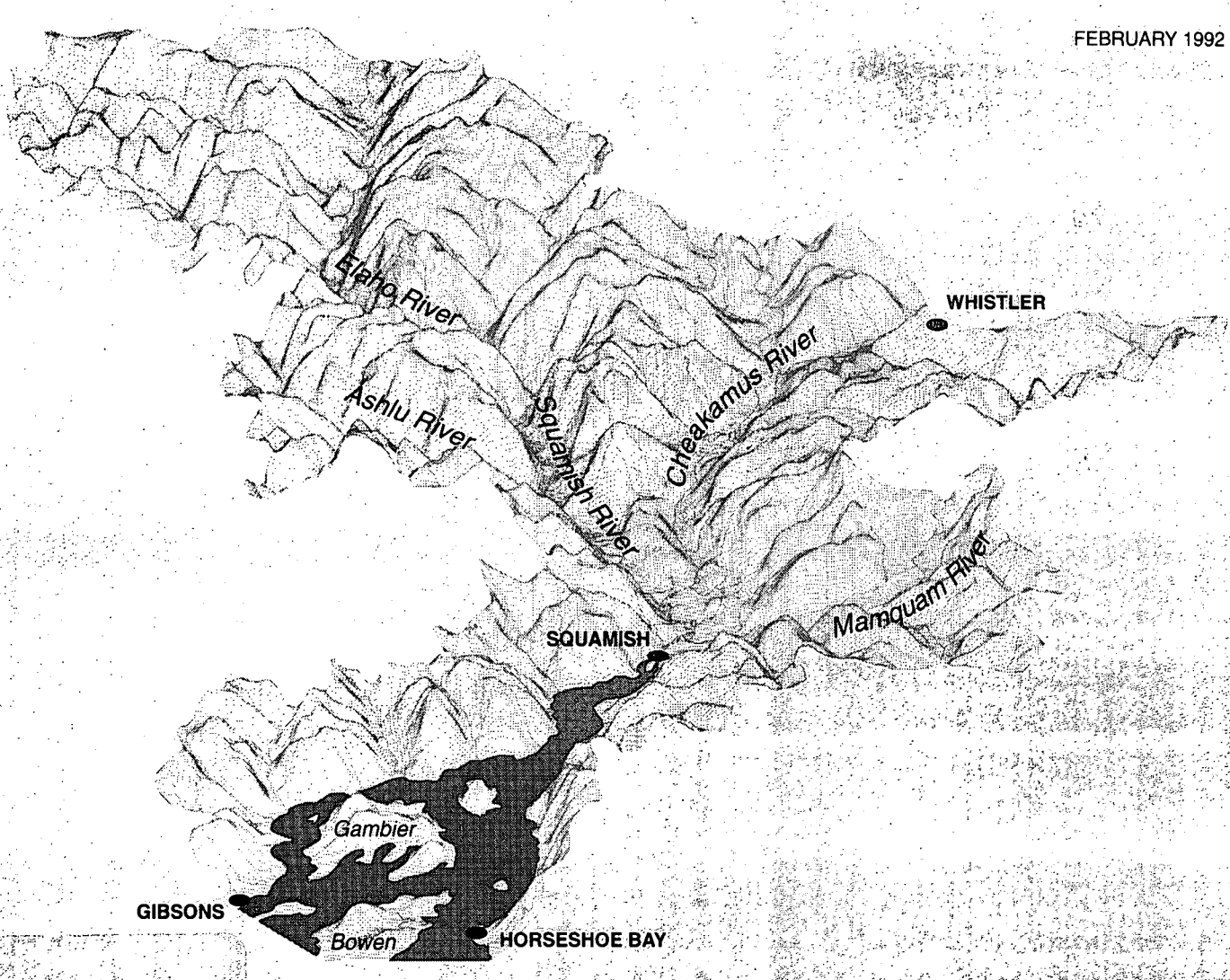
HOWE SOUND WATERSHED

Environmental Science Workshops and Public Meetings

Summary of Proceedings

FEBRUARY 1992



Environment Canada
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HOWE SOUND WATERSHED ENVIRONMENTAL SCIENCE WORKSHOP

AND

PUBLIC MEETINGS

October - November, 1991

Summary of Proceedings

Prepared for:

Environment Canada
Conservation and Protection
Pacific and Yukon Region

Prepared by:

Regional Consulting Ltd.
Vancouver, B.C.

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Michael McPhee

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PREFACE

This report was prepared by Regional Consulting Limited under contract to Environment Canada, Conservation and Protection, Pacific and Yukon Region (Contract No. KA601-1-0348). The contract was under the supervision of the Scientific Authority, Dr. Vic Bartnik, Head, State of Environment Reporting Division, Conservation and Protection, Environment Canada. It should be noted that these proceedings are summaries of presentations made at the technical and public workshops. For specific details, readers should contact the individual presentors. The authors acknowledge the assistance of the various government agencies, workshop panelists, educational institutions and the general public who all contributed to the information contained in these proceedings. Special recognition goes to Tim Turner for his cooperation in coordinating the public workshop sessions.

Avant-propos

Ce rapport fut preparé par Regional Consulting Limited sous contrat d'Environnement Canada, Conservation et Protection, Région du Pacifique et du Yukon (Contrat No. KA601-1-0348). Le contrat fut supervisé sous l'autorité scientifique du Dr. Vic Bartnik, chef de la division Rapport sur l'état de l'environnement, Conservation et Protection, Environnement Canada. A noté que ces délibérations sont des sommaires de présentations qui ont été données aux ateliers techniques et publiques. Pour plus de renseignements, les conférenciers de chaque présentation devraient être consultés. Les auteurs sont reconnaissants de l'assistance de plusiers agences governementales, des panalistes des ateliers, des institutes éducationnels et le publique en général qui ont contribués à l'information contenu dans ces délibérations. Tim Turner est spécialement remercié pour sa coopération dans la coordination des ateliers publique.

(Ce document sera disponible en français seulment sur demande)

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PART 1

SUMMARY OF HOWE SOUND WATERSHED ENVIRONMENTAL SCIENCE WORKSHOP

October 1, 1991 9.00 a.m. Introduction

Bob Turner, (Geological Survey of Canada), Chairman of the Steering Committee, welcomed the participants and explained the basis for the focus on the Howe Sound watershed. He then introduced the organizing committee:

Colin Levings - Department of Fisheries and Oceans
Chris Pharo - Environment Canada
Walt Cretney - Institute of Ocean Sciences, Department of Fisheries and Oceans
Brian Clark - B.C. Ministry of Environment, Lands and Parks
Tom Pedersen - Department of Oceanography, UBC
John Rich - West Coast Environmental Law Society
Brian Ricketts - Geological Survey of Canada (Chairman, Technical Committee)

There were two major purposes of the meeting:

- to develop a network of people working on Howe Sound and to encourage collaboration on interdisciplinary research,

- to present scientific information to the public and to generate public discussion of the Howe Sound environment.

Tim Turner, on contract with Environment Canada, organized a series of 5 workshops in Gibson, Squamish, Whistler, West Vancouver and Vancouver. There were day-long information sessions, and displays presented by Federal agencies, Provincial ministries, industry and public groups etc. The purpose was to share scientific information with the community and hear from local groups which have a knowledge of the state of the system. Following each information session there were evening Panel discussions.

Following the workshop, a process was established for preparation of a state of the environment report by Environment Canada. Vic Bartnik is the coordinator for Environment Canada, and Alan Ferguson and Mike McPhee are the consultants assisting in planning this endeavour. The focus of the SOE report will be both to inform the public and assist decision-makers. A technical report with the

papers presented by participants will be published in spring 1992 through Department of Fisheries and Oceans. A newsletter will also be produced to inform relevant parties of the research and monitoring efforts in Howe Sound.

Participants in the meeting were faced with two challenges:

- limiting the use of jargon associated with different disciplines and promoting good communication;

- focusing on the overall question regarding the health of the system and how it is changing through time.

Bob Turner then described the Field Guide. Its purpose is to synthesize information and draw on expert contribution and expertise in different fields. Comments and contributions to it are welcome. The Guide will also be distributed at public meetings.

October 1, 1991 Morning Session

Chairman: Tom Pedersen, Department of Oceanography, UBC

The Howe Sound Fjord: Geological and Geophysical Evidence for its Origin and Quaternary Development

Tark Hamilton, Pacific Geoscience Center, Geological Survey of Canada

Abstract

Marine seismic profiles and regional maps are used to identify Howe Sound's geology and sedimentary processes. The fjord incises the Coast Mountains about halfway from Georgia Strait to the Garibaldi Arc. The narrow reach from the Squamish River mouth to the Porteau Sill has depths to 285 m. Flow is confined to <55 m over the sill while lower Howe Sound has depths >245 m. Bedrock relief is great and sediment thickness locally exceeds 500 m. Despite regional lineations of 41^0 and 131^0 in the geology, gravity, magnetics and seismicity; no active faults are known.

Substrates include: modern sand to superhydrous silt, tailings and organic waste, glaciomarine turbidites, diamicts and various bedrock types. Rock is restricted to slopes over 30^0 and hills.

Layered reflectors and diffractors characterize proglacial turbidites (>17,000 B.P.), typically 150 to over 450 m thick. Variable offlap and lenticular deposits imply multiple ice lobes. Some strata suggest ice incursion from the south. Outcrop is restricted to the eroded fjord walls and floor. The top of this facies dips slightly from Porteau to Horseshoe Bay, possibly due to ongoing uplift in the Coast Mountains.

The Porteau Sill is one of the few fjord sills in western Canada that is a terminal moraine. Built on eroded glaciomarine deposits and bedrock it marks a stillstand or readvance during the last ice retreat. Its coarse sediment has an arcuate structure with bedding dips that steepen upsection to 28^0.

In upper Howe Sound the main source of modern sediment is the Squamish River delta. This acoustically coarse and gassy sediment thins to < 10 m along the basin axis. Seismic data show that no significant Squamish sediment traverses the sill to the south.

Silt from the Fraser River plume enters via Queen Charlotte Channel to accumulate on the flat basin floor in water >200 m. Since deglaciation, this has formed a transparent to faintly laminated wedge shaped deposit which tapers from >90 m off Horseshoe Bay to about a metre on the Porteau Sill and is absent further north. From seismic character and correlation, the sedimentation rate is highest in southeast Howe Sound, and there it is still less than 7.5 mm/yr. The Fraser silts also thin to the west, and do not extend into the westernmost Howe Sound or Thornborough Channel. The distribution of the Fraser silt resembles that of the peak velocities for the surface currents. The only modern sediments in western Howe Sound are small debris fans from high gradient streams and local reworked lags.

In addition to the 2 main sediment sources restricted to the lower (Fraser) and upper (Squamish) Howe Sound, are local sources from erosion of unconsolidated sediment and from industry such as tailings, mills and outfalls. The low sedimentation rates in many parts of this fjord, imply that pollutants are not being buried or diluted and are likely to persist.

Presentation

Tark Hamilton, Pacific Geoscience Centre, GSC

The intent of the presentation is to give an overview, or perhaps an "underview", of the regional geology since this is the basis of the substrate for a lot of the environmental sciences and processes in the Sound. The first thing to note is that in the regional geological map showing older granitic rock and volcanic sedimentary rocks, there is little obvious relationship between the shape of the fjord and bedrock geology. In terms of bedrock geology, there is no compelling geological control, such as large faults, for why this fjord is here.

The other relevant characteristic is shown in eleven years of seismicity (earthquake) data. If you look at the density of seismicity in the region and compare it to the density of seismicity around Howe Sound proper, it appears that there is less activity in the Sound. There is no evidence therefore of underlying fault control.

Howe Sound is a fjord which was carved by ice. A lot of the history as written in the geological substrates was controlled by paleo sea level. The bathymetry shows a break in slope at about the 130 m contour where the bathymetry is rather complex, and is shallow and smooth below this level. It looks like this contour is the maximum depth through which changes in sea level (transgression and regression) were reached. At some point in time, this might have been the lowest emergent coastline. There are places that are incised below any possible paleo sea level; probably holes dug by glaciers.

The other aspect that controls Howe Sound geology is that it is a basin which accepts sediments, particularly from the Fraser River. There is both mineral and organic material being deposited in Howe Sound from the Fraser system.

Various miscellaneous data provide an overview of the Sound's regional bathymetry, which includes incised troughs caused by ice. Seismic lines which provide an interpretation of subsurface features show holes in excess of 700-800 m below the southern part of Howe Sound and Georgia Strait. Deep holes, glacially incised, collect a variety of sedimentary materials. The total unconsolidated sediment thickness is in excess of 500 m in certain places, predominantly due to relief on the bedrock and a thick glacial marine section.

After the glacial deposition and modification by ice, local basins were created, providing sites for accumulation of material. The available data suggest that relatively little material was deposited, in the order of 25 m, due to rapid deglaciation, as opposed to a long stable ice front shedding lots of material. The most important part of the sediment for understanding the environmental geology of the region is "hemi-pelagic", in the form of mineral matter falling through the water column and derived from the Fraser delta. This accumulation probably mostly accumulated in the last 6,000-10,000 years. A wedge-shaped accumulation, thickest towards the Fraser, can be observed - these are the modern sediments at the southern part of the Sound. The wedge, on the order of 90 m thickness, thins markedly in a northerly direction.

The sill at Porteau Cove defines the upper and lower parts of Howe Sound. An east-west profile line from the Porteau sill to Port Mellon shows very thin sediment accumulation from the Fraser (< 10m at the Port Mellon end). In Thornborough Channel there has been very little net accumulation of bottom sediments, primarily from episodic processes. The lack of sedimentation in the western portion of Howe Sound has important implications for the exposure of contaminants.

The sediment thickness map shows that sediments, primarily from the Fraser, are thickest in the southern portions of Howe Sound, especially where current velocities are the highest. Even though there is a sediment plume from the Squamish, it is totally overwhelmed by the sediments from the Fraser River.

There are also sediments deposited on land during glaciation which are currently being eroded and are accumulating in the two identifiable basins which are accepting this modern sedimentation.

Physical Oceanography of Howe Sound, B.C.

Steve Pond, Department of Oceanography, University of British Columbia

Abstract

Howe Sound is a British Columbia fjord which empties into the Strait of Georgia. There is a sill of 70 m depth about 17 km from the head. Beyond the sill the width increases from about 3.5 km to 20 km at the entrance. The outer triangular basin has many islands and an average depth of about 200 m. It is freely connected to the Strait and, except for the influence of the estuarine circulation of the upper region in the upper few metres, is oceanographically part of the Strait of Georgia. Inside the sill the width is a roughly constant 2.5 km; the channel is somewhat sinuous; the inner basin has a maximum depth of almost 300 m.

The Squamish River flows in at the head and has an average annual discharge of 242 m^3/s, one of the larger outflows into a fjord in British Columbia. The runoff is seasonally modulated with a peak in late spring which is two or so times the annual average. This fresh water input causes a lower density layer of a few metres thickness and drives an outflowing surface current of a few centimetres per second. There is an estuarine return flow below of comparable magnitude. The tides also produce currents of a few centimetres per second. The tidal currents show considerable variation in amplitude and phase with depth indicating that internal tides are generated at the sill. Wind driven currents in the upper layer have amplitudes of tens of centimetres per second and totally dominate the near surface currents. There are substantial lateral variations in the near surface currents and in the estuarine return flow.

The deep water inside the sill is fairly homogeneous and usually has fairly low oxygen levels. Partial or total replacements occur from time to time raising oxygen and density values. Replacements to the bottom occur in late fall or early winter at intervals of one to three or four years. Replacements to intermediate depths occur more often and sometimes occur during freshet in late spring (or other times associated with short high rainfall periods) as well as in the late fall-early winter period.

Presentation

Steve Pond, Department of Oceanography, UBC

A map of the bathymetry shows the effects of the freshwater input at the surface layer and the sill which divides Howe Sound at Porteau. The classical view of this type of situation is that the main changes are along the vertical fjord canal. Little variations are assumed between one side and the other. An aerial photo shows some of the near surface circulation. The Squamish River waters enter, impinge upon the shoreline and move down the Sound. Winds can blow up the Sound and inhibit normal outflow of turbid waters. Fresh water occurs to a depth of about 5 m where the river discharge enters, and by 10 m depth ocean waters prevail. Some salt water accumulation can also be seen at the sill.

UBC oceanography students endeavoured to track the currents of Howe Sound to get a picture of near surface circulation, by observing velocities at different locations and times. In the vicinity of

Britannia Beach, the effects of wind are readily observable. They calculated a velocity of the upper layer to be in the order of 5 cm/second. A lot of the near surface circulation is therefore wind driven.

At about 13 km from the head, near the sill, surface water moves out of the Sound when the winds are low. When the wind blows up-channel the surface water is pushed back up the channel. Eventually the circulation becomes more uniform across the channel. There is also enormous variability within the Sound. Observations taken at four periods for three days show surface circulation. The river discharge cuts across to the west side and moves down channel, separating off Stick Point and gradually spreading out.

Student research attempted to see how currents might vary with depth, measured in low-wind conditions. The data showed that along the west side of the Sound, which contains the outflow river water, the inflow water beneath is less than the other (east) side of the Sound.

Observations with current meters in the upper part of the Sound near the sill show that currents in the deeper part of the inlet are highly variable with time. The wind effects can be seen down through the water column, although they are certainly strongest at surface. Data showing 6 month average of currents recorded an average outflow of about 4 cm/sec water at 5 cm depth going back in, and variable water movement at other depths.

Thus, water movement is affected by wind-driven forces, tides and long-term average outflow associated with Squamish River. Water can also enter the upper part of the Sound from outside the sill from time to time. During the winter, the density of the water outside the sill can increase enough to cause flow over the sill into the inner basin. Evidence from Bell (1973) on oxygen levels shows a major exchange down to the 200 m level where low-oxygen water is displaced upward by these dense inflowing waters. Inflows of oxygen-rich water typically occur each year; however in some cases inflow events are absent for several years.

The Weather and Climates of Howe Sound

Peter L. Jackson and Douw G. Steyn, Department of Geography, University of British Columbia

Abstract

Howe Sound is a steep walled channel oriented perpendicular to, and dissecting, a substantial northern hemisphere topographic barrier (the Coast Mountains). As such, it (as well as the other fjords along the coast) links the elevated interior plateau of Central British Columbia with the coast. These topographic factors result in fascinating local modifications to the regional climate and weather. In order

to illustrate this, and build a picture of the weather and climates of Howe Sound, topographic modifications of the five main synoptic weather types of British Columbia defined by Suckling (1977) will be examined.

The most singular meteorological phenomenon encountered in Howe Sound (and all of the fjords of British Columbia and Alaska) is the locally named Squamish wind. These winds occur in Howe Sound mainly in winter (in Suckling's (1977) "Land High" synoptic type) when an intense anticyclone building over Alaska and Yukon moves southward. The coastal mountains act as a partial barrier, separating the cold, dense air associated with the anticyclone from the warmer, less dense maritime air mass. This density difference results in a strong cross coastal pressure gradient, and often very strong winds through gaps (such as Howe Sound) in the mountains. A field study of the Squamish winds in Howe Sound will be presented with numerical modelling results from that study. The results show the winds to be a strongly forced (by both synoptic conditions and topography) meso-scale phenomenon with considerable diurnal and spatial variability.

Presentation

Peter Jackson, Department of Geography, University of British Columbia

Howe Sound is surrounded by 1,500 m mountains on either side, it contains a large body of water, and it forms part of a channel that dissects the Coast mountains and links the interior plateau to the coastal zone. These topographic features affect the regional climate and result in a distinctly local climate in Howe Sound.

Topography is the primary determining feature. It has influence on the windfield and the temperature structure. The windfield influences the horizontal and the vertical force of the wind. The ramifications in the horizontal component are, during the wintertime, the Squamish winds, and in the summertime, the seabreeze enhancement which occurs mainly further up the Sound. One of the influences of topography on temperature structure is that when air is forced to rise it cools and results in precipitation.

In the summertime, the standard synoptic pattern is a ridge of high pressure oriented north-south and very little wind. Wind rose data at Squamish airport in August shows the most frequent direction of winds from the south and winds are quite light. Typical seabreeze daytime circulation involves decreased pressures over the land, forcing air up the Sound and up the valleys. At night, the opposite happens; the land cools, pressure increases and cool air drains off the land down the channels and down the slopes.

In the wintertime, the typical pattern involves a low pressure centre near the coast, a stronger pressure gradient pattern and higher precipitation on the coast. As the fronts move through, the wind

flow is up the Sound, converging up the valley and up the slope, accounting for higher precipitation. Precipitation increases as one moves up the Sound, for a given return period.

The annual average precipitation data show the up-slope effect with the highest precipitation over the mountain peaks, and the convergence effect where precipitation increases moving up the Sound.

The Squamish winds normally occur with a synoptic weather pattern of a high pressure system over Yukon/Alaska/north with a dome of cold, dense air, and a low pressure system on the coast. A typical outflow event involves Arctic air in the interior, maritime air on the coast, and Arctic air trapped by the Coast mountain range. A wind rose diagram for Pam Rocks shows the wind channelled and predominantly from the north. A schematic diagram of a Squamish wind shows cold dense air in the interior which is partially blocked by the Coast mountains and is pushed out, under the influence of the pressure gradient, through the channels and fjords. If the air is thick enough, it may flow over the mountain ranges as well.

A simulation model of the Squamish winds showed that after approximately 11 hours, the outflow winds reached a maximum. A vertical cross-section shows a descending jet of about 25 knots, at about 700 m elevation, which is confined mainly in the southern part of the Sound.

The effects of Howe Sound on local weather are thus characterized, in the horizontal component, by distinct windfields including Squamish winds in the winter and seabreeze enhancement in the summer, and, in the vertical component, precipitation enhancement, up-slope effects, convergence of winds in the Sound, and as temperature decreases with height, greater precipitation at higher elevations.

Discussion of Hamilton, Pond and Jackson presentations

Carl Amos (Bedford Institute of Oceanography) presented data from studies by Jim Syvitski and David Prior indicating two different views of sedimentation from that presented by Tark Hamilton. Syvitski concluded that most sediment entered from the head of the fjord and that processes in the estuary are important in controlling deposition. Prior concluded that sediments derived from the margins, flowing from side streams, especially mass flow events, are major sources of sediment. It appears therefore, that there are three alternative views of the source of sediments: Fraser River, Squamish River and side streams.

Ted Hickin (SFU) suggested that all views are correct. The Fraser River contributes outside of the sill, the Squamish River inside the sill and the side streams are important contributors.

Tark Hamilton (GSC) agreed that there are complex sediment transport mechanisms but that there is no evidence about where the Squamish River sediments end up. He pointed out that the observed transparent layer of silt, up to 90 m thick in this case, is not apparent in other coastal fjords in B.C. It is associated with the Fraser River. We need to do chemical or mineralogical tracing, some mixing models and dating, for example using Cesium 137 and 210 Pb to try to understand accumulation rates on the bottom.

Tom Pedersen (UBC) also stated that what needs to be done is detailed dating. Fortunately there are some good inorganic chemical tracers available for determining the influence of the Fraser River on sedimentation in the Sound.

Tark Hamilton (GSC) noted that the data showed that the net accumulation of uncompacted sediments is quite low in the Sound except for in the southern parts. Mike Bovis (UBC) referred to the Mount Cayley and Mount Garibaldi landslides and the massive sedimentary and sedimentation displacement in the lower Squamish valley. Episodic sedimentation dominates the system.

Colin Levings (DFO) asked about long-term climate in Howe Sound and whether there is any information on decade-scale changes in climate. No data appear to be available.

Sylvain Zimmerman (Bowen Island) asked about the length of time which might be required to cover up toxins which are accumulated. Karen Drysdale referred to the Britannia Mine tailings data where over 13-14 years after closure there was about 14 cm of fresh sediment on top of the tailings. A sedimentation rate of about 1 cm/year therefore occurred in the area of Britannia.

How much of the sediment is re-worked and how does it affect the benthos? Low oxygen levels in the upper portions tend to suppress benthic activity. Colin Levings noted that benthic fauna is quite diverse near the sill but closer to the Britannia tailing the number of organisms drops off.

Tark Hamilton distinguished between muddy water flowing out of the surface of Howe Sound and episodic events from the Squamish River. Debris torrents certainly have these effects on sedimentation but they do not transgress much of the regional basin floor. The mass contribution is relatively small however; this is the problem with steep slopes on the margins of the fjord, there is so little net sedimentation that the dynamic and catastrophic sedimentary processes which have been written for

10,000 years have left their traces. He stated that one can infer too much dynamism and too much net influence because of the busy traces in the data.

