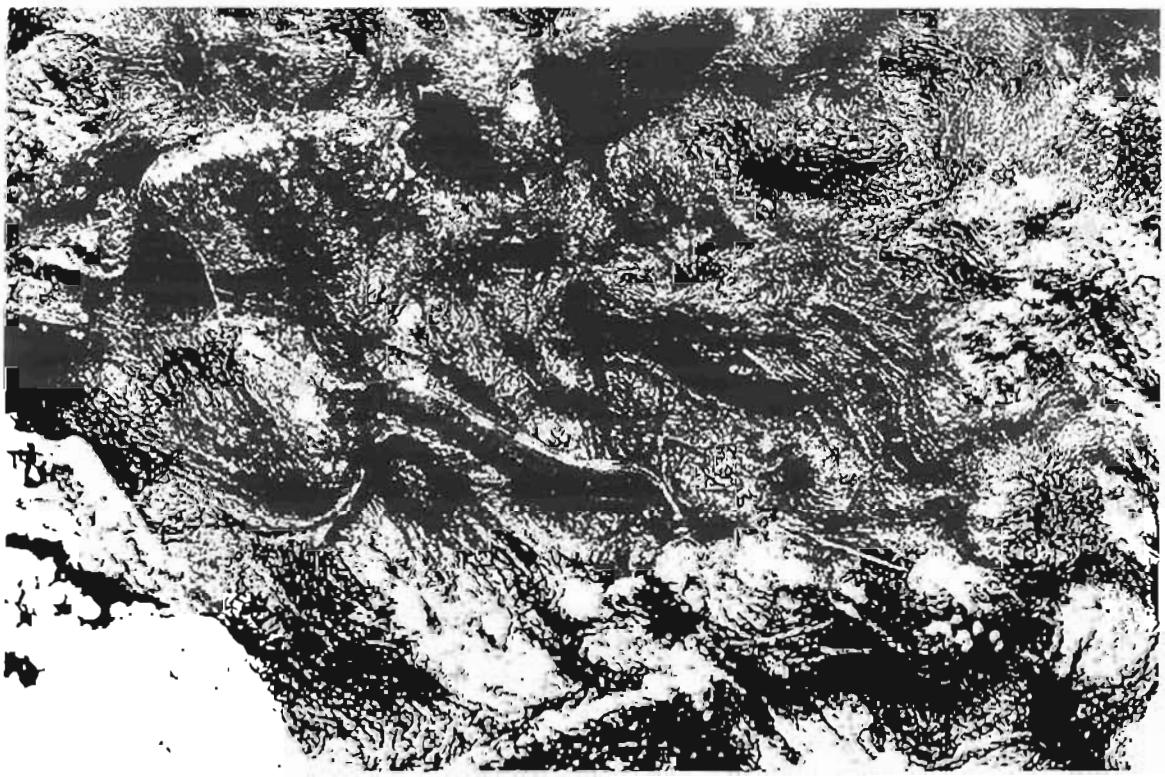

Figure 5- Crescent Gunnel (*Pholis laeta*)

