Human Influences on Orcinus orca within St. Johnstone Strait

Human Influences on Orcinus orca within St. Johnstone Strait

Dawn Smith
College 8
E.S. 195
Ken Norris

Christi Bricknell
Cowell College
E.S. 195
Ray Dasmann

U.C.S.C., Fall 1987

University of California, Santa Cruz, Ca.

Table of Contents

Introduction

The northern community of Orcinus orca has been studied in depth for 13 years. Most of the information on this species has come from Robson Bight due to easy access, predictability of orca movement and committed researchers. The St. Johnstone Strait community of orcas is significant to the species as a whole because it is an isolated population genetically and geographically. Other orca populations are not as easily accessible, therefore, knowledge gained from the St. Johnstone Strait population is valuable for other orca management plans.

Human use of St. Johnstone Strait has increased dramatically in the past decade. Industrial, commercial, recreational and research activities are influencing orca population and habitat. The purpose of this paper is to tie together the massive amount of independent research already done so that a wider perspective may be gained. A summer was spent at Robson Bight in order to obtain a first hand perspective of the orca's habitat as well as to update current research information. The content of this has been taken from a review of literature, interviews with researchers and locals, as well as our experience as members of the Rubbing Beach Study Team.

Natural History of Orcinus orca in St. Johnston Strait

Orcinus orca is a cetacean within the family Delphinidae under the order Odontoceti. Orcas are the largest dolphin in the delphinidae family. Mature females reach 27 feet long with a 3-foot dorsal. Males mature up to 30 feet long with a 6-foot dorsal. They are easily recognizable from other cetaceans because of their distinguished markings and from the male's comparatively tall dorsal fin. Orcas are charcoal black with a grey/white saddle, white ventral surface and a small white patch just behind the eye.

The life span of orcas are similar to humans. They may live up to 100 years, however males usually live to 50 and females live to 60 or 70. Sexual maturity is reached in females between 9 and 10 years old and between 12 to 13 years for males. Although the orca gestation period is not known, it is believed to be 16 months.

Calves are 8 feet long at birth. Female calves stay within close proximity of their mothers until they are sexually mature. An exception to this rule is when other siblings are born (first calf must be at least 2-3 years before weaned) demanding closer attention. The female calf will stay with her immediate family unit until she has too many children of her own. At this point the female might branch off and form her own family unit within the pod.

Male calves are unique in that they stay within close proximity to their

mothers all their lives. Male orcas also engage in babysitting behaviors of their younger siblings. This type of behavior is rarely seen within mammalian species. Theories of males best preserving their nearest genes due to over abundant male populations within a breeding pool are sometimes used to explain male babysitting behaviors and commitment to their matriarchs in Jackle and Wolf species. The ratio of male to female orcas in St. Johnstone Strait is almost evenly split.

In British Columbia there are three orca populations: two resident communities and a transient community. The two resident communities divide their territories at a distinct tidal line. The transient community's territory includes the area both south and north of the resident communities and beyond. Therefore, there are two orca communities that will be affected by Robson Bight management plans: the northern resident community and the transient community.

Breeding takes place from different pods but always within the same community. It is believed that communities have been reproductively isolated for generations. When considering management plans, it is crucial to know if these three communities are indeed distinct populations. Many different studies comparing behavior, acoustic foraging and physical observations have concluded that these three communities are indeed separate and that they may have been so for many generations.

The transient community is the most obvious and is even thought to be so different as to possibly be a separate species. Physical differences that distinguish transient orcas are different chormosomal banding patterns, slightly different total body size and coloration, smaller and more hooked female dorsal fins. Transients' behavior is also very different from that of the two residents. Transients feed primarily on other marine mammals. This explains why they can coexist within resident territory. Transients often travel alone or in smaller family groups. They are predominately silent, a behavior associated with their foraging success (it is proven that other marine mammals become alarmed by transient sounds).

Acoustic studies have shown no intercommunication between the three communities and a distinguished dialect from each (especially with the sounds made by transient orcas). This is important because although each pod is acoustically identifiable, pods do communicate within and only in its own community.

There are roughly 200 orcas that use the St. Johnstone Strait area. There are 165 orcas in the resident community. This community consists of 17 different pods with each pod consisting of several related family units. The remaining 35 orcas are from the transient community. Transient orcas frequent the Robson Bight area much less and because of the nature of their social structure, they often travel alone or in much smaller groups.

