COLLABORATIVE INVESTIGATIONS OF WATER QUALITY POLLUTION PATTERNS: WORKING WITH THE KYUQUOT/CHECLESEHT FIRST NATIONS IN BRITISH COLUMBIA

by

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ABSTRACT

In 2004, large-scale closures to shellfish harvesting were issued in Kyuquot Sound, British Columbia, leaving many in the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations without an important industry. To respond to the closures, government regulators and the community worked together to produce a pilot Conditional Management Plan (CMP), which expanded the monitoring rights of the community, and now includes joint responsibility and coordination of the plan.

Drawing upon co-management and common property theory, this study presents a case in which a geographically isolated community worked with government agencies to increase their participation in lower-level shellfish management activities. Through this, there was an enhancement of the capacity of the community to engage with regulating agencies about water quality sampling and policy agenda setting. Through time and repeated interactions, these early relations may help to develop local and governmental capacity to work cooperatively and collaboratively, perhaps thus moving closer to co-management of shellfish resources.

Keywords: shellfish management; co-management; common property theory; First Nations; collaborative research, communication

Subject Terms: co-management – fisheries; shellfish management – case study; First Nations - communication

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GLOSSARY

Canadian Shellfish Sanitation Program (CSSP)	The CSSP is a cooperative program administered jointly by Environment Canada (EC), the Department of Fisheries and Oceans (DFO), and the Canadian Food Inspection Agency (CFIA). It is responsible for ensuring the protection of the public from the consumption of contaminated shellfish by monitoring recreational and commercial harvesting within Canada (EC, 2004).
Civil Society	Intermediate institutions (businesses, volunteer organizations, educational institutions, media, churches, unions, etc.) that builds on family as the primary instrument of socialization, values, knowledge, and transmission of that knowledge (Fukuyama, 1995).
Common pool resource (CPR)	Resources that are characterized by difficulty of exclusion, and subtractibility.
Community-based monitoring (CBM)	Whitelaw *et al.* (2003, 410) define it as "a process where concerned citizens, government agencies, industry, academia, community groups, and local institutions collaborate to monitor, track, and respond to issues of common concern.
Conditional Management Plan (CMP)	A CMP involves an agreement between the three federal agencies of the CSSP (DFO, EC, CFIA) and the stakeholder groups. In Kyuquot it would allow openings based on the premise that high fecal coliform counts are seasonal. Because counts have been shown to be consistently lower and within internationally accepted standards in the winter months, harvesting could occur according to a management plan.
Depuration	On the west coast of Vancouver Island, it refers to a process in which shellfish product from contaminated beaches is sold to licensed processors who bathe the clams in tanks of flowing disinfected water for 48 hours, allowing them to purge themselves of harmful bacteria and viruses.
Fecal Coliform (FC)	Fecal coliform is a group of bacterium commonly associated with the breakdown of scat from mammalian (terrestrial or marine) or avian sources. Following international regulations, it is used by Environment Canada as an indicator of the presence of fecal matter, which could carry viruses or bacteria which can be harmful to humans.

Local Ecological Knowledge (LEK)	LEK is knowledge about a particular place that is gained through life experience and an understanding of the human-environment relationship.
Shellstock	Refers to the meat of shellfish (clam, oyster, scallop)
Traditional Ecological Knowledge (TEK)	TEK is knowledge gained through life experience in a particular place that takes into account the human-environment relationship. That knowledge and the resultant practices and beliefs are passed down through generations (from Berkes 1999).

LIST OF ACRONYMS

APC: Adverse Pollution Condition

CBM: Community-based monitoring

CFIA: Canadian Food Inspection Agency

CMP: Conditional Management Plan

CPR: Common-pool resource

CSSP: Canadian Shellfish Sanitation Program

DFO: Department of Fisheries and Oceans

EC: Environment Canada

KCFN: Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations (Kyuquot/Checleseht)

WCVI: West Coast Vancouver Island

INTRODUCTION

Shellfish Closures and their affect on Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations

Shellfish harvesting closures in First Nations' traditional territories on the British Columbia coast are occurring due to growing water sanitary concerns, and the social and economic repercussions for harvesters and their communities are severe. There are barriers to successfully opening new areas for harvesting, some of which lie in historical and institutionalized patterns that severely limit effective action. One such barrier includes the inability of the outdated Canadian Shellfish Sanitation Program (CSSP) to respond to localized variations. Although the program has reportedly been slated for review, it is the Canadian version of internationally agreed upon regulations that may take a great deal of time to change. A second barrier that is more feasible to study during time-limited master's research is the lack of full utilization of the capacity that exists within small First Nations communities to undertake water quality monitoring and to analyse and mitigate sources of pollution of growing waters. Here I analyze the nature of the second barrier and suggest ways of overcoming it. Through the community capacity analysis, I also identify a viable management strategy that would allow for harvesting openings in Kyuquot Sound on the west coast of Vancouver Island (see Figure 1).

This research is relevant to the co-management literature since it provides a case study where those who depend on a natural resource for economic sustainability take steps towards shared responsibility for managing the resource with the government

agencies through investigation and monitoring (Holm *et al.* 2000). This study examines the process through which the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations community refused to accept blanket closures to shellfish harvesting and instead worked with the agencies to research pollution patterns and to create and adapt the government regulations. Before this research began, the community capacity to monitor and thus participate even in a minor way to decision-making had not been fully utilized, and the necessary institutional and social landscape for cooperative management was lacking. However, significant skills did already exist, and the water quality/sanitation closures provided a catalyst to design a context for community-government co-management. Furthermore, this case emphasises the two-way need of 'capacity building' exercises to consider that the agencies also must develop the capacity to learn how to work with and empower co-management institutions. In this document however, I have focused most of my attention on the work of the community.

Figure 1: Map showing Kyuquot Sound and Checleset Bay on Vancouver Island

Modified from www.stay-in-canada.com/.../map-canada-en.jpg

Why was this research important in practice?

In September 2004, following three years of testing for fecal coliform levels in Kyuquot Sound and Checleset Bay, on the west coast of Vancouver Island in British Columbia, numerous closures to shellfish harvesting were issued, as prescribed under the Canadian Shellfish Sanitation Program (CSSP) (EC 2004). This research was catalysed by these widespread closures that covered 8423 hectares of growing waters (pers. com. Environment Canada). Such closures are not a new phenomenon for coastal communities in Canada, especially in areas where there is substantial human settlement and/or industry. For instance, by the end of 2004, British Columbia alone had 123,832 hectares closed to harvesting of shellfish, compared with 752,600 hectares of coastline that is surveyed (EC 2005a). In these areas, CSSP standards do not allow harvesting in order to protect human health from the consumption of contaminated shellfish.

However, Kyuquot, the only community in the area, has a population of about 200 people, and so is not likely to contribute sufficient pollution to account for such extensive closures. Repercussions of contaminated shellfish growing waters range from cultural losses and health risks[1] for local residents, to economic impacts caused by the loss of harvesting opportunity, which include local loss of jobs and income. Furthermore, the closures affect not only wild clam harvesters and shellfish tenure investments, but also First Nations' Food/Social/Ceremonial rights to access traditional resources, as acknowledged by the Sparrow decision in 1990 (Allain 1996).

To respond to the closures, Environment Canada, as the lead agency of the CSSP charged with water quality issues, was unable to conduct intensive investigative sampling because of budgetary and staffing constraints. Instead, the agency looked toward stakeholder engagement through community-based monitoring, which offers a process that could help alleviate some of the governmental monitoring burden, while developing the regulating agency's capacity to communicate and deal with the concerns of small, localized communities. By engaging local community members, this process increases avenues of communication between government and First Nations fisheries researchers, a noted barrier to successful management (Eley *et al* 2006, Ostrom *et al* 1999, Beach and Pinkerton 2006). It would be difficult for governments to build effective management protocols with Aboriginal people who are going to take over many management responsibilities if proper communication avenues were not created.

[1] Local knowledge tells us that Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations community members traditionally harvested shellfish in the winter months when accessing fin fish was difficult due to weather constraints. Many people still go out in the winter to collect clams, and eat them without any reported illnesses. Because of this, when they hear that the area is closed due to contamination (decided based on fall-time fecal coliform levels), they do not believe the credibility of the standards. Therefore, if a true contamination occurs in the winter months, community members will not be safeguarded against the health repercussions, and therefore the standards are currently exposing the community to an "environmental injustice" (Chess *et al*, 2005).

Devolving monitoring and data collection responsibility to the community institutionalizes a process in which they could participate in activities that influence resource management decision making. Although the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations fisheries staff already had extensive skill and experience in water quality and shellstock monitoring, potential for further development of capacity existed. For instance, communication and trust linkages between themselves and the three CSSP federal government agencies needed strengthening, and more in-depth understanding of government regulations and protocols was desirable. Understanding and participating not only in data collection, but also in analysis and policy agenda setting is the key to the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations' ability to consider and strategise future clam management policy.

Capacity building is often a two-way street, and the lack of capacity in this case study is caused in part by inadequate funding or dispersal of funds, poor understanding of mutual interests and needs, and inadequate time and planning for communication strategies.

Specifically, for this research, the three main objectives were:

1) To look at the source of the bacterial contamination and to determine if there are noticeable patterns that affected counts.
2) To develop local capacity to identify problems plaguing the shellfish industry and to be involved in the data collection, analysis and the policy agenda setting. And
3) To develop government agency capacity to research pollution concerns and to strategise management options with the local community.

What is the importance of this question in the social science literature?

The term "co-management" was first used in the 1970s to describe the relationship that US aboriginal tribes in Washington State wanted to have with state managers (Pinkerton 2003). The tribes, having always depended on the fisheries, sought the power to participate as a partner in the planning of their management. The term was used synonymously with the word 'cooperation', and suggested that resource management problems could best be dealt with by bargaining for mutually beneficial outcomes for all users (Pinkerton 1989). Since then, the concept of communities working with higher-level governments to manage resources has been used in cases throughout the world, and has been the subject of numerous studies. It has been shown that arrangements such as these can respond in a flexible, adaptable, and precautionary manner to ecosystem and societal variations (Pinkerton 2003). In addition to this, if applied properly, co-management can avoid opportunistic behaviour by binding individuals into ongoing relationships, and can create incentives for community members to enhance their resource because they have greater information and control over its management (Singleton 1998).

Co-management theory and common property theory have dealt with issues of making agreements, building working relationships/social capital, creating harvest rules and protocols, etc. Case studies in the literature often describe tasks that define access rights, though the management of these rights may fall along a spectrum of full co-management. However, today's world has problems beyond access to resource rights. Environmental contamination and degradation do not follow imposed boundaries. Yet, Agrawal (2003) points out that much well-regarded co-management literature such as

Wade (1994), Ostrom (1990), and Balland and Platteau (1996) fail to pay attention to the environmental conditions that affect management. True co-management of resources must include monitoring and ensuring environmental integrity, regardless of the source of pollution. This need for attention to habitat protection as a fundamental aspect of management was noted by Pinkerton and Weinstein (1995) and by Pinkerton (1991, 1992).

This report describes water quality research that was undertaken in cooperation and collaboration with a First Nations community and various government agencies. The environmental conditions that caused the shellfish sanitation closures provided a research window through which to focus this case study. The goal of the research was to work with the community to enhance their capacity to engage with Environment Canada and other CSSP agencies about water quality sampling and policy agenda setting. The resultant creation of a Conditional Management Plan (CMP) in the area expanded the monitoring rights of the community, and now includes joint responsibility and coordination of the plan to open three small areas to harvesting which will test the local ability to enforce regulations. Through time and repeated interactions, the small monitoring and management responsibilities currently delegated under the CMP may expand to provide an opportunity for greater collaboration between the agencies and the community, and thus perhaps move closer to co-management of the shellfish resources.

BACKGROUND

Description of the community

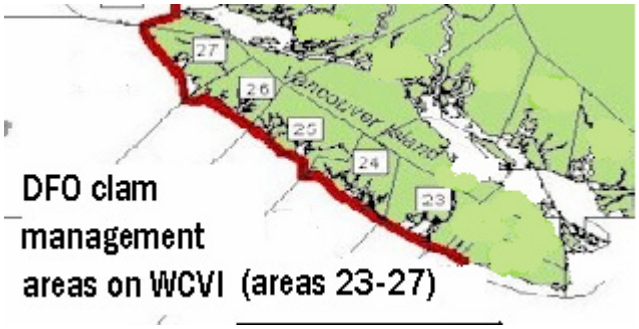
Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations have a community of approximately 200 full-time residents living in Kyuquot Sound. There are 25 people owning individual commercial clam harvest licenses and 30 more licences designated as Aboriginal Commercial Licences (ACL), which are owned by the band and allocated internally (Qu'West Consulting Services 2004). Many more people depend on this activity for subsistence, or participate in commercial digs under depuration[2] contracts. Because of Kyuquot's geographic isolation, there are few employment options near the reserves and therefore there is a great dependence on the shellfish resources. Some local shellfish aquaculture initiatives in the form of oyster long-lines, deep-water scallop culture, and clam beach seeding have emerged in recent years. Although these operations, led by the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations or by private tenure holders, have the potential to provide some consistent employment opportunities, wild harvest will continue to meet the needs of a large portion of the community in the near future. For a thorough description of Kyuquot Sound/Checleset Bay and its land use, see MSRM (2003).

[2] On the west coast of Vancouver Island, depuration refers to a process in which clam product from contaminated beaches is sold to licensed processors who will bathe the clams in tanks of flowing disinfected water for 48 hours, allowing them to purge themselves of harmful bacteria and viruses.

Description of the resource

The most commercially sought-after clam species on the WCVI is the Manila Clam, an exotic variety introduced inadvertently in the 1930s with Japanese oyster seed (Dovetail Consulting 1997). Clams are sedentary, and survive in the intertidal substrate of productive beaches on the coast. By law, commercial diggers on the WCVI need an Area F clam license (Z2) and thus the number of legal harvesters is limited and the boundaries are subdivided into areas 23-27 (see Figure 2). In addition to the commercial fishery, First Nations people have unspecified rights of harvest for their food, social, and ceremonial needs, and recreational and subsistence harvesters participate all along the coast. Although the growth rate of clams is fairly predictable, stocks can be destroyed by over-harvesting by people (destroying habitat or removing spawners and undersized clams results in less recruitment and a population which cannot replenish itself), by wildlife (some species such as sea otters are known to "wipe out" a beach, feasting on as many clams as they can find before moving on to the next beach), by storms (destroying the beach habitat and thus killing the clams), or by cold weather (killing vulnerable clams and reducing recruitment).

Figure 2: Area F sub-areas for clam management on WCVI (adapted from DFO 2006)



Bivalve shellfish (clams, oysters, scallops, etc.) are filter feeder species, meaning that any contaminants in the surrounding water are filtered through the animal and accumulate inside its body for the duration of its exposure to impure conditions (EPA 2003). Fecal coliforms are common bacteria found in the digestive tract of warm-blooded animals that assist in the breakdown of food and the absorption of nutrients (EPA 2003). They can enter the marine environment directly from the scat of marine mammals, from birds, from land-based mammals via the upland (e.g., rainfall flushing watersheds), or from point sources such as boats, faulty septic fields, or municipal sewer outfalls (EC 2002). Because these bacteria can survive in the marine environment for some time and are relatively inexpensive to detect through testing, they are used as an indicator organism in the CSSP to signify the presence of non-point source sewage pollution (EC 2005a).

Description of the Canadian Shellfish Industry

The Canadian Shellfish Sanitation Program (CSSP) is responsible for ensuring the protection of the public from the consumption of contaminated shellfish by monitoring recreational and commercial harvesting within Canada (EC 2004). It is a cooperative program administered jointly by Environment Canada (EC), the Department of Fisheries and Oceans (DFO), and the Canadian Food Inspection Agency (CFIA). Specifically, EC undertakes the surveying and sampling of growing waters; DFO is involved in the monitoring and enforcement of regulations including shellfish harvesting closures; and the CFIA undertakes biotoxin monitoring, audits processors, and ensures the safety of products intended for sale to consumers. Many of the sampling regulations and protocols

of the CSSP are based upon internationally acceptable standards, set to protect sale of products into foreign markets.

The shellfish industry within British Columbia is booming, recording an increase of $16.6 million in landed value between 2002 and 2003, which brought it up to $120.3 million (DFO 2005a). At least part of this boom can be attributed to the increases in subsidies and the promotion of shellfish aquaculture by federal and provincial governments as a tool for economic growth. However, despite these propitious statistics, today the wild fishery is experiencing mounting struggles. These include challenges such as increased harvesting pressures, expansion of commercial aquaculture tenures, industrial pollution, and recently, tests indicating increasing biological (i.e. fecal coliform) pollution[3]. This has especially affected the clam industry in British Columbia, resulting in a decline of $4.7 million in landed value in 2003 (DFO 2005a).