Bob Turner (GSC) noted that the Thornborough channel area has little sedimentation from the Fraser or Squamish but Rainy River creates a fan delta near Port Mellon and sediment rates can be high. Tark Hamilton stated that we need to calibrate sedimentation in a specific place; over a distance of a few hundred metres the net accumulation in the last 43 years is different by a factor of three so that this process is chaotic on a very small scale. The processes at specific locations cannot be sufficiently explained at a regional scale.

Ted Hickin suggested that sedimentation rates at the upper end of Howe Sound may be relatively low, some rain out but much is transported out in the upper layer. Tides have little influence. Carl Amos showed that bedload material is trapped in the first km of the upper Sound and fines and hemi-pelagic material are deposited at a rate between 10 and 1 cm per year. Deposition is relatively insignificant 10 km down the Sound.

Peter Jordan (UBC/MOF) noted that much of the high sedimentation is deposited upstream of Squamish and that delta advancement has also reduced sediment discharge into Howe Sound. Carl Amos suggested that current processes, affected by anthropogenic influences, may not be representative of the long-term average. Tom Pedersen also noted that due to dyking, the Fraser sediments are now projected directly into Georgia Strait rather than being trapped in the estuarine system and therefore the rate of input has surely gone up.

Hydrodynamic and Sedimentation Modelling in Howe Sound

Jim Stronach, Seaconsult Marine Research Ltd.

Abstract

A high resolution, three-dimensional hydrodynamic model of Howe Sound has been developed. This model employs a horizontal grid spacing of 390 m, and uses 8 levels in the vertical. It calculates the 3 components of velocity, as well as time-varying density fields. The model is forced at its open boundaries by a larger model of the Strait of Georgia, using a 1.95 km resolution, by surface wind stress, and by Squamish River flow. The verification of the model will be briefly discussed, as well as significant flow features.

The velocity fields from the hydrodynamic model are used to drive a sediment transport model, which is currently under development. The purpose of this model is to simulate the horizontal advection of fine particulate material as it sinks to the sea floor, with particular reference to variations induced by the different sinking rates associated with different grain sizes. Settling rates for source materials will be determined by both literature reviews and by laboratory experiments. The model results will be compared

with recent measurements of the spatial variability of grain size distributions of seafloor sediments in Howe Sound.

Presentation

Jim Stronach, Seaconsult Marine Research

Considerable research has been undertaken, aimed at developing three-dimensional models of Strait of Georgia - Juan de Fuca. These models are quite sophisticated, taking account of internal waves, tides and responses to wind forces to predict water and sediment movement. The model for Howe Sound is based on a 400 m grid spacing pattern. The base wind data for simulation were taken from Pam Rocks. The model shows the velocity of waters at 0-5 m, 5-15 m and 60-90 m depth. The wind and tide effects are shown on the surface layer. Down one layer, there is a strong counter flow. Between 60-90 m depth, the circulation impinges the top of the sill.

The hydrodynamic model results were produced with data from a thesis by Joe Buckley. The observed jet from Squamish River hitting the east shore and deflecting to the west shore is reflected in the model and provides a reasonable corroboration of the model. Comparison of mean velocity calculations and recordings also shows similar agreement in the results.

The sediment model sought to simulate grain size and deposition by grain size. The mean Squamish River flow in 1975, peaking on July 7 was used along with data on sediment concentration to determine sediment input and grain size distribution based on Monte Carlo simulation. The sediment distribution in Howe Sound was observed on a 2-km grid model at 100 hour intervals. The data show that the peak of sediment supply sinks just past the sill. After 69 days, there is minimum sediment still in suspension and a deposition of 4.2 cm having been accumulated. The bulk of sediment is deposited at the river mouth.

The Sediment Transport Regime of Howe Sound: Implications to the Dispersal of Contaminants

Patrick McLaren, GeoSea Consulting Ltd.

Abstract

This study, instigated by the Ocean Chemistry Division, was designed to undertake a sediment trend analysis in order to determine the relationship between particle-associated contaminants and the natural sediment transport regime. A sediment trend analysis is a technique developed by GeoSea which uses the relative changes in grain-size distributions to assess: (1) the net patterns of sediment transport; (2) the relative probability of each size of material being moved, and; (3) areas of erosion, dynamic equilibrium, accretion and total deposition.

The above information may be used to predict the transport behaviour of contaminants such as heavy metals, dioxins and hydrocarbons according to the following rules: (1) contaminant loadings (in the sediments) decrease rapidly along high energy transport paths where sediments coarsen in the direction of transport; (2) there is no net increase or decrease of contaminant loadings when sediments are in dynamic equilibrium; (3) contaminants increase along transport pathways undergoing net accretion, and; (4) the greatest contaminant concentrations are found in environments of total deposition (i.e. once a contaminated particle is deposited, there is no further transport).

For this study, 300 grab samples were analyzed for their complete grain-size distributions. The results of the sediment trend analysis showed that upper Howe Sound (between Squamish and the sill at Porteau Cove) is an environment of total deposition dominated by the Squamish River outflow. Over the sill, transport is also in a down-fjord direction; however, many sample sequences showed slight net erosion. A clockwise flow was determined in Thormbrough and Ramillies Channels, where total deposition is occurring.

The analysis showed that, with the exception of the sill, the fjord bottoms are a sink for contaminants. Once deposited, they will remain and become buried in the sediment. This finding is supported by repeat surveys of the mercury content contained in the sediments of upper Howe Sound. Because the environment is one of total deposition, contaminant "hotspots" will have a defined relationship with specific sources, rather than to a concentration build-up along transport pathways.

Presentation

Patrick McLaren, GeoSea Consulting Ltd.

Is there a marine or coastal development that does not require an understanding of sediment movement? Sediment movement is important to understanding how contaminants are behaving. The aims of sediment transport study include three elements: the direction of movement, the erosion, transport and deposition processes and the rate of sediment movement and deposition.

Sediment trend analysis can address the first two elements but not the third. However, a good understanding of direction and a qualitative understanding of whether the environment is eroding, accreting or in dynamic equilibrium will assist in determining where to measure rates for example.

Techniques to produce this information include process mechanisms where sediment traps are used to measure accumulation and numerical models are used to assess sediment movement. One of the principal problems is the difficulty of validating the results. The sediments themselves are the net results of the physical processes.

We can for example take sediment measurements along a beach to record grain size distributions. What we want to know is if there is a relationship between the down-current samples with the up-current samples. Is there a change in the grain size distribution that relates one to the other. If the answer is yes, then we can determine another function, "x", where x is the statistical relationship

between the sample sites representing the relevant probability of sediment moving from one site and being dumped at another site, regardless of the specific transport processes.

On a perfect transport direction path, the mean grain size gets coarser or finer with the direction of transport. If we know what the perfect transport direction is, then we can expect a relationship between grain size distributions (r^2). Three factors can decrease the multiple coefficient correlation are 1) as you deviate from the perfect transport pathway, r^2 will decrease, 2) sediments may be unrelated to transport, and 3) if extraneous material is dumped into the natural transport regime.

The function x lying within a deposit represents the probability that, for every particle leaving a deposit, there is an equal probability that the same sized grain will come back into the deposit (dynamic equilibrium). If the x function is finer than the deposit, then more sediment is entering the deposit than is leaving. If x is coarser than the deposit, the deposit must be eroding. There is a fourth situation where x is increasing over all the distributions in the deposit, creating a situation where no further sediment movement occurs. Because contaminants associate with the particles, the pathways will vary with sediment transport regimes.

A database of sediment grab samples taken at 1 km spacing down the fjord provided the basis for the Howe Sound study. The objective was to look at transport trends which are statistically acceptable. Based on the analysis of sediments, Howe Sound can be divided up into four environments: a) from Squamish estuary to the sill (total deposition occurs), b) from the sill to northern Bowen Island (a down-fjord net transport), c) Thornborough Channel where total deposition occurs in a clockwise motion around Gambier Island and d) out into the bay south of Gambier Island where total deposition is occurring. The time dimension depended upon the 15-20 cm-depth samples.

In upper Howe Sound, the x function increases over the whole distribution of the sediments. This suggests that once a particle hits it does not move anymore. In the lower Howe Sound, below the sill, the x function is horizontal and suggests that a probability of deposition based on size is no longer occurring (no size sorting process) and that contaminant concentrations are not likely to occur (probability of equal distribution of contaminants, also suggested in low levels of contaminants near Woodfibre). In Thornborough Channel a very high x function occurs with total deposition; similarly increasing x function near Gambier Island. The grain size does not change very much above the sill, indicating that large size particles drop out.

The r^2 values were generally very high except in Thornborough Channel. The sediment data are very confusing in this area. Dumping in the area may be affecting transport.

Squamish Estuary Management Process

Dennis Deans, Department of Fisheries and Oceans

Presentation

The morning discussion on sediment transport and the three opinions offered, typified the problem of making decisions where there are many different scientific views. There has been considerable pressure on the Squamish estuary since the arrival of the white man. Port development by storage and handling and foreshore developments have significantly altered the estuary. A comparison of 1930 and 1978 air photos shows the major changes, primarily occurring between 1968-1972. Construction of Squamish Terminals continued the change to how the estuary works. The training wall especially altered the river location and the biological character of the estuary. Fish population decline may be linked to construction of the training wall.

In 1979, the Federal and Provincial governments agreed to create a management process for the estuary. Four study teams looked at air and water quality, land use, habitat and recreation. The results of these studies were submitted to a Steering Committee. The basic conclusion was the need for an environmental review process so that any development had to be fully reviewed, along with public involvement. The development approving agencies, the major landowners and the economic development agencies were expected to be part of the process. A framework of area designation was established to guide the management program.

In 1982, the proposed Squamish Estuary Management Plan was presented. A Coordinating Committee and a Technical Subcommittee were established. The working review activities are undertaken by the Subcommittee and the results are submitted to the Coordinating Committee for decision-making. The area designation system included a conservation designation on the west side of the management plan area, an industrial and commercial designation on the east side, and a planning and assessment designation in the middle area.

The Steering Committee is somewhat unique; it is not a government committee. It has the major landowner (B.C. Rail) and local government (District of Squamish) on the Committee. A process is also incorporated for public comment. The management process is a continuing balancing act between environmental sustainability and economic development. The net result is that decisions take a lot longer.

Three examples provide illustrations of the process. A proposed log handling facility expansion was reviewed and approved. The proposed expansion of Squamish Terminals was rejected on the grounds that materials handling on the current site could be better improved and the expansion was unnecessary. The third example involved an application for dredging and fill in the Mamquam Channel. The Committee approved the development but the developer failed to comply with the terms of approval. The result was the requirement for a compensation fund ($30,000) for habitat restoration at the dredge spoil site. However, the owner of the land did not agree to this restoration project. This situation brought to a head the need to revisit the plan and the management process.

The Committee is currently re-addressing the planning and assessment designation. Some of the discussions have been private due to property investment concerns. Once an agreement has been reached regarding the revised long-term management plan for the estuary, it will be presented to the public for review.

Discussion of Stronach, McLaren and Deans presentations

Patrick Lucey (UVIC) asked about the Squamish Estuary Management Committee's consideration of activities and management upstream of the estuary. Dennis Deans referred to other planning processes for addressing the issues outside of the estuary and the involvement of Committee members in those processes.

A participant asked why B.C. Rail is on the steering committee. Dennis Deans replied that from the very beginning the company was included because they are the major landowner in the estuary. In developing environmentally sustainable economic activity the developers have to be part of the process. Ann Hillyer (West Coast Environmental Law Association) asked about the level of public involvement and whether it has changed given the planning process is now occurring behind closed doors. Dennis Deans stated that the public process was in place before 1986. Currently the proprietary information on B.C. Rail's long-range plans prevents discussion in public. In November, the draft proposal will be presented to the public through a public information session and then a forum and opportunity for written comment. After consideration of the public input, the Committee will have to go back to the public to explain the final plan.

Bert Hargrove (UBC) asked about the vertical component of flows in Howe Sound and whether the sill would not directly affect the deposition of materials. Jim Stronach indicated that there is very little vertical movement evident since the water is not moving fast enough and close to the sill it is driven by tides and winds. Steve Pond commented that it is difficult to get a persistent vertical

component because the density structure does not allow it; the water below is heavier. Where you do get vertical motion is where you have dense enough water entering at the sill level and falling down the sill.

Bob Turner asked about the receiving environment for Port Mellon and Woodfibre. Jim Stronach stated that the Port Mellon data showed total deposition but more tidally driven than at the Woodfibre site, explaining the tapering off of the contaminants on either side of Port Mellon. Dumping could occur on an ebb or a flood so that contaminants could be moving in either direction before becoming deposited, although there is still a net flood direction. By Montague Channel, the Hatfield data suggest a very low, ubiquitous concentration. At Woodfibre, total deposition is clearly defined from the Squamish River outflow and it seems that highs are only observed in the down current, ebb-transport direction. Once deposited, there is no opportunity for those particles to move elsewhere.

October 1, 1991 Afternoon Session - Part 1

Chairman: Chris Pharo, Environment Canada

Waste Water Discharges to Howe Sound and Their Apparent Significance

Les Swain, B.C. Ministry of Environment, Lands and Parks

Abstract

The B.C. Ministry of Environment, Lands and Parks is presently preparing a water quality assessment for Howe Sound. Integral parts of the water quality assessment are to document water uses of, and waste water discharges to, Howe Sound. This paper will present an overview of water uses of Howe Sound, including recreation, boating, and use by aquatic life. Waste water discharges to Howe Sound will be identified, including the well known pulp and paper discharges. Some ambient water quality impacts which have been noted as a result of these discharges will be documented.

Presentation

Les Swain, B.C. Ministry of Environment, Lands and Parks

The salmon escapements to the Squamish River show some dramatic declines over the decades. If we ignore the chum salmon doubling in the seventies, the return numbers indicate some concern in Howe Sound, although pollution may not be the sole cause since fisheries catch and habitat changes are also factors.

In terms of permitted discharges under the Waste Management Act, there are about six domestic sewage discharges ranging from 5-75 m^3/day. These would be expected to have very little impact. There are probably hundreds of septic tanks and tile fields around Howe Sound that are not required to be under permit to the Environmental Protection Division, being covered under the Health Act. Small volume discharges include domestic sewage receiving either primary or secondary treatment and usually discharged through pipes 10-15 m below low water mark. Any impacts are very localized. Around Squamish there are some major discharges, the most notable being Woodfibre mill which has a current permitted discharge of 76,000 m^3/day, CanOxy with a discharge of about 55,000 m^3/day and District of Squamish (through two sewage treatment plants discharging to the Squamish River and Estuary) with about 10,000 m^3/day.

Other discharges of note include, Howe Sound Pulp and Paper at Port Mellon with 76,000 m^3 treated effluent and 76,000 m^3 cooling water/stormwater, the Britannia Mine acid mine drainage discharge and the community of Lions Bay sewage discharge.

In preparing water quality objectives, besides knowing the waste water discharges, the ambient water quality must be studied. A recent monitoring program has included data collection at a number of sites around four areas: CanOxy (2 sites), Woodfibre (4), Britannia Beach (2), and Port Mellon (4). The 1989 survey of sediments showed tetra-and trichloroguaiacol values 5 km from Woodfibre at about 1/2 the Woodfibre site concentration and by Anvil Island declining to background levels. At Port Mellon, values are approximately one-half in both directions 5 km away from the site, and at background levels 10 km away. After hearing the presentations this morning, the equal dispersion of concentrations from Port Mellon is surprising.

The other monitoring component was measurement of the same chemicals in the zooplankton at the same sites. A similar pattern occurs of concentrations being highest adjacent to the pulp mills. In the case of Woodfibre, the zooplankton sampling does not indicate widespread dispersion of the chloroguaiacols but in the case of Port Mellon concentrations are apparent at nearby sampling stations.

In 1990, dioxin and furan monitoring was undertaken. '2,3,7,8 - trichlorodibenzo dioxin is the most toxic of these. (Toxicity measurement is based on a wide range of mammalian experiments and meant to give a relative comparison between the most toxic 2,3,7,8 TCDD, and other congeners or isomers. There is a lot of variability. Generally there are more data on mammalian toxicology). The highest concentration values are at the sites of the two pulp mills. The dioxin/furan objective has not been set, although the International Joint Commission has established an objective in the Great Lakes of 10 picograms/gram of 2,3,7,8 TCDD in sediments. Using that as a basis, the Howe Sound data far exceed

this objective at Woodfibre and is about twice the value at 5 km distance. At Port Mellon, the data also exceeded this objective but at 10 km is well below this objective. Similarly, at the control site, the values are about 3 picograms/gram.

In 1991, toxicity testing was carried out, including sand dollar bioassays on pore water sediments, Microtox on the pore water, and Microtox on the solid phase of the sediments. The results on the sand dollar bioassays and the pore water Microtox showed no measurable toxicity. Water quality monitoring was also undertaken, showing similar results to previous monitoring.

Britannia had very high copper values up to 1130 micrograms/litre with high values also recorded at 15 m depth. Data are from monitoring carried out in previous years.

Impact on Pristine Mountain Rivers of Waste Waters From Remotely Located, but Recreationally Accelerated, Wilderness Development

Patrick Lucey, Department of Biology, University of Victoria

Abstract

A three year field study, in experimental streams, quantified the nutrient contribution of sewage effluent from the recreational community of Whistler to the Cheakamus River, British Columbia, with particular reference to phosphorus. Fisheries and aesthetics are adversely affected at algal biomass values exceeding 2500 ug/cm^2; it was experimentally determined that this would likely occur given an increased river level of ortho-P of 2.0 ug/L. The latter is equivalent to an increased sewage effluent discharge of 5339 to 5884 m^3/day, based upon optimal phosphorus stripping within the community's sewage treatment plant. The revealed river's limited nutrient assimilative capacity, in view of the proposed new development, resulted in Whistler community developing a Liquid Waste Management Plan which would effect sewage effluent discharge into the adjacent Squamish River. A subsequent stream-trough study is being conducted to assess how the effluent diversion would affect Squamish River water quality, especially with respect to the development of undesirable algal growth. The latter could potentially adversely affect fisheries spawning and rearing habitat.

Presentation

Patrick Lucey, Department of Biology, University of Victoria

The project began in 1986, originating with concerns about algal biomass in the Cheakamus River. There are three major sections of the river: upstream of the sewage treatment plant, downstream of the plant but above the dam, and downstream of the dam. The Cheakamus River represents one of the most important suburban wilderness environments outside of the Lower Mainland. It is increasingly the focus of recreational activity. One of the problems was the growing algal biomass accumulation below the dam; the problem did not appear to be occurring above the dam.

The sewage treatment plant includes secondary treatment with a form of chemical tertiary treatment (alum added to precipitate phosphorous). Downstream of the sewage treatment plant about 6 km the river does not have much algal growth compared to downstream of the dam. The research tried to characterize the sensitivity of the river to nutrient loading. A stream trough system was set up at the dam site. The study protocols in 1987 sought to pick field sites for water chemistry and biology study. The sewage effluent chemistry was analyzed and the question posed whether the river was orthophorus limited. A whole-river ecosystem study was done to assess river responses by withholding alum and measuring changes.

In 1988, experimental troughs were established to determine the ortho-P limiting factor of the river to target the nutrient ranges, and to characterize the quantity of biomass in the river in relation to ortho-P loading. The artificial stream trough was constructed and designed to add known concentrations of nutrient. The algal responses were readily apparent. In control troughs, little growth occurred, in troughs with nitrogen addition, little growth occurred; and in troughs with orthophosphorus or orthophosphorus and nitrogen, considerably enhanced growth occurred. Very small additions of orthophospate resulted in significant growth rates.

In 1989, the research attempted to refine the understanding between orthophospate and biomass. At day 14, day 36 and day 47, minimal growth was observed, with the least growth in the control and in the nitrogen troughs. In phosphorous troughs, after 46 days in the 20 ppt (parts per trillion) of orthophosphorus, well below detectable levels (1 part per billion) there was an increase in growth; at 80 ppt growth was enhanced; at 80-120 ppt there was not much difference, as was also the case in moving to 250, 400 and 420 ppt, relative to the 80 ppt.

This year's (1991) growth at similar concentrations of nutrients, is significantly higher than in 1989. The data show that the control values had a long, slow process of accreting before an increase in growth occurs at 50 ppt. The second year, the same pattern of biomass accrual is apparent, a slow increase followed by rapid growth.

The task was to determine how much effluent could be discharged, in terms of ortho-P concentration, that will result 30 km downstream in a given biomass increase. We plotted percentage increase in ortho-P versus percentage increase in biomass accrual such that a 13% increase in algal biomass would result from a 0.5% increase in ortho-P.

The unusual biomass accrual distribution in the Cheakamus River can be explained by the introduction of the dam which has fundamentally changed the physical and chemical characteristics of the river. Local logging has opened up the riparian canopy, created higher light levels. The reservoir behind the dam is acting to precipitate sediment resulting in lower turbidity and higher light levels downstream. The lake also acts as a barrier to the downstream drift of invertebrates. Much of the downstream water is drawn from a lake strata which is relatively nutrient rich water. This situation required Whistler to consider a variety of liquid waste management options. The selected option was to build a pipeline from the treatment plant along Highway 99 to Shadow Lake and into the penstocks and out into the Squamish River.

As a result of this proposal, another experiment was set up adjacent to the Squamish River about 1 km downstream from the penstocks. There has been considerable difficulty in operating the experiment on the Squamish River due to fluctuating water levels and sedimentation from flash floods.

Natural and anthropogenic sources of stress can produce unanticipated and unprecedented ecosystem responses. Models that simulate ecosystem responses to stress cannot usually anticipate surprises.

Discussion of Swain and Lucey presentations

Brian Clark (MOELP) pointed out that based on the nutrient studies, the B.C. Ministry of Environment, Lands and Parks has stated that no further development should occur in the Cheakamus drainage until the wastewater additions can be managed. Patrick Lucey (UVIC) suggested the need to distinguish between sewage wastes which are inevitable and those which we have a choice whether to produce and discharge. A participant asked about water quality objectives and Les Swain indicated that there is an interest in eventually adopting ecosystem-based objectives. The usual approach is that the water quality objectives do not apply within 100 m of the discharge point.

Mindy Brugman (NHRI) asked about the water quality inputs into the Cheakamus River. Patrick Lucey stated that they were able to characterize the upstream and tributaries. The volcanic sources in Rubble Creek are relatively high in orthophosphate and this was taken into consideration. While the public focus has been on sewage discharge at Whistler, the study concluded that reservoir operations are a major factor in understanding the algal growth problem and nutrient flux within the Cheakamus River. The sewage treatment plant discharges above Daisy Lake and although nutrient levels are high, biomass productivity and accrual is much lower than occurs downstream of the lake. The operations of the dam affect both upstream and downstream wastewater and river management.

An Overview of Squamish Basin Research at Simon Fraser University

Ted Hickin, Department of Geography, Simon Fraser University

Abstract

From 1977 Ted Hickin and his graduate students in the Department of Geography at Simon Fraser University have been conducting research into the geomorphology, sedimentology, and morphodynamics of Squamish River and its floodplain. Results of these studies are contained in two M.Sc. theses and a Ph.D. thesis and in ten papers published in various research journals. Work continues and several additional papers are forthcoming.

Individual studies on Squamish River include an examination of mean flow structure in bends of the lower meandering reach (Hickin, 1978), the origin, morphology, and stratigraphy of 'concave-bank benches' in the meandering reach (Hickin, 1979), the role of vegetation in conditioning process and form of the channel (Hickin, 1984), the downstream gradation of particle sizes in the river bed and bars (Gary Brierley, 1984 and Brierley and Hickin, 1985), an inventory of channel changes derived from sequential aerial photography (Henry Sichingabula, 1986), the geomorphic impact of the October 1984 flood on channel planform (Hickin and Henry Sichingabula, 1987), the contemporary sediment flux to Howe Sound (Hickin, 1988), suspended sediment concentration and calibre in relation to surface-flow structure in Squamish estuary (Ken Rood and Hickin, 1989), a comprehensive inventory of the sediment and internal structures of Squamish River floodplain (Brierley, 1989), and the Holocene sediment budget of Squamish Basin, particularly sediment supply (Greg Brooks and Hickin).

Other related work includes studies of wetland environments and aquatic plants on Squamish Delta (Ian Hutchinson and Susan Smythe, 1986, 1989).

Work continues on detailing the Holocene geological history of Squamish Basin and its link to the behaviour and morphology of Squamish River (Greg Brooks) and further work on the estuary flow and sediment transport dynamics is in progress (Hickin, Ken Rood, and others).

Presentation

Ted Hickin, Department of Geography, SFU

A series of studies have been undertaken by SFU students and faculty on sediment sources, transport and deposition in the Squamish River basin. These studies include five groups: surficial geology and geomorphology, fluid mechanics and flow processes sedimentology of the floodplain, river planform dynamics, and the estuarine environment (see list of work - "Research Conducted in Squamish Basin" by Department of Geography, SFU).