The findings of albino orcas from different populations indicates

inbreeding which further supports genetic isolation.[1]

Mortality and Natality

According to studies on other cetacean populations, Orcinus orcas potentially have a minimum calving interval of every three years. Current calving interval for the resident community in St. Johnstone Strait is approximately 8-9 years. Observed calving interval for the transient community is longer. Bigg also noted that population growth after heavy 1960-1970 exploitation of orcas in St. Johnstone Strait was only 1.8%, relatively low for a recovery.

Orcas may reach sexual maturity before physical or social maturity. 80% of the females and 60% of the males are sexually mature between the ages of 12 and 16, although a "D" whale had a calf this year at the age of 9 (Bigg, 1987) Social maturity is defined as an individual who has become a part of the breeding population. Socially mature whales are usually between 15 and 20 years old. The mortality rate is highest for socially mature males. Socially mature male mortality rate is 2.5%, losing 20% over a 5 year period. The average estimated age of mortality is 27 (David Bain, Orca Workshop, 1987).

Eighty percent of the first offspring are males. There has been considerable concern about the large number of males born in proportion to females for this orca population. The problem is further intensifed by their high female mortality rate. Forty percent of the captured orcas from this population were female (David Bain, 1987). With new calves born in 1987, the health of the present population looks stable although these calves need to be sexed to see how they will add to the breeding population.

Within the last few years there have been at least nine resident whales with evidence of bullet scars. Three of these orcas died when shot, five are still alive today. Two orcas have become entangled in fishing nets in 1986, resulting in one death (Robin Tailor, 1987). There are also two known residents who have been severely injured by boat propellers (A9 and A25). Such evidence indicates that other orcas have probably been shot, disrupting pod structure and community growth.

[1] An all white calf was captured and released off British Columbia in 1970 and Cousteau photographed an albino off the Juan de Fuca Strait. Richard Ellis, Dolphins and Porpoises, 1982.

Tsitika Valley and Robson Bight Habitat

Robson Bight lies directly under the Tsitika River watershed on the northeastern side of Vancouver Island, midway between Kelsey Bay and Port NcNeill. The Tsitika River Valley rises from sea level of 1,769 m in elevation and is one of the last unlogged watersheds for Vancouver Island. The two main tributaries are Catherine and Claud Elliot Creeks. Precipitation at lower levels averages about 254 cm per year.

The forest within the Tsitika watershed is very thick and lush. Forest composition includes Coastal Western Hemlock, Subalpine Mountain Hemlock, mature and over-mature Douglas Fir, Pacific Silver Fir, Sitika Spruce, and Red and White Western Cedar. Western Hemlock and Pacific Silver Fir, mostly over 300 years old, are the dominant species of trees and are utilized for commercial value (Tsitika Planning Committee, 1978). Small portions of the watershed have already been clearcut and new logging roads have reached the the east end of the reserve boundary.

Besides being one of the main watersheds for Vancouver, the Tsitika River is a large and diverse salmonid run. Salmon species that return to the river each year include approximately 6,000 pink salmon (Oncorhynchus lata), 2,000 coho salmon (Oncorhynchus kisutch) and a small number of sockeye (Oncorhychus nerka) and chinook salmon (Oncorhynchus tshawytscha). There are also several trout species that inhabit the Tsitika year round; rainbow (steelhead), cutthroat, and Dolly Varden char.

Pink and chum salmon are confined to the lower reaches of the Tsitika River by a canyon and 1.2 m waterfall located 3.2 Km upstream of the tidewater. Coho salmon and steelhead are found throughout the drainage. It is also important to note that 70% of the salmon migrating to the Fraser River pass through St. Johnstone Strait adjacent to the estuary.

Some unique and vital habitat areas in Robson Bight are the estuary point where the river empties into St. Johnstone Strait, the kelp beds and eel grass beds. These areas play a key role in producing food and rearing salmonids. In the last 10 years more salmonid have been migrating through the east side of St. Johnstone Strait (through the reserve) and there has been a correlated increase in orca population (Jeff Jacobson, 1987).