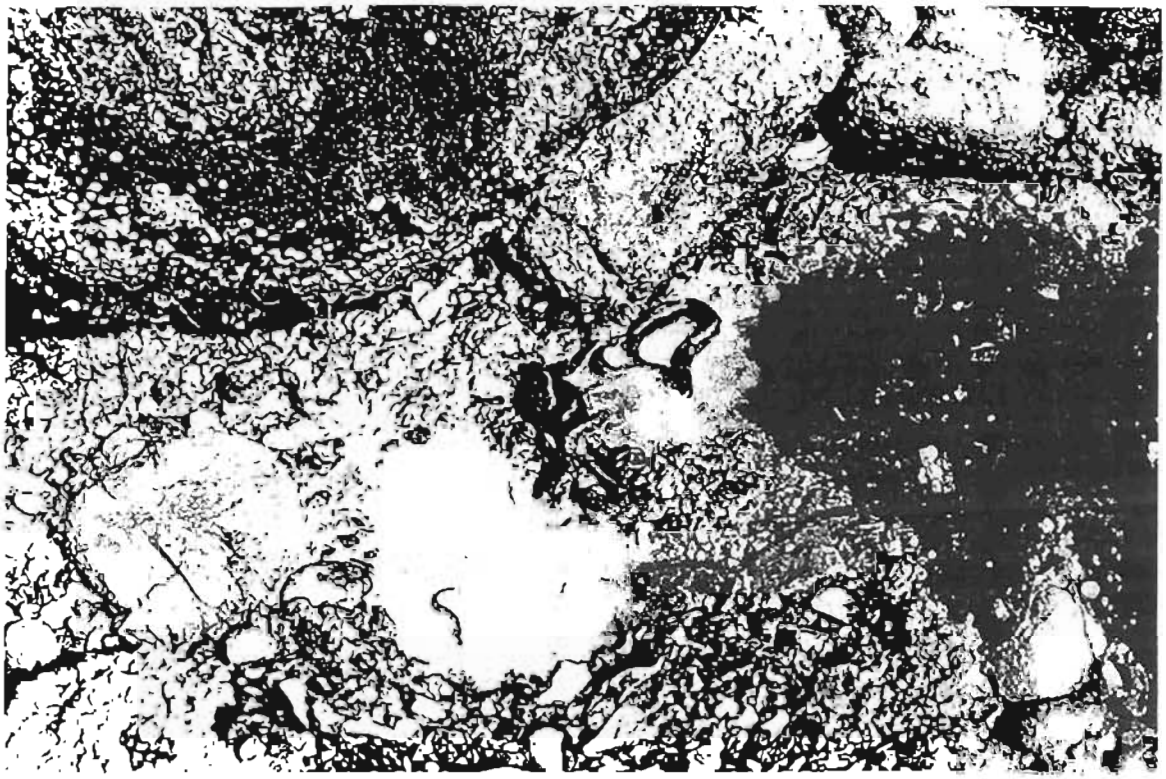

Figure 6- Several exposed *A. purpurescens* are present in the depression of this large rock