The work undertaken by Greg Broaks sought to assess the Holocene sediment budget. He identified the areas within the upper basin from which materials are being evacuated and by looking at surficial geology, tried to reconstruct what occurred over a long period of time.

In the upper Ashlu River, like other areas upstream, there is extensive fill, much of it incised. When did this material move down the hillside, rapidly after deglaciation or after a long period? The

fines are of particular interest because they in part give a record of damming. The SFU studies have studied these geological features.

In Elaho River, there is also terraced accumulation of sediments which occurred after glaciation. There is an area of canyon rockfall which acts as a downstream control. Further up the valley, the SFU studies have carefully logged the sediment supply picture.

The upper Squamish River does not contribute much sediment. Some rockfalls have affected the river. Further downstream, the Squamish is profoundly influenced by volcanic sources, such as Mount Cayley, which bring enormous amounts of material in the form of debris flows. Episodic sedimentation in the Mount Cayley area is particularly prominent and provides the basis for contemporary sediment supply. One of the deposits is a single event, a catastrophic occurrence of about 5,000 years ago where part of Mount Cayley collapsed, moved downward and dammed the Squamish River.

Evidence in the sediments seem to suggest the occurrence of tephra (volcanic ashes which have settled out from eruptions) dating about 5,000 years ago, or alternatively this may simply be dust produced at the time of collapse.

The river studies have looked at within-channel processes. Although the Squamish River is a high energy, gravel and sand bed channel, there are locations where extremely fine material occur. They occur on the outside river bends where the flow is forced to change direction rapidly and flow separates. These sediment accumulations may be good areas to examine pollutant loadings because they are relatively undisturbed for several decades, provide a time scale and are fine sediments which adhere to material.

Channel studies have utilized Provincial aerial photography to provide a picture of morphological changes. The data have been analyzed and are available.

Studies are also ongoing on the Squamish delta. They are trying to relate the present rate of propagation of the delta (4 m/year based on bathymetric differencing and available sediment data) to long-term processes. Models predicting delta growth are driven by sediment concentrations based on only three years of measurement, so long-term rates are important to understanding delta processes. One preliminary sample taken 2.75 km back from the delta front and 15 m below the reworking level of the river indicates a date of 625 years age; i.e. 4m/year which may in fact be the long-term stable mean.

Mass Movement and Sediment Yield in the Howe Sound Drainage Basin: The Significance of Industrial Development

Peter Jordan, Forest Sciences Section, Vancouver Forest Region, B.C. Ministry of Forests

Abstract

Landslides and debris flows are widespread natural processes in the Howe Sound drainage basin, as in all mountainous regions, and are responsible for much of the sediment entering river systems and the ocean. An important question for resource management is the extent to which industrial development, especially logging, has increased the sediment yield.

The watersheds of the upper Squamish River and several of its tributaries, which are extensively glacierized and include Quaternary volcanic centres, have very high sediment yields. Additional contributions of sediment from industrial activity are likely to be negligible. However, other watersheds have low natural sediment yields, which in some cases may be significantly increased by mass movement and erosion related to logging or other development. The Squamish River dominates sediment inputs to Howe Sound. Increased sediment input from other sources is probably not significant to the sediment budget of the sound as a whole; however, it may be very important locally for streams or estuaries with valuable aquatic habitat or which are used for water supply.

The Mamquam River does not have extensive natural sediment sources, compared with other parts of the Squamish basin, but logging covers much of its watershed. Numerous landslides and debris flows during heavy rainstorms in 1990 illustrate the importance of logging roads and clearcuts as sediment sources, and show that mass movement may be delayed for several decades following logging. Mashiter Creek displays some evidence of an increase in sediment yield following logging, and a subsequent decrease a few decades later. In Britannia Creek, and possibly Furry Creek, mass movement directly or indirectly related to mining has substantially increased the sediment yield. Mass movement and soil erosion resulting from pipeline construction in 1990 have been significant as sediment sources in several watersheds.

Presentation

Peter Jordan, B.C. Ministry of Forests

The studies of sediment budgeting attempt to determine the natural sources of sediment, the development-related sediment sources and the ways to minimize the effects of development. The main natural sources of sediment include glaciers, landslides, debris flows and rivers cutting into glacial deposits. Development-related sources include roads, roads and roads - the chief cause of unnatural landslides.

The upper Squamish River is typical of a prolific sediment source while the Mamquam and Stawamus rivers are typical of a less-prolific source. The upper Squamish is characterized by large glaciers, high mountains and volcanoes. The increased river width downstream is indicative of these sources. A high proportion of the watershed is ice-covered and as the glaciers retreat a lot of unstable, young glacial sediments are exposed and collapse, producing high sediment yield. The high relief adds to debris torrents and rockfall which also supplies sediment.

The collapse of Mount Cayley volcano several thousand years ago and small landslides (e.g. 1963, 1984) have been sources of sediment. Much of the landslide material is coarse gravel which never reaches Howe Sound. Even without major landslides and debris flows, the creeks draining volcanic sources are important to the system. The Quaternary volcanic centres are extremely important to sediment supply to Howe Sound.

In contrast to the upper Squamish, the southeastern part of the Howe Sound basin has less prolific sediment sources. The terrain is less steep, 25% is logged and the river valleys are narrower, indicating much lower natural sources.

Estimates of natural sediment yields for the Squamish River above Cheakamus are probably similar to Lillooet River, about 300 m^3/km/year. Typical small watersheds in B.C. that do not have volcanoes or extensive glacier cover range about 1-20 m^3/km/year. How much sediment does logging and road construction create? There are no measurements in B.C. to speak of, but based on literature in other areas, for areas of active roads and steep terrain, values of 1,000 m^3/km/year are possible; generally for average logged terrain with just a few landslides, values in the order of 10-100 are likely. The upper Squamish probably has sediment yields of about 300; only about 5% is logged which may contribute about 10 to the total 300. On the other hand, with a watershed like the Stawamus or Furry Creek with a natural sediment yield of greater than 20, if 25% is logged, another 10, 20 or even 50 units of sediment yield may be added.

Many development-induced landslides are associated with old roads. These are usually caused by old, abandoned plugged culverts, by drainage diversions or by collapse of the fill part of the road. In much of the Mamquam drainage, an excessive number of kilometres of road per area logged has been constructed given the terrain, leading to many landslides. In terrain this steep, if the road network had been built with due regard for the landslide susceptibility of the terrain, logging could have been done with probably one-half as many km of road. Transmission line and particularly pipeline construction in the Stawamus drainage have also created landslide problems which could have been avoided.

Britannia Creek watershed is one of the most disturbed in Howe Sound, primarily the legacy of 80 years of mining and old logging. There is a very large potential bedrock landslide feature in upper Britannia Creek, with some question as to whether the open pit excavation at the base of the mine has caused the movement to accelerate in this particular feature. Recent high sediment flows in Britannia Creek was a result of past development in the valley, primarily old mining roads which have been re-opened rather poorly, and to some extent, from problems related to demolition of an old dam.

In the case of the Mamquam River drainage, the Forest Service has embarked on a program to map the watershed to identify landslide prone area, and to inventory old logging roads to see which ones are in unstable condition. The next phase is to commission a study to de-construct the worst of the old roads.

Discussion of Hickin and Jordan presentations

Mike Bovis (UBC) noted that the Mamquam valley had been dammed by landslide and accumulation of fine-grained sediments has been created by catastrophic events with enormous implications for sedimentation. He also asked about the cause of overbank deposits of one-half metre or more in thickness: possibly during a mega flood which generated a large pulse of sediments? Ted Hickin agreed with the view that sediment supply in Squamish River is episodic and almost single event dominated, so that short periods of record can be misleading. The Elaho River is a good example; there are some suspended sediment concentration records which allow extrapolation of trends but they are completely misleading in that they were derived in a period when nothing was really happening.

Tom Pedersen asked about pipeline construction and why such landslides occurred. Peter Jordan suggested that the impacts would have been avoidable, particularly if proper environmental assessments were done. Similarly with logging, identification of landslide prone areas can significantly reduce landslides from roads. Another participant asked about the alternative explanation of suspected "tephra". Peter suggested that a major landslide would have created enough dust to cause a false tephra.

Carl Amos questioned the negative view associated with sedimentation. Peter noted that the prevalent assumption is that sediment increases are bad for water quality and aquatic habitat. Most of the sediment sources discussed were bedload type material, an increase of which tends to cause the river to aggrade and increase its width, creating an engineering "inconvenience". Questions were also posed about pipeline and old logging road landslide impacts and responsibilities for management. Colin Levings asked about whether the Squamish River was still cutting into the west delta. Ted Hickin stated that a long-term adjustment is occurring involving a major re-positioning of the river. Many examples of sloughing and tension cracks are apparent on the western bank.

Tim Turner asked about the long-term status of the training dyke. Ted Hickin noted that dredging could reduce the infilling problem. The adequacy of the dykes is confronted with the fact that the Squamish River floods are getting larger and larger each year. The data do not suggest a stationary series and the design standards may therefore not meet the magnitude of floods possible on the river.

Another question was posed about the extent to which information on catastrophic events is incorporated into planning and issues of "acceptable risk". Brian Clark noted the experience on the Cheekeye fan in managing risks.

Ted Hickin asked about the rates of settling in the delta which appear to be relatively large. No knowledge of settling was presented. Termination of the Mamquam estuary was associated with natural evulsion of the channel into the Squamish River. In response to a question about the effects of logging on washouts on the Squamish Highway, Peter Jordan indicated that some are related to logging while others are due to natural causes. Natural events can be made worse by logging or land use practices which expose or supply more sediments.

October 1, 1991 Afternoon Session - Part 2

Chairman: Mike Nassichuk, Department of Fisheries and Oceans

Overview of the Marine Ecosystem of Howe Sound

Lee E. Harding, Environmental Protection, Environment Canada

Abstract

The upper Howe Sound basin is a true fjord, approximately 290 metres at the deepest point, bounded by the Squamish River estuary and a shallow sill (61 m) near Anvil Island. The waters of the upper basin are strongly influenced by salinity, temperature and current changes associated with freshwater input. A pronounced stratification occurs during freshet (May to September) of the Squamish River and extensive silt loading and turbidity result. Progressive density differences between water outside the sill and the water inside the sill, which entrains lower-density fresh water from the Squamish River, cause periodic renewal of bottom water in the inner basin.

Throughout upper Howe Sound, the impact of turbidity from the Squamish River reduces primary productivity during freshet. Turbidity from the Fraser River plume also intrudes into the outer basin. However, the light attenuation properties of bleached kraft pulp mill effluent (BKME) are the major cause of reduced phytoplankton productivity near Woodfibre. Under certain conditions, nutrient enrichment from the effluent can enhance productivity if light conditions are suitable.

Surface dissolved oxygen (DO) is strongly influenced by the Squamish River flow. The stratification created during freshet dilutes and disperses effluent discharged at the surface. The effects of tides, winds and currents also lessen the impact of BKME. Poor flushing and exchange because of restricted subsurface flow over the sill results in progressive hypoxia. Renewal occurs approximately every three years. Extremely low DO (< 1.0 mg/l) is typical of the deep basin in between renewals.

The Squamish Estuary is a detrital-based community, with considerable production of plant biomass by rooted emergents providing a carbohydrate base for detritivores, which in turn nourish secondary consumers and so on. Salmon and steelhead rear in the estuary and migrate up the river, providing seasonal fare for eagles and other scavengers and predators.

Biological communities (intertidal and subtidal) are greatly modified near the two pulpmills, and on tailings deposits from the abandoned mine at Britannia. The Squamish Estuary was extensively restructured, reducing freshwater-saltwater mixing with consequent effects on marsh vegetation, and altering sediment deposition patterns. Mercury contamination from a chlor-alkali plant in Squamish, and dioxin/furan contamination from the two pulpmills have caused fisheries closures (the latter still in effect). Contamination with copper from the mine can be observed in mussels and oysters.

Presentation

Lee Harding, Environment Canada

Howe Sound is divided into an inner basin and an outer basin. The consequence of a deep basin is anoxic conditions which occasionally occur and kill benthic organisms. The benthic-pelagic coupling, involving the exchange of surface and bottom waters, is a particularly important process affecting the biological communities.

Rocky substrates around Howe Sound can have complex attached algae and invertebrate communities. The Squamish estuary is especially important to the biological productivity of the Sound. Emergents supply a lot of the plant detritus to the system. Log booming has also changed the character of the subtidal communities. As much as 50% of the primary production (marsh) of the estuary may have been lost as a result of industrial development.

Mussel tissue samples have shown high levels of copper at certain sites in the Sound, particularly near Britannia mine. Mercury levels in sediments have also been elevated associated with an old chlor-alkali plant. There is a legacy of persistent contaminants and continual disturbance of these contaminants in sediments and biological recycling is an ongoing concern.

There are two active ocean dump sites in Howe Sound. A source of past contamination is tributyl-lead which was used on marine vessels, although no apparent data exist. While dioxin, mercury and other pollutants have been reduced, their accumulation still affects the biological community. It was estimated that in 1980, some 40% of the shoreline was occupied by log booms.

Ecosystem health can have various meanings. It is not adequate to only focus on specific contaminants in fish or organisms. Ecosystems are complex and disturbance to one species does not provide an understanding of changes. What needs to be done at a very minimum is to determine the ecosystem level processes which might lead to ecosystem state changes (e.g. eutrophication, bioaccumulation and biomagnification at successive levels, effects on connections between trophic levels).

Environmental Monitoring through Natural History Research

Jeffrey B. Marliave, Vancouver Aquarium

Abstract

Documentation of newly observed natural history phenomena is the primary goal of Vancouver Aquarium research in Howe Sound. Ancillary to that goal, however, is the desire to provide a basis for future comparisons, a continuum of baseline data on marine life in Howe Sound. Emphasis has been on early life history of marine fishes and shrimps, but those life stages are ephemeral, with expected inter-annual and long term fluctuations. To balance this emphasis on planktonic larval forms, projects also have been initiated for monitoring larger, more long-lived forms such as harbour seals, intertidal starfish and glass sponges.

Accomplishments to date from ichthyoplankton surveys include disproof of the assumption of planktonic drift dispersal for larval rocky shoreline fishes, demonstration of larval polymorphisms, new taxonomic descriptions of larval fishes and discovery of late larval distribution of Pacific whiting. Beds of Agarum kelp have been identified as juvenile nursery habitat for spot prawns, and year-class fluctuations have been documented. Censusing of harbour seals at Popham Island has included photographic identification of individuals and monitoring seasonal changes in sex and age structure of the colony. Studies of seasonal movements of Pisaster starfish and growth rates of hexactinellid sponges provide monitoring of more stable populations of benthic life. Long-term commitment to these projects will provide a basis for gauging changes which may occur in the quality of Howe Sound as a habitat for marine life.

Presentation

Jeff Marliave, Vancouver Aquarium

In 1983, the Aquarium gained access to Popham Island, the most southwesterly island in Howe Sound, to undertake natural history research. Many of the studies involve taxonomic identification and description, and ecological studies that use standard gear in a novel fashion. The first project at Popham Island focussed on the concept of planktonic drift dispersal. For rocky shore, intertidal species there is a logarithmic decrease in density from the rocky shore to offshore, whereas for most fish families, they are relatively uniform in distribution. In Bowen Bay, looking at contiguous sites (rocky, boulders, cobble, sandy), the primary intertidal fish are the [bleney] eels and the sculpins do not get displaced in the longshore direction in addition to not being displaced offshore. The interpretation is that for these intertidal fishes, if there were environmental impact in a bay, one could not hypothesize a high recovery potential on the basis of planktonic drift of larvae.

The field research focused on various species which go through disappearing acts in their late larval stages. In Howe Sound the whereabouts of the later stages of Hake, now called Pacific Whiting, were identified. Newly hatched eggs of Hake have never before been seen in Howe Sound. The interpretation is that in the fjord environment, Pacific Whiting has evolved such that where the bottom

is deep and there is very high ratio of shoreline to sea surface, they recruit to their nursery habitat in the horizontal whereas the open Pacific population settles vertically to the bottom because the Continental shelf is relatively shallow and the shoreline is relatively far away.

Various fishes utilize the near shore habitats in Howe Sound for juvenile rearing. During the early Spring, Pollack larvae concentrate in the back eddies of the discharge from Squamish estuary. Studies of prawn densities during the past 5 years have been completed at Popham Island, at southwestern Gambier Island and Finnisterre Island at northeastern Bowen Island. Recent studies have concentrated on stable populations of longer-lived organisms. Transplant experiments with sponges have been undertaken and their growth has been monitored at various depths. Sponges tend to collapse during the winter and expand during the summer. Some interesting research is also taking place on the functional morphology of sponges. In the intertidal area, a keystone species selected was the common starfish. There have been major population explosions in the late 1970s and again in the late 1980s, with tremendous impact on the mussel/barnacle zones. The starfish appear to adjust their positioning in relation to tidal patterns. Studies and release programs are also underway on the harbour seals of Howe Sound.

The purpose of the research is to document natural history phenomena and in the long-run if a continuum of observations can be maintained, to establish a baseline of data that will permit assessment of any changes which may be occurring in the zoology and marine habitat.

Salmonid Habitats and Production in Howe Sound and its Drainage Basin: Status of Current Knowledge

Colin Levings and Brian Riddell, Department of Fisheries and Oceans

Abstract

This paper synthesizes existing knowledge of habitat and population ecology of salmonids in Howe Sound. Spawning and rearing habitats of salmonids in the Squamish River basin have been modified by hydroelectric developments, logging, dyke construction and some sewage pollution. The rearing habitats in the Squamish estuary have been modified by port construction and major portions of the wetlands have been permanently lost. Foreshore rearing habitats further seaward in the Sound have been affected in localized areas by disposal of mine tailings, pulp mill effluent, and log storage. Catches of salmonids are significantly reduced from historical levels. Overfishing and habitat factors are implicated as reasons for the decreased production.

Presentation

Colin Levings and Brian Riddell, Department of Fisheries and Oceans

There are at least eight commercially or recreationally important species of salmonids in Howe Sound, three of which are managed by B.C. Ministry of Environment, Lands and Parks. The major focus of this presentation is on chinook salmon.

Chinook spawning areas in Squamish and Cheakamus River are only generally known because of the turbidity of stream flow. Chum and coho juveniles or adults also utilize some of the tributaries of Howe Sound. There is limited knowledge about the fresh water life stages; based on scale analyses, most of the adult chinook spend a year in fresh water. Chinook rearing habitats are particularly important in the mainstem. Steelhead, chinook and coho also use the groundwater fed side channels and tributaries, with mostly steelhead and Dolly Varden in the upper headwaters. There is therefore, some distinct spatial partitioning of the different species.

The construction of a dam on the Cheakamus River has significantly affected flows. A comparison of pre-control and post-control flow means and range shows that in the Fall period when spawning is occurring, the range has been reduced. Major alterations have also occurred in the estuary. Studies have been done on the central part of the estuary in the 1970s when the training wall was built. The former Mamquam estuary has also been lost to industrial development.

A significant amount of rearing occurs in the estuary, with residency of several species for at least several months each year. Chinook appear to arrive in May from upstream in the river and then grow in the estuary. This is a question which needs to be addressed through tagging.

In Howe Sound itself, numerous small creeks have chum and coho salmon. Some of the streams still produce significant numbers; others are unable to support salmonids due to pollution levels.

Chinook stock assessment involves determining a productivity curve to relate numbers of spawning fish in one year to the numbers of progeny or adults which return in subsequent generation. A spawning objective is set where the yield (i.e., catch = difference between a diagonal line at a 1:1 ratio of returns; spawners and the productivity curve) is maximized. Presently, the Squamish chinook stock is considered to be very depressed relative to their spawning objective.

Different species and different populations of these species can have different productivity curves. Highly productive stocks can be fished at a high level (66-75%) of the total. Many populations are less productive due to overfishing or habitat alterations.

Assessment of the Squamish chinook stock cannot be based on total production because most of the fish are not caught in the area around the Squamish River. The hatchery tagging data suggest 38% are caught in the Georgia Strait sport fishery but over 50% of the recoveries occur north of Johnstone Strait, including 17% in Alaska. Further, chinooks caught in Howe Sound are not necessarily local stocks. The Squamish stocks are caught as young fish in the sport fishery and older fish in northern waters. The adult return migration occurs in June/July, arriving in terminal areas in early August; they are the earliest spawning chinook stocks in southern B.C.

The escapement records based on visual counting surveys indicate that during 1953-1990, historical levels of chinook were up to about 20,000 but declined through the mid-1970's until currently at only about 1,000 fish. This is particularly disconcerting since hatchery production has increased significantly but adult return to the river has not increased proportionately.

Under the Pacific Salmon Treaty, Canada has agreed to increaase chinook spawning numbers to a level of 8,000 fish by 1998. If this objective is not met, major fisheries may be closed to achieve this spawner goal. A major challenge now is to determine whether the stocks are being overexploited or whether habitat is limiting chinook recovery. This is the critical question which needs to be addressed over the next five years.

Discussion of Harding, Marliave, Levings and Riddell presentations

A participant asked about the strategy to address the Chinook issue. Brian Riddell described the proposed 5-year program on the Cheakamus to enhance stocks, identify escapement and monitor exploitation. Work is needed however, or the habitat and spawning issues to determine the mortality bottlenecks in the life cycle. A question was posed about the effects of major floods (1975, 1981, 1984) on the declining stocks. Major flow events may be creating a loss of spawning gravel, and along with manipulation of the flow regime, restricting habitat availability. Comparison with other similar stocks does not suggest overexploitation as the reason for a lack of recovery.

Pressures are also apparent on coho stocks. Chum salmon stocks are in good condition, while pink salmon have virtually disappeared. Patrick Lucey asked about a possible relation between algal

biomass increase and Chinook decline. Brian Riddell indicated that there may be a temperature and flow problem for spawners but a direct link between periphyton and Chinook is unlikely.

Organochlorines in the Marine Environment of Howe Sound

L.W. Dwernychuk, Hatfield Consultants Ltd.

Abstract

Studies on the environmental effects of pulpmill activities in Howe Sound have been carried out by various groups since 1975. These studies addressed sediments, benthic/intertidal/pelagic organisms, plankton and water quality. These earlier programs were relatively inconsistent with respect to overall study design on both temporal and spatial scales.

With increasing public and regulatory interest in bleached kraft pulpmill effluents, the Department of Fisheries and Oceans, Department of Environment and Department of National Health and Welfare were involved in the collection/analyses of biological tissues from Howe Sound in 1988. The interpretation of data for specific organochlorine compounds during the 1988 programs resulted in a closure of the commercial harvest for shrimp, prawn and crab in portions of Howe Sound (November 1988). It was stated that these closures were implemented as a result of unacceptable levels of dioxins/furans found in consumable tissues.

Subsequent to the initial closure, Howe Sound Pulp and Paper Limited and Western Pulp Limited Partnership were issued directives from Environment Canada (Environmental Protection) in December 1988 to design and implement a baseline organochlorine survey.

This study was conducted in January/February 1989 and focused on sediments and biological tissues. Subsequent to submission of data and a review by Department of National Health and Welfare, Department of Fisheries and Oceans extended closure boundaries in the Sound.

During 1990, a comprehensive monitoring program was initiated. This investigation examined effluent dispersion through dye tracer studies, contaminants in sediments and groundfish, AOX/chloroform at specific depths in the Sound, water quality profiles (pH, temperature, dissolved oxygen, salinity) from surface to near-bottom depths and community analyses on subtidal benthic macroinvertebrates. The two Howe Sound mills also conducted an additional crab program in September/October 1990. This study repeated sampling at previously targeted sites.

Pursuant to a further directive from Environment Canada and the Department of Fisheries and Oceans in February 1991, a Trend Monitoring Program was initiated in Howe Sound addressing dioxins/furans in tissues of crab, prawn and shrimp (in addition to select sediment locations); this program was targeted as an annual study to be performed during the February/March period to facilitate data comparability (site-specific and with other coastal regions).

This presentation will focus on organochlorines detected in certain ecological compartments within Howe Sound (i.e., sediments and crab muscle and hepatapancreas tissues). The data review will encompass the time span of 1988 through 1991. It should be noted that at the time of abstract preparation, organochlorine analyses on recently collected sediments and crab tissues are in progress.

Presentation

Graham Bruce, Hatfield Consultants Ltd.

Water quality monitoring studies in 1989-1991 have been done at consistent sites with consistent methodology, providing the beginning of a trend analysis. Water samples have been analyzed for AOX and chloroform, and profiles were taken of physical parameter. Various sediment sampling stations have also been used. Crabs have also been analyzed for contaminants in muscle tissue and hepatic pancreas.

A series of trawls have been used which cover most of Howe Sound. The data generated by organchlorine studies can be somewhat difficult to interpret. Analysis of discrete water samples for AOX has been done for three years of data. Sediment quality has also been analyzed based on 1990 data collection. This has included particle size analyses to identify the relation between AOX loadings and particle sizes. No association has so far been identified in the data.