The clam fishery on the WCVI does not generate a great deal of wealth. Although shellfish landed value ranks second in British Columbia's fisheries, clams (excluding geoduck and horseclams[4]) account for only 2% of that value (DFO 2005b). Many of the harvesters dig clams only for subsistence, while others use it as a supplement to their regular income. In the 1998-99 season for instance, the average earning per license was only $2,685 on the WCVI (Dunlop 2000). Other diggers, especially of the First Nations communities on Vancouver Island, engage in the harvesting of shellfish for their own dietary needs based on their cultural history and their food, social, and ceremonial rights.

[3] Many people involved in the shellfish industry do not believe that the biological pollution is increasing (Beach 2005). Instead, they point towards a change in testing methodology (field and lab) and frequency, which could account for findings of higher fecal coliform levels. This opinion assumes that the changes through time is reflecting changes in Environment Canada monitoring, not changes in pollution patterns.
[4] Geoducks are harvested by underwater divers which require specialized equipment and licenses compared to manila clam harvesters. Geoducks and horse clams both enjoy high prices and are usually classified separately from other types of clams when describing landed value.

The government-generated revenue from this industry is thus minimal, and so the agencies in charge of managing it have limited resources to give back.

Although the wild clam fishery does not generate a great deal of revenue, it is of considerable importance to small communities such as Kyuquot, especially because of the severe decline in fin fisheries and other industries of the area such as mining and logging. In the 1980's the shellfish harvesting effort on the WCVI increased substantially in response to those declines in other industries (Dunlop 2000), and it appeared as if clams would experience the same market failures as described in Hardin's (1968) *Tragedy of the Commons*. Harvesters and biologists recognized that it would be more profitable for everyone if shellfish resources could be cooperatively managed and conserved to ensure long-term sustainability. In order to do so, the communities came together with government agency employees to better manage the resource, and the result was the creation of the Area F Clam Management Board in 1998. The main task of this board is to limit the effort put into the harvest by identifying allowable collection days (Dunlop 2000). However, it was set up with the intention of adopting more co-management responsibilities through time, where community representative board members could participate in the planning and implementation of management plans and policies along with government regulators (Berkes *et al.* 1991). Therefore, limited capacity already exists in the communities to manage certain aspects of the fishery.

Explaining the Closures

The current method used by Environment Canada to assess the level of fecal contamination is the Adverse Pollution Condition (APC). The sampling occurs during the worst-case scenario in this purposefully conservative method. For instance, the sampling would be timed to happen during the "first flush"[5] event after a dry spell or accumulated snowfall, which on the Pacific Coast would be in the fall and in the spring. The theory behind this methodology is that if the samples are found to be "clean" (or have only low fecal coliform counts) when they are most likely to be polluted, then the shellstock would also be clean at any other time during the year. This is not an ideal sampling method in the case of west coast clams, because it does not record accurate monthly variations, nor take into account the fact that clam harvesting traditionally and currently occurs in winter. However, according to Environment Canada, the APC method is the most practical under limited budget and time allowances for surveying the vast Canadian coastline.

Shellfish harvesting closures on the BC coast due to human pollution (ie. sewage, industrial) have been expanding. Yet both shellfish harvesters and decision makers are uncertain about the reasons behind the elevated coliform levels. Two main questions arose during preliminary surveys (Beach 2005) of community members, industry stakeholders, and government officials:

[5] During the dry period, animal scat accumulates in the terrestrial environment, especially near streams and rivers where animals gather to drink. The "first flush" refers to the first significant rain or snowmelt that would then wash the accumulated scat into the rivers and streams and into the marine environment.

1. Is there a seasonal trend to the findings? For instance, are the counts lower in the winter months when harvesting occurs in Area F than when the samples are taken under the APC sampling protocol?
2. What is the source of the high fecal coliform levels in parts of Kyuquot Sound/Checleset Bay?

The Seasonality Hypotheses

Applying the APC method, large areas of Kyuquot Sound were closed to harvesting in 2004. Interviews with local community members and harvesters revealed that there was a common conception that the fecal coliform levels would be much lower during the winter period, the time of year during which harvesting actually occurs (Beach 2005). Since the pollution, spanning such a considerable area, is not likely to be caused by septic systems from the community, the accepted hypothesis from government regulators was that hinterland drainage (terrestrial mammals and avian species) was the most likely source (pers. com. with Environment Canada employee, July 2004).

A combination of factors would contribute to the higher spring and fall counts compared to the winter. The hypothesis can be described as follows. During the dry summer months, scat would accumulate on land, and then during the heavy rainfall events in the fall, it would be flushed down. Furthermore, during the fall period, many animals such as bear come down to the rivers to feed on the salmon travelling upstream to spawn. They would then be spending more time close to watercourses and so they would be contributing fecal matter directly to the rivers that fed into the ocean. In the

winter, some scat would still accumulate, and would be flushed down with the mountain snowmelt, but more dramatically, animals that hibernate or move inland in search of food during the winter months would return in the spring. This would account for higher activity near rivers and streams, and thus higher fecal coliform loading levels in 'flush months' of April and May.

The Source Hypothesis

Since the source of the high fecal coliform counts was not likely to be human, some of the community and government actors generated hypotheses naming combinations of seals, sea otters, sea lions, bears, deer, avian species, and kayakers as the sources. However, the most frequently repeated community hypothesis was that bears and/or avian species were most likely contributors during the period of time when Environment Canada routinely does water quality monitoring.

Political Hypotheses

Alternative hypotheses regarding the reasons for the high bacterial numbers were that they could be attributed to the large-scale clear-cut logging done in the region, or it could simply be a purposeful political manoeuvre on the part of government to keep First Nations members from accessing shellfish, either commercially or under their Food/Social/Ceremonial rights. The former suggestion refers to the fact that local logging practices may lead to more concentrated fecal coliform levels in hinterland drainage because the removal of trees often leads to greater runoff (less soil retention) and a

reduced ability to breakdown animal scat (less time in contact with soil micro organisms). The latter suggestion is an understandable outcome in the absence of community involvement in the decision making process. Many community members are frustrated, feeling that their concerns have not been fully considered by government officials who only enter their territory twice annually for a few hours a time, and have little knowledge of the underlying conditions. (pers. com., Kyuquot band members, 2004).

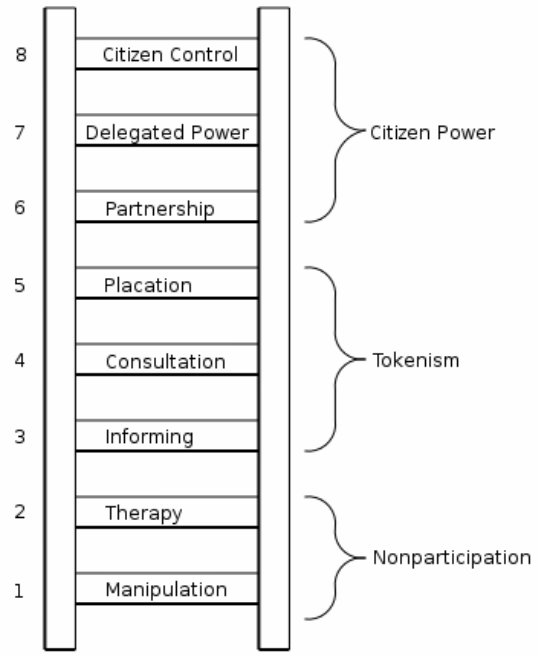
Regardless of the source, it is obvious that sufficient natural science research into the origins of the water quality concerns in Kyuquot is lacking. While traditional knowledge tells us that shellfish harvesting has been occurring in communities such as Kyuquot for centuries without concern for contamination (Ommer and Turner 2004), the current rigid rules of the CSSP that oversees the commercial and trade aspects of the industry is constraining local harvesting patterns. Shellfish harvesting is an essential economic activity for Nuu-chah-nulth people, and short-sighted closures may have important social ramifications (pers. com., Nuu-chah-nulth Shellfish Development Corporation employee, 2004). Without more localized study into the source and spatial dynamic patterns of the fecal coliform problem, west coast Vancouver Island harvesters are feeling cheated and neglected by government regulators in Ottawa (pers. com., clam harvester, 2004).

LITERATURE REVIEW

Focussing the case study within the literature

The data collection and analysis duties undertaken in Kyuquot Sound/Checleset Bay fall into the sixth rung of partnership on Arnstein's *Ladder of Citizen Participation* (Arnstein 1969). Sherry R. Arnstein noted that citizen participation in planning can be categorized into one of eight 'rungs', ranging from manipulated or empty participation at the bottom, through decision consultation in the middle, and up to citizen control at the top where there is real power to affect outcomes. The government agencies and the Kyuquot/Checleseht community can benefit from working together to ensure consistent sampling. This may lead to greater trust in local capabilities, which could increase community power to participate more fully in shellfish harvest planning.

Figure 3: Arnstein's Ladder of Citizen Participation reproduced from Arnstein, 2006.



In terms specific to fisheries management, Pinkerton (2003) explains that the successful exercise of rights at one level often depends on the exercise of rights at higher and lower levels. For instance, if the community has the right to participate in data collection and analysis as lower level activities, then they will be better prepared to participate in more complex harvest management decisions. Although participation in those lower level management activities does not constitute full co-management, developing the capacity of the government agencies and communities to work together in these tasks is an early but important step.

In order to facilitate a healthy working relationship, mutual trust should be established. Fukuyama (1995) decried social engineering as a sole answer to societal challenges. Instead, to meet the challenges, he points toward culture and the importance of a healthy 'civil society', which has high levels of trust among actors (Fukuyama 1995). Working together collaboratively in Kyuquot Sound could not have been successfully imposed simply because of mutual benefits for government agencies and the community; instead, involvement in shared experiences on the land and communication helped to establish a base of social capital.

The method that researchers or decision makers choose to involve citizens is an important reflection of their trust in the ability of the participants, and that involvement will ultimately decide the success of programs. Pinkerton and Weinstein (1995) explain that the scope of co-management power depends on the number of management activities shared, and the degree to which a party can control or influence decisions for each activity. Silver and Campbell (2005) note that if research is linked to possible policy changes but does not call for local participation, community members are left in a

situation which can lead to tension and mistrust between them and the government/researcher, low compliance with regulations, and a policy that does not reflect the social/cultural context of the region. For these reasons, the research described in this research project consciously sought to involve local community members in the collection of water quality data which could influence classification. Furthermore, steps were taken to enhance local knowledge about the government policy surrounding shellfish harvest and closures in order to increase the value of community input into policy decisions.

Clams as a common pool resource (CPR)

A common pool resource (CPR) is characterized as having (i) difficulty of exclusion and, (ii) subtractibility, meaning that the use of the resource by one user reduces the amount available for others (Ostrom *et al.* 1994). Because of the biological nature of clams and the legal and social[6] harvesting restrictions on the WCVI industry today, they can be considered a CPR, specifically falling under the "group property" category due to the need for an Area F harvesting licence (Pompe and Rockwood 1993; Ostrom *et al.* 1999). In this case, all Area F clam licence holders purchase a right to collect clams, and thus share responsibility for ensuring the sustainability of a yearly crop. For this reason, group management may be more appropriate than state or individual management.

[6] The nature of the isolated communities on the WCVI, and the relatively small and socially connected characteristics of Area F clam license holders often results in peer pressures that limit harvesting by individuals. For instance, an individual may be dissuaded from adding clams from a "contaminated" beach to a load of clams for sale because other harvesters would discourage this because the entire load could be discarded if problems arise, and everyone would lose out.

The theory on the value of and threat to these CPRs has evolved considerably over the past few decades. In 1954, Scott Gordon warned that the "commons" resulted in failed fishery management, and this assumption enjoyed widespread and long-held credence. However, some have argued that he misused the "common property" description, and instead was referring to open access (Hanna 1990). The misuse of the term is significant, since open access assumes the complete lack of property rights, which according to Coase (1960), would result in environmental and social troubles arising from competition for scarce resources.

More recent common pool theorists have asserted that CPRs could be managed successfully as group property if specific user conditions and rules of access were established (Ostrom 1990; Pinkerton 1989; Agrawal 2003; Baland and Platteau, 1996). For instance, Baland and Platteau (1996) emphasized that small groups of homogenous members that live in close proximity to the resource, and that have effective enforcement mechanisms established, as well as experiences of cooperation, could effectively manage CPRs. The Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations community has varying degrees of all of these characteristics.

The prediction that resource users will overexploit a CPR is based on the model that assumes that all individuals are selfish, make decisions in isolation from others, and that they are only interested in maximizing short-term self-gain (Ostrom and Walker 1997). However, that prediction is not supported in field research or in controlled experiments where certain conditions are met, such as when people can communicate with one another, make rules, and sanction compliance with the rules by monitoring and enforcing them, etc. The model was not supported by the tit-for-tat strategy (Axelrod

1984), in Ostrom's design principles, in Pinkerton's lists of conditions promoting cooperative success (1989, 1992, 1998), nor in Agrawal's attention to the nature of the resource and market conditions (2003). What is evident is that interacting without establishing effective roles that limit access and define rights will ultimately lead to resource degradation, either in the form of overuse, or in the lack of resources to maintain and improve the CPR (Ostrom *et al.* 1999).

Management Options for Clams in Kyuquot

In November 2004, the Aquatic Management Board released a report entitled *Marine Water Quality on the west coast of Vancouver Island: an assessment of the issues and options facing the shellfish industry* (Beach 2005). This report pointed toward possible options for west coast Vancouver Island communities like Kyuquot, which are facing closures due to fecal coliform pollution. In summary, in the interim[7], Kyuquot has two main options to explore: depuration and a Conditional Management Plan (CMP).

In the short term, depuration allows harvesters to gain an income, though the returns are less per pound than that of the wild harvest. Lower returns are unappealing to the harvesters, who put themselves at high risk and undergo costly travel in order to harvest from remote locations, and who already feel that the clam prices are low. Furthermore, depuration does not address the needs of recreational harvesters, nor of First

[7] Both of the options of depuration and a CMP perpetuate the inherent monitoring design problems of water quality sampling under the CSSP. Longer-term options would be to explore more effective sampling techniques (indicators that are more reliable, testing substrate/meat instead of water, frequency of tests, etc). However, any of the above sampling changes would require a great deal of study and acceptance from international regulators, which could take a great deal of time. Therefore, depuration and CMP are listed as short-term options that allow for continued sampling and harvesting.

Nations harvesters for their Food/Social/Ceremonial rights. Neither does depuration address the problem of identifying and rectifying the sources of the sanitary concerns, which may increase in the future. The Kyuquot/Checleseht Band Manager explained his concerns about having depuration as a single option: "Depuration is not ideal for a number of reasons. It creates a dependence on the depurator; it gives us a lower price per unit; and it ties us to the depurator for processing and marketing. If we didn't have to depurate and we could do our own marketing; then we could bring in more money for the community" (pers. com., 2006). In addition, DFO policy requires that depuration be done only after a stock abundance survey on a particular beach, which is costly and time-consuming.

However, depuration does provide some local management opportunities that include limiting the number of harvesters and limiting the portions of a beach open to harvesting at any particular time, as well as the usual monitoring and patrolling duties performed by the Kyuquot fisheries crew. Since 1999, a few depuration digs have been occurring in Kyuquot Sound and Checleset Bay (Pinkerton and John, 2006). Although 25% of the harvesting opportunity is offered to other Area F harvesters outside of the community, this has meant that only two outside diggers could come in, thus acting as a *de facto* exclusion mechanism for Area F diggers who do not live in Kyuquot Sound. Furthermore, the costs of travel to Kyuquot Sound for such sparse harvesting opportunity deters many people.

The other short-term option for Kyuquot is to undertake a Conditional Management Plan (CMP). The CMP allows for harvest openings throughout the potentially cleaner months, yet is a costly venture for small communities and can be

difficult to manage. It would involve a careful agreement outlining liabilities and responsibilities, and periodic governmental audit, as prescribed by Harrison (2001). It would also result in the choice of a limited number of beaches that would be opened for harvest each season.

In many ways, managerially at least, it is similar to how the depuration digs have been administered in the area. Like the depuration digs, the advantage of this arrangement is that the cost of travel for limited harvesting opportunities works as an informal excluder of outside harvesters. In addition, similar to the depuration arrangement in Kyuquot Sound/Checleset Bay, the CMP calls for on-the-grounds monitors during a dig, which will help to patrol the beaches and enforce the harvesting rules. Therefore, three main factors influenced the choice of further study of the CMP option: the price paid to harvesters is higher; the costly and time-consuming stock abundance surveys are not required; and through more frequent water quality sampling, there is a favourable potential to remove the closures[8].

Before a CMP could be developed, intensive sampling was required to find out if patterns could be attributed to a season or to a trigger. This was a costly venture considering that it did not guarantee openings if the winter findings failed to be within the acceptable standards. Although community members wanted to see water and shellstock sampling occurring during the winter (harvest period), Environment Canada was constrained by the difficulty in accessing the remote area. Especially in the winter, weather is highly variable on the west coast of Vancouver Island, and it is not always safe

[8] If over time, consistent pollution patterns such as those found during this study period are confirmed, the entire area may be opened instead of select beaches. This pattern may also extend to other communities on the WCVI and elsewhere who face similar seasonal contamination issues.

to fly floatplanes. Although the area is accessible overland by a combination of highway, logging roads, and boat, it takes a significant amount of time, approximately 7-8 hours from Vancouver with ideal driving and ferry conditions. It is therefore impractical for Vancouver-based Environment Canada technicians to sample intensively during the winter months.

Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations, on the other hand, have members that are very experienced in fisheries management and environmental monitoring, and they are trained in water quality monitoring under EC standards. These researchers live in the area, and so could schedule monitoring sessions around the weather. However, the idea that community members should undertake the monitoring and a portion of the enforcement costs stands in contrast to the Pigouvian approach in which market externalities are compensated for by government intervention in the form of taxes or subsidies[9]. Theoretically, monitoring pollution is part of the government's role. However, in this case the community needed to encourage cooperation and collaboration in order to ensure that the necessary sampling was undertaken. Whether the community is able to overcome the dilemmas of incurring the monitoring and enforcement costs in the long term depends on their perceived gain from accessing the resource. Ostrom *et al.* (1999) point out that they must highly value the future sustainability of the resource. During the 2006-2007 harvesting season, the full costs of the CMP will be incurred by the KCFN, and this will demonstrate their level of commitment to monitoring in order to harvest.

[9] In this case, because the pollution problem appears to be non-anthropogenic in origin, taxing the polluter is not an option. Instead, subsidising the shellfish industry would be the Pigouvian alternative. This could mean that the government would cover all of the costs of monitoring and remediating the pollution problem in order to ensure that the shellfish industry is not constrained by the externality.

CMP and Future Clam Management Options in Kyuquot Sound

Generally, users of a CPR fall into one of four categories: those who always behave in a self-interested way and never cooperate in dilemma situations (free-riders), those who are unwilling to cooperate with others unless assured that they will not be exploited by free-riders, those who are willing to initiate reciprocal cooperation in the hopes that others will return their trust, and a few genuine altruists who always try to achieve higher returns for a group (Ostrom *et al*.1999). Resource users in Kyuquot Sound/Checleset Bay and government agency workers who support community water quality monitoring most likely fall into the second category: they are willing to cooperate as long as their inputs are not exploited. Both groups are hoping that the pilot Conditional Management Plan will result in experiences of cooperation. Nowak and Sigmund (1992) explain the importance of these interactions, since they enable those who use reciprocity to gain a reputation for trustworthiness. Thus, both groups (the harvesters and the government agency workers) would be willing to cooperate to overcome CPR dilemmas such as pollution concerns, and this would lead to increased confidence in one another, which could be the bridge toward greater cooperation. Ostrom *et al*. (1999, 280) support this idea in stating that, "groups of people who can identify one another are more likely than groups of strangers to draw on trust, reciprocity, and reputation to develop norms that limit use". Establishing this trust and identity is especially important in government-community relations, since the former is often seen as being a distant entity without any real local connection (pers. com. Kyuquot/Checleseht member 2006).

Nowak and Sigmund (1992, 252) mention that "TFT [Tit-for-Tat] acts as a catalyser. It is essential for starting the reaction towards cooperation. It needs to be

present, initially, only in a tiny amount; in the intermediate phase, its concentration is high, but in the end, only a trace remains". This point means that previous cooperative experience such as successful community monitoring, paired with local leadership, will in effect reduce the users' costs of coming to fuller cooperative agreements and ultimately finding effective solutions to CPR dilemmas (Ostrom *et al.* 1999). Many authors agree that repeated interactions paired with clear, articulated social consequences of free riding increase the likelihood that people will be accountable for their actions (Ostrom *et al*. 1999, Ostrom 1990, Pinkerton 1989, Singleton 1998). However, both the government agencies and the community will be cautious about the fact that generosity often leads to exploitation, and that early reneging on responsibilities may result in the collapse of the agreement and threaten future interactions.

Why community-based monitoring?

The inclusion of community representatives from Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations was essential for promoting the internal community capacity to analyze, locate, and mitigate sources of pollution or problems. In general, stakeholder participation in natural resource management has been gaining widespread acceptance (McGlashan and Williams 2003, Beierle and Konisky 2001) and frameworks are being developed in order to aid in directing efforts such as community-based monitoring (Pollock and Whitelaw 2005). Agrawal (2003, 246) describes communities as having "high levels of social capital, which permit them to undertake collective tasks far more efficiently in comparison to state bureaucracies, and to do so far more equitably than market-based solutions". However, community-based monitoring efforts tread a fine line,

and as Sharpe *et al.* (2000, 33) warn, it should not be used to legitimize "the dismantling of environmental monitoring and enforcement programs". Instead it should build upon existing monitoring programs, and be used as a tool to address localized complexity, uncertainty, change and imperfection when dealing with natural systems and social institutions.

Whitelaw *et al.* (2003) mention that CBM is growing in importance in Canada because of factors such as: the needs of decision-makers for timely information on local environmental changes, the limited use of government monitoring data and information by decision makers, governmental cuts to monitoring programs, the increasingly recognized need to include stakeholders in planning and management processes, and the desire of citizens to contribute to environmental protection. The paper explains community-based monitoring as a tool with the potential to benefit all parties involved. Government agencies can benefit through the extension of their monitoring networks, cost savings, flexibility to carry out fieldwork during non-conventional times, contributions to government planning through enhanced public participation, and the ability to provide alternative feedback on change (Whitelaw *et al.* 2003). For communities, CBM contributes to the development of social capital through the engagement of volunteers, the creation of important connections and partnerships, the identification of community and resource values, and the increased ability to influence local decision-making in support of sustainability (Whitelaw *et al.* 2003).

Although a strategy for encouraging cooperative research was used in this study, the implementation of CBM in different communities should consider its complexity and diversity and realize that a set linear process is not applicable in all situations. For a more

generic framework for establishing community-based monitoring, see Pollock and Whitelaw (2005), who suggest three general characteristics for CBM frameworks; that the framework be context specific, iterative, and adaptive to a changing natural and cultural environment.

METHODS

This research project is based upon a single case study. Yin (1994) describes five different circumstances where this is appropriate.

1) To confirm or challenge a theory or to represent an extreme or unique case
2) To explain complex causal links in real life interventions
3) To describe the real-life context in which intervention has occurred
4) To describe the intervention itself
5) To describe a phenomenon which was previously inaccessible

My research falls into the third category in which I, as the researcher, acted as a catalyst for the development of a shellfish harvest management plan in order to deal with a pollution issue that had prohibited access to the resources. The government, in devolving some monitoring responsibility to the community, has allowed the stage to be set for future co-management agreements with the community as the capacities of both groups increase.

The research approach used was participatory action research. According to Gilmore, Krantz and Ramirez (1986),

> Action research...aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process.

When I began this study, I had wanted to be involved with meaningful research in the area of water quality, and I had wanted the research to have the potential to ameliorate access rights of marginalized communities to an important resource. Throughout my two years working in the area, the research has developed and evolved a great deal. However, I always had in mind the ideal of an inclusive research design that incorporated the input of government policy experts, natural scientists, non-governmental interest groups, and First Nations community members in an attempt to foster greater cooperation and promote success through an acceptable and sustainable access condition. Specifically, the inclusion of community representatives from Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations was essential for promoting internal community capacity to analyze, locate, and mitigate sources of pollution or problems. A strategy was chosen for the water quality research in Kyuquot whose purpose was to increase the local applicability of the findings through the incorporation of aspects of traditional/local ecological knowledge (TEK/LEK) and government policy expertise into the research strategy.

The strategy and findings are based upon participatory action research undertaken by myself in the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations community. The work spanned two years between June 2004 and May 2006, with over twelve visits ranging in length from an overnight stay to a week at a time in order to scope the project through meetings and interviews with community members, conduct water quality sampling with the local researchers, and present the findings.

Strategy for cooperative research

1. Preliminary interviews of stakeholders to frame the issue

The first task was to learn about some of the issues that dealt with how water quality affected the shellfish industry on the west coast of Vancouver Island, and to try to identify some of the options that were available for ensuring or promoting access. To do this I interviewed 38 people with first hand knowledge of the local shellfish industry through their capacity as biologists, government representatives, wild shellfish harvesters, shellfish aquaculture farmers, and First Nations community leaders, among others. The interviews were done in a semi-structured manner, with 5-12 questions. Also known in the literature as "governance or network analysis", this stage is an inclusive undertaking which can help to determine a wide range of potential causes and solutions for the perceived problems, as well as to identify champions (Pollock and Whitelaw 2005). These initial interviews were helpful in identifying key members of government, stakeholders, and communities with whom future interactions would be most useful. Within the span of the interviews, which ranged in time between three minutes to almost two hours, it became obvious that some individuals of the sample group were more interested than others in the subject and in helping to find solutions. These contacts proved valuable in later stages of the research design.

I conducted an extensive literature review throughout the interview process as new issues or options were introduced. In November 2004, my report describing the findings of the initial interviews was released by the West Coast Vancouver Island Aquatic Management Board (Beach 2005). The report provided a general overview of water quality issues on the WCVI, but it also focused on the problems of specific

communities like Kyuquot. The findings were presented to the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations, the West Coast Aquatic Management Board, the British Columbia Shellfish Growers Association (BCSGA), and the Area F Clam Management Board.

2. Appropriate recruitment and community input into research design

With the overview report completed, I then sought funding for investigating a CMP in Kyuquot that would require collaborative work between the regulating government agencies, and the community. Environment Canada responded with funding, specifying the need to incorporate capacity building.

Before planning the water quality research, I travelled to Kyuquot in August 2005 and sought community input and visioning into the research design though a community meeting followed by one-on-one meetings. This second step built on the previous step in that community members gave input into identifying the problems, and then saw their input taken seriously, as I asked them to contribute to planning the research design.

TEK has been recognized as being of essential importance in environmental resource management, and should be used in conjunction with natural science (Turner *et al.* 2000). In Kyuquot, it was important to allow for community input into the research design in order to show respect for local wisdom and sovereignty. That incorporation came in the form of asking for input on hypotheses that the community felt were most important to study, for sampling sites that are most appropriate to help answer these questions, and for potential trainees that would be best suited for the job. I then met one-on-one with community members with knowledge of logging practices, aquaculture, and

any other activity that might affect the shellfish industry in the area and to discuss the research and its planning (including finances). With limited funding and time constraints to access remote locations for sampling, eleven sites were selected for study. Two criteria were used in this process. The first was the economic importance of the shellfish beach, and the second was to ensure comparable reference sites between logged and unlogged watersheds.

Even after the sampling had begun, I continued to seek community input in order to improve upon the design and increase community awareness of government regulations and of the study. For instance, on November 6, 2005 I met with members of a developing Clam Co-management Committee[10] in Kyuquot. The members that were present all held clam harvest licences and had an interest in the water quality study. Many things were discussed at the meeting, including some hypotheses about the reasons behind the closures, why the counts were high now, the current sampling regime under the Canadian Shellfish Sanitation Program, and potential options for the community. Environment Canada's sampling results from 2001-2004 were spread out on a table and the group looked at the fecal coliform counts to decipher how to read the analyses. For instance, I explained that the CSSP standards state that out of 15 samples, the median or geometric mean fecal coliform Most Probable Number of the water cannot exceed 14/100ml MPN, and not more than 10% of the samples can exceed a fecal coliform MPN of 43/100ml. The group then discussed the Conditional Management Plan (CMP) and how this could be coordinated within the community. Specifically, the roles of the CMP were examined: that of water samplers, shellstock samplers, beach monitors, and an

[10] Dr. Evelyn Pinkerton and Jennifer Silver are researching community efforts to move toward co-management of the clam fishery and have called together a Clam Co-management Committee to discuss options and issues.

overall coordinator. The group talked about how the community could compensate these members if the management plan were in place, since funding for water quality research will not be guaranteed after the completion of this pilot study. The members of the Committee were eager to give input into the design of the CMP and to learn about the current conditions. This was an excellent avenue for raising community awareness of the issues, since those that are not directly involved in the study could still have input. The community of Kyuquot is obviously concerned with the future sustainability of the resource and has stewardship potential to contribute to that sustainability.

3. Communication with relevant local advisory committees and area-based boards

There are various stakeholder groups working on the issues surrounding shellfish harvest on Vancouver Island. During the course of this research, it was important to contact these groups to inform them of the study, as well as to gain valuable input. For instance, a research proposal was presented to and endorsed by the Area F Clam Management Board as well as the West Coast Vancouver Island Aquatic Management Board. These Boards are made up of members of several communities with an interest in fisheries resource management and sustainability. The Boards are intended to represent all west coast Vancouver Island communities with an interest in sustainable fisheries resource management and have been set up to support management decisions regarding resources while working towards sustainable and fair management processes. Although this point is listed as a third step, communication to these public bodies was an ongoing process as I kept them up-to-date on planning, progress, results, and potential for continuity or extension.

4. Capacity building through training for community-based monitoring

Before a community can undertake independent monitoring, proper training must be conducted and equipment supplied. For Kyuquot/Checleseht to undertake water quality sampling which Environment Canada could use in their shellfish classification, official training was required. The community members who were trained for water quality research had pre-existing roles within the band's fisheries program and prior training. Originally, the intent was not to have fisheries program staff involved in the study, but it soon became apparent that the venture would not otherwise be as successful. Many members of Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations depend on sporadic contracts throughout the winter for their income, especially with the loss or decline of more stable forms of employment, such as clam harvesting. Since the water quality researchers could only expect employment once to twice monthly, there was a reluctance to fully commit. Those who were employed by the band for fisheries work already had steady employment and were more suited to the job, especially since they would most likely continue the work after the funding for this pilot project ended.

The training session was held on October 7, 2005 in Kyuquot Sound/Checleset Bay. Originally four community members plus myself were to be trained at this session; however, two people could not make it due to illness and other commitments. An Environment Canada employee conducted a 'classroom' session to explain the CSSP requirements and EC water quality monitoring methodology before the group went out on the water.

On the water, the group went from site to site, and the EC employee demonstrated the water sampling technique.

This involves putting a sterile sample bottle in a pocket on the sample rod, then dipping the bottle face down two-inches below the water surface, then inverting it and letting the water fill. When the bottle is removed from the water, it is sealed and put into the cooler. A log sheet is filled out that describes the location, the time, the temperature of the surface water at the first station, and any observations of animals or anthropogenic sources. The samples are then sent to an Environment Canada certified lab for analysis.

Figure 4: Sampler preparing to take a water sample

After the training, I asked one of the researchers for a semi-structured interview about the usefulness of the training session. He had done water sampling for Environment Canada in the past, and so had been through the training session before. However, he was "glad to have the opportunity to participate in this study. Because of the closures, we have less harvesting options than before, so we want to know what's available to us" (pers. com., 2005). The community obviously wants more involvement in the management of their resource, especially in areas where they have the capacity within the band to undertake tasks. For full answers to the survey, see Beach 2006 and Appendix C.

5. Collaborative or cooperative fieldwork

The next task was to model collaboration in a manner that would exercise the field skills of community members, while providing assurance to government that protocols are being properly followed. This research took a middle path between the very expensive field sampling done by Vancouver-based Environment Canada staff that fly in to take a sample and fly out the same day, and the more economical sampling by community members who only need to fly the sample out. Following this middle path, I drove in to the community from Vancouver in one day, was billeted overnight, took the samples collaboratively with the community samplers the next day, and drove the sample out to the laboratory on the same day as my return to Vancouver. Occasionally I did not participate, in order to test whether protocols were being carefully observed in my absence.

Writing collaborative fieldwork into budgets could help to better train community members, or provide assurance that already-trained members are meticulously following the protocol, while allowing governmental or other outside researchers direct exposure to TEK. Huntington (2000) emphasizes the fact that "locally hired field assistants have often contributed far more to research than mere logistical support" (Huntington 2000, 1272). The training session alone is often considered sufficient, although past problems with community monitoring groups could have been amplified by a lack of full understanding. As the Kyuquot/Checleseht Band Manager notes, "I believe that it is better to work through things together than to do a single sampling session if you want sampling without mistakes" (pers. com. 2006). Furthermore, doing the sampling in the community fisheries vessel (rather than the government airplane), in combination with the other steps, can allow the development of a collaboration far greater than the one

described by Huntington. The symbolic gesture of faith in the navigational skills and experience of the community fisheries staff during weather which does not permit the government plane to fly into the Sound is an important trust builder.

Integrating First Nations members into the water quality sampling process builds the capacity of the communities to understand and to communicate with government about the issues that are affecting their livelihoods. Since an intensive sampling program was being attempted in Kyuquot Sound as part of the development of the Conditional Management Plan, I accompanied the samplers on most sessions in order to answer questions and to help with logistics. In the first sessions, I took part as one of the technicians, having also been trained at the beginning of the project. During the latter sampling sessions, the community researchers became more involved in planning. A Coordinator Checklist was developed which helped to ensure that all of the necessary tasks for a sampling session were undertaken (such as calling the lab a day prior, remembering log sheets, etc.). The final sampling session was independently planned and undertaken by the community researchers.