Temperate estuaries are considered to be areas of comparatively low species diversity. This is true for the Tsitika estuary due to the particularly harsh environment caused by extreme tidal changes and violent seasonal fluctuations. The estuary is where the salmonid spends a lot of time physically adjusting and changing food preference from fresh to salt water (smolting). Due to salmonid smolting and the physical characteristics of the river, which confined pink and chum to the lower regions of the river, the estuary holds an extremely high population of salmon. Shoreline substrate

of the Bight is 40% rock, 25% cobble-boulder, 35% mud, sand or gravel. The shoreline is steep, dropping quickly to 220m. The deepest areas of the strait reach 440m.

Rubbing Beaches

Outside of the estuary are several shallow coastal areas within Robson Bight called rubbing beaches. These beaches are composed of small smooth, rounded pebbles. The rubbing beaches are considered a "core" area for the orcas and are one of the main reasons they come to the reserve. Rubbing behavior is unique to the northern community of orcas and although they have been seen to occasionally rub in other areas they have habituate to two specific beaches. Interviews with local fishermen indicate that the orcas have been using the beaches for at least 20 years and probably a lot longer.

At the Rubbing Beaches orcas are observed to do less traveling, less feeding and more play, resting, social rubbing and rock rubbing. The rubbing beaches also serve some sort of social function between family groups. On one occasion, up to 102 whales (representing many pods) used the beaches for over an hour's period of time. (Rubbing Beach Study Team, 1987) The longest rubbing session lasted for 4 hrs. 35 min., again with pods using the beaches together with overlapping times (the A30s rubbed for three and a half hours and the I11s rubbed with them and left an hour later).

All members of a pod rub, although occasionaly 1-3 adults stay outside of the beach and remain in the middle to the strait. Calves are the most exuberent and they generally rub or play non-stop. Older whales were often observed resting (hanging motionless at the surface between rubs). Whether this resting behavior is due to energy expended from rubbing or a behavior unrelated to rubbing we are not sure.

A recent study of the rubbing beaches (see Appendix 1) indicated the following: Fifty percent of the total known whale time in hours spent in St. Johnstone Strait was spent at the beaches. Orcas were present at the beaches every day except two between July and August. Orcas spent an average of 20% of each 24 hr day at the beaches. As much as 80% of the orca community used the beaches during the month of July and 68% of the community used the beaches in August (Rubbing Beach Study Team, 1987).

The rubbing beaches are extremely sensitive areas. The orcas react dramatically to boats while in the beach area. (Please see Boats interactions at the Rubbing Beaches, page 9) From day and night time study with the use of hydrophones it was evident that boat noise was important in determining the length of the orcas' stay (Rubbing Beach Study Team). Boats interrupting a rubbing session often ended the session. When the strait was

busy with whale oriented boat traffic, whales would usually bypass the beaches. Whales were seen considerably less and for shorter periods of time when commercial fishing was on. Whales predictably came to the beaches when the strait was quite. Generally, quiet times at the beaches would be between 5 p.m. and 9 a.m. when researchers, whale watchers and sport fishermen were not about. However, orcas would stay for long rubs during the day when the strait was "free" of boats.

Comparision of boat interactions at the rubbing beaches to boat interactions outside the beach area suggest that the rubbing beaches are both an extremely sensitive habitat to orcas and highly vulnerable to human interference. Sensitivity of the beach area for the orcas cannot be stressed enough. Certain individuals may react strongly to people on the shore whereas other individuals may not. Because orcas' social structure is highly developed, it is likely that one member of a pod can in turn effect the entire pods use of the beaches and there for all members of the pod must be equally respected.

Reserve

In 1982, a small portion of the Northern Orca's habitat was made into an Ecological Reserve. The objective of this reserve was, "to protect key habitats for killer whales, to prevent harassment of whales while using those habitats, and to maintain unique opportunities for killer whale research and interpretation" (C/Eco 1987). This marine reserve is 8900m long and extends 1000m offshore. Two unique features included within the Robson Bight Reserve boundry are a small portion of the unlogged Tsitika Estuary and the rubbing beaches.

The Department of Ecological Reserves designed a permit system which granted selected researchers and photographers access to the reserve. To apply for a permit a project abstract must be submitted along with a specified time frame. These projects are then evaluated and either granted or refused a permit. Since the permit system only addresses researchers and photographers, a large portion of actual reserve users are neglected. These non-permit users include commercial fishermen, whale watching boats (private and charter), log barges, and cruise ship. More inclusive management plans are needed to regulate the effects non-permit reserve users may have on the whales.