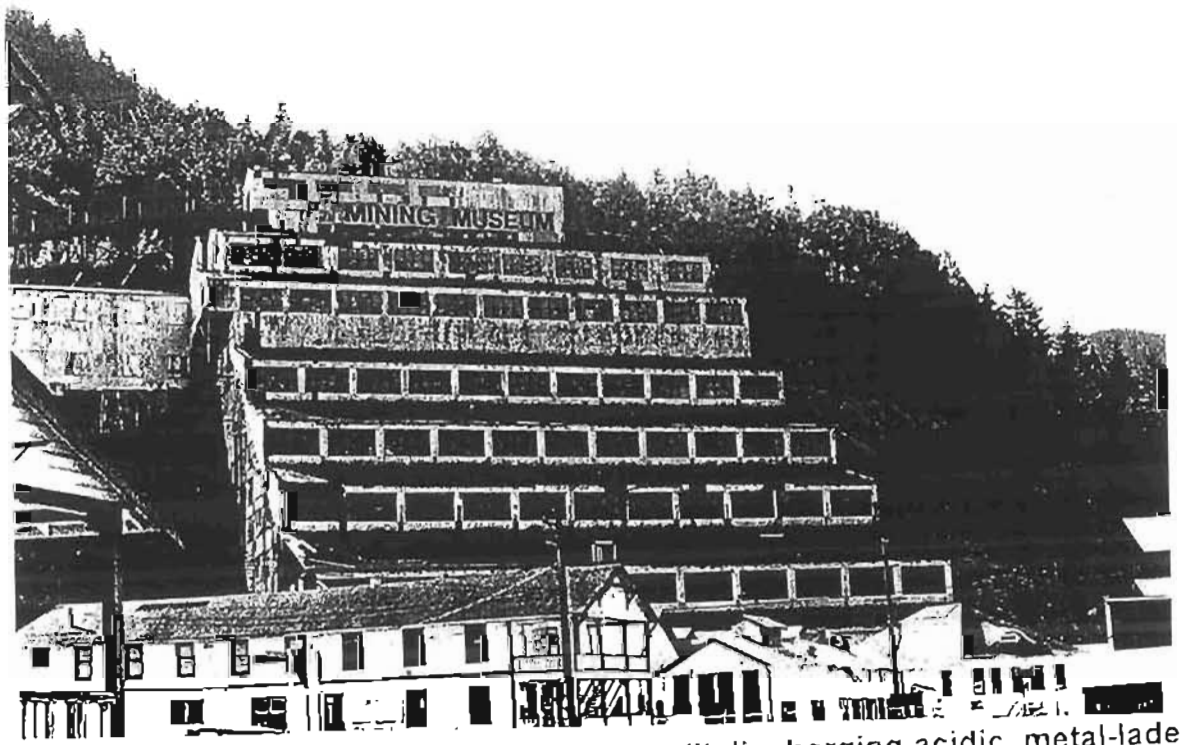

Figure 7- Abandoned copper mine which is still discharging acidic, metal-laden water into the marine environment