6. Communication of the research findings to the community and decision makers in appropriate language

The sixth step in the research strategy was to report the findings from the research back to the community in a language that is clear and devoid of technical jargon. When technical language is necessary, every effort should be made to include clear descriptions. At the community meeting where the project findings were presented, the local researchers facilitated the communication of the research findings to those in attendance.

Prior to the meeting, we met to review the presentation, and they consulted me on which information would be the most interesting to the community, and on appropriate language for conveying that data. During the meeting itself, one of the researchers introduced me, and presented a portion of the management plans. It was a good opportunity to exchange information, and to make the community aware of the role of their researchers, so that everyone will feel comfortable in approaching them with questions or concerns. The communication can help to illustrate the accomplishments of the local participants, to justify their efforts, and to build the general knowledge about environmental trends and government policy (Pollock and Whitelaw 2005).

It is not only important to have the research findings communicated to the community, it is also vital to have those findings relayed to decision makers in a timely and appropriate manner. Vaughan *et al.* (2003, 400) emphasize "the limited ability of environmental monitoring programs and projects to go beyond the detection of change to the larger issues of societal linkages such as informing decision and influencing behaviours". To relay the findings to the government decision makers, I kept representatives from the three federal agencies involved in the CSSP (EC, DFO, and CFIA) up-to-date on sampling findings and provided them substantial input into the development of the Conditional Management Plan (CMP). Furthermore, I gave a presentation on the CMP at the Pacific Regional Interdepartmental Shellfish Committee (PRISC) meeting in April 2006. PRISC is the body that makes the ultimate decisions about classifying an area as opened, closed or conditionally opened based on the sampling results from Environment Canada and the CFIA.

7. Follow-up interviews of research participants to establish lessons learned

Participatory research could be a valuable tool in involving community members in crucial research that will affect their resources. However, full follow-up is a vital component of the capacity building process, as too often researchers collect information, but fail to relay that information back to the communities or to ask them to consider its local applicability. For instance, in order for the trained researchers to have a full understanding of the water and shellstock research in which they participated, they needed to see the results as they came in, and to be able to think about the meaning of patterns. Follow-up can also aid in fostering the continuity of relationships and of monitoring research, because all parties can be confident that attempts were made to address their needs. Pollock and Whitelaw (2005, 220) mention that "without an understanding of motivations, monitoring programs may fail to appeal to local interests and concerns". Follow-up surveys, whether formal or informal, are a good check to determine whether participants' original expectations were met and to make sure that the participants are aware of how the research will be used. Silver and Campbell (2005) note that if communication is lacking regarding the use of collaboratively collected data for policy recommendations, participation may actually damage community-government/researcher relationships and ultimately discourage participation in future initiatives. Moreover, the community researchers would like to understand how their work fits into the bigger resource management picture.

Surveys of the community researchers were done following the training session at the beginning of the research, and then again after the independent sampling session (see Beach 2006). Furthermore, check-ins with the community researchers were done at

various points throughout the research to see if anything was unclear or if they had any questions.

Not surprisingly, based on my participation, water quality was ranked as the highest threat to the shellfish industry. The Kyuquot participants also noted management strategies that could help address the problem, reflecting the fact that seasonal fluctuations are easier to work around than addressing the source, which is mostly wild animals and birds. The community researchers also felt that they had the capacity to continue water quality sampling for Environment Canada's portion of the CSSP. The capacity of the community to sample and to access labs, as well as funding for the fisheries program (staff, boat, sample analysis costs) were ranked as the most important factors that would contribute to the continuation of these monitoring programs. Furthermore, the participants were interested in further research into water quality, including looking at other contaminants and threats.

8. Continued discussion and support

The final step in the research was the continued discussion and support. Once the research is completed, the government officials and the community should continue efforts toward integrative problem solving. The resource managers will stand to benefit from local expertise in future projects, and the communities will be empowered by the augmented understanding. Furthermore, the increased data will help generate new options or views. Trust between parties will develop with increased responsibility and positive results. For Kyuquot Sound/Checleset Bay, a Conditional Management Plan was developed which will foster greater partnership between the CSSP regulating agencies,

and the Ka:’yu:’k’t’h’/Che:k:tles7et’h’ First Nations, since they will coordinate sampling following acceptable protocol, and will report to the necessary agencies.

RESULTS

Seasonality analysis

Based on the preliminary interviews (Beach 2005), a community-generated hypothesis was that the winter counts of fecal coliform would be lower than the non-winter counts. For the statistical analysis, winter was defined as December-March, and non-winter as April-November[11]. When the laboratory analysis noted that the fecal coliform count was below the detection limit of 2 fecal coliforms/100ml MPN, a conservative value of 1 was entered into the database. Figure 5 shows the fecal coliform counts recorded at each station over the period of this study. It shows that the counts were very high in October, then fell below the standard of 14 f.c./100ml during the winter months.

[11] Readers may note that the non-winter classification actually encompasses three seasons (spring, summer and fall). Obviously, these times of the year experience vastly different rainfall patterns. However, they are all characterized with high fecal coliform levels. There are 'first flush' events that occur in the spring (starting in April and running through May) and the fall (starting in October and running through November). During the summer months, the waters may be contaminated by higher densities of kayakers and boaters. Furthermore, shellfish harvesting is prohibited in Kyuquot Sound and Checleset Bay during the summer months because of blooms of harmful algae that cause red tide (or Paralytic Shellfish Poisoning). For this reason, all three 'contaminated' seasons were lumped into one season for analysis. Unfortunately, consistent rainfall data does not exist for the area, and so broad generalizations (such as a flush period in October/November) needed to be made.

Figure 5: **Fecal coliform counts over the project (October 2005-March 2006). The points represent single samples taken from each site, but because of time and weather constraints, not all sites were sampled each time.**

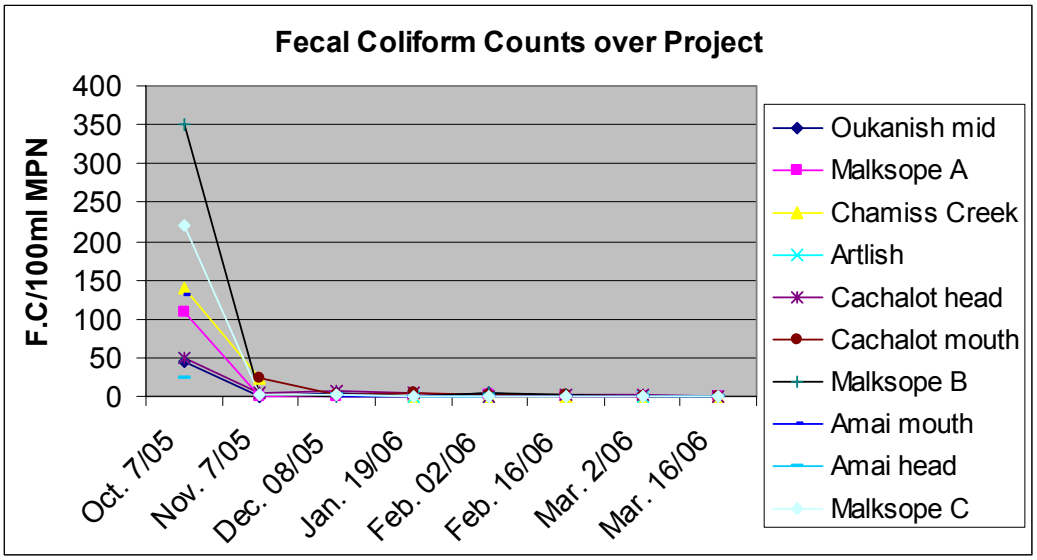


Figure 6 shows the fecal coliform counts using historical Environment Canada data starting in October 2001 and extending through the course of this research until March 2006. At all stations, the spikes of high counts shown in the figure are found during the non-winter months of April-November (see Appendix A for maps of Kyuquot Sound and Checleset Bay sampling stations). Figure 7 uses the data of Figure 6, but zooms in on the portion of the graph below the 50 f.c./0100ml on the y-axis. This allows the reader to better note the proportion of counts above the CSSP median fecal coliform standard of 14 f.c./100ml and below the CSSP maximum fecal coliform standard of 43 f.c./100ml.

Figure 6: **Fecal coliform trend from October 2001 to March 2006. Each point represents a single sample taken from the corresponding site.**

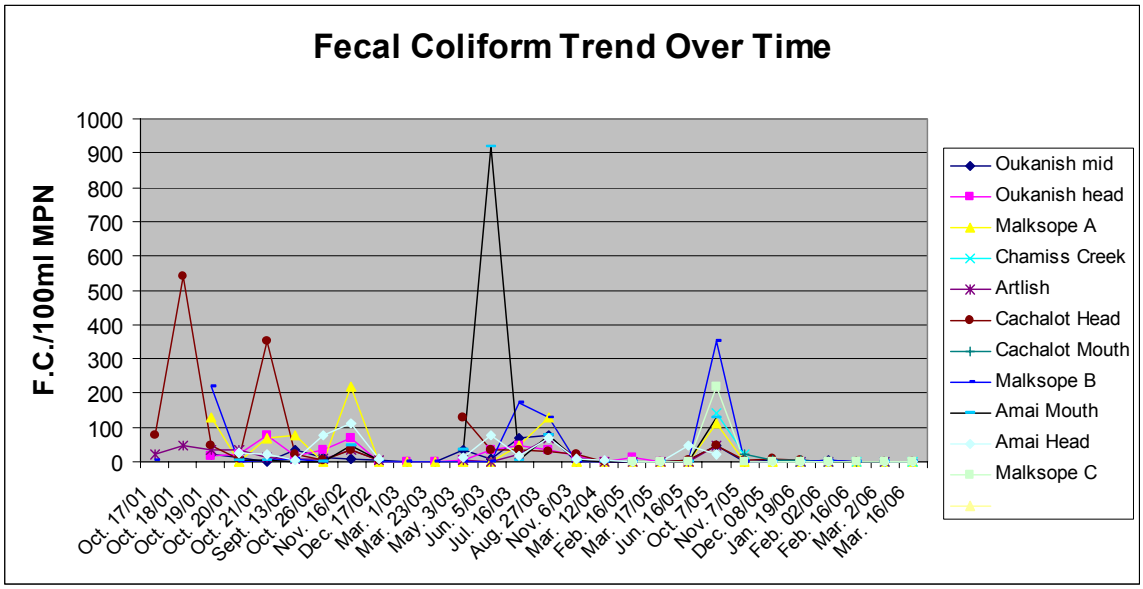
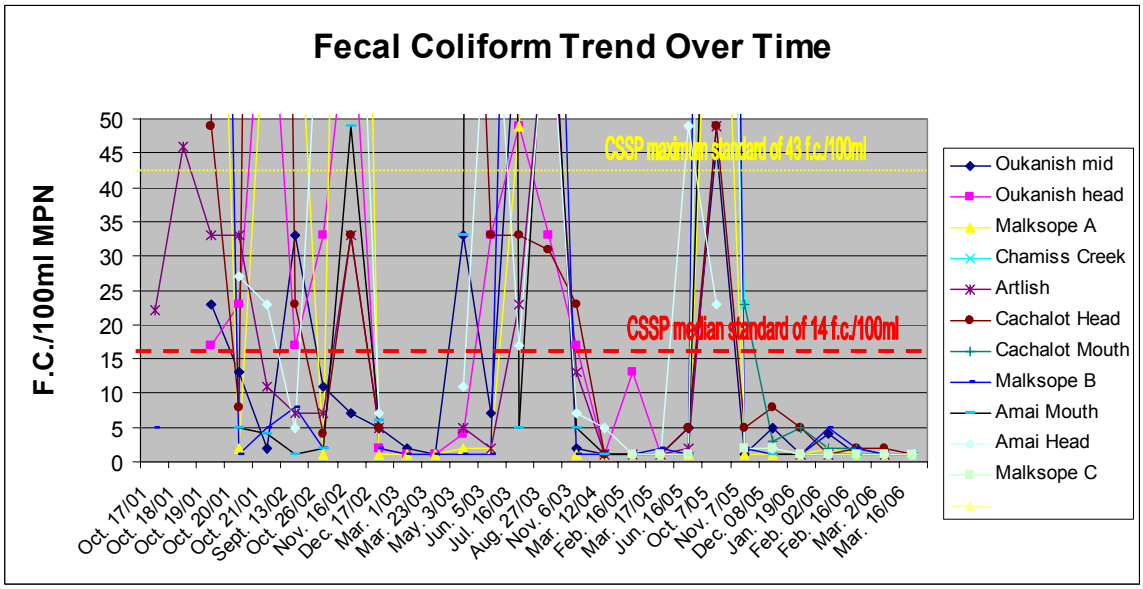


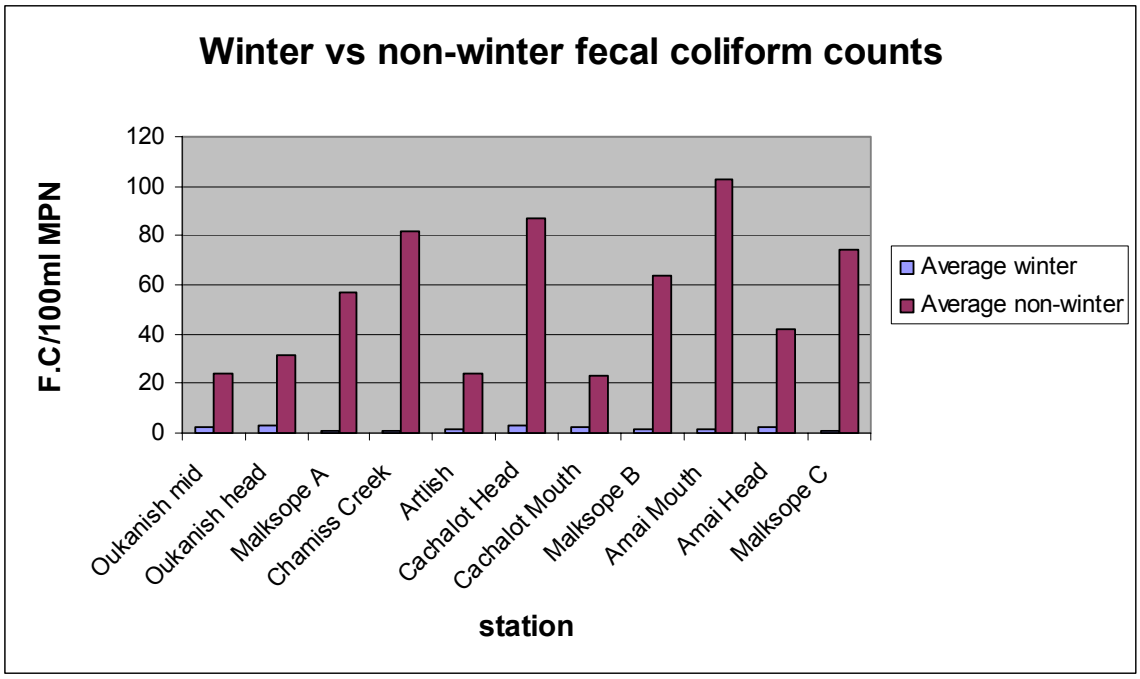
Figure 7: **Fecal coliform trend from October 2001 to March 2006 zoomed in to see counts below 50 f.c./100ml and noting the CSSP standard median of 14 f.c./100ml and the CSSP standard maximum of 43 f.c./100ml.**



Using the historical data (from October 2001-March 2006), an average of fecal coliform counts at each sample station during the winter and non-winter periods was

taken. Figure 8 shows the winter versus non-winter trend, and it clearly demonstrates that the average non-winter fecal coliform counts are much higher at each sample station.

Figure 8: **Comparing winter (December-March) and non-winter (April-November) average fecal coliform counts at each sample site. There were twelve possible winter sampling periods and sixteen possible non-winter sampling periods for each site.**



Finally, a Poisson Trend analysis was done using Environment Canada's data from October 2001 through March 2006. The analysis found a p-value of 1.25e-06 between the winter data and the non-winter data, clearly demonstrating the significance of the difference.

This information shows that there is a seasonal variance in the fecal coliform counts[12], and that during the winter months there is an opportunity for harvest openings. A Conditional Management Plan would allow such seasonal openings, and so was developed by myself working with the community researchers, the province, and three federal agencies: Environment Canada, Fisheries and Oceans Canada, and the Canadian Food Inspection Agency.

Logging analysis

The mountains around Kyuquot Sound/Checleset Bay show definite signs of large-scale clear-cut logging. In some areas, historical logging practices have taken trees from whole mountainsides, from the ocean right to the peak, with little or no riparian buffer. Numerous times during my work in the community, people voiced a desire to have a hypothesis tested as to whether the logging is having an impact on the fecal coliform counts. This came up in personal interviews, in community meetings, and even in an Area F Clam Management Board meeting, with members outside of the Kyuquot/Checleseht area expressing curiosity about the findings.