Sampling for 3, 4, 5 - trichloroguaiacol in 1989 and 1990 shows a downward trend, with one unexplained increased sample. Some elevated levels occurred in Thornborough Channel, associated with the pulp mills. Dioxins, 2, 3, 7, 8 - TCDD, in crab muscle tissue was high in some areas, but appears to be declining since 1989. Similar patterns appear with the furans.

Geochemical Behaviour of the Buried Britannia Mine Tailings Deposit in Howe Sound

Karen Drysdale, Department of Geography, University of Victoria and Tom Pedersen, Department of Oceanography, University of British Columbia

Abstract

The Anaconda Mine at Britannia Beach, B.C. operated for 75 years, dumping a tailings slurry enriched in copper, zinc, and lead into the restricted inner basin of nearby Howe Sound. We report here the extent of metal contamination still evident in the surface sediments of the sound (despite roughly 16 years of dilution by natural sediments) and the present reactivity of those tailings. Analysis of 150 surface and core samples from throughout the sound show that copper, zinc and lead are still enriched in sediments near the original mine outfall, though metal levels are considerably diluted relative to concentrations found shortly after the mine shut down. With distance from the mine site, metal levels rapidly decrease in surface sediments in both basins, approaching normal background levels for the area. Porewater analyses were undertaken in two cores to determine the redox conditions within the sediments, which in turn can determine the reactivity, or mobility, of trace metals. The inner basin, which is periodically hypoxic at depth due to restricted deep water circulation, has a compressed redox profile: the sediments are anoxic very close to the sediment/seawater interface. Dissolved Cu and Zn are enriched in surficial pore waters in both the inner and outer basins ([Cu]= 215 nM and 132 nM respectively; [Zn] = 32 uM and 1.6 uM, respectively) but decrease rapidly within the top 2-3 cm, indicating active removal at shallow depths. Dissolved interstitial Pb contents, in contrast, are universally low (< 3nM). The absence

of dissolved sulphides in porewaters (despite the presence of sulphate reduction) indicates that authigenic sulphides are precipitating in the deposits. Such reactions probably account for the depletion of dissolved trace metals at depth. The data strongly suggest that metal release from the buried tailings is effectively prevented by the existing diagenetic regime.

Presentation

Tom Pedersen, Department of Oceanography, UBC

The presentation, based on research by Karen Drysdale (UVIC) and Pedersen (UBC), discussed the areal and vertical distribution of tailings and the chemical reactivity of the tailings on the sea floor.

In total, 102 core samples were taken, and the top two cm were analyzed. The samples cover most of Howe Sound but do not include shallow waters. Elemental compositions were determined by x-ray fluorescence (major and minor elements) in order to define the general sediment sources. The sodium to potassium ratio (Na/K) in surface sediments shows the influence of the Squamish River in the northern part of the Sound and to some extent the Fraser River in the southern part. This reflects sediment texture and mineralogy.

The upper basin is dominated by the Squamish River discharge with the distribution of sediments confined largely to the west side of the Sound. Organic carbon levels in surface sediments reflect the influence of pulp mills in Thornborough Channel. C/N ratio in sediments can be used to show organic material inputs. These sources include cellulose fibres adjacent to pulp mills and Squamish River terrestrial organic material, although away from these point sources overall organic matter content is low..

Copper levels in the surface sediments are low in the southern part of the Sound and high near Britannia Mine. The levels were much higher 15 years ago (Thompson, IOS in the mid-1970s), as high as 1410 ppm at Britannia and 200-300 ppm north of Anvil Island. Current levels show reductions to 300 ppm and less than 120 ppm at these same locations. Zinc concentrations are also high near Britannia and relatively high around Gambier Island.

The metal/Al ratios in sediment cores reflect the Britannia mine influence. In trying to understand how metals behave in interstitial waters, if a steady state is assumed, the role of bacteria in utilizing the available oxidants with the highest energy yield is important. Oxygen falls to zero at shallow depths in interstitial waters (measured using proxy indicators) of the outer basin sediments. The data indicate copper is diffusing up into the water column from surface sediments and down into

the sediments at depth, as is zinc. In the inner basin, dissolved copper and zinc levels are high at the surface and very low at depth.

The implications are that remobilization of Zn, Pb and Cu from the buried tailings is unlikely to be occurring. However, what is still unclear is the behaviour of the exposed tailings on the fjord wall and whether oxidation is occurring.

Discussion of Bruce and Pedersen presentations

Peter Jordan asked about where tailings were deposited. Tom Pedersen stated that for many years they were dumped into Britannia Creek; in 1927, a pipeline was built into shallow water, and deeper outfalls were built in later years. Mike Bovis (UBC) stated that perhaps the clays in the deep water sediments are not true clays, and this would explain the lack of affinity of contaminants to clays. Tom Pedersen suggested that the data do not support this theory; they are true clays.

October 1, 1991 Evening Session - Poster Presentations (Abstracts)

Aspects of Postglacial Sediment Supply to Squamish River

G.R. Brooks, Department of Geography, Simon Fraser University

Abstract

Recent work has focused upon two major components of the postglacial sediment supply to Squamish River: mass movement from Mt. Caley, and the reworking of glacial deposits. Mt. Caley is the largest Quaternary volcano in the central portion of the Garibaldi Volcanic Belt. Stratigraphic work examining debris avalanche and backwater deposits along the bottom of Squamish Valley reveal a long chronology of debris avalanches and river impoundments attributed to debris avalanches. This chronology began with a massive collapse of the Mt. Caley volcanic cone ~4800 years BP which generated the largest of the debris avalanches (~2 x 10^7 m^3). Subsequent debris avalanches have been smaller (up to ~2 x 10^7 m^3), but have occurred regularly up to the present day. These debris avalanches and related secondary debris flows form an episodic sediment supply to Squamish River. The present unstable character of the Mt. Caley cone suggests that they will continue to supply the river in the future.

Extensive incised valley fill deposits in the five major tributary valleys identify the occurrence of a major sediment transfer into the trunk valley. The valley fill deposits relate to the Fraser Glaciation and consist of ice-contact glaciofluvial, and glacio-lacustrine, deposits. Radiocarbon dating of fluvial terraces excavated into the valley fills indicates that the incision generally ceased thousands of years ago, with the most representative date being ~4150 years BP from Ashlu Valley. The volume of material involved varies considerably between valleys (6 x 10^6 to 3.6 x 10^8 m^3), reflecting local valley morphology and late Quaternary history. The incision of the valley fills is believed to represent the primary source of the reworked component of paraglacial sedimentation.

The reworked and mass-movement components of the sediment supply condition the contemporary morphology of Squamish River and also control the present position and rate of advance of Squamish Delta.

Glacier Water Input into Howe Sound from Garibaldi Lake Region

Melinda M. Brugman, National Hydrology Research Institute

Abstract

The seasonal timing and volume of water input into the Howe Sound region is strongly modulated by the presence of glaciers, some of the largest of which occur in the Garibaldi Lake region. This paper treats the impact of Sentinel Glacier on the level of Garibaldi Lake and the downstream string of lakes and streams through which the water discharges. This study is important because glaciers make a large impact on the amount and timing of runoff generated, water stored enroute in lakes, and water discharged into Howe Sound from the Garibaldi Lake Basin, and because of the related hazard potential of large landslides at Barrier Dam and in vicinity of Rubble Creek. Generally the highest lake levels occur during late summer, and have been assumed to be due to glacier runoff, although lake levels should be highest near the time of maximum snow melt in late spring to early summer. This issue is examined using a simple surface runoff and lake water storage model, that is coupled to a model of the local groundwater flow and glacier mass balance behaviour.

Glacier extents have dramatically reduced in the region since the 1920's and have apparently caused a reduction in summertime runoff into the lake. Average glacier water input into Howe Sound is estimated using Sentinel Glacier as an index basin for the other relevant glaciated areas. Future trends of glacier runoff into Howe Sound from the basin are projected for doubling of atmospheric CO_2 and attendant warming; these are compared to effects of possible return to "Little Ice-Age" conditions. Glacier water input is an important component of the water balance in Howe Sound, and may change significantly during the next century.

Spatial and Temporal Distributions of Dioxins in Subtidal Sediments from Howe Sound, B.C.

Walt J. Cretney, N.F. Crewe, R.W. Macdonald, D.W. Paton,
Institute of Ocean Sciences

Abstract

Howe Sound, a fjord system contiguous with the Strait of Georgia, has two bleached-kraft mills at Woodfibre on the upper basin and Port Mellon on Thombrough Channel. Subtidal surface sediments were collected at mid-channel at varying distances from both mill sites to look for trends in the PCDD and PCDF distributions. Sediment cores were collected and age-dated to examine the historical records of these compounds as well as those of PAHs, PCBs and other selected organics and metals. In surface sediments, the concentrations of PCDDs and PCDFs generally diminished with distance from the mill sites. In cores, 2,3,7,8 T4CDF, the H6CDDs and the H7CDDs were found to exhibit elevated concentrations dating from about the time of the introduction of chlorine bleaching of pulp. The O8CDD concentrations, however, were found to have been elevated for a period of time before that. These results and those from other congeners, organic compounds and the metals are consistent with a time-varying, mixed input of mill and combustion derived dioxins and furans.

RGS: A Regional Environmental Survey?

Paul F. Matysek and Steve Sibbick, Geological Survey Branch, Environmental Geology Section, B.C. Ministry of Energy, Mines and Petroleum Resource

Abstract

Since 1976, the British Columbia Geological Survey Branch, in cooperation with the Geological Survey of Canada, has conducted Regional Geochemical Surveys across the province to assess mineral potential and stimulate exploration in the mining sector. Samples of stream or lake sediment are collected from second order streams every ten square kilometres and analyzed for upwards of 30 elements such as copper, zinc, lead, antimony, arsenic, bismuth, cadmium, mercury and uranium. Water samples collected at each site are analyzed for uranium, fluorine and pH. During sample collection, the physical characteristics of each sample and the surrounding sample site are recorded. To date, over 1.3 million analytical determinations have been performed on 38,000 samples covering approximately sixty-five percent of British Columbia. Constituting one of the largest geochemical databases in the country, this high quality data are available both in digital and map format. In 1990, a survey in southeastern B.C. included analysis of waters for total concentrations of arsenic, cadmium, copper, lead and zinc sulphates. The Howe Sound drainage basin was surveyed in 1981 and 1989.

Regional Geochemical Surveys provide information on the composition of bedrock within drainage basins as well as information on the physical characteristics ofthe drainages themselves. Studies of RGS data have indicated that natural background concentrations of elements in sediments vary widely and are strongly dependent uponthe underlying rock type.

Potential applications of the RGS dataset include its use as a baseline database to assist in the determination of acceptable levels of elements in lakes or streams. In addition, the RGS dataset can also aid in the identification of areas which contain abnormal levels of deleterious elements. Expertise in sampling techniques, analytical methods, quality control and data reduction procedures utilized and developed over the 15 year lifetime of the Regional Geochemical Survey will benefit environmental studies in British Columbia.

Sea Floor Sediment Transport Processes: Howe Sound, British Columbia

David B. Prior and Brian D. Bornhold, Pacific Geoscience Centre, Geological Survey of Canada

Abstract

High resolution acoustic surveys of the sea floor in Howe Sound reveal a variety of high energy sedimentary processes, that create distinctive bottom topography and near-surface sediment distributions. Interpretation of side scan sonar and subbottom profiler data indicate that very energetic underwater processes such as landslides, debris flows and turbidity currents distribute sediment within the sound.

At the front of the Squamish Delta, the river distributary channels feed offshore channels, incised into the subaqueous slopes and carry coarse sediment. Associated features such as flute marks and arcuate sea floor scarps suggest a combination of turbidity currents and shallow sliding.

Slope instability has been documented at the Wood Fibre fan delta, where dramatic changes in nearshore bathymetry accompanied damage to the jetties. The underwater slopes of the dan delta are cut by chutes, scarps and rotated blocks leading downslope to debris aprons arranged around the base of the fan wedge.

Subaerial floods, debris torrents and debris flows feed sediment to the shoreline of the sound at various locations, including Britannia Beach and M Creek. Offshore Britannia Beach there are coarse-grained sediment splays that trend downslope to a large area where intricate patterns of intersecting scarps bound sediment blocks displaced by shallow translational sliding. Further downslope there are hummocky, blocky debris accumulations marking the down-fjord limit of the landslide activity. Off M Creek and other similar high relief catchments along the eastern flank of the sound there is evidence of sediment dispersal away from the shoreline by debris avalanching down the steep underwater slopes, forming distinct debris lobes, and sand and gravel splays.

The marine component of the Howe Sound environmental system thus includes episodic, near-bottom, geological processes that determine sediment distribution in the sound, involving dispersal for long distances away from stream and river mouth sources. High discharge from the surrounding drainage basins is accompanied by low retention of the sediment at the coastline. Sediment is remobilized and bypasses the nearshore areas, introducing large volumes of coarse sediment to the basin floor. Beneath the apparently tranquil surface of the sound there are high energy events which affect the stability of nearshore engineering structures and which should be considered in environmental land use planning of the coastline and sea floor.

October 2, 1991 - Boat Tour of Howe Sound

Howe Sound Pulp and Paper Modernization

Ron Wilson, Howe Sound Pulp & Paper Limited

Abstract

In June of 1990 the first portions of the newly modernized Howe Sound Pulp and Paper complex started up, signalling a new era in environmental performance for the complex. When the decision to modernize the plant was made in 1987, one of the overriding design guidelines was to utilize the most advanced technology available to minimize the plants impact on the receiving environment. The best possible technology was incorporated into the design, including the first oxygen delignification plant in British Columbia as well the ability to bleach pulp using only oxygen and chlorine dioxide. An oxygen based secondary treatment system for the liquid effluent started up in September of 1990 and coupled with primary and secondary clarification has brought effluent discharges down well under permitted levels. The complex also has the most restrictive permit levels in the province for the discharge of AOX and current discharges are well within permit levels. Overall discharges to Howe Sound have decreased by over 70% despite an increase in pulp production and the installation of a new newsprint machine.

Presentation

Ron Wilson, Howe Sound Pulp and Paper

The reconstruction and expansion of the pulp mill at Port Mellon is a $1.1 billion program which will be completed in 1992. Some $114 million of this is associated with environmental components. A new product line, newsprint, has been added to the rebuild of pulp operation. Current production is 833 Kraft and 380 TMP tonnes/day; design production is 1049 Kraft and 525 TMP (thermo mechanical pulp) tonnes/day.

Major reductions in effluent and emission contaminants have been predicted and measured. TRS (total reduced sulphur) has decreased by 70%, and particulate by 85%. BOD (biological oxygen demand) in the effluent has declined by 52%, TSS (total suspended solids) by 22% and AOX by 35%. The primary treatment facilities involve a primary clarifier, a cooling tower and a spill pond, while secondary treatment is an efficient biological process which meets 100% acute toxicity tests. Initial experience with the UNOX secondary treatment system has shown that it is able to cope with variability in the effluent.

As the markets evolve toward a low-brightness pulp, reductions in chlorine will occur through a shift to oxygen bleaching. They are attempting to recycle as much water as possible but this has not been successfully done in any kraft mill to date.

It was suggested that the increased output of ammonia, in an environment which is nitrogen limiting, could create eutrophication concerns. Process requirements, however, control the amount of ammonia which is generated. Other concerns are the increased output of chlorate associated with chlorine dioxide substitution, which can be toxic to plants and marine benthos.

Western Pulp's Squamish Operation

William Rempel, Western Pulp Ltd.

Abstract

A brief history of the Woodfibre pulp mill was presented as well as a description of the mill as it exists today. The marine activity associated with the complex was described. Effluent discharge characteristics and loadings to Howe Sound were also reviewed. A similar overview of air emissions was given together with comments on ambient air quality analysis in upper Howe Sound. The presentation concluded with a description of projects underway to further reduce the environmental impact of this operation on Howe Sound.

Presentation

William Rempel, Western Pulp Ltd.

A modernization program is also underway at the Woodfibre pulp mill, at a cost of $70 million (1989-1991). This includes the addition of secondary treatment facilities, a low odour recovery boiler and incineration of non-condensible gases in the lime kiln. Design production is 700 tonnes/day.

Significant improvements have been made to pollution control. Particulate emissions now meet Level A objectives; TRS is substantially reduced, TSS is reduced from 95 kg/tonne of pulp to 5 kg/tonne, and BOD is well below the Level A objective. Dioxins have been reduced by substituting up

to 50% of the chlorine with chlorine dioxide, and the use of pertachlorophenol treated wood chips has been eliminated. Chlorine use has changed from 71 kg/tonne in 1987 to 23.5 kg/tonne in 1991. AOX discharge has been reduced from 7 kg/tonne in 1987 to an average 2.3 kg/tonne in 1991; 1.6 tonnes of AOX is discharged per day.

The effluent treatment facilities involve both oxygen and air activated systems. A 12-hour retention time is used. Government standards for effluent will be met by the end of 1992.

Volcanism in the Howe Sound Drainage Basin: Hazards from the Garibaldi Volcanic Belt

Catherine J. Hickson, Cordilleran Division, Geological Survey of Canada

Abstract

The Howe Sound Drainage Basin is part of the geologically dynamic west coast of North America; the result of subduction of the Juan de Fuca Plate off Vancouver Island. As a consequence of subduction, the region is subject to volcanism and earthquakes. A chain of volcanoes extend northward from California (the Cascade Volcanoes) into British Columbia where they are referred to as the Garibaldi Volcanic Belt (GVB). The GVB consists of three major strato-volcanoes; Mount Garibaldi (just north of Squamish), Mount Cayley (25 km west of Whistler) and Mount Meager (just north of the drainage divide) and other smaller, less voluminous centres.

Volcanism in the GVB started some 3 million years ago and eruptions have continued into the Holocene Epoch. The most recent well documented event, a plinian eruption from Mount Meager, about 2,300 years ago, blocked the Lillooet River and spread ash across southern B.C. into Alberta. It has been recently suggested that some postglacial landslides and debris flows may have been volcanically triggered, if true, it would indicate the belt is more active than presently thought. Hot springs are found at both Mount Cayley and Mount Meager. The geological record of lava flows and volcanic debris suggests that both basaltic eruptions, and infrequent violent explosive eruptions, may both occur in the future. Small basaltic eruptions may have little or no warning; explosive eruptions usually have associated earth tremors that will be detected on the regional seismic network. Subduction continues and with it, the potential for future volcanic eruptions.

A continuing hazard in the GVB is posed by the extreme relief of many vent areas and the unstable nature of volcanic deposits. Landslides and debris flows from these volcanoes pose a very real threat. Landslides from Mount Cayley (Dusty Creek slide) and the "Barrier" blocked the Squamish and Cheakamus rivers during the 1800's. Debris flows originating on steep volcanic slopes have much greater run out distances than those generated in non-volcanic areas. When human development is pushed into these drainages, this hazardous aspect of the volcanoes must be taken into consideration during planning.

Presentation

Catherine Hickson, Geological Survey of Canada

There are three volcanic fields in or adjacent to the Howe Sound watershed: Mt. Garibaldi, Meager Mtn., Mt. Cayley, all of which are located within the Garibaldi Volcanic Belt. Southwestern British Columbia overlies a subduction zone in which oceanic material is being forced down under the continental plate. This unstable situation creates a basis for volcanic activity.

Mt. Baker is the most likely of the volcanoes in the region to erupt. It last erupted in 1872. Mt. Garibaldi last erupted 10,000 years ago. Like Mt. St. Helen's, it is an explosive-type volcano. Mt. Meager erupted 2,000 years ago and created ash fall as far away as Alberta. In general terms a hazard zone of about 20 km exists around a volcano.

In the short-term, hazards are in the form of debris flows, such as occurred with the eruption of Mt. Cayley. This is also potential for major rock avalanches.

Hazard zonation is needed to address the potential effects of eruptions. Monitoring is undertaken on a continuous basis through an extensive seismic monitoring network, but it is difficult to distinguish volcanic activity from other seismic activity. Volcanoes which have been dormant for long periods tend to explode more rapidly. Based on data from the Lithoprobe seismic program, a magma chamber is suspected to exist 12 km under Mt. Cayley, presenting some element of concern.

Squamish River Estuary

Presentation

Colin Levings, Department of Fisheries and Oceans

The first dykes were built in the Squamish estuary in 1890, near the Mamquam River. In 1935, the "town dykes" were constructed and in 1950 major dyking of the Mamquam Channel was completed. Not long after, the railway was completed. The 1970s saw additional filling for port and industrial development and dyking. In 1990, additional filling occurred in the Mamquam Channel area for dry land log sorting.

The estuary is dominated by freshwater, creating low salinity in the surface layers. The marshes of the Squamish estuary are an important source of benthic detrital material. Until about 1970, the detrital food web significance had not been recognized. The benthic invertebrates are largely benthic

detritus feeders. Chinook utilize the estuary in May and June; coho smolts migrate out in spring and the fry seem to rear in the estuary in July. According to Fishery Officer reports herring used to spawn on eel grass present in the estuary and herring were observed up to the mid-1960s.

Habitat restoration initiatives include culverts in the training wall, rejuvenation of the tidal channels in the central delta, and removal of dredge spoil.

Assessment and Control of Acid Rock Drainage, From Britannia Mine Site

Linda M. Broughton, Steffen Robertson and Kirsten (B.C.) Inc.

Abstract

The decommissioned Britannia Mine is located at Britannia Beach approximately 48 km north of the city of Vancouver, on the east shore of Howe Sound. The underground and open pit mine was operated by the Britannia Mining and Smelting Company Ltd. from 1905 to 1963 at which time it was purchased and operated by Anaconda Mining Company until shutdown in 1974. During operation, approximately 45 million tonnes of ore were processed for recovery of copper and lesser amounts of silver, zinc and gold.

Acid rock drainage (ARD) containing elevated acidity and metal levels has issued from the Britannia site since the operational period, discharging into Britannia Creek and Howe Sound. In 1972, in an attempt to improve drainage quality from the site, acidic mine water was diverted within the mine workings for treatment in a copper cementation plant prior to discharge at depth to Howe Sound. Recent investigations however have indicated that contaminated water is again draining directly into Jane Creek and then into Britannia Creek and ultimately into Howe Sound.

We recently completed an investigation of ARD from the Britannia mine site for the B.C. AMD Task Force. An assessment of acid generation and the sources of contaminated drainage was conducted, and alternative options for control and remediation developed. Site water quality data were compiled in a Geographic Information System (GIS) with recent topographical data for graphical display of the sources of contaminated drainage, and the current physical nature of the site.

The Britannia site could provide a rather unique opportunity for research and investigation into ARD processes and control. The site is readily accessible by road with a long history of ARD potentially from all components of any mine site; open pits, underground, tailings, waste rock and construction materials. Consideration should be given to developing the site as a research facility, and also as an opportunity to disseminate information to the public regarding acid rock drainage and the measures that can be taken to assess and remediate these sites.

Presentation

Linda Broughton, Steffan Robertson and Kirsten Inc.

The Britannia Mine closed in 1974. It remains a substantial source of acid drainage due to the oxidation of sulphide minerals. The Report of the B.C. Acid Mine Drainage Task Force recommended a program for management of the acid mine drainage.

The mine contains about 80 km of underground workings and a few open pit operations. Contaminant loadings have decreased about an order of magnitude since mine closure. There are three general strategies for managing acid drainage: try to control acid drainage reaction; limit migration of contaminants and/or collect and treat the drainage. At Britannia, the management of the underground workings was considered in terms of a) diverting clean water to reduce contact with sulphides, b) blocking the portals to discharge, and c) treating the drainage downstream through an active (e.g. lime neutralization) or passive (e.g. wetland) treatment process.

Britannia provides an opportunity to learn about acid mine drainage and to research remedial measures.

Britannia Mine Tailings

Presentation

Karen Drysdale, University of Victoria and Tom Pedersen, University of British Columbia)

The mine tailings at Britannia Beach present problems of leaching of contaminants, acid drainage, and potential landslides. Between 1898-1927, tailings were dumped into Britannia Creek, and from 1927-1974 they were dumped into the intertidal zone and shallow water. The tailings have also been carried downslope by episodic events.

The tailings deposited on the beach are being oxidized and act as a source of metals contaminants. The tailings deposited in deep water, however, are in an anoxic environment and are probably not releasing metals.

Dissolved copper concentration are low at depth in the tailings and high at the surface of natural sediments. Studies indicate that tailings are not reacting on the seafloor and there is no evidence of copper and zinc in deep water; tailings located in deep water are not oxidizing and releasing metals. The major problem of high copper levels originates from the creek where the plume is rich in dissolved Cu. The contaminants are having a serious effect on the foreshore aquatic growth. The extent to which Cu is biovailable is highly variable. There is limited information on the uptake and fate of copper. Some recolonization is nevertheless taking place as rock weed growth is slowly beginning to appear in the area.