The summer range of this orca population is 1000's of km, with the majority of this time spent in their "core" range of 80 km. The Robson Bight Ecological Reserve consists of a mere 9km, which is only a small fraction of their total range. Although the reserve is small in contrast to the total range, the whales do spend a signigficant amount of time within its

boundaries (Darling). The role the reserve plays in conserving the whales unique habitat is very important, however the reserve is too small to adaquately protect the orcas as a species (Darling, 1986).

Boats are allowed in the reserve when whales are not present. Although there is an information officer, most boats are not aware that the reserve is closed when whales are present. There is a problem with boats entering the reserve knowingly and unknowingly when whales are in the reserve. The problem is increased further by the lack of authority to control boaters in the reserve. If a boat enters the reserve and whales appear, the vessel is requested to maintain a 300m distance from the animals at all times. Recreationists often entered the reserve accidentally, unaware of these regulations or unable to distinguish the exact boundaries (R. Taylor). To prevent this unintentional non-permit activity the reserve needs to be obviously defined with larger signs marking its boundaries and restrictions.

A 600 m buffer strip of land directly above the marine reserve is in the process of being purchased. Although this buffer strip is a step in protecting the shoreline and adjacent waters, it will only offer minimal protection from proposed logging plans higher in the watershed. Logging roads and clear cutting will eventually erode this barrier, possibly damaging ecology of the estuary and beach areas.

Boat Users and Impacts

Boats that are present in St. Johnstone Strait are usually non-whale oriented or whale-oriented. Most commercial traffic such as: cruise ships, fishing boats, tugboats, tankers and cargo ships, is considered non-whale oriented. While recreational boats: pleasure boats of all sizes, sailboats, research boats and kayaks, are often whale-oriented.

As Darling points out, sport fishermen and recreational users fall into both categories. The fishing boats would occur regardless of the whales, however most of them take advantage of opportunities to whale-watch. Many recreationists come specifically to see the whales; others don't become aware of the whales until an unexpected encounter occurs.

Duration of whale encounters were noted and the results indicate that the biggest whale users are the researchers (29.8%), followed by the charter vessels. Special attention should be given to these two boat types due to their long-term encounters with whales in which close directional movements are engaged in.

The natural beauty of British Columbia and the presence of orcas, attract huge amounts of people. The tourist industry is growing rapidly due to the increasing publicity given to this area. Whale watching boats inside

the reserve has increased from 34% in 1984, to 42% in 1985. (D. Brigs 1987) Due to their enormous numbers and lack of proper whale-watching techniques recreationists can be especially noisy and disruptive to orcas. Tourist boats are often seen chasing pods or stopping and starting their engines.

There is a debate concerning the impact researchers, photographers and whale-watchers have on the whales they're focusing on. Studies have shown that wild mammmals can habituate to a "steady predictable background of human activity that is not animal-oriented" (West Coast Whales, Vol. 2, No. 1). These studies also showed however, that marine mammals will not habituate to close boat- animal encounters in which the mammal is being closely approached or chased. In fact, these activities have been shown to signigficantly disturb the animals. What are the long term consequences resulting from continued disturbance? This question is extremely important since the amount of human activity surrounding this orca population is growing steadily.

According to Sue Kruse, whales would frequently respond to close boat approaches (less than 400m) by swimming faster. Fifty-four percent of boat/whale data concluded that "potentially disturbed" animals swam 1.4 times as fast as undisturbed animals (Kruse, 1983). This behavioral response was consistent over the entire summer, indicating orcas are not habituating to close boat encounters.

Another reaction often exhibited by whales when boats were within 400m is an increase in a tendency to swim towards open water. In St. Johnstone Strait whales favored a westerly course after boat encounters (Kruse, 1983). This westerly direction leads whales out of the narrow strait and into the open water of the Queen Charolte Strait. Other odontocete species have fled constrictive waterways due to boat disturbances. Stewart et al. (1983) reports belukha whales headed out of rivers into open water as a response to outboard motor sounds.