People often shared a similar hypothesis that fecal coliform counts downstream of a young forest recovering from clearcutting may be higher than any other area because more animals, such as deer, are entering the area to eat the young vegetation. Without trees, moss and shrubs to absorb moisture, there is a more rapid flow of water over the soil surface and through the soil sub-surface. Without a canopy to disperse the energy and

[12] Because of the lack of consistent sampling during certain months, such as summer months, it is difficult to increase the resolution of the temporal patterns by dividing the seasons further. What is evident is that there have been periodic spikes in fecal coliform levels during all months except for those categorized in the "winter" period (Dec-March).

the force of rain, that water affects the soil more directly. Finally, without tree roots to stabilize the soil, fecal matter washes downslope more readily, especially on the steep slopes[13]. This would also suggest that the counts might be higher in the non-winter period because of the quantity of rainfall, but that after the flushing of the spring and the fall, the winter months may show less variation between sites.

To attempt to test this hypothesis, I met with members of the community involved in logging directly, or in engineering logging cuts. Those people shared their own observations about unlogged areas, and provided me with logging maps that depicted the major cuts. Using this information, I then referred to a SH Scientific Systems Ltd. (2004) watershed analysis report. This report also gave percentages for the amount of area that was recently logged, old growth, and unlogged in each watershed, as well as the mean annual flow and maximum predicted flow. A comparison among watersheds was done (see Table 1) to evaluate sites with similar mean annual flows and contrasting percentages of logging.

[13] Fecal coliform is used as an indicator bacteria because it is commonly associated with the breakdown of mammalian scat. However, other bacteria such as *Klebsiella* can react similarly in lab tests as does coliform bacteria, yet be relatively harmless. *Klebsiella* is bacteria that are associated with the breakdown of wood and so can produce false-positive readings in recently logged watersheds. Environment Canada is aware of this phenomenon, and routinely tests the coliform bacteria further to confirm the species. For instance, in a 2004 check for false positives caused by *Klebsiella* in Kyuquot Sound, Environment Canada found that this accounted for only 0.3% of high fecal coliform counts (pers. com. 2004). For this reason, *Klebsiella* has not been a concern for this report. For more information, see Beach 2005.

Table 1: **Comparison of logged mean annual flow, maximum predicted flow, and percentages of young and old growth forests.**

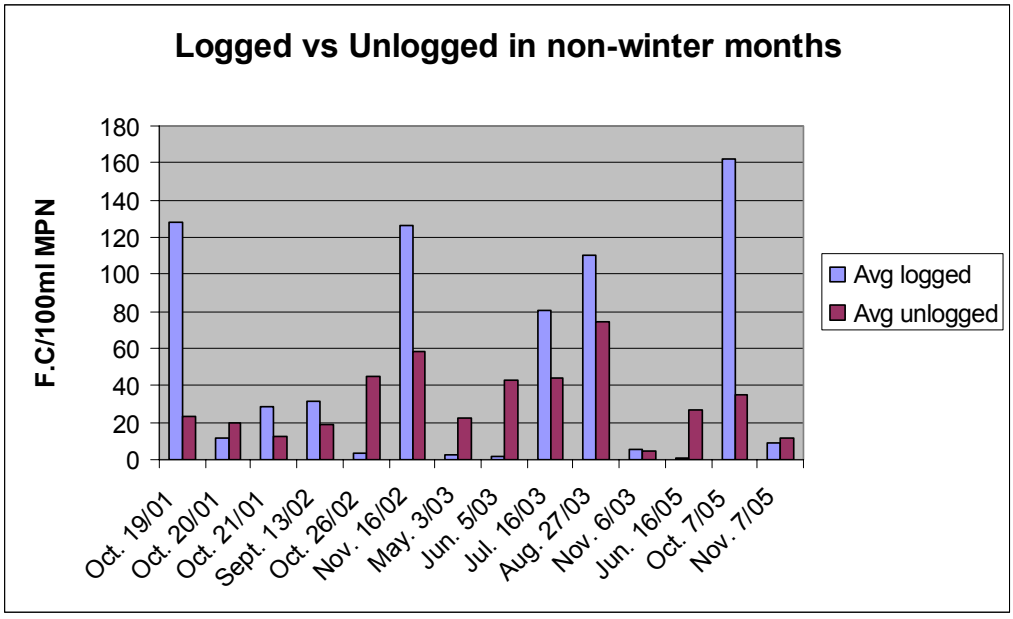
Unlogged					Logged				
Site	Mean ann. flow (m^3/s)	Max predicted flow (m^3/s)	% young forest	% old	Site	Mean ann. flow (m^3/s)	Max predicted flow (m^3/s)	% young forest	% old
Oukanish A	8.28	81.75	0-3	83-99	MalksopeA	6.17	70.26	18-34	35-48
AmaiHead	1.98	29.55	21	73	Chamiss	1.48	17.92	51.03	17.29
CachalotMout	3.97	52.66	0-14	83-97	MalksopeB	6.17	70.26	18-34	35-48
					Artlish	15.38	156.93	4.98	39.94

Figure 9 shows variations in the fecal coliform counts in logged watersheds and unlogged watersheds during the non-winter months. It shows that the average unlogged counts are often lower than the average logged counts, but the relationship is not significant. Removing all other non-winter months except for October and November (as the most significant "first flush" months) shows a similar pattern, but to find true significance, a researcher would need to obtain a more consistent record of samples and obtain more accurate reference sites for the logged and unlogged watersheds. Although another useful analysis would be to correlate rainfall data with the fecal coliform counts, this data is not consistently available for Kyuquot Sound. Instead I can only hypothesize that the months that produce a great deal of pollution from logged areas are also those months that experience higher than average rainfall events. This hypothesis can be supported by salinity data[14] (see Appendix E for raw data). For instance, on October 26, 2002, Figure 9 shows that the average fecal coliform count from unlogged watersheds is

[14] Another factor that may influence salinity is the tide (ebb, flow). If the tide is high, there may be more mixing with freshwater, thus reducing the salinity levels.

higher than that from logged watersheds, which is an abnormality in the pattern. However, the salinity count for that time is high (averaged 26.4 ppt across all sites), showing that there was very little rain before the samples were taken. If this is compared to the October 7, 2005 data, the salinity for that month is comparatively low (average 9.8 across all sites), showing that a heavier rainfall event occurred prior to sampling and thus more freshwater was diluting the sea water[15]. Unfortunately, thorough comparisons between logged and unlogged datasets were beyond the scope of this research and instead I can only suggest patterns that require further study in order to prove or disprove the significance of logging effects. This analysis lends some support to the first flush hypothesis and shows that the question is worthy of more in-depth study.

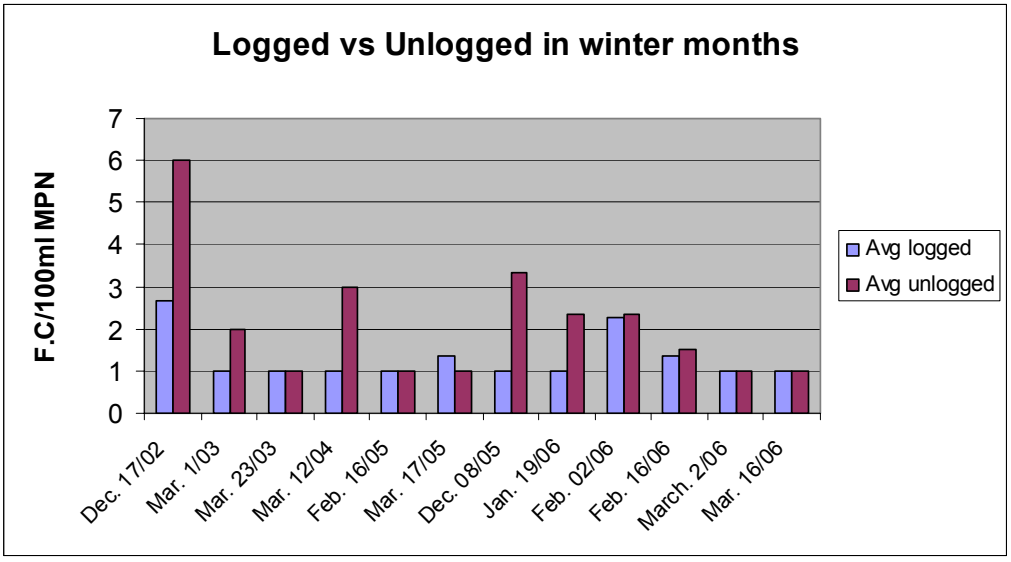
Figure 9: **Non-winter (April-November) variations in fecal coliform between logged and unlogged watersheds. Each bar represents an average across all reference sites (see Table 1) sampled on the specified date.**



[15] Also note that fecal coliform bacteria survive and reproduce more readily in fresh water.

Figure 10 shows that the fecal coliform counts in logged and unlogged watersheds in the winter months vary much less than in the non-winter months (NOTE that all of the values on the y-axis are below the 14 fecal coliform/100ml MPN standard of the CSSP).

Figure 10: Fecal coliform counts in logged and unlogged watersheds in the winter (December-March) months. Each bar represents an average fecal coliform count across all reference sites (see Table 1).



The statistical analysis of the data involved a Poisson Trend Analysis. The analysis showed that there was no statistical difference (p-value of 0.421) between the fecal coliform counts in logged versus unlogged watersheds, though the results indicate that there seems to be more bacteria in logged areas. The difference however, is not enough given the variability in these data to state with any certainty that the observed difference is undeniably caused by the state of the watershed. It should be noted that these data are unbalanced in that there are less data during the winter months and there are large gaps between samples during some years, and thus the power of the test is not uniform.

Although the statistical analysis did not demonstrate a significant relationship between the logged and unlogged watersheds, a more thorough study on this topic (more watersheds, data collected over a longer period of time, data collected with more regularity) may reveal different results.

Microbial Source Tracking (MST)

Microbial Source Tracking (MST) can be referred to as the genetic fingerprinting of bacteria and can be used to identify the exact source of fecal contamination (Source Molecular Corporation, 2005). According to the Institute for Environmental Health (IEH, 2005), traditional pollution monitoring methods used by Environment Canada are not appropriate for tracking the specific source of bacterial contamination in the environment. Instead standard tests for fecal coliform as an indicator of fecal pollution can simply suggest potential sources of contamination based on shoreline surveys identifying possible point causes. For remote areas facing closures from non-point or unknown sources, identification information is critical. Because it is still in its developmental phases, there is not yet a standard acceptable MST methodology, especially since different technologies may be more appropriate for different questions in diverse geographical locations. However, the Institute of Environmental Health, which provided the MST services for this research, has been used in numerous projects across Canada and the US, including use by the US Environmental Protection Agency and the Washington Department of Ecology (IEH 2005).

Heather Osachoff of Environment Canada explains that the agency uses a DNA method to identify source, looking at bacteroides as a fecal indicator (pers. com. 2005).

This technology is appropriate for more developed locations where sources are most likely to be from humans, ruminant animals (deer, cow, sheep), or domestic animals (cats, dogs, pigs, horses). However, it does not provide sufficient information to identify sources when the cause is most likely to be wild terrestrial animals, marine mammals, and avian populations, such as is the case in Kyuquot Sound, and so in this case, ribotyping is the most appropriate technology (Woodruff and Evans 2003).

This research relied on the laboratory services of Dr. Mansour Samadpour of the Institute of Environmental Health who developed a ribotyping technique termed Eco RI / Pvu II variant, which isolates and genetically fingerprints strains of *Escherichia coli* from the water and source samples (IEH 2005). It can be used to identify specific hosts because fecal coliform bacteria will adapt differently to differing intestinal environments, creating variations among members of the same species (IEH 2005). Through the identification of these genetic differences, it is possible to associate bacteria with specific sources. The bacteria from the contaminated environment are compared to a library of known isolates, of which IEH Inc has approximately 120,000 source isolates (IEH 2005). For more information, please see Source Molecular Corporation, 2005 and IEH, 2005.

The Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations community asked that this research attempt to identify the sources of the winter time fecal pollution. Because of cost constraints, only two sites were chosen to represent the logged (Chamiss Bay at NW088) and the unlogged conditions (mouth of Cachelot Inlet at NW102) in Kyuquot Sound. From each site, 30 samples were taken twice in the winter, on January 19 and on February 2. The samples were first sent to North Island Laboratories in Courtenay, BC to plate the fecal coliform colonies for transport to the IEH laboratory in Seattle, WA. The

fecal coliform findings at those times were extremely low, often below the detection limit of 2 fecal coliforms per 100ml. The levels were not anticipated, based on the historical data from Environment Canada.

Colonies were isolated, and Dr. Samadpour's team was able to identify 75 colonies, and match 70 of them to a known source in the isolate library. The results show that avian species are the biggest contributor, accounting for 40.4% of the January counts, and 69.6% of the February counts, for a total of 49.3% overall at both stations. Marine mammals accounted for 17.3% of the observed sources, and were virtually the same at both sample stations.

Because the fecal coliform levels were so low during the sampled winter months, there is a strong possibility that something that is causing the high counts in the "worst-case" months may not be there during the cleaner winter months. It is important to note that no matches were made to bear fecal matter, which is not surprising, since the samples were taken during the winter hibernation period of January and February. Log sheet data from October notes that many bears are found near the sampling sites, probably feasting on salmon (see Appendix D for log sheets). The counts at that time were extremely high in comparison to the rest of the research findings, averaging 124 fecal coliforms/100ml across the sites compared to January's[16] average of 1.8 fecal coliforms/100ml. Further testing in October should occur in order to explore this hypothesis.

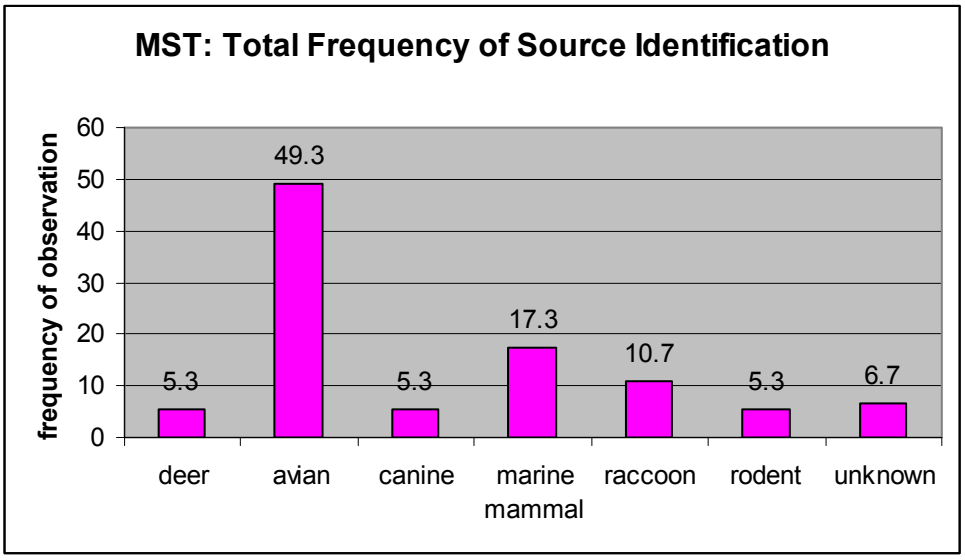
Table 2 and Figure 11 show the total frequency of the source identification of isolates at both sites in January and February.

[16] Note that there were no bears recorded in the log sheets during the winter months.

Table 2: **MST results showing the total number of observations and the frequency of each source identification from NW088 (Chamiss Bay) and NW102 (Cachalot Inlet) in January and February 2006**

Source Species	Observation	Frequency
Deer	4	5.3
Avian	37	49.3
Canine	4	5.3
Marine mammal	13	17.3
Raccoon	8	10.7
Rodent	4	5.3
Unknown	5	6.7
Total	*75*	*100.0*

Figure 11: **Total frequency of source identification of isolates at NW102 (Cachlaot Inlet) and NW088 (Chamiss Bay) in January and February, 2006**



The Kyuquot Sound Conditional Management Plan (CMP) and the Area 26 Harvest Management Plan

Based on the water quality findings of seasonal variations, and on the demonstrated capacity of the community to undertake the sampling, a Conditional Management Plan (CMP) and a Harvest Management Plan (HMP) was developed for

Kyuquot Sound. For the first trial season (December 2005-March 2006), I acted as the coordinator of the CMP[17]. However, a Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations member worked closely with me and will take over the duties during the 2006-2007 season. The Kyuquot/Checleseht fisheries crew, who will be re-trained in November 2006, will undertake the water quality sampling and patrolling of open beaches. Harvesting in Kyuquot Sound, according to the HMP, will then be open to any Area F Clam License holder (see Appendix B for map of open beaches).

A CMP and an HMP of this nature has never before been attempted in Canada. It is slated to be a pilot project to try to determine if plans such as these can be undertaken and implemented by small communities in partnership with federal government regulators. For further details on both plans, see EC 2006a and 2006b.

The development of community capacity to undertake data collection and analysis

In December 2005, an independent sampling session was attempted, yet was not executed because of preparation difficulties and because the timing of the samples was close to Christmas. This event revealed that steps needed to be taken towards true independent sampling, since the Kyuquot/Checleseht fisheries crew had never fully attempted full coordination of water quality sampling. During each sampling session between January and March 2006, additional duties were handed over to the samplers and the future coordinator. A fully independent sampling session was undertaken in March, though some problems still existed.