Britannia Creek Flooding

Presentation

Bernie Claus, Environment Canada

Britannia Creek has a long history of major floods. Newspaper accounts of the flooding in 1906, 1921, 1933, 1963 and 1991 atest to the severity of the debris torrents on the creek. It is primarily the amount of debris, and its associated hazards, which makes the floods so significant. Several debris sources have been identified, including those associated with roads, channel sides and sources within the channel.

The slope of the alluvial fan forces material to be dumped in the channel, creating a damming effect. In the recent flood, the river diverted within the fan and created ponding behind the railway which was eventually breeched.

More floods and debris flows are inevitable, but their severity and effects can be reduced. Policies should restrict the high hazard areas to day use only.

Squamish Highway Debris Flows

Presentation

Lionel Jackson, Geological Survey of Canada

The Squamish Highway crosses high energy streams prone to debris flow events along the east side of Howe Sound. Debris flows are a mixture of rock, sediment and water.

The Howe Sound debris flows are different in that they tend to break down to sand size grains due to the mobility and turbulence. Debris flows initiate on slopes greater than 30^0, deceleration and deposition begins where stream bed slopes decrease to 15^0. Debris flow movement generally ceases on slope less than 5^0.

Weather conditions, notably water saturation of soils and heavy rainfall (including rain or snow), stimulate debris flows. Much of the debris is initiated by failure of material adjacent to streams and in-stream material. The recurrence intervals associated with debris torrents are 2-5 years in Howe Sound.

October 2, 1991 - Howe Sound Watershed Environmental Science Workshop

Evening Keynote Address

"Understanding Sustainable Development"

Bill Rees

School of Community and Regional Planning, University of British Columbia

Sustainable development has been around for a long time as a concept. It was picked up as a broad approach to integrated resource management by the World Conservation Strategy in 1982. The concept was further popularized by the volume "Our Common Future" which was a product of the World Commission on Environment and Development, also known as the "Brundtland Commission". This commission was the starting point of the current debate on sustainable development.

The Brundtland Commission examined the state of the environment on a global scale, and identified the causes of ecological deterioration particularly in the Third World context. It concluded that most of the problems were rooted in poverty worldwide. In Third World countries, overpopulation by people living on lands that should not be used for agricultural purposes depleted the fuelwood supply, thus contributing to the fuelwood crisis. The deforestation of watersheds further exacerbated the existing problems of overpopulation and malnourishment. Ecological decline in Third World countries is therefore closely linked to poverty in these countries.

The Commission did not, however, provide any analysis of the sequence of cause-effect relationships that gave rise to this situation. It can be argued that Third World poverty and the resultant ecological deterioration are results of the pattern of global investment and economic development. Such a pattern of investment forces Third World countries to devote much of their natural capital assets to the production of cash crops (including timber) for export, in order to pay for their national economic development, in the hope of integrating into the global mainstream economy. The Brundtland Commission failed to identify this phenomenon.

The Commission came up with a proposed solution to these problems. It argued that the answer lies in a re-invigorated world economy; with a five to ten fold increase in the scale of global economic and industrial activity by the middle of the next century, given that world population stabilizes around eight billion people. The rationale underlying the solution is that an economy of the prescribed scale would bring Third World countries to approximately Western European standards of living, and would provide adequate economic surplus to the world economy to be ploughed back to natural environment husbandry.

The problem with the proposed solution is that there is no analysis on how to sustain a five to ten fold increase in global economic activity, and at the same time, maintain and preserve the ecosystem. The two major inadequacies of the Commission are:

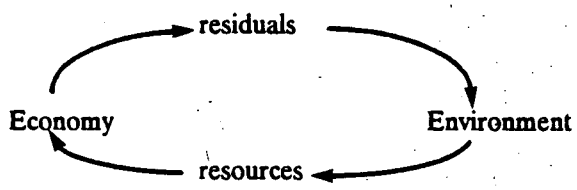
1) its lack of socio-demographic analysis which would otherwise show the real cause of poverty, namely the pattern of international investment and the nature of Third World economic development; and,

2) its lack of evidence to show the capacity of the world ecosystem capable of sustaining the prescribed high levels of economic growth.

Economics is essentially a model with various assumptions, but any model is only as good as its starting assumptions. The current economic model on which the world operates has fundamental flaws from the perspective of ecological reality. Likewise, if a model is to be used for policy development and implementation, the policies can only be as good as the assumptions of the model. If a model is flawed, the policies derived from it would fail when being applied to the real world.

The model on which most of today's economic policies are based is derived from Neoclassical economics. The principal founders of Neoclassical economics made an explicit choice to base this school of thought on Newtonian Physics, with the intent to "create an economic model to serve one's self-interest". Economics is essentially the science of efficient allocation of resources. While economics is erected on the basis of Newtonian Physics, ecological science is based on the laws of Thermodynamics.

Textbook economics operates separately from the real world, and the evolution of the economy is seen as separate from the rest of reality.



From the diagram, we see that the economy draws on the environment for resources, and the economy returns residuals to the environment. The diagram represents a notion of separateness of the economy and the environment; this is the first assumption of Neoclassical economics. The second assumption is the circular flow of exchange or money in the economy. Money can circulate indefinitely in the economy; money can create wealth, and there is no theoretical limit to such growth. The third

assumption is the notion that natural resources are substitutable by human ingenuity. In free markets where resources are treated as commodities, the scarcity of a resource will push its price up, the price will increase to a point where consumers will reduce their consumption of this resource. Since the price mechanism regulates the demand for the resource, and thus conserves a stock of that resource, there is no need for the discussion of resource crises. Alternatively, the rise in price for that resource will lead us to find substitutes for it. Hence the market system stimulates the conservation of natural resources, and it also stimulates human ingenuity to find technological solutions which did not exist in nature. In economics, the problems of the limits to growth are eliminated on the following grounds:

1) the mechanical circulation of exchange in the economy
2) no real dependence on natural resources, and that technology can be a good substitute based on the assumption that human ingenuity will eliminate all problems of the external environment.

In contrast to the notion of separateness, ecological relations recognizes the dependency on the rest of reality, in particular, the dependency on resources. Ecology recognizes that the human economy is a subset of the ecosphere. From an ecological standpoint, the circular flow of exchange and mechanical reversibility of demand and supply are not entirely true; rather there is an element of irreversibility. Natural systems tend toward disorders and any transformation of material will result in loss.

The ultimate goal of all nations is to increase their productive efficiency. In actual fact, every act of economic production is consumption, or energy and material transformation; since natural resources and energy are used up to produce the end product. Energy is dissipated into the environment during the process.

The second assumption that there is no theoretical limit to economic growth is false. Economic activity can in fact decrease the potential for future growth.

The third point that natural resources can be substituted by human ingenuity is founded on misleading assumptions. From an ecological perspective, natural resources do not exist in the market. This can be illustrated by the depletion of the ozone layer, which is equivalent to the destruction of a natural resource. There is no known substitute for this resource.

From the old model where sustainable development depended on growth, whereby a surplus is generated to replenish the environment, a new model has evolved. The new model converges on

ecological economics, with thermodynamics as the starting point and different assumptions with radically different conclusions.

The basic principle of the new model is that certain ecological or biophysical processes and commodities are essential for the survival of civilization. On such a principle, a new management model is erected to promote the sustainability of civilization.

What are the necessary conditions for sustainable development? The premise of continued growth in our economy is unsustainable. There is substantial evidence of this. Global warming may be a phenomenon by the middle of the next century. There is no agricultural area in the world that has not been subject to massive soil erosion. Around the world, the erosion rate is at 26 billion tonnes of top soil per year. Water tables are in decline worldwide. Water quality is in deterioration.

There are at least 26 major variables that are deteriorating in a global context, such as the loss of tropical rain forests and the loss of species.

Some economists have begun to agree that there are critical ecological material resources and critical essential process resources such as photosynthesis that we cannot be without; that their losses would be irreversible and too great a risk to take. Therefore, there is a need in whatever development paradigm that we adopt to elevate the notion or the principle that there are "life-support functions of the ecosphere" that must be maintained at all costs.

In conventional mainstream economics, capital refers to machinery and financial capital. Biological or natural capital was never considered. Instead, these were considered as free goods provided by nature and not considered as productive capital. This is reflected in our national accounting system. When we calculate our GNP, it is equal to the value of all the production of goods and services (the income flows of all goods and services) minus the depreciation of manufactured capital. The accounting has never included the deterioration of the natural environment and the depletion of natural resources. The only forms of capital accounted for are manufactured capital and financial capital.

Now it is recognized that the external environment represents an array of capital assets that are essential for the continued productivity of society. The first steps that were taken to incorporate natural capital accounting into economic planning were in France, Norway and Indonesia six years ago; the most prominent example being Indonesia. These countries attempted to see what the effects on GNP data would be if the depreciation of natural capital assets were accounted for in their natural

income flows. In the case of Indonesia, economists looked at forestry, petroleum and gas. They looked at the normal GNP data, then subtracted from that the forest, petroleum and gas capital consumed. The result was a 40% reduction in the GNP.

The World Bank did an elaborate study for the whole of the U.S. economy, incorporating a whole array of conditions of natural capital. It showed that throughout the period of analysis the GNP data were used, with adjusted accounting for the last 25 years, the U.S. had a stable level of adjusted net welfare. For the last decade, it has been in steady decline as shown by welfare accounting.

We now have two primary statements in the current literature on the vital conditions for sustainable development (with the assumption of constant population and a stable standard of living):

> *1) Each generation should inherit from the previous one at least an equivalent aggregate stock of natural and manufactured capital.*

In order to achieve sustainability over time, there should be a constant stock of natural capital. "Aggregate" implies that underlying the statement is the principle of substitution. It is legitimate to liquidate our forestry or fisheries capital provided that we re-invest the proceeds in an equivalent form of manufactured capital. "Equivalent" means manufactured capital that supplies an equivalent income stream for a certain number of jobs. For example, it is perfectly legitimate to liquidate B.C.'s forest resources, as long as we use the proceeds to establish a diversified industrial base and provide jobs to the economy. This is the Neoclassical interpretation of sustainable development.

The second statement runs contrary to the first one.

> *2) Each generation should inherit from the previous one at least an equivalent stock of natural or biological capital assets.*

This is where the debate resides. To what extent are we able to draw on our natural capital assets and substitute for them manufactured capital assets and still achieve sustainability?

Economists now recognize the life support functions of biological capital and have begun to adopt the second definition of sustainability. It is also recognized that the substitutability principle carries with it an excessive risk to future generations.

The world economy has entered a different era. It has grown 5-fold since the end of the war, now averaging 3.5% growth per annum. If a mean growth rate of 3.5% per annum for the world continues, it would mean a 5-fold rate of growth for another 50 years, and the Brundtland objective might be achieved. However, from an ecological perspective, human enterprise in the global economy co-ops for its own use 40% of all photosynthesis in the terrestrial environment. A single species co-ops 40% of all photosynthetic activity, which is the real production occurring on the planet. Even if we double our current rate of photosynthetic activity, it is questionable whether the world ecosphere could sustain human beings and maintain the environment.

This goes back to the economist Hicks decades ago. "Hicksian Income" according to him, is the level of consumption that is sustainable. It is the level of consumption over a period of time that leaves us as well off at the end of the period as we were at the beginning; it is the level of consumption that we can maintain without risking our productive assets. This decades' old concept is now re-emerging in the context of sustainable development. We should therefore live off the interest of the productive assets; if we consume not only the interest, but also some of the productive capital, and continue to do so over the long run and at an increasing rate, the result would be devastating.

For the first time, the scale of economy approaches the scale of ecosphere in terms of volume, energy and material transformation. We are now approaching the whole of the total photosynthetic transformation. One response to this is encapsulated in the phrase, "think globally, act locally". One way to act locally is to organize ourselves into bioregions, i.e., the one we have to live on based on watershed boundaries (e.g. Squamish-Howe Sound watershed). The whole of North America is divided into a variety of bioregions.

One of the consequences of absolute free global trading under the old model is that, for any relatively scarce resource in the market, despite a price increase, there will always be some demand, so our natural resources will still be exploited and depleted. (e.g. Vancouver's land price has increased to an extent where many can no longer afford to live here).

If we produced some resources for consumption and subsidized the surplus for trade, as in the definition of Hicksian income of sustainability, the conditions of trade would be driven by the availability of ecological supply rather than the price of resources in the global market.

If we think about the impact of current global microeconomic policies on the state of the world's natural resources - for example, the B.C. economy and the way it is structured. Are we maintaining a

constant stock of natural capital assets? Are we having a sustainable form of development in terms of maintaining an aggregate stock of natural and manufactured capital assets?

The process we are engaged in with respect to the natural resource sector is one of liquidating our natural capital assets on a wide scale and not even re-investing the proceeds in manufactured capital and diversifying the economy. Even from a Neoclassical standpoint, the B.C. economy is not performing well, and not leaving the next generation an equivalent stock of natural and manufactured capital assets.

The wealth of our country comes not from our ingenuity, but from our vast reserves of natural resources in relation to the small population. We are shipping our real wealth offshore in dividend payments and natural resources, and not investing in our natural capital assets. This region is not in a steady state.

Third World environmental degradation has catastrophic impacts on human lives - e.g. flooding in Bangladesh has resulted in hundreds of thousands of refugees. The rise in sea level by one metre and the resulting flood damage will lead to the disappearance of some Third World countries anticipated by the end of the next century. The present value of a tree in a bush in these countries for non-market ecological support functions is higher than the current market value of commercial wood operations.

The current market system, because of its failure to recognize a whole array of real economic values that are resident in natural resources, enables private owners or lease holders of that resource to capture the enormous private benefits while simultaneously imposing equal or greater public or social costs over the world population.

Over the long-run, logging in this way after 40 years will have taken from the forest the equivalent of the standing crop. We will have taken as much wood from the forest as it had in the outset. However, we are only cropping the interest, the capital remains intact. At the end of the rotation (another 40 years), we can have another crop. On the other hand, if we clear-cut, it would be uncertain if we would still have another crop after 100 years. This ecologically sustainable selection logging may return you less financial capital, but we get two to three times the product than we would if we clear-cut. Even assuming there is another crop after 80-100 years, the clear-cut approach at best gives us two crops, while the other at least three, because we still have the stock of capital. If we are concerned about production, this approach may actually give us more product than clear-cutting, and we would have protected the environment and its natural resources. Also more jobs would be created, because this approach is more labour intensive as a result of reforestation. If we integrate our economic

policies with environmental ones, in this case, forestry policies, we would have more people working on reforestation, restoration and the re-creation of lost ecosystems.

The current economic system is biased towards capital liquidation in getting a higher return in the short-run without re-investment in the resources which are the basis of our wealth. The other approach yields both economic and non-economic benefits that are immeasurable.

October 3, 1991 - Morning Session

Chairman: Lee Harding, Environment Canada

The Phytoplankton Ecology of Howe Sound

John Stockner, Fisheries & Oceans Canada

Abstract

The production, distribution and abundance of phytoplankton in Howe Sound were studied from 1972 to 1978. Results of this 6 year field study coupled with laboratory bioassay experiments revealed a very heterogeneous population distribution with considerable spacial, temporal and interannual variability. Greatest population abundances and highest daily and annual rates of carbon production were in the seaward boundaries of the Sound contiguous with the Strait of Georgia where average annual values often were >350 gC/m^2/yr. The least productive regions of the Sound were off the Squamish River delta and in waters adjacent to the pulp mills and Britannia copper mine where values were typically <50 gC/m^2/yr. Severe light attenuation in surface waters of the Sound extending from Squamish to Anvil Island and caused by turbid, glacial Squamish River and stained pulp mill effluent discharges, were thought to be the major factors limiting rates of primary production in Howe Sound. Strong seaward flushing of the surface layer and stable stratification from May to October with summer declines in available nitrate-nitrogen also influenced phytoplankton dynamics in certain regions of the Sound. An annual spring diatom 'bloom' is a common, dominant feature in all coastal B.C. fjords. In Howe Sound it usually commenced in April just off the Squamish delta and moved progressively seaward down the Sound over about a 3-4 week period. But in some years it was restricted and/or eliminated by poor spring weather conditions or early Squamish River discharge which influenced the production dynamics of the Sound. Autumn blooms were common in the seaward boundary waters but not in other regions of the Sound where turbidity and hydrographic conditions either prevented or dampened the autumnal response. Some possible effects of removal of perturbations or addition of nutrients to the surface layer of the Sound will be discussed relative to the maintenance of a productive and 'healthy' plankton community in Howe Sound.

Presentation

John Stockner, Department of Fisheries and Oceans

The large drainage basin of Howe Sound has a tremendous impact on its marine waters. The Squamish River particularly has a major influence on salinity and nutrient distribution. Ten research

stations were occupied in 1972 for about three years in Howe Sound. In these early years, pollutant discharges at Britannia Creek and Woodfibre were substantial.

Detailed nutrient chemistry profiling was undertaken in the early 1970s. ^{14}C samples were used to estimate productivity in Howe Sound. There outer waters were highly productive and productivity declined moving into the upper parts of the Sound. Primary productivity also varies significantly between years. In association with production increases in the spring, nitrate is driven almost below detection levels. Light is an important regulator of production. The primary productivity data show a strong trend associated with light attenuation affected by the Squamish River. Areas of low productivity in Howe Sound are the mine site, the pulp mill and areas under the direct influence of the Squamish River. Also influencing primary productivity is zooplankton which consume the phytoplankton. A map of productivity was prepared in 1974-75.

Studies adjacent to the pulp mills showed major effects on organisms. The effluent contained considerable nitrogen, particularly ammonia, and significant phosphorous. Four stations two km away from the mill were established. There was a strong attenuation of light at the outfall which was reflected in primary production levels. The effluent was tested with three cultures of marine algae. The phytoplankton proved to have an ability to adopt to the effluent and given time, to grow. Some comparison with 1991 data from Pam Rocks station, in addition to anecdotal accounts, suggests that the Sound is currently more productive than in the early 1970s. In the future, if the Squamish River is dammed and turbidity reduced, primary productivity within the Sound would be substantially increased (though severe negative consequences might be expected on fisheries due to dam construction). With the growth of Whistler and Vancouver, forestry activity, mill discharge of nitrogen and phosphorous, the result is a much more productive boundary water and inner Sound. The future of Howe Sound is therefore one of increasing productivity. There is also a need to undertake picoplankton productivity studies and bacterial production studies.

Dioxins and Furans in Cormorant Eggs and Tissues of Diving Ducks Collected in Howe Sound

Phil Whitehead, Canadian Wildlife Service

Abstract

Since 1977, the Canadian Wildlife Service has monitored several persistent environmental contaminants in the eggs of Great Blue Herons nesting in the Strait of Georgia. The goal of the Program is to provide information on industrial contamination of estuaries and intertidal mudflats in the Strait, and possible implications for the health of resident birds. In 1982, a method for measuring dioxin (PCDD) and furan (PCDF) residues in eggs was developed, and became part of the monitoring protocol. The first

eggs analyzed were collected from a colony near the Fraser River estuary and contained elevated levels of some 2378-substituted congeners. Levels of 2378-TCDD, the most toxic isomer were high enough to be embryotoxic in a sensitive species. In 1987, chlorine bleaching of pulp was identified as the probable source of the PCDD/Fs in the Strait. Recently the Canadian Wildlife Service began collecting Double-crested cormorant eggs from Christie Inlet in Howe Sound. Levels of 60 ng/kg of 2378-TCDD, 107 ng/kg of 1378-PnCDD and 237 ng/kg of 123678-HxCDD were found in 1988. The following year, 2378-TCDD had fallen to 30 ng/kg, while higher chlorinated congeners were less than 1/5 1988 levels. In 1990 levels were almost unchanged from 1989. In addition, samples of several species of over-wintering diving ducks were collected near the Port Mellon mill in early spring, 1990. Liver and muscle tissue of all the ducks contained PCDD/Fs. Fish eating species were the most contaminated followed by benthivores and herbivores. Western grebe, for example, contained 46 ng/kg of 2378-TCDD, 29ng/kg of 12378-PnCDD, 77 ng/kg of 123678-HxCDD and 109 ng/kg of 2378-TCDF. These data show the value of fish-eating birds as indicators of environmental quality.

Presentation

Phil Whitehead, Canadian Wildlife Service

In 1982, Canadian Wildlife Service discovered elevated levels of dioxins and furans in Great Blue heron eggs taken from a colony near UBC. The levels were large enough to launch a comprehensive program to assess dioxins, furans and other chlorinated hydrocarbons throughout the Strait in Great Blue herons and cormorants.

In 1990, nine cormorant colonies were selected, and are being monitored annually to 1995 to provide trend data. Collections of eggs from diving ducks have also been undertaken.

The data show some high levels of 2, 3, 7, 8 TCDD and TCDF at Crofton and UBC. Contaminant levels in Great Blue herons at Crofton appear to have generally increased up to 1987 and have since declined. Similar patterns are apparent in cormorants, although 2, 3, 7, 8 TCDD was generally lower. The time series data show quite high levels in 1988, declining to low levels in 1990, both in Howe Sound and Crofton. Data on diving ducks also show a pattern of elevated 2, 3, 7, 8 TCDD and TCDF, which led to health advisories on consumption.

Toxicity has been analyzed in terms of toxicity equivalent units (TEQ's) based on the most toxic congener, 2, 3, 7, 8 TCDD. The monitoring data were presented showing the relative toxicity of the contaminant levels, with a similar pattern as the absolute values. PCB's have never been considered a problem until recently because it was known that levels had declined sharply since the late 1970s. Levels are generally below 2ppb and likely to continue falling slowly. The use of TEQs allows an evaluation of total toxicity levels. PCBs contribute much more than the dioxins to total toxicity, except at Crofton. The level of total toxicity is higher than expected.

Effects on bird populations are not well known. Some data on nesting pairs, show double-crested cormorants varying in populations. No major population effects have been observed. But studies of the Crofton site show that chicks were smaller and physiologically affected. Defects in cormorant chicks have been found in the Great Lakes (0.225%) and recent data in the Strait of Georgia (0.136%). In comparison with other studies in Europe and in Michigan, the Strait of Georgia results are relatively minor. While dioxin levels are comparatively insignificant, dioxins and PCBs have nevertheless been found in birds throughout the Strait and they do contribute significantly to the total toxicity.

Neoplasia and Biomarkers in Fish and Bivalves, Collected near Pulpmills

Dawna Brand, Department of Biology, University of Victoria

Abstract

Sublethal toxicity tests make it possible to detect incipient effects on fish and shellfish and aids in the estimation of threshold concentrations for various pollutants. Multidisciplinary efforts, often those in which pathology is allied with biochemistry, is an effective approach for documenting exposure to and evaluating the effects of pollutant stress. Our research is concerned with the examination of the impact of pulp mill effluents on marine benthic organisms by measuring a suite of selected stress responses. Three British Columbian pulp mills were surveyed. Two species of flatfish (Parophrys vetulus and Hippoglossoides elassodon) and deposit-feeding bivalves (Yoldia thraciaeformis and Macoma calcarea) were collected. Samples were examined histopathologically for idiopathic lesions and biochemically for the induction of MFO enzymes and metallothioneins. Preliminary results have revealed a 20% prevalence of idiopathic liver lesions in flatfish, the presence of fused and stunted gill lamellae, and the induction of MFO enzymes and metallothioneins. This bioindicator approach can serve as an early warning signal and give insight into causal relationships between stressors and effects resulting from a complexly contaminated marine environment.

Presentation

Dawna Brand, Department of Biology, University of Victoria

The research focussed on the effects of pulp mill effluent on three biological levels: physiological, biochemical and histopathological. The survey included three pulp mills, Crofton, Port Mellon and Woodfibre and one reference site at Satellite Channel. The studies utilized two species of bottom feeding fish, English sole and Flatfish sole, and two species of bivalves which feed by ingesting sediment particles.

Analysis was done on livers and gills in the fish. Liver lesions and distortions and stunted growth to gill lamellae were found more often with fish collected near the pulp mills. Cross pathology of the liver tissue did not show any unusual effects but in sectioning the analysis found a 30% incidence of

certain lesions in the samples near pulp mills and a 5% likelihood of lesions in the samples from Satellite Channel. Other unexplained metabolic disorders on accumulation of iron were evident.

In addition to pathological parameters, the analyses looked at enzyme parameters. Storage problems with the flatfish presented problems with analyses of the tissues. Some problems existed with the Satellite Channel reference site due to proximity to stormwater discharges and other disturbances. Another lesson was that one species of Flatfish sole cannot be compared with an English sole from another site, due to different types of activity occurring in each type of fish. Bivalves reflected the same results of depletion over time and differences between species.