Duffus and Deardens' study (1986) illustrated that whales may change either group speed, orientation or spacing in response to boats. Out of 123 recorded encounters, 20% exhibited a change in at least one of those three categories. For example, 20.56% of the whales observed travelled in a slow, directional, tight pattern before boat contact. This figure dropped dramatically to 0.53% after boat encounters (Duffus and Dearden, 1986). The long term effects of these pronounced short-term behavioral changes are unknown, but could be far reaching.

Splash rates of orcas increased around boats: 34.4 splashes per hour with boats, 19.6 when no boats were present (Briggs, 1987). Briggs also noted longer dive intervals during boat encounters, a behavior often associated as an escape mechanism.

Harrassment has two types of effects, short term and long term, as

defined by Norris and Reeves, 1978. Direct effects of human disturbance which results in avoidance behaviors, flights or aggression are labeled short-term. Long term effects are defined as a reduction in biological fitness due to human disturbance. "Fitness related harrassment includes habitat destruction or disruption of energy budgets and 'critical behaviors' like reproduction, rest, and feeding" (Norris and Reeves, 1978). This last definition is extremely important to consider since the orcas in St. Johnstone Strait have been seen reportedly less in long resting lines (Jacobson, Ford, Ellis, 1987 Orca Workshop).

Marine mammals remaining in an area of continued disturbance may be habituating to the disturbance or merely tolerating it due to a biological necessity of the area for feeding, mating and calving .

The idea of marine mammals tolerating repeated disturbance in an area they require to maintain biological needs is not unreasonable. One example is the repeated return of white whales to estuaries in Northern Quebec despite severe overhunting that has reduced population levels (Finley et al., 1982). Similarly, the Harp Seal hunt off Canada's east coast claims a high proportion of the pups each year, yet whelping patches remain predictable (Payne, 1978b).

Many marine mammals have shown to be sensitive to activities less traumatic than hunting. Gray whales no longer calve in San Diego Bay due to heavy human use, pollution and habitat disruption (Rice and Wolman, 1971). It has also been speculated that the decline in harbor porpoise populations in United States is due to increased human activity.

Boat Interactions at the Rubbing Beaches

During July and August of 1987, 1045 boats traveled past the rubbing beaches within 300m from shore. Most boats hug the shoreline when passing. One-hundred and seventy-nine of these boats were at the beaches when whales were present. Most of the boats at the rubbing beach area are commercial fisheries: 30 boats set nets at the beaches, 111 commercial boats traveled by, 7 skiffs from the commercial boat exploring the coast at leisure (Briggs, 1987).

The rubbing beaches are a favored fishing spot. Commercial boats often moored at beach two between openings for as long as a week in order to claim their fishing spot. Beach two is also in a sheltered cove so that up to seven boats would congregate in the area before and during fishing, sometimes taking turns setting nets.

The number of boat/whale encounters at the rubbing beaches increased at the end of the summer because fishing openings were delayed. In July, 20 rubbing sessions out of 81 had boats present. August had 64 out

of 97 rubbing sessions interfered by boats. One rubbing "session" may have several boat encounters.

Boat/whale encounters at the rubbing beaches are defined as interrupt and return, interrupt and leave, wait to rub, passed by, short rub, passed with chase or no reactions to boats. If a boat approached rubbing whales, the whales often left their rubbing activities, going offshoe to return only after the boat passed. This is defined as interrupt and return. A wait to rub is when boats are around whales (or when boats are at the beaches as whales approach), and the animals will stay near the beach area but do not come in to rub until the boats have passed. The data for July and August 1987 boat/whale interactions at the rubbing beaches are as follows:

July

28	orca boat interactions total
5	interrupt and returns
19	interrupt and leave
3	wait to rub (one sea plane present with boats as well)
1	short rub
2	passed with chase

August

13	interrupt and return
55	interrupt and leave
4	wait to rub
16	pass by
29	short rubs
1	passed by with chase (no rub)
10	rubs with no reactions to boats present

Researchers and Photographers

Researchers

Researchers have the most intensive and long term interactions with the whales when compared to any other individual vessel type. (Taylor, 1985) Researchers accounted for 38% in 1985, and 29.8% in 1986, of all boat/whale interactions within Robson Bight. (Duffus, 1986) Out of the research conducted 40% are long trerm studies involving six or more years of fieldwork. Half of these researchers are from University of California at Santa Cruz (due to the ability to receive funding). Since the researchers are from the same university they've been able to successfully design projects that can be conducted from one boat, lessening the impact on

photographers: permit holders and non-permit holders. Researchers conducting I.D. work are not regarded as photographers in this discussion. Non permit holders include recreationalist as well as professional photographers whom are not granted a permit.