[17] The HMP won't be implemented until December 2006 since harvesting was still prohibited during the research period until the water quality findings showed acceptable levels, and the CMP was developed and signed by all parties.

One of the most significant problems was that the fisheries crew failed to report on the 24-hour transport of the samples. Under CSSP regulations, samples must be delivered to the laboratory within six hours. Because of the remoteness of Kyuquot Sound however, six hours was not feasible without air transport, and so an extension was granted with the stipulation that a minor report (often less than half a page) be submitted to Environment Canada. The report is necessary for international auditing purposes, and describes where the samples are kept overnight, and notes temperatures of the control[18] three times during the 24-hour period. The fact that the report was not properly recorded and submitted was a warning flag for the future viability of the Conditional Management Plan. However, only further sampling starting in December 2006 will demonstrate if the reports will be filled out and sampling can continue.

Other minor problems occurred during the independent sampling run in March 2006. There were problems in noting the sampling stations and in locating and storing field maps. Furthermore, there was a general failure to communicate with myself after the independent sampling run and with Environment Canada during the research period. Finally, during the 2005-2006 winter season, there was not a consistent and regular mussel sampling for Paralytic Shellfish Poisoning (also known as PSP or red tide). Although this was not a duty of the water quality sampling under the CMP, it is important for general monitoring purposes, and raised some alarms among the federal agencies as to whether the community will be able to sample consistently under the CMP. However, community members explained that the sampling did not occur partly because of difficult

[18] Usually, a bottle labelled "temperature control" is filled at the first sample station and the temperature is recorded. Once the samples are submitted to the lab, the temperature of the control is again recorded, to ensure that the temperature did not rise above 10C or below 0C, which could result in fecal coliform reproduction or die off. This, in turn could blotch the true fecal coliform counts of the growing water.

weather and the breakdown of the fisheries boat, and partly because harvesting was not occurring and thus there was confusion about why the PSP sampling still needed to occur.

All of the obstacles that occurred during the research period and the independent sampling run are surmountable with proper communication of protocol and motives. The consequences of improper sampling must be conveyed and the Kyuquot/Checleseht fisheries crew must be properly prepared if continued community sampling is to continue.

Placing the CMP in a larger context for cooperation

The water quality research presented an initial attempt to institutionalize a methodology of community sampling that can provide an opportunity for Kyuquot/Checleseht members to offer input into harvest rules in their traditional territories. The work was unique for the area in that it ensured that community-generated hypotheses were tested. The collaborative aspect of the research (between the community, the federal agencies, and the researcher) put the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations in a position to think strategically about future clam management policy. Discussions ensued about whether or not to plan for sub-area licensing and/or depuration as longer-term strategies. These discussions might not have occurred without the purposeful inclusion of community members in the scientific monitoring and policy formation because under 'normal' circumstances, the government simply imposes the restrictions and local people must adhere to the rules. If they fail to adhere, they can be penalized, which would deepen feelings of distrust among all parties.

Another positive result of the research was that the findings concretely showed, using CSSP approved sampling standards, that there are variations across the country and that the Program needs to be amended in order to be more responsive to local needs. Currently, the CSSP policy on shellfish closures and methods of measuring pollution is under review, and the federal agencies are working with concerned groups and provincial governments to ameliorate the program. The agencies are considering stakeholder partnerships, which could take a number of different forms, including greater cooperation between communities and government through shared responsibilities for monitoring. The Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations may be used as an example to guide change.

RECOMMENDATIONS

Based on the research that I was involved with in Kyuquot Sound and Checleset Bay, I have several recommendations for the community and for further research.

Implement the CMP and HMP

In the winter of 2006-2007, I believe that it will be beneficial to the community if they attempt to implement the Conditional Management Plan and the Harvest Management Plan. This will help to further develop communication avenues between the community and the federal government regulators, and to establish experiences of collaboration and cooperation. This will also enhance the community's capacity to collect and analyze data, and to make recommendations on setting the policy agenda.

Amend the CSSP

The Canadian Shellfish Sanitation Program (CSSP) has recently undergone severe criticism from industry stakeholders (Howlett and Rayner 2004, Blue Revolution 2004). First, critics argue that the original program is no longer practical as it was designed to meet the needs of a mostly wild fishery and is not designed for a diverse shellfish harvest sector (i.e., geoducks, deep-water scallop culture, etc). While wild harvesting still occurs, recently there has been an increase in promotion and investment in shellfish aquaculture ventures, which has resulted in growth of a less variable harvest (Blue Revolution 2004).

Related to this occurrence, there are more stakeholders in the industry today, partly the result of growing coastal communities and new commercial interests as other fin fisheries experience problems.

A second problem with the CSSP is that there is not one single lead agency to make the decisions. The program is a joint venture between three federal agencies, whereas the US National Shellfish Sanitation Program (NSSP) employs only one lead agency. This division of powers can be beneficial in obtaining expert opinion about different aspects; however, it can also "affect the capacity of state officials to deal with pressing issues in a timely and consistent fashion" (Howlett and Ramesh 2003). Associated with this is the tension between provincial and federal policy. Although the CSSP is headed by the three federal agencies, it also includes participation from the appropriate provincial governments. This poor coordination within the CSSP parties is evident in British Columbia's promotion of shellfish aquaculture. For a number of years, the provincial government has been promoting aquaculture investment and expansion without consultation with Environment Canada regarding appropriate growing areas (i.e., finding out where closure or prohibition areas occur). The result has been the lease of tenures in areas that are unfit for harvest due to water quality issues. This has led to frustration among the harvesters who had assumed they had the right to collect shellfish from their leased tenures.

A third criticism of the CSSP is common to many government programs: limited availability of monetary resources. Without built-in adaptability to compensate for the lack of funds, there is a restricted ability to deliver the existing program, let alone to undertake innovative research into other possible modes of administration. For instance,

the current expansion of aquaculture ventures has increased the water quality sampling needs of the industry. Scallop and oyster rafts grow the animals at depths exceeding five to ten meters. However, the CSSP regulations of water quality calls for samples to be taken from the top six inches of water, an area that is often contaminated by freshwater runoff which would most likely be substantially diluted and thus not harmful when contamination reaches depths below one meter. Although aquaculturalists regularly raise this point, the CSSP has not yet had the capacity to respond.

Fourth, the sampling requirements of the CSSP are set up based on average conditions in shellfish harvest, such as proximity to laboratories and urban centres. For instance, in many parts of Canada, it is relatively easy to have the water samples transported from the study area to a federally approved laboratory for analyses within the required six hour time period. However, in remote locations such as Kyuquot, this constraint can severely limit the sampling ability of communities, since the driving/boating distance alone under ideal conditions without any mishaps can take five hours. Therefore, any difficult weather or traffic delays would void the reliability of the samples. Special considerations for different locations could help harvesters to feel that their needs are being addressed.

Given all of the design problems with the CSSP Monitoring Program that were mentioned above, it is evident that the program needs to be adaptable to localized variations.

Overcoming challenges of not utilizing full capacity of the community

Before the research began in Kyuquot Sound and Checleset Bay, the First Nations community there already had the ability to hypothesize about problems plaguing their natural resources and to conduct research. However, that capacity was not fully utilized in a way that could influence resource management policy. With government funding cuts and with many First Nation groups moving towards fuller self-governance, the concern for utilizing existing community capacity is growing in importance. Governments need to enhance their relationships with First Nation communities such as the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations in order to better prepare them for managing their resources, and to aid the government themselves in being able to better understand resource and human interactions.

Fuller capacity utilization in shellfish management planning in Kyuquot Sound can be realized through the effective communication of the international standards and protocols that govern the Canadian regulations. A more conscious attempt should be made by government representatives and communities to communicate with one another. Many reasons exist for breakdowns in communication, and in this case, the fault lies with both parties. Reasons include unintentional intimidation of community members by use of technical and unclear language, complex federal policy, histories of mistrust, unwillingness of community members to make the time to attend meetings and speak with government representatives, and lack of time for proper discussion. On the other side of the coin, government officials do not always absorb information from community members regarding their expertise and history on issues specific to the area. Although there is an important bank of this traditional ecological knowledge (TEK) emerging from

generations of intimate involvement with forests and fish, it has largely been disregarded. The information is only partly considered by current government officials, and new harvesters are not always obtaining the critical wisdom from their elders, making the TEK at risk of being lost. Making a conscious attempt to understand one another will demonstrate to the communities and the regulating agencies the value of each other's input.

Fuller capacity utilization can also be realized through further cooperative work, which would transmit skills and knowledge across cultural barriers. Sampling, monitoring, and enforcement duties, such as those necessary under the Kyuquot Sound CMP and HMP, is an example of cooperative work. Further discussions with the community about future resource management issues, such as finfish surveys or management options, would also support increased learning opportunities.

Further research

A number of options for further research came up during the course of the work in Kyuquot Sound and Checleset Bay and here I will name a few. First, the question about how extensive clear-cut logging is affecting the shellfish growing waters should be undertaken. This could include research into changes in the hydrology of steams that are modified by the cuts and the increased debris, or study could focus on changes in animal behaviour in clearcut areas (frequency of use, changes in species that exploit the area, etc.). The effects of logging on downstream marine environments are still relatively unknown and further scientific research should be undertaken.

Second, in relation to the heavy logging practices in the area, research into whether an abundance of chelators[19] in the growing waters is affecting the fecal coliform counts should be preformed. Although the high salinity of seawater does not enable reproduction of terrestrial bacteria such as *E. coli*[20], the salt content alone does not cause bacterial die-off. Instead, a combination of sunlight, temperature, and specific marine bacteriophages cause the mortality of terrestrial bacteria in the marine environment (Parsons *et al* 1984). Nevertheless, Jones (1963, 1964) found that adding a chelating agent actually prevented the lethal effects of seawater. Increased lose debris is found in the aftermath of clearcut logging, and this can contribute humic acids which can then combine with natural environmental metals to form chelators. Parsons *et al.* (1984) explain that when near-shore environments contain a large amount of organic material (from pollutants or natural sources) this enables a greater survival of fecal bacteria in the marine environment. Therefore, a possible influx of natural chelators in Kyuquot Sound/Checleset Bay from significant runoff of woody debris might cause higher findings of fecal coliform than would be expected based on human and animal population estimates. This would be especially pronounced during first flush events when more accumulated debris would be washed into the rivers and creeks.

Third, further Microbial Source Tracking work should be done in order to identify sources during the fall and spring period when Environment Canada routinely conducts water quality sampling. The data for this aspect of the report was only collected twice

[19] Chelation refers to the binding of a ligand to a metal ion, which forms a stable chelate. Examples that can be found in the natural environment include the binding of amino acids and humic acids to cations such as iron, zinc, and copper.

[20] *E. coli* is short for *Escherichia Coli*, and is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. The presence of these bacteria is an indication human or animal waste contamination. Although most strains of *E. coli* are harmless, some strains such as 0157:H7 have caused illness in humans (EPA 2006).

during the winter period when fecal coliform counts were extremely low. Further testing could help to identify water quality issues during identified periods of high fecal coliform counts.

Fourth, further work with the CSSP government regulators should be done in order to realize some of the amendments that are needed for the Program.

Finally, a fifth area for further research would be to look at the success or failure of the CMP after it has been realized in the winter of 2006-2007.

CONCLUSION

Throughout the course of the research, Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations members were trained to undertake water quality sampling under the CSSP and were involved in planning sampling and harvesting plans for Kyuquot Sound and Checleset Bay. The research itself was spawned by the needs of the community to understand closures that raised substantial scepticism and anger, partly because they doubted the science utilized in the decision making process, and partly because their livelihoods depend on access to this important resource. Furthermore, the research helped the community in their attempt to move toward co-management[21] of their shellfish resources, which would include monitoring and ensuring environmental integrity.

Three main objectives directed this research. The first objective was to look at the source of the fecal pollution and to determine if there were noticeable patterns that affected counts. The Microbial Source Tracking helped to show that the source, at least during the winter months, was not human but instead consisted mostly of avian species. Further testing during known periods of high fecal coliform counts could enhance the strength of the MST data. The Poisson trend analysis showed that there were predictable temporal variations in the high fecal coliform counts, a trend around which harvest openings could occur. For instance, fecal coliform counts were within acceptable standards between December and March, the season that coincides with historical openings. Finally, the Poisson trend analysis did not show a significant difference

[21] Research is being conducted with the Ka':yu:'k't'h'/Che:k:tles7et'h' First Nations by Dr. Evelyn Pinkerton and Jennifer Silver on options for clam co-management.

between logged and unlogged watersheds, though further studies should be undertaken that compare more watersheds over a longer period of time in order to make a more accurate assessment (i.e., more monthly data may be able to more accurately show temporal variations).

The second objective of the research was to develop the local capacity to identify problems that plagued the shellfish industry and to be involved in the data collection, analysis, and policy agenda setting. Involvement in these activities is key to the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations community being able to consider and strategize about future clam management policy. Theoretically, monitoring pollution is part of the government's role. However, in this case, the community needed to encourage cooperation and collaboration in order to ensure that the necessary sampling was undertaken. Early on in the research, it became apparent that significant capacity to identify problems and undertake monitoring already existed in the community, but that the capacity was underutilized in guiding policy decision making. By including community members in all aspects of the research, from problem identification and hypothesis development to monitoring and harvesting planning based on the results of water quality testing, a greater understanding about the research was created. The hope is that greater participation will lead to a more robust CMP and HMP than would have otherwise been developed without community input. Although the CMP and HMP may not be viable in the long-run because of high sampling costs, it will provide an opportunity for cooperation among First Nations and government agencies. The CMP expanded the officially-recognized monitoring rights of the community and has created a

situation of joint responsibility and coordination of the plan, and of enforcement of harvest regulations

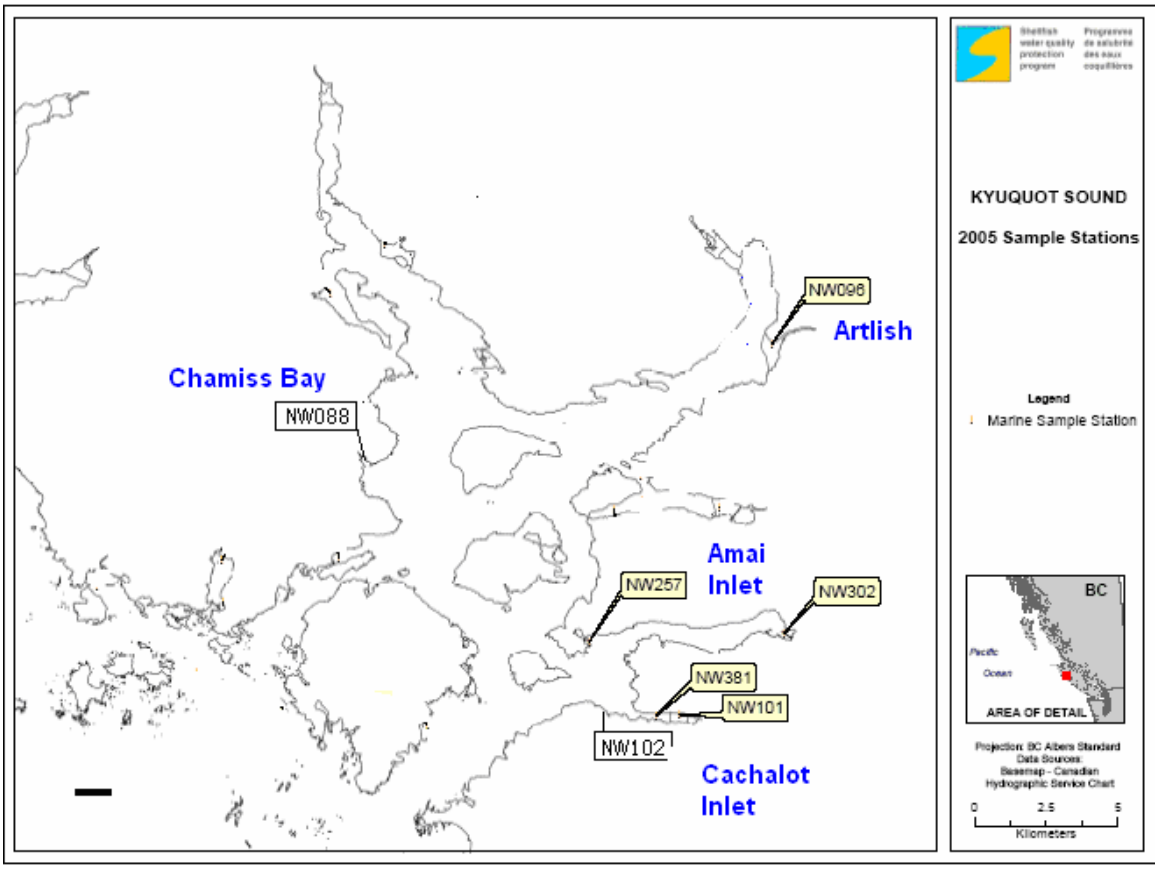
The third objective was to develop the capacity of the federal government agencies to research pollution concerns and to strategise management options with the local community. Relationships between the Kyuquot/Checleseht fisheries crew and individuals in the CSSP federal agencies were strengthened during this research and this will provide further context within which they can work together. Ultimately, involvement of local people will decide the success of programs and the trust that the researchers or decision makers have in the community will be reflected in how they choose to involve citizens. Engaging local community members increases avenues of communication between government and First Nations fisheries researchers, which is a noted barrier to successful management.