One encouraging enzyme analysis was metallothioneins which are induced by metals as well as other stress factors. There is a very strong correlation between pulp mill activity and reduction in metallothioneins.

The analyses are very preliminary based on one year's field data and relatively small sample sizes. Even though the current toxicity tests (e.g. LC-50) provide good responses to pulp mill effluent, the actual physiological processes occurring are not due to discharge of effluent per se but rather to the turnover of contaminants already present in the sediments which lead to the type of cancer lesions discussed.

Discussion of Stockner, Whitehead and Brand presentations

A participant asked about phytoplankton and ozone depletion. John Stockner referred to the current research on the effects of u.v. light on phytoplankton in the Antartic Ocean. Recent research indicates that ozone depletion and u.v. penetration can kill phytoplankton. If species do not evolve which are u.v. tolerant, major disruptions to the food chain and even a severe collapse of the krill food chain in the southern ocean may result.

Lee Harding asked about the frequency and severity of toxic algal blooms associated with Cladocerous. John Stockner noted that the two species of algae which are deadly to fish were not present in the early 1970s but did appear in the 1991 samples. The whole Strait of Georgia is not ideal for aquaculture because of the presence of certain algae which can lead to fish mortality.

Phil Whitehead was asked about contaminants in eagles. No studies have been done in Howe Sound, but in other estuaries, higher dioxin levels have been found in bald eagles. It was also noted that dioxins are mutagenic at high concentrations. Phytoplankton appear to be quite tolerant to

dioxins, but zooplankton have not been tested. The health effects related to fish consumption was also questioned. Concentrations of contaminants in flesh is not as high as in livers.

The discussion focused on forecasts of increased primary productivity in Howe Sound. John Stockner stated that he has estimated effluent loading and indicated that the mills represent about 20% of the total carbon increase. Although ammonia may be reduced per tonne of pulp, the potential exists to generate significant levels of productivity.

Forest Ecosystems in Watersheds draining into Howe Sound

Fred Nuszdorfer, B.C. Ministry of Forests

Abstract

The watersheds of the rivers (Cheakamus, Elaho, Mamquam and Squamish), and streams that form part of the Howe Sound system encompass an area of approximately 463,000 ha and extend from sea level to 2678 m at the peak of Garibaldi Mountain. Three of the 14 biogeoclimatic zones of British Columbia occur in these watersheds. The Coastal Western Hemlock zone predominates. The Mountain Hemlock and Alpine Tundra zones are also found.

Some of the major upland forested ecosystem associations that are present are: Western Hemlock - Amabilis Fir Blueberry, Western Hemlock - Flat Moss, Douglas-fir - Salal, Douglas-fir - Western Hemlock - Falsebox, Mountain Hemlock - Amabilis Fir - Blueberry. On floodplains Sitka Spruce - Salmonberry, Black Cottonwood - Red-osier Dogwood and Black Cottonwood - Willow are the major forested ecosystem associations present. The ecosystems in the area have soil moisture regimes ranging from very dry to wet. Soil nutrient regimes tend to be very poor to medium due to the dominance of the granitic bedrock that was the parent material of many of the soils of the area.

Two ecological reserves have been established in the watersheds of the Howe Sound system: ER 69, Baynes Island - black cottonwood ecosystems on an island of the Squamish River (71 ha) and ER 48, Bowen Island - ecosystems representative of the drier maritime part of the CWH zone (397 ha). Parks also offer some protection of ecosystems (e.g. the montane and subalpine ecosystems of Garibaldi Provincial Park - 53,000 ha in the area).

The forests of the area provide habitat for a wide variety of species; influence the quantity and quality of water that reaches streams and rivers, affecting drinking water, anadromous and resident fish and other species; provide a scenic view for travellers to destinations such as Squamish, Whistler, Pemberton and the interior of the Province; provide a recreational experience for many; stabilize soils on slopes; release oxygen and are a sink for carbon dioxide. In addition, lower elevation forests have provided substantial timber for the forest industry and are expected to continue to provide it, albeit at reduced levels, in the future.

The Ministry of Forests research in the area is testing different genotypes of species, methods of controlling unwanted species, tree response to application of fertilizer, and characterizing forest ecosystems.

Presentation

Fred Nuszdorfer, B.C. Ministry of Forests

The recent publication, "Forest Ecosystems of British Columbia" provides a compendium of the ecosystem attributes in the province. In Howe Sound, the Coastal Western Hemlock biogeoclimatic zone predominates, but Mountain Hemlock and Alpine Tundra zones also occur. Examples of these zones in the Squamish River basin were presented. There have been various intervening disturbances to the forest ecosystems, notably fire, logging and flooding. Two ecological reserves exist in Howe Sound, at Baynes Island and on Bowen Island.

There are pockets of old growth in the upper Elaho drainage which remain to be analyzed. There is a need to expand the focus on protecting biodiversity in the watershed, and to provide special consideration toward old growth stands.

Wildlife Diversity in Old Growth Forests, and Managed Stands

Dale Siep, B.C. Ministry of Forests

Abstract

1. We have completed 2 years of research comparing wild life diversity and abundance in Coastal Western Hemlock old growth stands (>250 years), 40-80 year old second growth stands and clearcuts. Study sites include the Queen Charlotte islands, southern Vancouver Island and the lower mainland.

2. Many species such as chipmunks, long-tailed voles, orange-crowned warblers, juncos and song sparrows are most abundant in clearcuts.

3. Numerous species live primarily in forests but are equally abundant in old growth and 40-80 year old second growth stands (eg. shrewmoles, flying squirrels, red-backed voles, western flycatchers, Townsend's warbler, golden-crowned kinglets, Ensatina salamanders).

4. Most bird species that require snags for feeding and nesting live in both old-growth and second-growth forest but are more abundant in old growth because of the greater abundance of snags (eg. sapsuckers, brown creepers, nuthatches)

5. Two species that appear to nest almost exclusively in old growth forests are the marbled murrelet and the spotted owl.

Implications:-

- the greatest abundance and diversity of wildlife will occur in areas that provide a good mixture of habitat types including clearcuts, second-growth coniferous forests, old-growth forests and hardwood stands.

- second-growth forests can provide habitat for most of the wildlife species that live in old-growth forests if they are managed to ensure that they contain abundant snags, decaying logs and gaps in the canopy to allow shrub growth.

- There are some species such as the spotted owl which live almost exclusively in old-growth forests and sufficient amounts of old-growth habitat must be protected if they are to be maintained.

Presentation

Dale Siep, B.C. Ministry of Forests

A joint research project is underway with CWS to compare vertebrate diversity in old growth areas, logged areas and secondary forests. The results suggest that vertebrate species are equally common to all areas. Certain species of small mammals are abundant in early serial habitats (recent clearcuts). Many forest-dwelling species (e.g. shrewmole) are not abundant in clearcuts but are equally abundant in second growth and old growth. Woody debris on the forest floor is often important to wildlife and high levels of utilization can restrict the habitat of many species.

Differences in bird densities emerge in forest canopy birds or birds which nest in standing dead trees or feed on species in dead standing snags. Old growth is important to these species. But second growth can also be managed to provide snags and cavity-nesting species of birds. Some species such as Spotted Owl only appear to occur in old growth forests.

The marbled murrelet, a sea bird which nests in large coniferous trees, seems to be totally dependent on old growth forest for nesting habitat. The populations are currently abundant but are dependent on old growth forest which is rapidly disappearing.

White-tailed deer also seem to be dependent on old growth forest for winter range. Equally important to the issues of old growth preservation is how the other forests, second growth and silviculture plantations, are managed.

Discussion of Nuszdorfer and Siep presentations

The question was posed about the location of old growth forests in Howe Sound. Fred Nuszdorfer indicated that almost all Coastal Western Hemlock areas (dry units) have been logged. At higher elevations, there are still areas of old growth moist sub-maritime Coastal Western Hemlock. In areas of lower elevation, there remain some stands of old growth which need to be preserved.

There were also questions about the number of harvests which can be supported before nutrients in the soil are depleted. Studies of nutrient cycling suggest that except for very sandy soils, nutrients will not be depleted provided that some organic material is left behind. The results from modelling third rotations are less reliable.

In response to questions, Dale Siep stated that the marbled murrelet nests during June to August. The fate of species which thrive in clearcuts when succession takes over is unclear; some may be displaced. The proposal to log next to the ecological reserve, depending upon light penetration on the habitat edge and increased predation, could change wildlife use. A 200 m buffer strip was suggested, although public use will also affect the reserve.

Dioxin Mediated Shellfish Closures in Howe Sound

Mike Nassichuk, Department of Fisheries and Oceans

Abstract

In early 1988, a monitoring program was initiated to document the presence and concentration of dioxins and furans in aquatic organisms near British Columbia pulp and paper mills. Preliminary data on dioxins and furans in selected finfish and shellfish from Howe Sound indicated that elevated levels of certain dioxin and furan congeners were present in prawns and in the hepata pancreas(digestive gland) of Dungeness crab. Subsequent and more intensive monitoring led to the closure, in November 1988, of a portion of Howe Sound near the Port Mellon and Woodfibre pulp mills to all harvesting of prawn, shrimp and crab. In June 1989, the shrimp and crab closure to all user groups was expanded to include an additional part of the Sound in the vicinity of Keats Island and all of Howe Sound was closed to commercial crab fishing. A consumption advisory was also issued recommending that the hepatapancreas of crab taken from that portion of Howe Sound open to recreational or Native harvesting not be consumed. Monitoring of aquatic organisms in Howe Sound is continuing and results obtained will be used to determine when areas closed to fishing can be reopened.

Presentation

Mike Nassichuk, Department of Fisheries and Oceans

The program for monitoring dioxins 2, 3, 7, 8 TCDD and furans 2, 3, 7, 8 TCDF near pulp mills in Howe Sound has provided data on the contaminants in softshell clams, prawn, crab muscle, crab hepata pancreas and rockfish. The monitoring began in May 1988 and led to prawn, shrimp and crab harvesting closures. Typically TCDF has been higher than TCDD near pulp mills.

Tests on crab hepata pancreas led to closure of all crab fishing in the upper part of Howe Sound and Thornborough Channel. The monitoring in 1989 again revealed high levels in shellfish. All commercial crab fishing was closed in Howe Sound. Whether closures will continue depends upon the

persistence of dioxins and furans and the extent to which sedimentation buries the accumulation of contaminants. New dioxin regulations are to be issued very soon.

Health Hazard Assessment of Dioxins and Furans

Bev Huston, Health and Welfare Canada

Presentation

Health advisories are issued based on contaminant data and consumption factors. The significance of chemical residues in food depends upon the toxicity of the contaminants and the likely human exposure to these.

Dioxin is highly toxic to some test species and much less toxic to others. Exposure to sub-lethal doses of 2, 3, 7, 8 TCDD shows similar symptoms as acute effects. There is also a dose below which no effects can be observed. Basic studies also show that these compounds are not mutagenic. There are less data on TCDD but comparative studies show similar effects.

Toxic equivalency factors (TEF) have been used to assess the relative significance of contaminant levels. 2, 3, 7, 8 TCDD has an equivalency factor of 1 and other congeners are rated in relation to this. A safety factor of 100, in terms of total equivalency units, is generally used to determine the tolerable daily intake (TDI). For the purpose of calculating exposure, it is assumed that on average, 40g/day of fish is consumed by regular fish eaters, and an average of 20g/day for eaters of crab hepata pancreas. Consumption of crab hepata pancreas from crabs harvested in Howe Sound would considerably exceed the Tolerable Daily Intake (50 times more) and therefore a health advisory has been issued.

Discussion of Nassichuk and Huston presentations

The discussion noted that results can differ with individual animals tested, such as the variability in 1989 crab muscle data. Some two-thirds of the 1990 crab data were within Health and Welfare limits. The extent of contamination in Howe Sound is generally understood; the use of a composite sample with an average 20 crabs for testing is being considered. Knowledge of cumulative and synergistic effects is weak and it is more difficult to isolate cause and effect.

There is no evidence of elevated dioxin levels in Georgia Strait adjacent to Howe Sound. There does not appear to be any concern over the dispersal of contaminants into Georgia Strait.

There are uncertainties as to whether crabs migrate in to and out of the region, but some migration is suspected. Only a small portion of Dungeness crab populations, for example, appear to migrate any more than a few kilometres. The question of effects on higher levels in the food chain - marine mammals etc. was posed. There appears to be no evidence and little knowledge of sub-lethal effects on many species and the ecological significance of the contaminants.

October 3, 1991 - Afternoon Plenary Session

Chairman: Mike Dunn, Canadian Wildlife Service

Mike Dunn (CWS) presented a framework for addressing the issues in Howe Sound. Three questions were presented:

1) What are the critical/essential elements of the Howe Sound drainage and ecosystem that we require to ensure sustainability?

2) What are the critical/essential elements that we require to support the resources and to ensure their long-term availability?

3) What are the critical/essential elements to assure cultural diversity?

He argued that when we analyze a system in isolation, we seriously compromise any useful understanding of how to achieve sustainable development. Three elements of a sustainable approach are reciprocity (e.g. no net loss of "natural capital"), symbiosis (e.g. collective/inter-related knowledge), and integration (e.g. interdisciplinary communication of common problems).

Carl Amos (Bedford Institute) presented some experience from the task force reviewing Bay of Fundy tidal power development. Two unpredicted problems arose - high fish mortality through turbines and siltation creating a loss of shellfish. Their major shortcoming was in attempting to study the impacts in a static context.

The scientific community failed to forecast the severe adverse effects of the project. EIA (Environmental Impact Assessment) is often based on simplified models of the real world which create a false sense of security in understanding ecosystems. The important aspect is that knowledge of the components can be well defined and mappable, but in contrast, the transformation functions (the arrows between the boxes) are not so well defined. The processes of transformation should be the focus of evaluation. Studies are needed which consider solutions oriented to decision needs, which address fate and significance of effects, and which monitor the accuracy of predictions.

The redesign of the management approach in the Bay of Fundy was based on:
- measuring all of the parameters considered to be important, on the same space and time scale;
- constructing an interpretation of the nature of the processes;
- not attempting to describe the environmental or to predict impact but rather to establish a process of self-education and experimentation in a multi-disciplinary approach.

Discussion of Dunn's presentation

The discussion began by attempting to identify the important components of the Howe Sound environment. It was suggested that a clear definition of the problem or the goal is needed to develop an approach to Howe Sound. A proposal to characterize the overall Howe Sound ecosystem was questioned as to its usefulness and a more problem-oriented focus was suggested. Is the environment being sustained and if not how can it be? One view on the approach was the need to define how the environment operates; another view focuses on addressing some selected issues.

The Ministry of Environment, Lands and Parks' program to define ambient water quality objectives and to address the major factors perceived to be degrading environmental quality (mills, acid mine drainage, estuary development) was suggested as a core focus for management of Howe Sound. Ben Kangasniemi (MOELP) noted that the process is to have an environmentally-driven, ambient perspective as opposed to the traditional approach of focusing on the capability of industry to control effects on the environment. Links are needed to industry and the science must assist with applied knowledge to better understand the effects of loadings on sustainability.

The general questions were framed as:
- What do we know?
- What do we need to know?
- What can we do with what we know?

Another set of questions are:
- What is required to sustain the "natural capital"?
- What is required to restore the "natural capital"?
- What are the specific problem areas?

An initial list of critical problems and research needs was attempted:

a) inadequate database of geological information and mapping;
b) other nonpoint sources of pollution;
c) toxicity of copper in the marine environment;
d) localized mineralization (sulphides, etc.) and how to manage;
e) cumulative nature of impacts and recovery potential;
f) assimilative capacity of the Sound;
g) residential and recreational development pressures;
h) tidal patterns and oceanography in the outer Sound;
i) indicators of the stress gradient;
j) sharing of data sets and sampling sites;
k) GIS database;
l) catalogue of research activities

Considerable discussion of the word "sustainable" took place. What are we sustaining? Ben Kangasniemi (MOELP) argued that we should consider our goal to be one of protecting and enhancing instead of sustaining. Mike Dunn felt that we should not ignore the bigger goal. Brian Ridell made the point that even if you did not exploit Howe Sound, you probably will not maintain what you have. Bernie Claus asked what we needed to do to sustain the natural capital.

John Stockner made the comment that although half of the papers dealt with geology, birds, forests etc., what is ultimately impacted is Howe Sound. What we need most is to know if Howe Sound is assimilating what we do to it in a basin sense. He recommends that from an aquatic science perspective to know how Howe Sound is coping we need to know more about the state of surface water quality today. In addition, we need to know what is the best use of Howe Sound today, forty years ago it may have been log storage.

Jeff Marliave referred to the lower Sound as a black box needing more understanding. Mike Dunn pointed out that besides water quality, another major gap was the atmosphere issue in terms of deposition. Walt Cretney added that the dioxin problem must be followed because when pulp mills "turn off the tap" for effluent borne BOD and dioxins, sludge from secondary treatment will be burned so we need to pay more attention to atmospheric fallout and transport. There is a follow-up need to keep looking at the long-term source. There was general consensus that Howe Sound needed a management plan.

The general recommendations for the follow-up program are:

1) To assist Ministry of Environment, Lands and Parks water quality objectives program as a nucleus for a comprehensive and collaborative approach to research.

2) To establish a network of contacts and a newsletter for improving communication.

3) To use the SOE reporting process as a vehicle for a more collective approach.

4) To establish a scientific advisory committee which will consider:

- sponsorship of multi-disciplinary research,
- flagship projects to focus research, and
- opportunities for participation in the Forestry Canada model watersheds program.

5) To hold another conference in two years which will report back on progress, in conjunction with ongoing state of the environment reporting.

PART II

SUMMARY OF HOWE SOUND WATERSHED ENVIRONMENTAL SCIENCE PUBLIC MEETINGS

Gibsons - October 22, 1991

Panel:

Bob Turner (Geological Survey of Canada) (Moderator)

Mark Graham (Vancouver Aquarium)

Ray Marsh (B.C. Ministry of Health)

Mark Roseland (UBC)

Barb Dabrowski (B.C. Ministry of Environment, Lands and Parks)

Mark Wareing (Western Canada Wilderness Committee)

There were 25 members of the public in attendance.

Bob Turner described the important objectives of the forum, including hearing from the audience. One of the purposes of the program is to assist input into a state of the environment report on Howe Sound. Each panelist had been asked to address the question of the current state of the Howe Sound environment.

Tim Turner presented an overview using slides, of the characteristics of the watershed and the issues confronting the Sound. He described the manner in which the watershed processes structure the character of the Sound. He showed how the watershed functions in an integrated manner; what happens in the upper watershed influence what happens in the lower portions. The physical parameters are important in determining weather, vegetation, hydrology and soils. He presented various examples of how the biological systems are shaped by the physical functions of the watershed.

There are two volcanoes of note, Mt. Garibaldi and Mt. Cayley. Evidence of volcanism occurs throughout the Sound. A tremendous amount of tectonic movement has influenced the formation of Howe Sound and the glacial history of the watershed is apparent in the many geological features. The role of forests is significant in controlling the complex relationship in the watershed. The tidal influence in the marine environment determines the vertical zonation of shoreline biological communities.

Tim described some of the historical changes in the environment of Howe Sound. Various contemporary issues relate to waste management, hydro power development, forestry, pulp mills,

estuary management, mine pollution and flooding and landslide hazards. Some of the questions and research presented at the scientific workshops were described. The question remains to what extent the resource industries and development are environmentally sustainable and what the long-term future of the watershed will be.

Bob Turner summarized the inter-disciplinary nature of the workshop and the results of the decisions. A commitment was made to the establishment of a scientific Committee dedicated to fostering an integrated approach to scientific research in Howe Sound. He noted that a field guide was prepared and is available; a set of proceedings summarizing the workshop and the public meetings will also be available in January. Reference was also made to the purpose of the state of the environment report and the role in influencing government decision-making. The sponsors of the public sessions were acknowledged:

- Energy Mines and Resources: Geological Survey of Canada
- Environment Canada: Atmospheric Environment Service, Conservation and Protection, Canada Parks Service
- Department of Fisheries and Oceans
- B.C. Ministry of Environment, Lands and Parks
- B.C. Water and Waste Association
- Canadian Geographic Society
- Canadian Geological Foundation
- Canadian Society of Zoology
- Chemical Institute of Canada, Environmental Division
- Vancouver Aquarium

1) Mark Wareing, Western Canada Wilderness Committee

Mark Wareing explained his forestry experience and familiarity with Howe Sound. He noted that 120 years ago the Howe Sound Whaling Company was harvesting humpback whales in the Sound, but they were out of business after 3 years as a result of over-harvesting. Our current system is not operating in a sustainable manner and we need to overcome the denial stage. The present societal blueprint does not respect the life support system; this concept of a life support system is central to maintaining ecological capital. We belong to a system which does not give sufficient recognition of ecosystem functions. We need to recognize these functions, and not only the commodities produced. This means switching from an anthropocentric view to a biosphere view. If the life support system is altered, the natural processes are often aggravated.

We need a 30-year action plan to shift toward a sustainable strategy. The life support system is also central to maintaining jobs and economic development. Forestry practices should be habitat-constrained rather than commodity-constrained. .

2) Barb Dabrowski, B.C. Ministry of Environment, Lands and Parks

Many of the issues may be related to policy rather than regional operations. The regional office is responsible for issuing permits, which are amended on an ongoing basis as knowledge and information evolves. The policy is established by headquarters in Victoria. The permits issued by Ministry of Environment involve effluent, emission, and solid waste discharges.

3) Mark Roseland, UBC

Elections can be used as a process of social learning. The recent election had a conspicuous lack of discussion on the issues of sustainable development. There are at least 80 definitions of sustainable development, but each have at least 3 elements:

- the need to re-integrate environment and economy;
- the inescapable commitment to the idea of social equity; and
- development cannot be viewed simply as economic growth; sustainable development is a different kind of growth.

Mark referred to a checklist he had prepared to determine "how sustainable is your community?".

4) Ray Marsh, B.C. Ministry of Health

With respect to health, the concern is with the absence of physical disease, but also with mental and social well-being. Humans are the main focus of our management efforts, but they are also dependent upon the material environment. Ray stated that the impact of the environment on physical disease is either virtually non-existent or non-measureable, while the impact on mental and social health is considerable. One of the major problems is a lack of local control and a lack of trust in local authorities. There seems to be a lack of trust in rational decisions; politicians appear to often lack factual input and are more interested in emotional responses to issues. One possible solution is the concept of a centralized clearing house to coordinate research and information collection.

5) Mark Graham, Vancouver Aquarium

The environment of Howe Sound is changing as far as the animal communities are concerned. In the 1970s, scientists predicted eutrophication of Howe Sound which in fact did not occur. Mark noted a Fall plankton bloom, identifiable by brown colouring, has appeared in Howe Sound. A pattern of large plankton blooms appears to be developing and needs to be monitored.

The sedimentation processes are also important as many pollutants get buried by this sedimentation. Mark also noted that herring spawning areas are being disturbed by log booming grounds and by natural sedimentation processes. The chinook and coho populations have declined dramatically; many of the important estuary marshes are being covered up by sediments or otherwise disturbed. Some stocks are also increasing while others are declining. The choices regarding maintenance of species diversity are important issues confronting Howe Sound.

Discussion of Wareing, Dabrowski, Roseland, Marsh and Graham presentations

A resident at Granthams Landing asked about permits issued for pulp mills and the extent of policing. Barb Dabrowski explained the pulp mill regulations; the requirements for monitoring and the Ministry's spot (unannounced) sampling operations. For air discharges, the permittees supply the Ministry with monitoring data.

A resident asked whether the discharge from the mills is greater than the Sound can take. He does not observe any fish jumping, bird feeding etc. near his residence on Thornborough Channel but on the outside of the Sound, this activity appears to occur. Mark Graham stated that there can be significant variability between sites. We do not know if the Sound is being adversely affected. Recently, a water quality monitoring program has been initiated which should assist in defining trends.

Another resident asked about the possibility of devising a strategy for sustainable development. Mark Roseland noted that it has been done elsewhere. Another resident suggested strongly that we need to include the politicians in this discussion. How is a state of the environment report to be used? It can be used to pressure politicians toward action. The objective is to have a better knowledge framework to guide decisions.

The Mayor of Gibsons asked about how the funding operates and how it is integrated in the Howe Sound program. Bob Turner explained the funding sources for the current program of public workshops. He suggested that the Scientific Advisory Group could serve to coordinate the data

collection process and research; in terms of public interest groups, the process brought together a network for information-sharing.

Gordon Wilson (MLA) referred to the limits to growth which need to be recognized. In recognizing the holistic perspective it is sometimes necessary to say no to development. There is a real difference between what constitutes economic development and what constitutes quality of life.

Mark Wareing referred to the proposed land use strategy and the need for a comprehensive biophysical inventory. Ecological capital equals economic capital. Stage 1 of the process should be to determine what harvest is sustainable. We need a long-term plan for sustaining the life support system. Mark Roseland stated that we can plan to achieve sustainable goals. The State of Oregon has a model process for a land use planning program driven by a comprehensive set of goals.