Robson Bight is both an exquisitely beautiful and relatively predictable habitat to document orcas and therefore attracts the attention of many professional and recreational photographers. Most photographs of orcas worldwide come from Robson Bight area. According to Robin Tailor (1985) a recent television documentary featured Robson Bight in some detail was slated for release in 35 countries. Because Robson Bight is in high demand by professional photographers the competition is high and this increases the demand for whale time amongst them.

In order to get new, different and better photos than previously produced professional and recreational photographers aproach orcas as close as possible. The behavior of both professional and recreational photographers is usually to leap frog. This consists of a boat moving in front of an individual or pod of whales until they pass, then leaving at high speed and abruptly reducing speed to idle or drifting. Professional photographers will keep this behavior up for long periods of time, sometimes from sunrise to sundown.

It has been noted by many (recreationalists, researchers, and charter boat operators alike) that photographers are also the most demanding as far as being the closest vessels in proximity to whales while often the least sensitive to whale movement. Personal recognition or economic interest of photographers often over rule their sensitivity to whales.

> "Ecological Reserve and Department of Fisheries and Ocean guidelines are not particularly effective where economic gain is involved. Some professional photographers are among the worst trangressors of the guidelines, especially since these people are often repeated visitors to Robson Bight and have reason to be fully aware of expected behavior" (Taylor 1986).

Because Robson Bight management system is fundamentally operated by request (no legal authority) a interesting correlation between behavior of permit holders and non permit holder photographers has been made. Photographers who apply for permits are therefore already willing to cooporate with the requested guidelines of the Dept of Ecological Reserves. However, photographers who either do not choose to apply or who are not granted a permit are already choosing to work undiplomaticly with the system. Photographers that are non-permit holders are amongst the most aggressive to control and the least sensitive to whales.

By August in the summer of 1986, three photographers and two

researchers had entered the reserve and closely approached whales without a permit. (R.Taylor, 1986) All boats are requested to stay completely out of the reserve when whales are present unless a special permit had been issued. This example illustrated the lack of concern for reserve regulations by some overzealous photographers.

Professional photographers work very independently. This means there is no peer pressure amongst them to examine methodologies or impact on whales (i.e., Do they really need to work from a boat? Are there more efficient techniques?) Professional photographers also have no databasing. This has resulted in large amounts of film which has not been published as well as a loss of information. A pool of shared information could help in reducing redundant photos and giving insights to particular photographers who may not be producing adaquate photographs for the amount of time and energy spent around the whales.

Commercial Fishing

Commercial fishing operations during openings are by far the largest amount of human activity within the reserve area. Gillnetters and seiners use all of Robson Bight as well as the rubbing beaches to set their nets or moor overnight. The highest density of fishing boats is usually in front of the estuary, they can be as close as 20-40 ft. from each other.

Near misses happen frequently and boat whale collisions have exlained many deaths in heavy traffic areas such as off the coast of Cambridge, England. At Robson Bight two known whales have been severely injured by boat propellers and one orca was trailing a fish lure snagged on its dorsal fin for months. Whales have been able to successfully avoid the maze of fishing nets and lines in Robson Bight until recently. In 1986 two separate incidences of whale entanglement occurred in the summer fishing openings (Taylor, 1987).

Commercial fishing boat crews have a lot of free time in between openings in which they relax, fish, target practice, whale-watch and engage in other various activities. Small skiffs are often seen darting back and forth between the boats, exploring the coastline, or following a pod of whales. This poses a problem especially near the rubbing beaches. The beaches are a favored fishing spot and are usually occupied even in between fishing openings. Commercial fishing boat tie off directly at the rubbing beaches and their skiffs land on the beaches regularly. Since the commercial boats are exempt from the reserve regulations, their small skiffs also act as though exempt from the regulations requiring a 300m distance between boats and whales. It should be made clear to fishing boats that when not fishing, their boat and their skiffs should be operated in the

same manner as any other recreationist. This includes maintaining the correct distance from whales and from sensitive areas like the beaches.