Throughout the course of the research, I learned a lot about working with First Nation communities and government, and about the Kyuquot/Checleseht people. The research constantly evolved to meet changing needs and to accommodate weather problems, vessel problems, and time constraints of the people involved. I was fortunate as a student to have flexibility in my time schedule and mindset, since research cannot always follow a smooth agenda. It is important that others working in such situations keep in mind the need to constantly be open to learning and change. Solutions are not always as easy as they appear. However, by working together even for a short period, we were able to come up with a solution that will allow harvest in the coming season and that will benefit the community and the regulating agencies.

APPENDICES

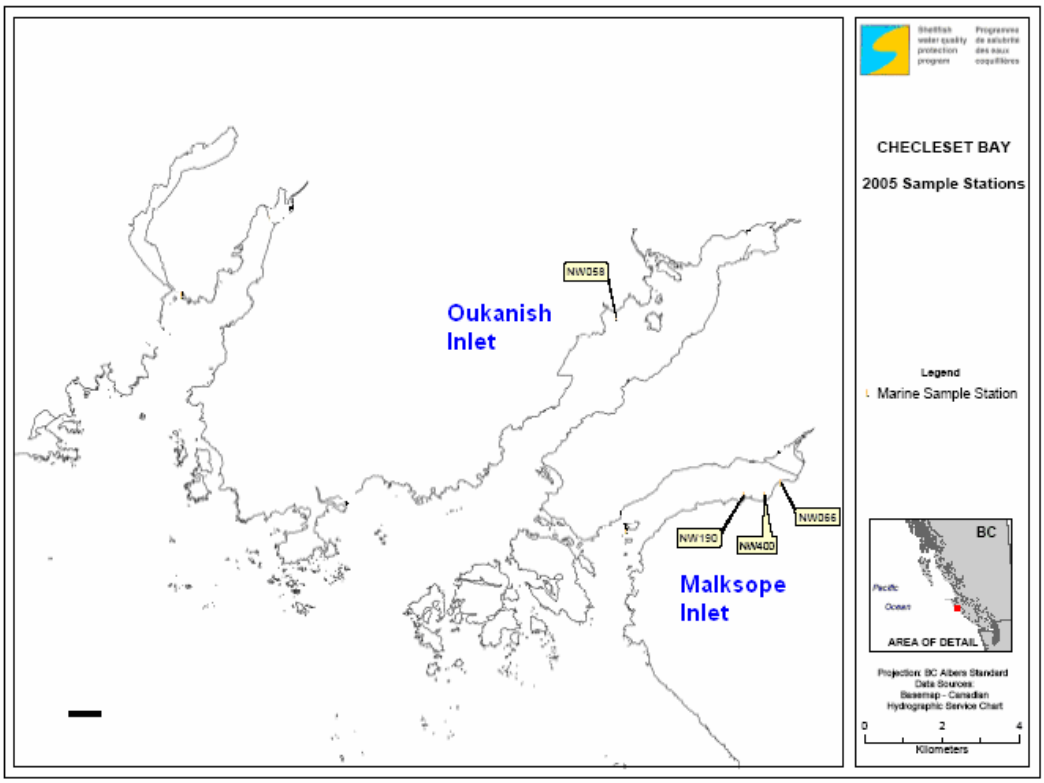
Appendix A: Water quality sampling stations

Figure 12: Kyuquot Sound sampling stations (source EC 2005b)



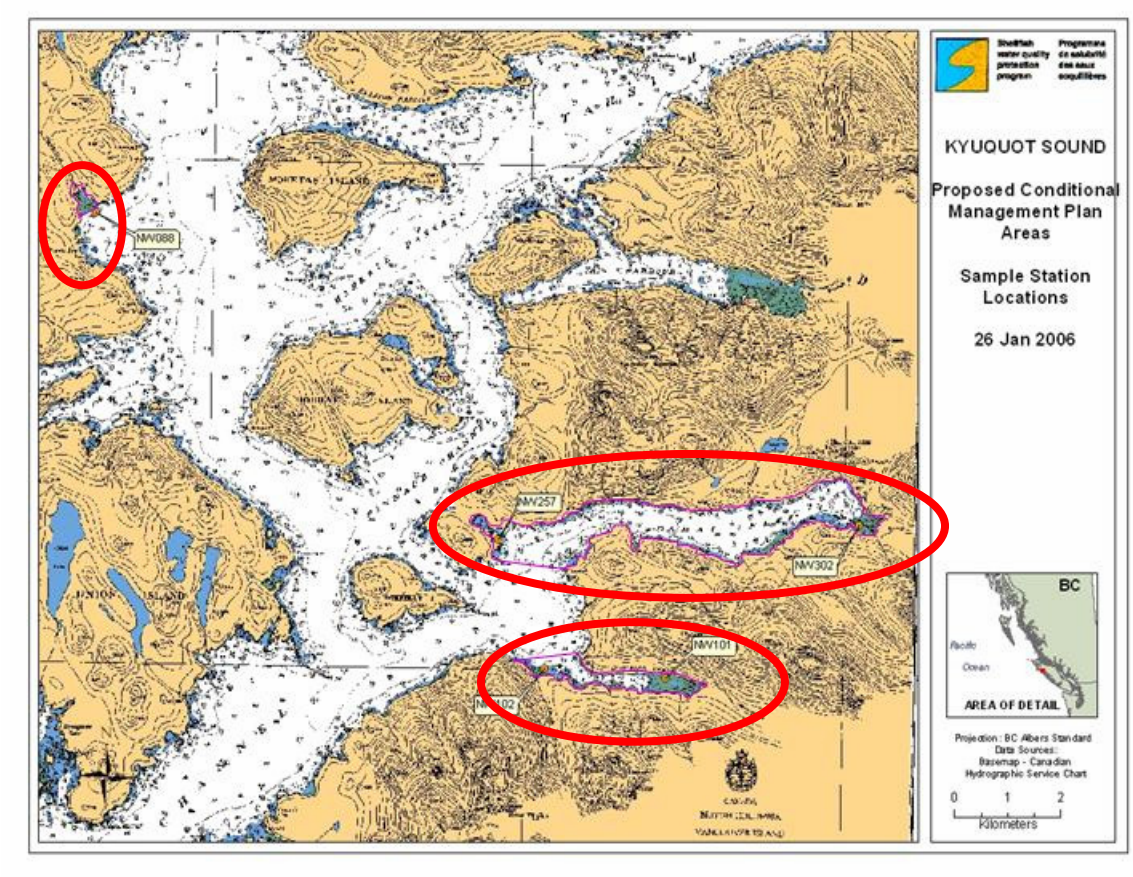
Where NW096 is Artlish, NW257 is Amai mouth, NW302 is Amai head, NW 101 is Chachalot head, NW102 is Chachalot mouth, and NW066 is Chamiss Creek.

Figure 13: Checleset Bay sampling stations (source EC 2005b)



Where NW061 is Oukanish head, NW058 is Oukanish mid, NW066 is Malksope A, NW190 is Malksope B, and NW400 is Malksope C.

Appendix B: Map of open areas for the Conditional Management Plan of 2006-2007 (source EC 2006a)



Appendix C: Survey done with water quality trainee from the Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations-November 27, 2005

1) What had you been expecting to learn at the training session?
A: Well [my colleague] and I have done all of this in the past, so we know the techniques. But it's good to get the go-ahead from Environment Canada and to be able to participate in the study.

2) Why were you interested in receiving training from Environment Canada to take marine water quality samples?
A: We're just glad to have the opportunity to participate in this study. Because of the closures, we have less harvesting options than before, so we want to know what's available to us.

3) Did you find the training session helpful?
A: It fits in to what we've done in the past

4) Was anything left unclear after the training session?
A: No, it seemed clear

5) Was anything not discussed that you would have liked to learn about?
A: No

6) Do you feel that you have a better understanding of the Canadian Shellfish Sanitation Program (CSSP)?
A: Yeah I guess. But we have been through it before.

7) Do you feel that you have a better understanding of Environment Canada's sampling protocol?
A: No, it's really the same as what we've done before.

8) What do you think is the biggest contributor to the high fecal coliform counts in your area?
A: Animals, but then again, they've always been here. So why is there a problem now? Sometimes it seems as if the government is purposely trying to keep us out of an area.

9) For what reason would you like to monitor the water in your area? (monitor pollution affecting commercial species? affecting personal food species?)
A: We want to know what is causing the high fecal coliform counts. Is it bears, or gulls, or otters?

10) Do community members eat clams from the closed areas?

A: Yeah, for sure. They eat them even from the beaches around the community, even when you can see the sewage pipes. But no one ever gets sick

If so, do they feel there is any risk to their health in doing so?
A: No, not really

How low or high would you describe the risk from eating shellfish from your area? (scale of 1-5, with 5 as high)
A: 1 or 2. No one ever gets sick

Appendix D: Research Log Sheets

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): _____March 16, 2006_____
Sampling Area: _____Kyuquot/Checleset NW05_____
Crew: Sampler _____Dan Short_____ Boat Operator ____Leonard John___
Weather:_____high
overcast_____
(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? **No** Yes Heavy Light
Sea Conditions:
_____calm_____
(e.g. Calm, ripple, chop, white caps)
Wind Speed: _0-5NW__estimated km/hour or **knots** (circle one)
Wind Conditions: __light_____(e.g. None, breezy, windy, stormy)

Marine Sample Station	**Time (24 hour)**	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW058	10:08	20 sea gulls, 20 ducks
Temp. Control #	10:11	Temperature: _5_ C
NW400	10:35	No wildlife
NW190	10:38	1 duck
NW066	10:41	17 ducks
NW257	13:15	1 stellar Jay
NW302	13:29	8 seals, 1 sea gull, 1 duck
NW101	13:53	2 ducks
NW102	14:12	2 ducks

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): ____March 2/06_____
Sampling Area: _____Kyuquot/Checleset NW05_____
Crew: Sampler _L. John, D. Short, K. Beach Boat Operator ___L. John_____
Weather:___high
overcast_____

(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? No **Yes** Heavy **Light**
Sea Conditions: _____ripple-
chop_____
(e.g. Calm, ripple, chop, white caps)
Wind Speed: _10-15 S.E. estimated km/hour or **knots** (circle one)
Wind Conditions: _____breezy_____(e.g. None, breezy, windy, stormy)

Marine Sample Station	**Time (24 hour)**	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW096	11:13	200 + geese, 16 gulls
Temp. Control #	11:13	Temperature: __9_____ C
NW257	11:40	1 seal
NW302	11:54	1 sea lion, 1 eagle, 33 ducks, 13 seals
NW101	12:15	15 ducks, 4 seals **(clam sample picked up)**
NW102	12:33	14 ducks
NW088	12:56	60 ducks, 7 seals
NW190	14:20	1 kingfisher, 1 duck
NW400	14:24	5 ducks
NW066	14:29	6 ducks
NW058	14:51	16 ducks, 1 sea otter

NOTES: Temperature control: 4pm March 2=1C
Temp control: 8am March 3=1C, 11:20am=0.5C

NOTES: high, high tide this time of year resulted in logs of debris in the water
Herring fish closer to shore lately, this might account for higher number of sea mammals close-by

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): __Feb. 16/2006_____
Sampling Area: ___Kyuquot/Checleset NW05_____
Crew: Sampler _Len John, Katie Beach_____ Boat Operator _Len John_____
Weather:___clear,
cool_____
(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? **No** Yes Heavy Light
Sea Conditions:
__ripple_____
(e.g. Calm, ripple, chop, white caps)
Wind Speed: _0-5____estimated **km/hour** or knots (circle one)

Wind Conditions: ___none_____(e.g. None, breezy, windy, stormy)

Marine Sample Station	Time (24 hour)	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW257	8:45	50 ducks **(clam sample, dug at sample time 8:40)**
Temp. Control #	8:45	Temperature: _5_____ C
NW101	9:00	20 ducks **(oyster samples taken from beach near rafts)**
NW102	9:30	70 ducks, 2 seals
NW088	9:50	7 gulls, 75 ducks **(Horseclam samples from beach) (note: tide too high to get Manila clams)**
NW058	11:10	10 ducks, 19 gulls
NW190	11:30	none
NW400	11:35	none
NW066	11:35	None **(clam samples taken from bag attached to buoy at 11:40)**

NOTE: Lab temperature control at 4:56pm, 1.5C (kept overnight in lab for analysis)

NOTE: Head of Amai completely iced over, could not get to the site

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): _February 2, 2006_____
Sampling Area: _Kyuquot/Checleset NW05_____
Crew: Sampler _D. Short, K. Beach, (J. Pynn) Boat Operator __D. Short, (Keith Cox)__
Weather:_sunny with clouds_____
(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? No **Yes** **Heavy** Light
Sea Conditions: ____choppy in open water_____
(e.g. Calm, ripple, chop, white caps)
Wind Speed: _5_____estimated km/hour or **knots** (circle one)
Wind Conditions: ___breezy_____(e.g. None, breezy, windy, stormy)

Marine Sample Station	Time (24 hour)	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW058	11:00	15 gulls, 8 ducks
Temp. Control #	11:00	Temperature: _6_ C
NW190	11:25	4 crows
NW400	11:30	

NW066	11:35	6 ducks **(Clam sample from NW067)**
NW088	13:15	2 seals, 60 ducks **(MST 15 samples)**
NW101	13:50	5 ducks, 10 gulls **(oyster samples off raft at NW381-taken from top tray)**
NW102	14:25	1 seal, 40 ducks, 10 gulls **(MST 15 samples)**
NW302	14:55	7 seals, 15 gees (overhead), 4 ducks
NW257	15:05	1 seal
NW096	15:35	2 seals, 12 swans, 5 gulls, 20 geese, 5 ducks

NOTE: Temperature Control at 10pm: 1.5C
Temperature control at lab 9:30am: 1C

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): __January 19, 2006_____
Sampling Area: __Kyuquot/Checleset (NW05)_____
Crew: Sampler _L. John, D. Short, K. Beach_ Boat Operator _Tony Hanson_____
Weather:__cold, low cloud cover, drizzle_____
(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? No **Yes** Heavy **Light**
Sea Conditions: __choppy
(3m)_____
(e.g. Calm, ripple, chop, white caps)
Wind Speed: _35-45__estimated km/hour or **knots** (circle one)
Wind Conditions: _____(e.g. None, breezy, windy, stormy)

Marine Sample Station	**Time (24 hour)**	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW058	11:15	50 gulls, 3 seals
Temp. Control #	11:15	Temperature: _7_ C
NW190	11:45	None
NW400	11:50	None
NW066	11:55	3 ducks, 1 gull, 5 oyster catchers, 2 crows
NW088	13:00	4 ducks **(MST 15 samples)**
NW102	13:35	1 seal, 10 gulls, 2 ducks **(MST 15 samples)**
NW101	13:50	6 ducks, 5 gulls
NW302	14:10	2 eagles, 1 gull, flock of geese overhead
NW257	14:25	3 ducks, 9 crows **(clam sample here)**

NW096	15:00	5 ducks

NOTE: Temperature control taken at 23:00=2C
Temperature control taken at lab at 10:00am=1.5C (January 20)

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): ___December 8/2005_____
Sampling Area: ___Kyuquot/Checleset NW05_____
Crew: Sampler __D. Short, L. John, K. Beach_____ Boat Operator __Tony Hanson, Jim Short
Weather:__high cloud, NNW wind_____
(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? No **Yes** Heavy **Light**
Sea Conditions:
___ripples_____
(e.g. Calm, ripple, chop, white caps)
Wind Speed: __0-5___estimated km/hour or **knots** (circle one)
Wind Conditions: ___NNW_____(e.g. None, breezy, windy, stormy)

Marine Sample Station	**Time (24 hour)**	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW058	8:33	4 ducks
Temp. Control #	8:36	Temperature: _____ C
NW066	9:07	None
NW190	9:15	6 ducks
NW400	9:20	14 ducks (lots of empty clam shells on beach)
NW101	11:05	Lots of birds (100 ducks, geese), 1 seal
NW102	11:10	50 ducks, 1 gull, 4 seals
NW302	11:25	30 ducks, 10 geese, 1 cormorant, 1 swan
NW257	11:40	6 ducks, 4 seals

NOTE: Temperature control at the lab: 3C

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): __November 7/2005_____
Sampling Area: _____Kyquot/Checleset NW05_____
Crew: Sampler __Len John, Katie Beach Boat Operator _Russell Hanson_____