Tim Turner noted that the concept of sustainability has not yet been adopted in the educational system. It needs to be fully recognized as part of the education process.

Another resident pointed out that the public is often more interested in their individual economic concerns than the environment. He referred to a public meeting on government restructuring which received a high turnout. Bob Turner noted that information dissemination is essential. The historical images of the changes which have occurred over the past decades can act as a strong catalyst to public interest. Mark Graham also referred to the need for effective public involvement programs.

A resident of Port Mellon referred to the leaching problem at the pulp mill landfill and the Hillside site, with runoff leaching into Howe Sound. The Bayside area is a particular concern, as is the 1978 permit for the mill's landfill site. Barb Dabrowski referred to various operating practices for handling leachates. A representative from the pulp mill referred to the design criteria and the new arrangements for recovering and collecting leachates from landfills.

Barb Dabrowski noted the relative scale of the leachate issues; the future of the landfill site is important in short-term management decisions. The Woodfibre landfill for example, is designed on stricter criteria than earlier landfills.

Bill Henderson from Gibsons referred to the organization of an environmental management strategy and the example of the "Hazelton Charter". Mark Wareing described the philosophy set out in the Charter, a community-based approach to sustainable resource use and economic stability. It reflects a worldwide pattern which focuses on the need to operate self-sufficiently. The Hazelton

Charter provides a clear vision for the future of the community and the local environment based on locally-managed, autonomous units.

Tim Turner noted the absence of leadership in recognizing the need for a sustainable approach to environmental management.

Jim Gurney of the Sunshine Coast Regional District supported the need to view Howe Sound as a unit. There is a concern that planning and studying can be used as an excuse for inaction. For example, the waste management group recommended various actions which are still being evaluated. Ferry sewage still discharges into Howe Sound. Many things can be done right away.

Mark Graham referred to the many signals in the environment which should be recognized as an indication that problems may be occurring. Gordon Wilson noted the approved dumping site in Thornborough Channel in Howe Sound and Strait of Georgia, and the need to include Environment Canada in this review process. The discussion focused on Thornborough Channel and the degree of pollution from ocean dumping which has been occurring.

A resident referred to the need for local control over permits. Jim Gurney described the responsibility of the Regional District. There is a need to manage the environment according to a watershed framework. Gordon Wilson pointed out the earlier discussions of a watershed approach in Howe Sound, which could provide a starting point. Bob Turner asked about the regional planning approach which could be used. There needs to be an arrangement within which a watershed approach can be established.

A resident suggested that society needs to separate wants and needs, and to reconsider priorities. He has seen great strides in cleaning up the air quality associated with the pulp mills in Howe Sound.

Another resident expressed concern about the whole log dumping and its effect on water quality. Mark Graham described the physical effects on habitat of dumping and secondly, the use of chemicals to treat logs which can be harmful to water quality and biota.

Tim Turner asked about the initiative for local round tables on the environment. Gordon Wilson explained the example of the Sechelt Inlet plan, with area designation, dispute resolution, etc. which could provide an alternative model to the round table approach.

Mark Wareing noted that the most prevalent influence is forest practices and the high cutting rates which need to be made accountable. There should be greater recognization of the limited supply of old growth stands and the need to involve the Forest Service in a new approach to sustainable development in Howe Sound.

Barb Dabrowski supported the need to develop cooperative approach and to promote the concept of a watershed region. Better relationships with local areas is needed in resource management. Some suggestions were made about whether an even broader approach might be appropriate. Various forms of liaison between watersheds are possible.

Bob Turner thanked the panelists and the audience for their participation.

Whistler - October 29, 1991

Panel:

Colin Levings (Department of Fisheries and Oceanc) (moderator)

Bob Turner (Geological Survey of Canada)

Ray Marsh (B.C. Ministry of Health)

Frank Baumann (Geotechnical engineering consultant)

Mike Wong (B.C. Ministry of Environment, Lands and Parks)

Oliver Thomae (B.C. Ministry of Forests)

Mark Roseland (UBC)

There were 28 people in the audience.

Colin Levings introduced the members of the panel and Tim Turner (consultant), the organizer of the public sessions. Tim Turner then provided an overview of the major physical and biological features of Howe Sound, as a context for the discussions. Using slides, he described the dynamic nature of the watershed. The focus of his presentation was to highlight the interactions between air, land and water which occur in the Howe Sound watershed; and how human activities affect the Sound.

Bob Turner explained the basis for the Howe Sound Watershed Environmental Science Project. The overall goal is to promote sustainable development and environment. The focus of the workshop and public process is to collect and share scientific data to promote interdisciplinary discussion and a wholistic approach to managing the environment. The workshop established a network of scientists and created a scientific advisory group. The various products being produced include the field guide,

the summary of proceedings, a technical volume of scientific papers and a framework for a state of the environment report.

1) Ray Marsh, B.C. Ministry of Health

Ray Marsh described his professional focus on the health of people rather than the environment in itself. Public health officials have to cope with both physical health problems and perceived problems. The environment provides a context and a source of health issues and is therefore important to health professionals.

He noted that people inevitably change the environments they inhabit. Humans are a very different part of the ecosystem, and environmental impacts are a people problem. Ray suggested that the concept of local control, involving a partnership between the public and existing management institutions, could provide the basis for new approaches to managing the environment.

2) Frank Baumann, Geotechnical engineering consultant

There are some unique hydrological and slope hazard characteristics of the Howe Sound watershed. These include (1) unstable volcanic soils associated with active volcanoes in the region, (2) glaciers which have left steep slopes and sediments high up in the valleys, (3) heavy rainfall which affects slope stability and debris flows, and (4) high human use (logging, transportation, etc.)

Frank noted the four major landslides which have occurred in the area and the innumerable small landslides. He suggested that the geotechnical hazards should be addressed through:

- a more pro-active approach which identifies and addresses problems in advance rather than reacting to events,
- better public access to information such as a Freedom of Information Act, and
- recognizing the "good news" that only a few areas have severe hazard limitations and that alternative land uses are often possible on some hazardous lands.

3) Mike Wong, B.C. Ministry of Environment, Lands and Parks

The focus of the Environmental Protection Division is to control and manage waste so as to protect the quality of air, water and land. The Howe Sound environment has very sensitive ecological systems which require protection.

Mike described the new directions which are evolving toward pollution prevention and the "four r's" - reduce, reuse, recycle and residuals management. The management of ecosystems such as those in Howe Sound requires a more cooperative partnership between industry, the public and government agencies. He noted the considerable progress in reducing pulp mill pollution.

4) Oliver Thomae, B.C. Ministry of Forests

Howe Sound watershed has a unique physiography and climate that govern the environment of the area. At least one-half of the area is ice, snow and rock. There are active volcanic processes, moderating marine climate and other physical characteristics which influence the environment. Within the watershed, there are nine biogeoclimatic zones; some 40% of the area has been logged and about 10% lies within protected areas. Urban uses, are rapidly reducing the forest land base. Fire has been controlled well beyond the natural level.

In terms of pathology of the forest, the watershed is in reasonably good condition.

Tree diseases have been generally controlled. From an integrated resource management perspective, the forests have been able to provide for a full range of multiple use demands. The health of the forest industrial environment however is under stress due to market constraints, changing technology, difficult terrain, reduced land base, etc. Habitat and species diversity has generally been provided for whereby the habitat requirements of most species have been met.

Society has placed enormous demands on the forest land base. The process of managing for timber, wildlife and other values, however, can address the needs of all forest uses.

5) Mark Roseland, UBC

Environmental issues can be viewed from the perspective of social learning. The Brundtland Commission promoted the concept of sustainable development. There are at least eighty definitions. The main elements of sustainable development are:

- a need to re-integrate the economy and environment,
- a commitment to social equity, and
- a recognition that development is more than growth

Mark reviewed a checklist for determining "how sustainable is your community?". He offered the concept of "natural capital" as a central focus to the design of a sustainable development approach. There is a finite ability to exploit resources without undermining their sustainability. Is the community's natural capital being managed such that it will provide for future generations or is it being drawn-down Financial capital may make us rich but it will not keep us alive.

6) Bob Turner, GSC

Some of the major highlights of the scientific workshop include:

a) Britannia mine pollution - metals contamination and acid drainage is occurring and creating a kill zone off Britannia Creek.

b) Britannia mine tailings dumped offshore - metals in sediments are stable and do not appear to be a source of pollution.

c) pulp mill effluent - effect on benthos and water quality; the worst damage is over but the pollutant legacy is unclear; the extent to which contaminants are being buried and their bioavailability is uncertain, but there is evidence that bivalves and fish are under stress adjacent to pulp mills and that elevated levels of dioxins and furans are occurring in birds at the top levels of the food chain.

d) salmon stocks - dramatic decline has occurred in chinook and coho, which could be a result of habitat disturbance and overfishing.

e) timber harvesting - effects on riparian habitat and old growth habitat for certain species.

f) hazard lands - continual occurrence of flooding and slides, with reactive rather than pro-active programs.

Colin Levings invited questions and comments from the audience.

A resident asked Dr. Marsh about the impact of industrial uses, the effects on human health and the possible use of indicators in the environment. He agreed that the environment can serve as an indicator. The constraints to multiple uses need to be recognized, such as the use of water supply areas and the resultant need to add disinfectant in order to control the effects of sedimentation on water quality.

He pointed out that lifestyle factors often overwhelm the effects of industrial pollutants on health. There is no evidence that local air pollution creates higher levels of lung cancer, but there are nevertheless numerous questions about the effects of pulp mill emissions. They are initiating a local program to address the public health air pollution issues in the Gibsons area.

A resident suggested that the Howe Sound area has a high incidence of respiratory diseases and that the air emissions from the pulp mills should receive greater scrutiny. Dr. Marsh described the problems of interpreting the survey work done by the Cancer Agency of B.C. and the lack of evidence indicating that lung cancer incidence is associated with environmental factors.

Mike Wong stated that we should be able to restore environmental quality but the process is slow. Society is demanding quicker, stronger actions. He referred to the installation of secondary treatment at pulp mills. Monitoring studies at outfalls have shown that crabs and other life do return and that dioxins do diminish with time.

Ray Marsh also noted the slow progress in water quality improvements. Dioxins and furans in particular, do not break down rapidly in nature. While there are few examples of effects on humans, it is prudent to stop their accumulation in the environment.

A long-time resident of Howe Sound described the changes in fish abundance and other observable indications of declining environmental quality. He asked about possible indicators. Oliver Thomae referred to biodiversity indices measuring the number and complexity of plant species, and survey data on wildlife habitat and abundance. Mark Roseland noted that indicators tend to measure known phenomena and do not deal well with the unknown. He suggested a focus on ecological integrity and referred to the 12 categories of indicators in his sustainable community questionnaire. He also suggested indicators should be an expression of the values of the community.

A resident referred to urban development and planning studies which have failed because so many variables are held constant and unrealistic assumptions have been made. She referred to environmental assessment procedures as a possible tool in the development review process. Mark Roseland also suggested the concept of "sustainable administration" and noted the use of an "eco-counsellor" in some European communities to provide preliminary advice to developers.

Another resident asked whether the forest industry could incorporate the concept of natural capital. Oliver Thomae referred to the historical changes in the declining forest land base and the fact

that the timber cut has not been adjusted accordingly. The harvest is likely to be reduced by 50% over the next twenty years. Intensive management strategies can only offset this reduction to a limited extent.

A comment was made about powerful interests which dominate community decision, and which inhibit sustainable development. Another resident asked about the impact of skiing development on water quality. Ray Marsh referred to some questions about the production of artificial snow and its possible effects. Frank Baumann noted the U.S. requirements that all water supplies be filtered, while few such requirements are imposed in B.C. Ray Marsh described the origins of the U.S. EPA regulations where lower levels of risk have been adopted.

A resident referred to the other "r" responsibility. He advocated the need for more educated decisions. Mike Wong described the considerable soul searching about public concerns and the need for new partnerships with the public and industry. A resident suggested that a greater lead role by the public and consumer awareness is an important aspect. Mark Roseland noted the use of procurement policies as a means of local leadership. A resident stated that government should provide more incentives to encourage public use of more environmentally friendly products.

Colin Levings referred to the interest in greater local environmental plans and decison-making and suggested that these should also be linked with a larger watershed management context. He thanked the panel and the audience for their participation and closed the session.

Howe Sound Senior Secondary, Squamish - November 5, 1991

Panel:

Chris Pharo (Environment Canada) (Moderator)

Mike Wallace (B.C. Ministry of Forests)

Frank Baumann (Geotechnical engineering consultant)

Mark Roseland (UBC)

Brian Clark (B.C. Ministry of Environment, Lands and Parks)

Ray Marsh (B.C. Ministry of Health)

Mark Wareing (Western Canada Wilderness Committee)

Bob Turner (Geological Survey of Canada)

There were 40 people in attendance.

Chris Pharo introduced the members of the panel. This was followed by Tim Turner's slide show presentation of the physical, biological and geological characteristics of the Howe Sound and the use of its resources.

Bob Turner gave an overview of the process. He explained the purpose and the basis for the Howe Sound Watershed Environmental Science Project. The purpose of the process and the workshop is to gather information for the basis of a wholistic and interdisciplinary approach to decision-making. The major question is how to manage the Sound in a sustainable fashion. The technical workshop established a network of diverse disciplines for improved scientific communication; and a scientific advisory committee to make recommendations on environmental concerns. The major concerns identified at the workshop were:

- Britannia mine effluent - copper contamination
- pulp mill effluent and atmospheric discharges
- salmon stock declines - chinook and coho
- overharvesting of timber - limited amount of old growth forests remaining
- protection of estuary wetlands

Another outcome of the public meetings was the Environment Fair with many informative displays. There were approximately 400-500 students at the Fair.

1) Frank Baumann, Geotechnical engineering consultant

He focused on the question of slope hazards in the Howe Sound drainage basin and provided a commentary on it. Slope hazards include landslides, both major and minor ones, and also flooding. The reason for Squamish being a unique place for slope hazards is due to three factors:

1) Mt. Garibaldi and Mt. Cayley - both are highly unstable, with sediments left behind and both have steep slopes
2) High rainfall
3) High usage - there is a high level of resource use ranging from recreation to settlement

The issue we face is how to respond to natural events in order to avoid disasters. The current approach to environmental problems is reactive rather than pro-active. Pro-active measures may include zoning. Another issue is the Squamish River floodplain, the Cheekeye fan and problems along Highway 99.

2) Mike Wallace, B.C. Ministry of Forests

Mike commented on the status of the forests in the watershed. He used the analogy of forests as the patient. The condition of the trees is complex since they may be young, medium or old; and there are extremes of geography, soil types, climate and seasons. There are nine biogeoclimatic areas in the Howe Sound watershed. Of the total forest land base, over 70% is disturbed, 20% is not available to timber harvesting, and the remaining 10% not available. The condition of the patient is generally good.

There are a whole range of demands on the forest base, such as old growth, preservation, habitats, recreation usage, landfills and right-of-ways. Increasingly, the forests cannot meet the demands imposed on it: roads are becoming increasingly extensive in order to access more remote timber stands; recreational uses are intensifying, not just in winter but throughout the year.

The Soo Timber Supply Area Management Plan is to be updated for public review. A workable compromise has to be developed in order to achieve the goal of sustainable development.

3) Mark Wareing, Western Canada Wilderness Committee

Mark Wareing described how forest management can be improved. We must first overcome the denial stage and acknowledge what has been lost in the Sound. From 1869-1871, the waters of Howe Sound were the exclusive domain of the Howe Sound Whaling Company. All the humpback whales were exterminated. There were giant Sitka Spruce and grizzly bears in Cypress Bowl, which are now gone. We have lost many options. We have to stop clearcutting, roadbuilding and other activities which cause soil erosion. Radical changes such as longer rotations, alternative harvesting methods and natural regeneration are necessary. These options are available currently, all we need is the will to implement them.

4) Ray Marsh, B.C. Ministry of Health

Ray Marsh focused on the major public health issues in the watershed. The central issue is the prevention of disease and the quality of life within a multitude of conflicting interests. Those interests that bear upon economic interests affect the quality of life. The major task of the public is to address and rationalize these conflicts.

5) Brian Clark, B.C. Ministry of Environment, Lands and Parks

He discussed the major sources of contaminants in the Sound. There are five main sources:
- Howe Sound Pulp and Paper - under permit
- Western Pulp and Paper - under permit
- CanOxy - permitted
- Britannia mine - not permitted
- waste discharges from sewage treatment plants - under permit

Major contaminants:
- chlorinated organics including dioxins
- mercury
- metals - zinc and copper

Pulp mills in the Sound have secondary treatment, improvement in contamination is expected, but has yet to be verified. Mercury from the FMC plant used to be high in the 1970s, but currently it is no longer a problem. Britannia mine is still a problem. We need to define what levels of contaminants will not create a significant impact on the environment. Water quality objectives are being set to achieve this.

6) Mark Roseland, UBC

In applying the concept of environmentally sustainable development to the Squamish area, we should clarify the economic terms we currently use. While an improved standard of living can be defined as an increase in Gross National Product (GNP), it can also be seen as a decline in our purchasing power.

The pattern of economic growth and development we now follow is unsustainable, and the necessary alternative to it is sustainable development. This concept has its original underpinnings in the U.N. report on sustainable development. There are three crucial elements in this concept:
1) re-integrate the environment and the economy; these two components should be parallel
2) commitment to social equity
3) development is more than growth as measured by the GNP

Our natural capital assets are finite and non-renewable. The ability of the biosphere to absorb pollution is limited. We should ask ourselves whether our community's natural capital is being

managed in a way that allows us to live off the interest of our natural capital. Most people usually think only of financial capital; we must begin to reorient ourselves to a new way of thinking.

A question period followed the above presentations. There were about 40-50 participants.

A question was put to Mike Wallace on the amount of wood there currently exists. There are two major management units:

1) TFL 38 - management working plan for TFL (Timber Forest License) is under review. Currently the AAC (Annual Allowable Cut) is 263,000 m^3

2) Soo TSA - currently AAC is 705,000 m^3, in 1995 it will be 590,000 m^3 representing an 18% drop.

Further reduction is needed in order to accommodate further demands. The long-term objective in the Soo TSA is an AAC of 400,000 m^3 in order to achieve long-term sustainable yield. We also need to better define environmentally sensitive areas etc. We need to have a better understanding of forest resources and integrate this knowledge with other uses for better decision-making.

A participant was concerned about estuarine resources and the implications of the reduction of the land base of the estuary. Bob Turner stated that fisheries habitat biologists are concerned about the loss of land base for habitat, and in turn, the future of salmon stocks. Bob Turner pointed out that we need to look at the value of the estuary for everyone, not just for Squamish residents. We need to look at the larger system as a whole.

Brian Clark discussed the proposed Squamish Estuary Management Plan. We need to reach compromises on different areas; one way of achieving this is through a high level of public involvement and to commit some of the land base to conservation. The level of commitment required has yet to be determined by all parties.

A participant wondered if some small site uses may destroy options for future uses, e.g. Britannia mine. He also asked what types of industrial uses in the estuary would be permitted. Brian Clark replied that all industrial uses would have to fit into the management plan, and would have to undergo environmental impact assessments, therefore not just any industry could be approved.

Another participant commented on the question of sustainability. We have to look at the balance sheet and not only the income statement just as Mark Roseland suggested earlier. If we concentrate on income only, we will only deplete our natural capital assets even more quickly. Mark Wareing stated that we have to look at the ecological functions separately, to see what the role of each component is.

These functions have to be understood in order to generate long-term sustainability. By looking at each component, we can start maximizing the resources we have left. In the case of soil, massive clearcutting has escalated soil erosion. There is a need to impose management constraints to preserve ecological functions.

A participant commented that we have all the tools and know-how, all we need is a process and the will to put this in place.

Another participant was concerned about the pollution levels and the measurement of them. He stated that there is next to nothing to measure the extent of soil erosion from logging. Mark Wareing state that ecological impacts in a way are the same as economic impacts; there is a $100 million loss per year in soil erosion, escalating at a rate of $10 million per year. In order to prevent soil erosion and maintain fish and wildlife habitat, we need to better study alternative harvesting methods.

Mike Wallace commented that studies for the Mamquam watershed are completed. The terrain analysis provides a very good basis for study on problems from past practices such as road building, installation and ROW's etc. Although the area covered is small, the lessons learned are very important.

Mark Wareing pointed out that this is a classic example of denial because it endorses clearcutting on a continuing basis. Mike Wallace argued that they are looking at specific rates of cut. Mark Wareing suggested that we should be involved in the public process, the community should be more directly involved in this process. The pre-harvesting silviculture plan has to be examined block by block.

A question was put to Patrick Lucey (University of Victoria) concerning the relationship of pollutants to the density of water, since there are different levels of pollutants in the water columns. Patrick Lucey commented that pollutants do not follow any one type of gradient in the water column, it is more like a roller coaster. Most particles end up in the bottom of the river bed.

A participant noted that the issue of denial is not right, with us all needing to acknowledge the wrongs we have done. What can the average logger do? Mark Wareing answered that we have mismanaged the forests for a long time, and we have been exporting logs on a massive scale. We are now faced with a drought issue (no wood left to cut). Loggers should therefore not blame wilderness groups. We should focus on the mismanagement.

A participant asked how we could get the average person to give up his disposable income. Mark Roseland replied that the best way is through education.

A participant suggested that there is a general consensus on the poor state the watershed is in. The question we face now is not the availability of jobs, but whether we will have a watershed left. Another participant made a similar point of the need to change our way of thinking because resources are what we ultimately depend on for survival. We need to look at alternative logging methods, e.g. horse logging. It is not necessary to take a cut in disposable income.

Patrick Lucey commented on the assimilative capacity concept. Whether an ecosystem can bounce back depends on its resilience. Each ecosystem is different. There are many diverse ecosystems in the watershed, for example, the Cheakamus is very different from the Squamish. There is also a lot of natural variability. It is therefore impossible to extrapolate the conditions and responses of one area to another. Without understanding ecology, we will not have sustainable economics.

Mark Wareing suggested that the community needs to make up its mind about its future. Find out who the key decision-makers are. Forest companies have to start to become accountable to the community. They have to surrender their monopoly over forest practices, their power should be taken away through the democratic process. Communities should take the initiative to look for alternative sustainable plans, instead of relying on industry and government to act on their behalf.

The Director of the Save the Howe Sound Society suggested an initiative to start a round table on the watershed. Tim Turner noted that this issue also came up in Gibsons. There are three regional districts, three forest districts and three school districts. Dan Cummings of Squamish-Lillooet Regional District said they could look at the round table concept. Area D in the Squamish-Lillooet Regional District is the bulk of the area of the watershed. Regional districts are the receptacle for difficult environmental problems, such as solid waste disposal. Although regional districts have little environmental control, they can play a role in information exchange.

An employee of the municipality commented that we are always looking for someone to solve our problems. It is time to act collectively, as no one person or group can produce the answers to our complex environmental problems. We must also think about the consequences of inaction.

A participant asked about the type of ongoing mechanisms there are. Bob Turner stated that for the Scientific Advisory Group, the network could be extended to include industry and the public. This would help to identify key problems, notwithstanding the complexity of the system. Also this could

promote information sharing. Chris Pharo talked about the State of the Environment public reporting process.

A participant asked about the possibility of a data bank or clearing house for studies of the watershed. A member of the panel answered that the data should be available in public libraries. There was a comment on the need to have someone or a group to drive the process.

Mike Wallace stated that the Ministry of Forests has a tremendous amount of information, unfortunately this information is divided up among three different forests districts.

Patrick Lucey commented that ecology should be institutionalized like health, law and order and fire protection.

Mark Roseland suggested the formation of eco-counsellors in communities.

A question was put to Brian Clark about the basis of allowing 1.5g of organochlorines per tonne of effluent. Clark stated a preference for setting limits based on the assimilative capacity of the watershed. A Canfor employee replied that there is no scientific basis for this level.

A participant suggested that the Squamish Nation should be involved in this process, as they have a lot to offer. Bob Turner answered that they were invited to participate.

A participant asked how we could get over public apathy. Frank Baumann replied that we need a system of total public information to keep professionals and government people honest. Public involvement is essential in bringing this about. A resident commented that professionals like Frank Baumann should be directly involved. An information clearing house is necessary for complete information access.

Patrick Lucey pointed out the difference between our system and the U.S., our Ministers and regulators have great discretion in their decisions.

It was noted that the NDP has promised a new Forest Practices Act, and suggested that this should contain lots of "shalls".

Ray Marsh stated that "standards" are often misinterpreted. In the case of pollution levels, a piece of legislation could be misinterpreted as legalizing pollution up to a certain level.