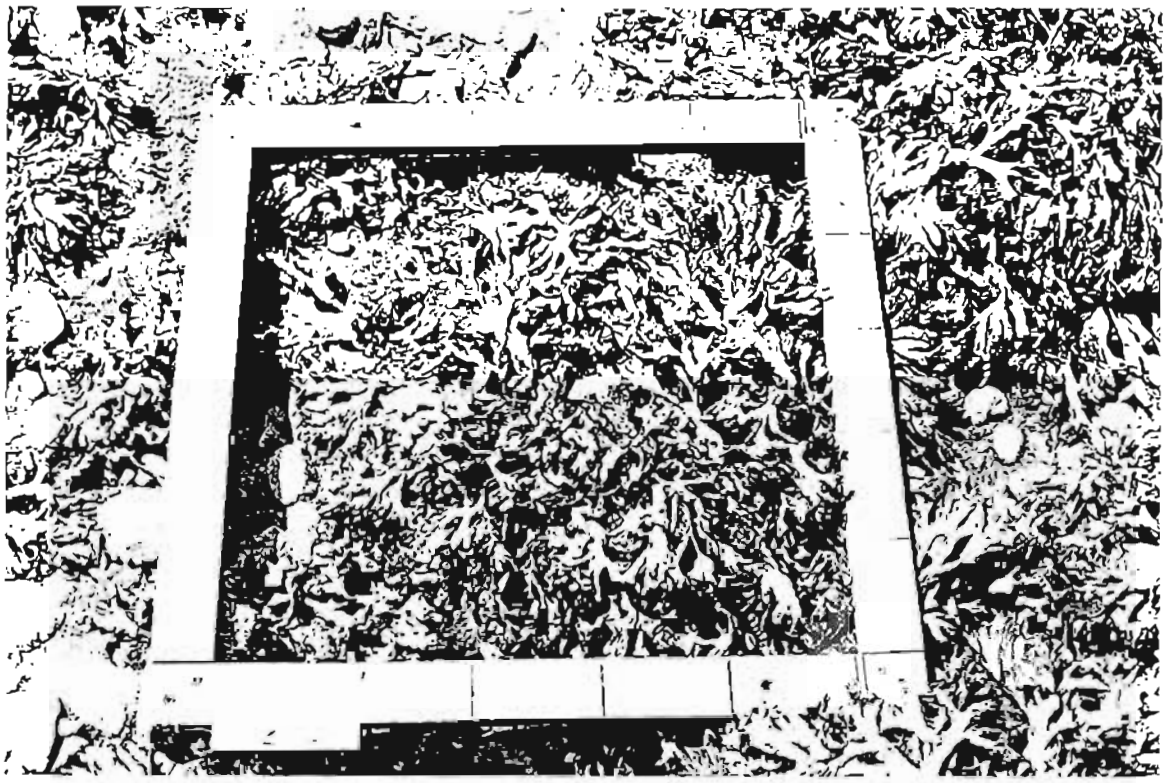

Figure 8- Example of a quadrat with approximately 80% fucus cover

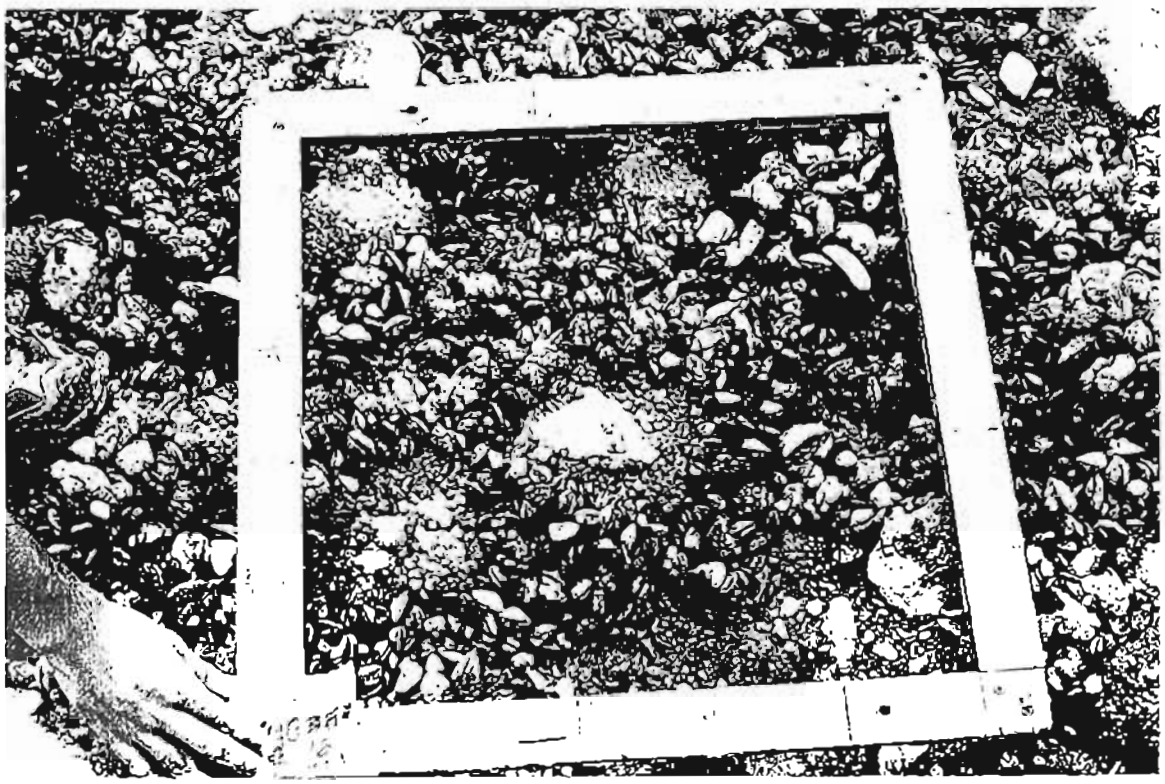

Figure 9- Example of a quadrat with no fucus cover

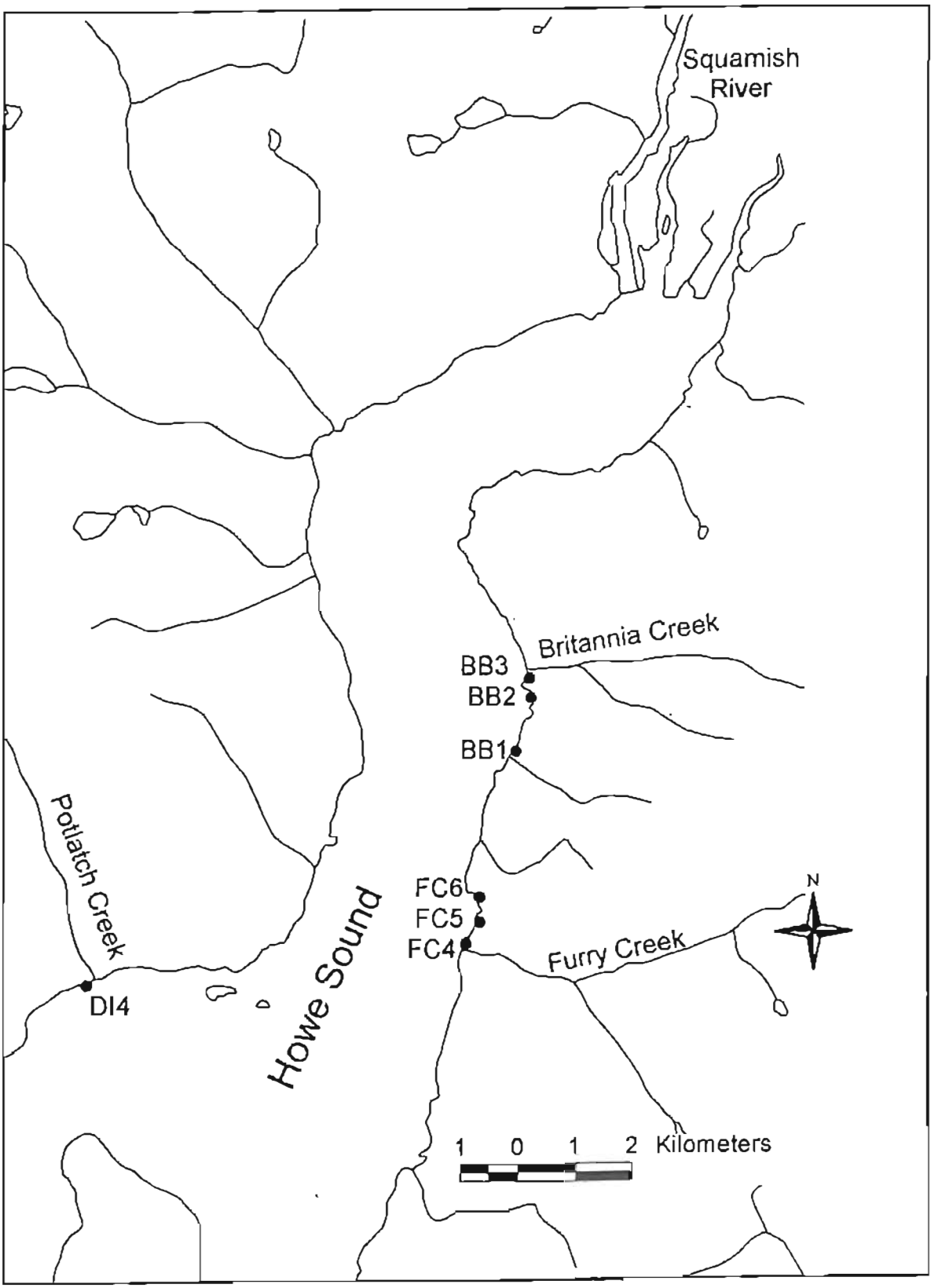

Figure 10- Map of Sampling Sites

Fucus Transplant Data							
Copper Content Analysis by GSC							
Sample Date: 230797							
	Furry Creek		Britannia Beach				
	Sample #	[Cu]	Sample #	[Cu]			
	2	83	2	>500			
	7	97	7	>500			
	8	81	8	>500			
	8a	96					
	9	99	9	>500			
	11	120	11	>500			
	14	97	14	>500			
	15	89	15	>500			
	17	110	17	>500			
	22	110	26	>500			
	28	79	28	>500			
	29	87					
	29a	100					
	30	120					
	34	110	34	>500			
	36	110	37	>500			
	39	110					
	40	88					
	40a	130					
Concentrations are ppm in dry tissue.							
500 ppm is the detection limit							
Sample #'s are as follows:							
	1-10:	Site A	43 m south of Britannia Creek, 6.7 ft. above 0 tide				
	11-20:	Site B	25.5 m south of Britannia Creek, 6.3 ft. above 0 tide				
	21-30:	Site C	60 m north of Britannia Creek, 6.6 ft. above 0 tide				
	31-40:	Site D	87.5 m north of Britannia Creek, 6.6 ft. above 0 tide				