Weather:___cloudy, drizzle_____
(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? No **Yes** Heavy **Light**
Sea Conditions:
___chop_____
(e.g. Calm, ripple, chop, white caps)
Wind Speed: _10-15__estimated km/hour or **knots** (circle one)
Wind Conditions: _____none_____(e.g. None, breezy, windy, stormy)

Marine Sample Station	**Time (24 hour)**	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW058	8:35	5 ducks
Temp. Control #	8:35	Temperature: _8.5__ C
NW190	8:55	Seal, duck
NW400	9:00	6 ducks
NW066	9:00	10 ducks, 3 seals
NW088	10:10	3 seals, 2 eagles, 50 seagulls, 27 ducks
NW091	10:25	60 ducks, 30 seagulls, 3 seals
NW089	10:30	70 seagulls, 40 ducks, 6 eagles, 2 swans
NW102	11:00	1 eagle, 1 seal, 8 seagulls, 1 loon
NW101	11:10	2 bears, 70 seagulls, 30 ducks

NOTE: Temperature Control at 11:44=2C
Temperature control at lab at 3:19pm=1C

ENVIRONMENT CANADA
SHELLFISH WATER QUALITY PROTECTION PROGRAM
LOG SHEET – MARINE WATER SAMPLING

Sample Collection Date (DD/Mon/YY): __October 7/05_____
Sampling Area: __Kyuquot/Checleset NW05_____
Crew: Sampler _L.John, D.Short, K.Beach, B.Galbraith Boat Operator_Peter Hanson_____
Weather:__mostly sunny, some cloud_____
(e.g. Clear, partly cloudy, overcast, foggy, drizzle, showers, rain, snow)
Rainfall in last 24 hours? No **Yes** **Heavy** Light
Sea Conditions:
_____calm_____
(e.g. Calm, ripple, chop, white caps)

Wind Speed: _<10___estimated km/hour or **knots** (circle one)
Wind Conditions: _____(e.g. None, breezy, windy, stormy)

Marine Sample Station	**Time (24 hour)**	**Observations** (e.g. #s and species of birds, marine mammals, domestic animals, boats, upland/beach users, water appearance)
NW058	8:35	120 gulls, 1 bear on beach, 1 seal
Temp. Control #	8:35	Temperature: _9__ C
NW066	9:10	1 bear, 6 gulls
NW400	9:14	1 bear, 3 gulls, 1 duck
NW190	9:18	2 gulls, 2 crows
NW088	10:10	1 eagle, 6 gulls, 5 seals, 7 ducks
NW101	10:35	8 ducks, 5 sea gulls, 2 seals
NW302	10:50	4 seagulls, 4 seals, 3 ducks
NW257	11:05	2 seagulls, 1 seal
NW11:25	11:25	150+ seagulls, 6 seals, 4 loons

Appendix E: Raw Data

Water quality analyses for fecal coliform and salinity

Sector	Station	Date	Time	Salinity (ppt)	FC/100g MPN	L/U/C	W/N
NW05	NW058	Mar. 16/06	10:08	14	<2	U	W
	NW058	Mar. 2/06	14:51	20	<2	U	W
	NW058	Feb. 16/06	11:10	22	<2	U	W
	NW058	Feb. 2/06	11:00	2.4	4	U	W
	NW058	Jan. 19/06	11:15	13	<2	U	W
	NW058	Dec. 8/05	8:33	26	5	C	W
	NW058	Nov. 7/05	8:35	19	<2	U	N
	NW058	Oct. 7/05	8:35	6	46	U	N
	NW058	Jun. 16/05	9:15	6	5	U	N
	NW058	Mar. 17/05	14:40	29	<2	U	W
	NW058	Feb. 16/05	9:45	22	<2	U	W
	NW058	Mar. 12/04	10:30	16	<2	U	W
	NW058	Nov. 6/03	10:25	28	2	U	N
	NW058	Aug. 27/03	9:40	4	79	U	N
	NW058	Jul. 16/03	10:05	4	70	U	N
	NW058	Jun. 5/03	9:30	26	7	U	N
	NW058	May. 3/03	10:10	26	33	U	N
	NW058	Mar. 23/03	14:25	0	<2	U	W
	NW058	Mar. 1/03	11:50	28	2	U	W
	NW058	Dec. 17/02	10:45	10	5	U	W
	NW058	Nov. 16/02	12:25	0	7	U	N
	NW058	Oct. 26/02	13:10	26	11	U	N
	NW058	Sept. 13/02	10:30	14	33	U	N
	NW058	Oct. 21/01	13:35	2	2	U	N
	NW058	Oct. 20/01	11:40	8	13	U	N
	NW058	Oct. 19/01	11:40	3	23	U	N
NW05	NW061	Jun. 16/05	9:20	4	<2	C	N
	NW061	Mar. 17/05	14:45	13	<2	C	W
	NW061	Feb. 16/05	9:55	12	13	C	W
	NW061	Mar. 12/04	10:40	15	<2	C	W
	NW061	Nov. 6/03	10:35	32	17	C	N
	NW061	Aug. 27/03	9:50	5	33	C	N
	NW061	Jul. 16/03	10:20	5	49	C	N
	NW061	Jun. 5/03	9:40	16	33	C	N
	NW061	May. 3/03	10:20	6	4	C	N
	NW061	Mar. 23/03	14:35	0	<2	C	W
	NW061	Mar. 1/03	12:00	26	<2	C	W
	NW061	Dec. 17/02	10:55	10	2	C	W
	NW061	Nov. 16/02	12:10	0	70	C	N
	NW061	Oct. 26/02	13:20	31	33	C	N

	NW061	Sept. 13/02	10:20	14	17	C	N
	NW061	Oct. 21/01	13:45	13	79	C	N
	NW061	Oct. 20/01	11:50	10	23	C	N
	NW061	Oct. 19/01	11:55	1	17	C	N
NW05	NW066	Mar.16/06	10:41	26	<2	L	W
	NW066	Mar. 2/06	14:29	26	<2	L	W
	NW066	Feb. 16/06	11:35	25	<2	L	W
	NW066	Feb. 2/06	11:35	5.9	2	L	W
	NW066	Jan. 19/06	11:55	25	<2	L	W
	NW066	Dec. 8/05	8:36	28	<2	L	W
	NW066	Nov. 7/05	9:00	26	<2	L	N
	NW066	Oct. 7/05	9:10	12	110	L	N
	NW066	Jun. 16/05	9:45	28	<2	L	N
	NW066	Mar. 17/05	14:20	20	<2	L	W
	NW066	Feb. 16/05	10:25	28	13	L	W
	NW066	Mar. 12/04	10:05	23	<2	L	W
	NW066	Nov. 6/03	10:50	32	17	L	N
	NW066	Aug. 27/03	10:10	15	33	L	N
	NW066	Jul. 16/03	10:45	9	49	L	N
	NW066	Jun. 5/03	10:00	29	33	L	N
	NW066	May. 3/03	10:40	24	4	L	N
	NW066	Mar. 23/03	15:00	0	<2	L	W
	NW066	Mar. 1/03	12:15	28	<2	L	W
	NW066	Dec. 17/02	11:10	24	2	L	W
	NW066	Nov. 16/02	12:50	0	70	L	N
	NW066	Oct. 26/02	13:40	32	33	L	N
	NW066	Sept. 13/02	9:45	28	17	L	N
	NW066	Oct. 21/01	14:40	5	79	L	N
	NW066	Oct. 20/01	11:15	10	23	L	N
	NW066	Oct. 19/01	12:35	3	17	L	N
NW05	NW088	Mar.16/06	12:51	20	<2	L	W
	NW088	Mar. 2/06	12:56	23	<2	L	W
	NW088	Feb. 16/06	9:50	17	<2	L	W
	NW088	Feb. 2/06	13:15	2.1	<2	L	W
	NW088	Jan. 19/06	13:00	3	<2	L	W
	NW088	Nov. 7/05	10:10	6.4	23	L	N
	NW088	Oct. 7/05	10:10	6	140	L	N
NW05	NW089	Nov. 7/05	10:30	1.6	26	C	N
NW05	NW091	Nov. 7/05	10:25	2.9	14	C	N
NW05	NW096	Mar. 2/06	11:13	28	<2	L	W
	NW096	Feb. 2/06	15:35	4.2	<2	L	W
	NW096	Jan. 19/06	15:00	7	<2	L	W
	NW096	Oct. 7/05	11:25	7	49	L	W
	NW096	Jun. 16/05	10:45	19	2	L	N
	NW096	Mar. 17/05	12:05	25	<2	L	W
	NW096	Feb. 16/05	12:30	28	<2	L	W
	NW096	Mar. 12/04	10:40	19	<2	L	W

	NW096	Nov. 6/03	11:15	30	13	L	N
	NW096	Aug. 27/03	10:30	8	70	L	N
	NW096	Jul. 16/03	10:50	5	23	L	N
	NW096	Jun. 5/03	10:05	30	2	L	N
	NW096	May. 3/03	11:00	20	5	L	N
	NW096	Dec. 17/02	10:50	4	5	L	W
	NW096	Nov. 16/02	11:00	0	33	L	N
	NW096	Oct. 26/02	15:45	16	7	L	N
	NW096	Sept. 13/02	10:55	14	7	L	N
	NW096	Oct. 21/01	9:45	12	11	L	N
	NW096	Oct. 20/01	9:55	6	33	L	N
	NW096	Oct. 19/01	8:50	0	33	L	N
	NW096	Oct. 18/01	9:00	4	46	L	N
	NW096	Oct. 17/01	8:55	6	22	L	N
NW05	NW101	Mar. 16/06	13:53	10	<2	C	W
	NW101	Mar. 2/06	12:15	8	2	C	W
	NW101	Feb. 16/06	9:00	22	2	C	W
	NW101	Feb. 2/06	13:50	3.6	<2	C	W
	NW101	Jan. 19/06	13:50	13	5	C	W
	NW101	Dec. 8/05	11:05	27	8	C	W
	NW101	Nov. 7/05	11:10	17	5	C	N
	NW101	Oct. 7/05	10:35	4	49	C	N
	NW101	Jun. 16/05	11:15	13	5	C	N
	NW101	Mar. 17/05	13:00	5	<2	C	W
	NW101	Feb. 16/05	11:45	22	<2	C	W
	NW101	Mar. 12/04	9:20	16	<2	C	W
	NW101	Nov. 6/03	9:55	32	23	C	N
	NW101	Aug. 27/03	8:40	22	31	C	N
	NW101	Jul. 16/03	8:25	9	33	C	N
	NW101	Jun. 5/03	8:35	22	33	C	N
	NW101	May. 3/03	9:35	24	130	C	N
	NW101	Dec. 17/02	9:35	10	5	C	W
	NW101	Nov. 16/02	9:30	0	33	C	N
	NW101	Oct. 26/02	14:00	31	4	C	N
	NW101	Sept. 13/02	9:30	25	23	C	N
	NW101	Oct. 21/01	11:10	13	350	C	N
	NW101	Oct. 20/01	11:15	4	8	C	N
	NW101	Oct. 19/01	10:20	2	49	C	N
	NW101	Oct. 18/01	10:30	7	540	C	N
	NW101	Oct. 17/01	10:20	6	79	C	N
NW05	NW102	Mar. 16/06	14:00	22	<2	U	W
	NW102	Mar. 2/06	12:33	22	<2	U	W
	NW102	Feb. 16/06	9:30	25	2	U	W
	NW102	Feb. 2/06	14:25	12.1	2	U	W
	NW102	Jan. 19/06	13:55	14	5	U	W
	NW102	Dec. 8/05	11:10	25	2	U	W
	NW102	Nov. 7/05	11:00	12	23	U	N

NW05	NW190	Mar.16/06	10:38	27	<2	L	W
	NW190	Mar. 2/06	14:20	28	<2	L	W
	NW190	Feb. 16/06	11:30	26	2	L	W
	NW190	Feb. 2/06	11:25	7	5	L	W
	NW190	Jan. 19/06	11:45	17	<2	L	W
	NW190	Dec. 8/05	9:07	28	<2	L	W
	NW190	Nov. 7/05	8:55	25	2	L	N
	NW190	Oct. 7/05	9:18	17	350	L	N
	NW190	Jun. 16/05	9:40	27	<2	L	N
	NW190	Mar. 17/05	14:30	27	2	L	W
	NW190	Feb. 16/05	10:15	28	<2	L	W
	NW190	Mar. 12/04	10:00	30	<2	L	W
	NW190	Nov. 6/03	10:45	32	<2	L	N
	NW190	Aug. 27/03	10:05	18	130	L	N
	NW190	Jul. 16/03	10:45	10	170	L	N
	NW190	Jun. 5/03	9:55	24	<2	L	N
	NW190	May. 3/03	10:30	26	<2	L	N
	NW190	Mar. 23/03	14:50	2	<2	L	W
	NW190	Mar. 1/03	12:10	30	<2	L	W
	NW190	Dec. 17/02	11:15	24	2	L	W
	NW190	Oct. 26/02	13:35	31	2	L	N
	NW190	Sept. 13/02	10:00	29	8	L	N
	NW190	Oct. 21/01	14:25	23	5	L	N
	NW190	Oct. 20/01	11:10	28	<2	L	N
	NW190	Oct. 19/01	12:30	2	220	L	N
	NW190	Oct. 17/01	12:05	13	5	L	N
NW05	NW257	Mar. 16/06	13:15	20	<2	C	W
	NW257	Mar. 2/06	11:40	24	<2	C	W
	NW257	Feb. 16/06	8:45	22	<2	C	W
	NW257	Feb. 2/06	15:05	11.2	<2	C	W
	NW257	Jan. 19/06	14:25	13	<2	C	W
	NW257	Dec. 8/05	11:40	24	<2	C	W
	NW257	Oct. 7/05	11:05	14	130	C	N
	NW257	Jun. 16/05	11:10	26	<2	C	N
	NW257	Mar. 17/05	12:35	23	<2	C	W
	NW257	Feb. 16/05	11:55	25	<2	C	W
	NW257	Mar. 12/04	9:50	15	<2	C	W
	NW257	Nov. 6/03	10:25	32	5	C	N
	NW257	Aug. 27/03	9:30	16	79	C	N
	NW257	Jul. 16/03	9:05	18	5	C	N
	NW257	Jun. 5/03	9:20	20	920	C	N
	NW257	May. 3/03	10:10	22	33	C	N
	NW257	Dec. 17/02	11:10	12	6	C	W
	NW257	Nov. 16/02	10:10	8	49	C	N
	NW257	Oct. 26/02	14:45	30	2	C	N
	NW257	Sept. 13/02	10:00	25	<2	C	N
	NW257	Oct. 21/01	10:35	15	4	C	N

	NW257	Oct. 20/01	10:45	14	5	C	N
	NW257	Oct. 19/01	9:50	18	11	C	N
	NW257	Oct. 18/01	9:55	18	13	C	N
	NW257	Oct. 17/01	9:45	16	8	C	N
NW05	NW302	Mar.16/06	13:29	20	<2	U	W
	NW302	Mar. 2/06	11:54	8	<2	U	W
	NW302	Feb. 2/06	14:55	11.2	<2	U	W
	NW302	Jan. 19/06	14:10	15	<2	U	W
	NW302	Dec. 8/05	11:25	26	2	U	W
	NW302	Oct. 7/05	10:50	12	23	U	N
	NW302	Jun. 16/05	11:00	11	49	U	N
	NW302	Mar. 17/05	12:30	12	<2	U	W
	NW302	Feb. 16/05	12:10	24	<2	U	W
	NW302	Mar. 12/04	9:35	14	5	U	W
	NW302	Nov. 6/03	10:15	32	7	U	N
	NW302	Aug. 27/03	9:10	16	70	U	N
	NW302	Jul. 16/03	8:50	20	17	U	N
	NW302	Jun. 5/03	9:05	18	79	U	N
	NW302	May. 3/03	9:55	10	11	U	N
	NW302	Dec. 17/02	9:55	10	7	U	W
	NW302	Nov. 16/02	9:55	0	110	U	N
	NW302	Oct. 26/02	14:30	18	79	U	N
	NW302	Sept. 13/02	9:50	26	5	U	N
	NW302	Oct. 21/01	10:50	25	23	U	N
	NW302	Oct. 20/01	10:55	17	27	U	N
	NW302	Oct. 19/01	10:00	5	70	U	N
	NW302	Oct. 18/01	10:10	19	79	U	N
	NW302	Oct. 17/01	10:00	24	2	U	N
NW05	NW400	Mar. 16/06	10:35	27	<2	C	W
	NW400	Mar. 2/06	14:25	28	<2	C	W
	NW400	Feb. 16/06	11:35	27	<2	C	W
	NW400	Feb. 2/06	11:30	5.8	<2	C	W
	NW400	Jan. 19/06	11:50	18	<2	C	W
	NW400	Dec. 8/05	9:20	28	2	C	W
	NW400	Nov. 7/05	9:00	26	2	C	N
	NW400	Oct. 7/05	9:14	10	220	C	N
	NW400	Jun. 16/05	9:45	30	<2	C	N
	NW400	Mar. 17/05	14:30	25	<2	C	W
	NW400	Feb. 16/05	10:20	30	<2	C	W

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