A resident asked about the effects on human health from pollution in Alice Lake. Ray Marsh replied that there are multiple uses of the drinking water that supply the watersheds. There is insufficient data to support the multiple uses of these areas.

A resident commented that we need an integrated watershed management plan. Mark Wareing suggested this approach does not adequately address our problems; instead we should first define what is required to support the ecosystems and ultimately sustainability.

The session was adjourned at 10.00 p.m.

St. George's School, Vancouver - November 12, 1991

Panel:
Paul LeBlond (UBC) (Moderator)
Bob Turner (Geological Survey of Canada)
Tom Pedersen (UBC)
Dale Siep (B.C. Ministry of Forests)
Mark Wareing (Western Canada Wilderness Committee)
John Clague (Geological Survey of Canada)
Brian Clark (B.C. Ministry of Environment, Lands and Parks)
Al Colodey (Environment Canada)

There were 40-50 people in attendance.

Paul LeBlond (moderator), Department of Oceanography, UBC welcomed the participants to the session. This session is a two-way process which encourages open discussion and criticism from all sides.

Tim Turner (GSC) gave an overview, using slides, of the physical and biological features of the watershed and the human processes that affect it. Each of the panelists had a specific question to comment on.

Bob Turner explained the purpose of the workshop, the focus and the goal of the process. He stressed the importance of understanding past and anecdotal information and native communities. There are several important points derived from the public meetings. At Gibsons, it was mentioned that there were arbitrary administrative and political boundaries. It is difficult to manage watersheds

on an ecological basis given these boundaries. We have to look at the existing management plans, such as the Sechelt Inlet Management Plan, the Squamish Estuary Management Plan and Forest Management Plans. Schools in the region have been very involved in educating people about the issues in Howe Sound.

A resident asked about the source of funding for the Howe Sound project. He was told that the project was funded by Environment Canada, Geological Survey of Canada, Department of Fisheries and Oceans and private scientific societies.

1) Tom Pedersen, Department of Oceanography, UBC

Tom Pedersen looked at the consequences of mining at Britannia. The two major consequences are:

- acid rock drainage
- impact of mine tailings - 40 million tonnes of tailings in the bottom of Howe Sound

Acid rock drainage is caused by reaction of iron sulphide minerals, (pyrite - fool's gold) with oxygen in the presence of naturally occurring sulphide oxidizing bacteria. The result is a very highly acidic solution which dissolves other metal sulphide minerals. High concentrations of dissolved copper and zinc are produced, which are highly toxic materials. There are 80 km of mine tunnels, water is pouring through this constantly.

A question was raised about whether the acid drainage occurs only at the surface. The reply was positive, since bacteria needs high amounts of oxygen.

A resident asked what was happening to the underwater tailings. The reply was in the tailings there is a concentration of several hundred ppm of copper. As for chemical reaction with the tailings, analysis suggests that there is little oxidation occurring under Howe Sound. As for animals taking up the copper, there is not much impact from the deep tailings. However, the effect is very serious along the shoreline.

A resident noted the problem of seepage from shafts and the open pit. The reply was that from an engineering perspective, drainage water could be diverted away from shafts and then the acid drainage treated.

2) Dale Siep, B.C. Ministry of Forests

The major question we are faced with is how to balance conflicting demands. How they are balanced depends on the political will and public demand at the time. Profits and income could be maximized through harvesting. Improvement in management is also needed, such as visual impacts along the sea to sky route. The next ten years will see a reduction in the size of clearcuts and logging. As for fish, forestry guidelines are being applied to protect streams and fish habitat. Also increasing amounts of money are being spent on promoting biodiversity and on wildlife habitat protection. The past policy was that of liquidating old growth forests and waiting for second growth forests to mature. An Old Growth Task Force is in place, as it is recognized that there are intrinsic values in old growth. Forestry wilderness values and policies are now being applied in the decision-making processes.

3) Mark Wareing, WCWC

Mark Wareing argued that the real issues have not been addressed or debated. It is important to balance functions and uses. Soil, air, water and biodiversity must be maintained in order to preserve our ecological capital. We have permanently disabled the Howe Sound watershed. Species such as the Humpback whale and the giant spruce have disappeared from the watershed. The best way to control erosion is to maintain forest cover. At Fitzsimmon Creek, there is potential flooding from mudslides. Too often have we heard about denial and underestimation of the problems. It is time to stop the denial; we should not accept information from government and industry as presented. If we are to survive, we have to look after our watershed. Community plans are needed for properly managing the Sound.

A participant asked if there is any monitoring of debris from log boom dumping. Brian Clark replied that it is mostly a biological dead zone in those areas where dumping and booming have occurred continuously.

A member of Steelhead Society of B.C. noted that the landslide into Ashlu River took a company two months to investigate. Mark Wareing stated that the protection of steelhead is a mere token. We cannot have current AAC's and protect all other resource values.

A resident questioned why DFO does not charge polluters who damage fish streams. Mark Wareing explained that sometimes laws are not being enforced.

A participant asked if the non-bleaching pulping process is working. M. Jordan (Howe Sound Pulp and Paper) replied that there were one week of trials with good results, but the financial cost is very high.

A resident asked whether logging companies could spread out to more remote areas. Dale Siep explained that all commercial timber has been allocated, thus these companies cannot move elsewhere.

A resident wondered if it would be practical and wise to reforest as quickly as possible after harvesting to prevent soil erosion. Mark Wareing commented positively on the idea and also suggested that cutting patterns have to be altered simultaneously.

Dale Siep noted that all timber allocation and harvesting prescriptions are only done after full ecological assessment. For some areas, clearcutting is most appropriate for the regeneration of certain species. The major sediment sources are road building and not from logged slopes. The problem of partial cutting is the increased road system which in turn causes erosion. The critical point is to have another growth of trees on these harvested areas within ten years.

4) John Clague, GSC

John Clague focused on the issue of landslides and the types of problems they present. The causes can be both natural and human induced. There are basically three types of landslides:

- Rockslides

The smallest slides are little rockslides. These are very frequent and are very costly. The Ministry of Transportation and Highways is responsible for the scaling and bolting of slopes. These slides can be human induced, such as excavated slopes from highway construction.

- Debris flows

These are off the east flanks of Howe Sound, down hillsides onto debris fans. These are naturally occurring in most areas of the province. The high number of debris flows in the Sound has prompted us to ask whether logging and particularly road construction have exacerbated the problem. Human activity could have aggravated the existing natural conditions.

- Volcanic activity

These are large landslides off Mt. Garibaldi and onto fans. There is tremendous pressure to build on the upper parts of Brackendale fan and Cheakamus fan. These processes are naturally occurring, and risks have to be evaluated.

The most recent landslide was in 1855 off the barrier onto Rubble Creek fan.

Tim Turner asked whether the Fitzsimmons Creek slide was natural or human induced. John Clague replied that it is uncertain if the slope is in danger of collapsing. The same was said for the slope above Britannia. There is a need to constantly monitor them for possible catastrophies.

A resident asked if earthquakes have a role to play in slides. The response was positive, earthquakes will lead to increased rockslides.

5) Brian Clark, B.C. Ministry of Environment, Lands and Parks

The presentation focused on human wastes and discharges. In Whistler there is a tertiary sewage treatment plant. Most of the time, waste management permits are met. Downstream of Daisy Lake, there is tremendous algae growth with high phosphate content. In the Lower Cheakamus, this is affecting fish habitat. Currently there is no more development allowed, and thus no further discharge to the sewage treatment plant at Whistler. Proposed discharges must go into the ground, where conditions are often unsuitable, because of the rocky nature of the soil.

A participant noted that it is not economically feasible to use ion exchange to treat sewage (ortho-phosphate).

6) Al Colodey, Environment Canada

The presentation focused on pulp mill contaminants. Effluent from bleached kraft mills are complex mixtures with chlorinated compounds. B.O.D. - biological oxygen demand, T.S.S. - total or temporary suspended solids. Toxicity - effluents are subject to an LC50 toxicity test. AOX - absorbable organic halogen has a poor correlation with toxicity.

Impact is measured as loading (tonnes/day)/environment (dilution - assimilative capacity)

Loading changes (1981-1991 tonnes/day) in TSS and BOD. AOX of both (Woodfibre and Port Mellon) mills show a downward trend even though Howe Sound Pulp and Paper has increased production. BOD effects - solids - D.O. demand and toxicity can all affect organisms and the foodweb.

Dyes are used in effluent in order to know the spatial distribution of the effluent and where to perform further monitoring.

The dioxin levels in crab hepatapancreas have raised questions such as whether it is safe for human consumption, and whether the fish are healthy. With respect to fish health near pulp mills, there is very limited information on biological effects of mill effluent.

A resident asked about possible improvements from shifting from chlorine to hydrogen peroxide. Another resident asked how rigorous the standards for fish inspection are. The reply given was that the standards are quite rigorous.

It was noted that the switch to hydrogen peroxide-based pulp is market-driven. In Europe the change is brought about primarily by environmental lobbying.

The mills have initiated monitoring for dioxins and furans. Most of the effluent is free of these contaminants now. The monitoring is paid for by the companies, but is approved by the federal and provincial governments.

A question was raised about the lack of independent sampling. Spotchecks are done and an audit of sampling methods is carried out. A participant also raised a question about air emissions from Howe Sound Pulp and Paper. An employee stated that tests are ongoing and that there is a conversion to natural gas. Questions were also proposed as to whether it is safe to breathe the air in the mill area.

Paul LeBlond thanked the audience and the panel for attending and adjourned the meeting at 10.15 p.m.

Sentinel High School, West Vancouver - November 23, 1991

Panel:

Lionel Jackson (Geological Survey of Canada)

John Stockner (Department of Fisheries and Oceans)

Bob Turner (Geological Survey of Canada) (Moderator)

Mark Wareing (Western Canada Wilderness Committee)

Colin Levings (Department of Fisheries and Oceans)

Fred Nuszdorfer (B.C. Ministry of Forests)

Guy Dauncey (author)

There were approximately 75 members of the public in attendance.

Tim Turner, using slides provided an overview of the physical, geological and biological features of the Sound, and the environmental issues facing it. This was followed by short presentations by Panel members.

1) Bob Turner, GSC

He provided an overview of the purpose of the Howe Sound project. The main objectives are to promote information exchange and interdisciplinary discussions for wiser decision-making. To this end, a scientific workshop was held at Bowen Island, and a scientific advisory group was established to provide recommendations on environmental concerns. The major concerns identified at the workshop were:

- effluent from Britannia mine impacting marine life
- impact of pulp mill effluent and atmospheric discharges
- decline of some salmon stocks (chinook and coho)
- overharvesting of valley-bottom forests
- loss of habitat in the Squamish River estuary

The major publications from the workshop will be the proceedings of the scientific workshop and the public sessions. Another outcome of the public meetings were the information fairs with many informative displays. Environment Canada is examining the possibility of preparing a State of the Environment Report for Howe Sound next year.

The major themes from other public sessions include:

1) The decision-making process. At Gibsons, the question was how to use information for better decision-making. Also there is a need for administrative boundaries to be based on watershed boundaries. In order to achieve better collaboration, a local round table has to be established.

2) Scientific data collection dates back only a few decades and is limited in scope. Science is limited with respect to providing us with answers to complex environmental problems. Watershed residents have valuable information on species abundance changes over time based on their personal experience in the Sound.

3) Watershed schools need to incorporate study of the natural science, history and human use of the Howe Sound watersheds into curriculum. Langdale Elementary School and Sentinel High School have both adopted Howe Sound studies in student projects.

1) Guy Dauncey, author "After the Crash"

He posed the question: why is it important to think about things in terms of watersheds?

This is because ultimately everything is totally dependent on the watershed. Our ignorance of the environment is incredible, for example, we do not fully understand soils; this ignorance is leading us to self-destruction.

We have imposed our thoughts on the ecosystem, this is manifested in various political administrations. However, there is no logic in the management of resources. We must reorganize administrative boundaries along watershed boundaries. He briefly outlined two examples of local management: the Oyster River Management Committee on Vancouver Island brings together a network of major players and experts; the Village of Hazelton has produced a discussion paper on watershed stewardship.

2) Fred Nuszdorfer, B.C. Ministry of Forests

Fred Nuszdorfer focused his discussion on the status of forests in the Howe Sound watershed. A great deal of analysis on timber supply has been done by the Ministry of Forests. The major question they looked at was whether timber supply is sustainable. It is reported that the Weldwood TFL rate of cut is sustainable for at least 200 years. The major users of the forests are hunters and recreationists. Currently these demands on the forests are being met.

As for the question of biodiversity, we have the same species as 50 years ago. However, there are problems with age classes, some older trees are now lost. In higher altitudes, these ecosystems still exist. In lower elevations, there is very little mature timber.

3) Mark Wareing, WCWC

Mark Wareing's discussion was on the type of improvements needed for forest management in Howe Sound.

Howe Sound was once the home of humpback whales. Due to extensive whaling, they were completely eliminated. There are at least 3,000 species of lifeforms in the Howe Sound watershed, with the majority in the soil. We have very limited knowledge about them, yet we carry on with the exploitation and destruction of the Sound. We must stop denying the fact that damage has been done to the watershed. We now have the opportunity to rehabilitate and restore damaged ecosystems. We must use longer rotations and place a 150 year moratorium on clearcutting.

4) Lionel Jackson, GSC

He commented on the nature of slope hazards in the watershed. There is only limited information on landslides and the hazards from individual slides, and there has not been any comprehensive mapping of landslides or such hazards. Landslides occur when material moves down through debris torrents or flows, particularly on the Squamish Highway. This natural process results in the formation of delta fans at the mouth. Another natural cause is the formation of unstable or incompetent rocks, such as the Gambier rock group.

Large landslides have also occurred due to volcanic activity, e.g. the eruption of Mt. Cayley has led to three major slides which dammed up Squamish River over the last 3,000-5,000 years.

5) John Stockner, Department of Fisheries and Oceans

John Stockner gave an overview of the health of the Sound in terms of two dimensions: time and space.

In regard to the time dimension, the Squamish River used to be one of the major salmon producers on the west coast. In the 1970s, there was rapid industrialization in the Sound. In the 1990s,

we are seeing improvements in pulp mills, the mine closure and the estuary seems to be in the process of recovery from some industrial activity (i.e. mercury contamination).

As for the space dimension, Environment Canada has produced a publication in 1991 titled "The Health of Our Oceans" listing Howe Sound as among those bodies of water having suffered the worst assaults.

6) Colin Levings, Department of Fisheries and Oceans

The discussion focused on the status of salmon stocks, the status of the habitat and the information base for these concerns.

We must realize that salmon are harvested far away from the watershed. Coho, chinook, chum, pink, sockeye, steelhead and Dolly Varden char are found in the watershed. Chinook stocks are particularly low; chum are spawning in small streams even in Mill Creek in Woodfibre. The whole picture is not well understood. Although fresh water spawning areas have been mapped, interrelationships, such as flooding, are not well understood. For the estuary, there is a good information base on the habitat. The Sound in general is seeing an improvement in water quality.

The presentations were followed by a question period.

A member of the Squamish Nation Band read a five-page letter which has been sent to federal and provincial ministers. The letter reviewed the history of Howe Sound from the natives' perspective. The letter was critical of ongoing pollution and ecological damage in the watershed. It argued that the cleaning up of the Sound must involve the natives. Indian people have a right to fish in the Squamish River. The letter also discussed the impacts of the dam on fish in Cheakamus River. The letter queried how safe are the safety levels for the human consumption of fish and for whom are they safe. Currently mercury in crabs is 27 times the permissible level. Dioxin and furan levels in fish muscle and the Sound in general are elevated. The letter also criticized the Crown for being negligent in not safeguarding the occupants' right to clean air, land and water.

A participant asked Fred Nuszdorfer how we can ensure sustainable forests. The response was that the 200 year figure was just a model limit and hypothetical. Mark Wareing stated that the Soo TSA annual allowable cut is being reduced dramatically, which suggested that it is not sustainable. There is also a lack of a Management Plan in place for the TFL. Guy Dauncey commented that we have to look at the effects of harvesting on soil.

A participant asked what other marine life exists around pulp mills. John Stockner replied that the plankton communities are found near pulp mills now that the discharge has been moved to deeper water. There is no real discernable difference between these areas and the rest of the Sound.

A participant wondered if there are any laws in regard to unlogged strips along watercourses. Fred Nuszdorfer answered that there are guidelines for leave strips which are area specific. Research indicates that we need to leave larger treed areas near water courses. New guidelines are being developed. Very often guidelines are not abided by, in which case, tougher laws are required. Mark Wareing commented that the new government will be introducing a new Forest Practices Act. The old Fish-Forest Guidelines do not acknowledge how watersheds work. It is a picket fence mentality; what goes on in the headwaters of the watershed ultimately affects the estuary.

Tim Turner argued that we often refuse to accept individual responsibility because it is easier to target others. The question we should ask ourselves is whether we are prepared to accept a major reduction in paper and wood supply over the short-term.

A participant questioned who is responsible for implementing and upholding federal legislation. Dennis Deans replied that Department of Fisheries and Oceans is responsible for upholding the Fisheries Act and Environment Canada is responsible for enforcing pulp and paper effluent regulations. There are two fishery officers in Squamish who assist with enforcement. John Stockner stated that the Islands Trust also plays a role in enforcement.

A participant asked where the nearest colony of humpback whales was and whether they could be reintroduced to Howe Sound. Mark Wareing replied that humpbacks are found off Vancouver Island and Hawaii. He said it was unlikely they could be encouraged to come back to Howe Sound because of the poor health of the Sound.

A participant suggested that in order to achieve the goal of sustainable development, a regional round table (a consensus process) is the first step towards this goal. Mark Wareing expressed that local people acting at the local level will be the first step. We should look at our local life support system and the ecological capital. The functions of the land must be protected. There is also a need to define the optimum healing strategy.

Guy Dauncey gave examples of how sustainable development was being addressed in other places. The first step is to form a non-profit society, with a responsible Board of Directors. We should use

employment creation grants, teachers and retired experts. This group would be a vehicle for speaking out for the interests of Howe Sound. He challenged the audience to start right now by gathering names of those people who would join such a group.

A participant asked what the recommended methodology is for forest harvesting. Fred Nuszdorfer answered that clearcutting is still preferred in some areas. The cost of road building is very expensive, but is generally cheaper for clearcutting. There are some areas where selective logging can be used effectively. We need to find a viable alternative to clearcutting, such as in the case of biodiversity protection, selective logging may be required. Mark Wareing argued that these theories of clearcutting being the best harvesting method are not proven in reality. Selective cutting can be just as effective. Clearcutting takes a short-term economic perspective. If we can finance a dam over 50 years, we can certainly finance a road system for selective logging. We have to realize that the more we clearcut, the faster we will terminate all the jobs.

Lionel Jackson suggested that selective logging could increase sedimentation if more roads are built. Mark Wareing disputed this idea. He suggested that cable and skyline logging can be used, whereby the need for roads is greatly reduced.

A participant commented that we need to look at biogeoclimatic zones in order to determine harvesting methods. These decisions are not just based on economic factors. Clearcutting is required in some cases, otherwise monoculture will result. Road construction is a major cause of environmental problems. Fred Nuszdorfer stated that most of the logging prescriptions and road building requirements are based on the biogeoclimatic zones. We are now planting far more species than we used to; forest management has improved considerably. He said much of the wealth in the province is generated from the forest industry.

A participant expressed doubt that responsible forest management in the Soo TSA was occurring; the reason being a continuously falling AAC. Fred Nuszdorfer replied that traditionally it has been a political decision that old growth would be harvested to build up an infrastructure in the province. Presently there is more concern about the ecological values in the old growth forests. Mark Wareing commented that the biogeoclimatic system is good, however the prescriptions are not always based on these systems.

Tim Turner on behalf of Brian Giles in Squamish questioned why recent changes in land ownership in the Squamish estuary were not brought before the public in the formative stages. Dennis Deans (Chairman of the Coordinating Committee of the Squamish Estuary Management Plan)

answered that proposed land changes in the plan are merely concepts, it will remain a proposal until these issues are resolved and the plan adopted.

A participant criticized the lack of time to respond to proposed changes to the Management Plan. With respect to the public meeting held in Squamish, the Squamish Nation is concerned that there has not been consultation with them. The participant was concerned that the Plan might lead to a dramatic expansion of the Port, which was initially proposed as a coal port. Dennis Deans described the port development proposal in the Squamish estuary and preparation of the Management Plan in 1982. The Committee then proposed amendments to the Plan. Firstly, a public information session and then a forum were held in Squamish to review the proposed changes to the Plan. Whether there would be other forums to follow has not been decided.

Patrick Lucey of the University of Victoria suggested that everything has been reactive instead of proactive. We should switch our way of thinking to proactive. Also ecology and economics should be parallel and dealt with together, rather than as separate and individual entities. We have institutions for almost all aspects of society, we should have similar institutions for the environment. We need community ecologists to monitor the health of the ecological community. He raised the point that Canadian environmental legislation gives ministers and civil servants much discretion, thus making it difficult for citizens to take effective legal action.

A resident stated that she is a commercial fisherman, but the Sound is now closed for commercial fishing. She is dissatisfied that the Fisheries Act is not being enforced, particularly in the area of pollution standards. Bob Turner replied that communities must demand that laws be enforced and improved.

Guy Dauncey summarized the session. He expressed that our traditional mindset of the industrial age still pervades society. We are in need of a big shift, driving our cars to Squamish will do more harm to the area than pulp mill effluent. We now have a great opportunity to initiate changes in B.C. with new political parties. Things such as whaling, slavery and child labour have been changed without disaster, we must now think positively if we are to do the same about environmental problems.

Bob Turner adjourned the session at 10.15 p.m. and thanked the panelists and the participants for a very stimulating evening.

SUMMARY OF KEY ISSUES ARISING FROM THE PUBLIC MEETINGS
October 22, 1991 - November 23, 1991

There were 5 days of Public Meetings in total, which started on October 22, 1991 and ended on November 23, 1991. There was an impressive range of public participation; with many insightful comments and ideas.

There were 25 members of the public in attendance at the Gibsons session. Residents were concerned about effluent from the pulp mills and the extent of regulations and monitoring. Concern was raised over the problem of leaching at the pulp mill landfill and the eventual leaching into Howe Sound. Residents were concerned about log dumping and its effect on water quality and biota. It was suggested that a watershed approach in managing the environment is needed; improved coordination among local areas and watershed administrative boundaries are needed. It was argued that there should be greater recognization of the limited supply of old growth stands and there is a need to involve the Forest Service in the approach to sustainable development. The "Hazelton Charter" was used as an example of an environmental management strategy, which is based on a community self-sufficiency approach to sustainable resource use and economic stability. The idea of local round tables on the environment was suggested.

The Whistler session had 29 participants. There was concern about the impact of industrial pollutants, such as pulp mill emissions, on human health. Concern was raised about the decline in fish abundance and other indicators which point to environmental degradation. The concept of "eco-counsellors" providing preliminary advice to developers was suggested. The idea of a greater leading role by the public on environmental issues and increased consumer awareness on the use of products less damaging to the environment.

The Squamish session had approximately 40-50 participants. There was concern about estuarine resources and the environmental implications of the reduction in the estuarine land base. There was also concern about the level of pollutants in the water. Questions regarding soil erosion due to logging, the issue of clearcutting and forest mismanagement were raised. It was pointed out that further reduction in timber harvesting is required to achieve long-term sustainable yield. Better understanding of forest resources is needed, this knowledge should be integrated with other uses for better decision-making. There was discussion on the proposed Squamish Estuary Management Plan. All industrial uses should fit into this plan and would have to be subject to environmental impact assessment. It was argued that ecological functions have to be looked at in order to determine the role of each component, so that we can maximize the resources we have left and achieve sustainability. The idea of

a round table on the watershed was again brought up. A data bank or information clearing house for studies of the watershed and information access was suggested. The need for "eco-counsellors" was again mentioned.

The Vancouver session had about 40-50 participants. Questions were raised about acid rock drainage, underwater mine tailings and seepage from shafts and the open pit. Residents were concerned about the monitoring of debris from log boom dumping; reforestation; biological effects of pulp mill effluent and emissions; fish health and the standards for fish inspection and the possibility of switching from chlorine to hydrogen peroxide based pulping processes.

Approximately 75 participants attended the West Vancouver session. The Squamish Nation Band was concerned that there has not been consultation with them in regard to the cleaning up of the Sound. Residents queried how to ensure sustainable forests and what the appropriate methodology for forest harvesting is. It was noted that we should find alternatives to clearcutting. There was emphasis on the need to look at biogeoclimatic zones in order to determine harvesting methods. The concept of a regional round table was mentioned again. There was criticism on the lack of time to respond to proposed changes to the Squamish Estuary Management Plan. There was also criticism about the lack of enforcement of the Fisheries Act.

APPENDIX I

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