Recreationists are often confused as to why fishing boats are allowed to operate in the reserve around whales and when they are excluded. This poses a management conflict that needs to be addressed to prevent recreationists from following the example set by the fishing boats. If management policy is continued the recreationists need to be educated about the exception granted to fishing vessels. In addition, fishermen need to be educated about the reserve and asked to create the least amount of disturbance possible. Further, boat interaction studies should include commercial fishing, especially near the rubbing beach area.

Food Web

One of the main attractions for the resident community at Robson Bight is the Salmonaid. Salmon are easy to find and abundant throughout St. Johnstone Strait, although they all eventually travel to the Tsitika to spawn. The highest population of salmonid are found at any one time in the estuary. Due to unsuitable habitat areas further up the river, the estuary is the main breeding ground for the salmonid. It is noted that most salmonid breeding takes place in the lower regions of the river due to the inability of pink and chum salmon to migrate past the waterfall.

It is imperative to keep the estuary as undisturbed as possible in order to maintain present population levels. Even now flooding is definitely a problem in disturbing distributed eggs. Also, the estuary is not as productive as it could be due to poor quality of the substrate for spawning purposes as stated in the 1979 Preliminary Results of a Baseline Study of the Lower Tsitika River and Estuary by Habitat Protection Division, Dept. of Fisheries and Oceans.

The number of food chains is rather small because of species which survive the naturally stressed conditions. Therefore, one must regard the estuarine ecosystem as quite vulnerable, because of the few pathways by which energy can move to primary producers to consumers at the top of the food pyramid (i.e. salmonids).

In fresh water (with the exception of pink and chum fry, which migrate out immediately after emergence), juvenile salmonids feed on drifting invertebrates. These drifting invertebrates can either be on the surface of the water or suspended in the water column. They can be produced within the river system (autochthonous) or outside the river system and enter it incidentally (allochthonous). Another major fresh water food source for salmonid are invertebrates which live anchored to or moving across the bottom.

The predominately available invertebrate for salmonid in the Tsitika is caddis fly larva. The predominant food supply in the estuary and across the rivermouth is another autochthonous, a mysid, Novamysis mercedes. One type of allochthonous invertebrate which accidentally enters the estuary is unique to the Sitka spruce forest. (The Sitka spruce forest surrounds the very braided estuary and the lower portion of the river.)

Outside of the estuary, one of the most productive areas producing food for rearing salmonids and other marine life is the kelp beds. Kelp plants not only convert nutrients and sunlight to living tissue which can then be grazed on by many organisms, but they offer shelter and substrate to a host of invertebrates and fish. Larger organisms feed on the smaller creatures associated with the kelp beds. As the kelp dies, it decomposes and provides nutrients to bacteria and plankton, resuming the food cycle anew. Most of the kelp beds (bull kelp, Nereocystis luetkeana) in Robson Bight are found in small scattered patches although there are a few larger kelp beds (the largest being 70 meters by 20 meters).

Pollutants

Plastics

The commercial fishing industry is responsible for large amounts of oil, plastic, and noise pollution in St. Johnstone Strait. The excessive problem of plastic littering is easily seen by any boater who is close enough to see the mix of logs and trash deposited on the shoreline by the daily tides. The authors observed the highest amount of plastics floating in the water directly after fishing openings. Plastics found in Robson Bight area included bic lighters, full containers of jet full, glad bags as well as pieces of fishing nets.

The problem of plastic litter needs to be addressed especially with its increase in use. A report by the National Academy of sciences estimated that up to 350 million pounds of packaging and fishing gear alone may be lost or dumped by commercial fishermen alone. Robson Bight is becoming an increasingly popular fishing spot especially since other popular spots are becomming fished out. The possibility of "ghost" nets increases with the number of fishing boats. Besides "ghost" nets, Marine mammals, sea birds and fish can become entangled, trapped, drowned, strangled or starved by other types of plastics. Plastics can also be eaten which could create health complications including starvation.

Acid Deposition

Acid deposition, commonly called acid rain, has completely depleted salmon stocks on the East coast. Acid deposition has become moe apparent globally and management issues should take note of what has been happening elsewhere. Over 60 thousand lakes are already dead in Canada alone.

Although acid deposition is not as big a problem on the West coast as it is on the East coast, it is still an important issue to address with regard to the orcas. Acid deposition causes concern because of its potential direct and indirect effects on St. Johnstone Strait ecology and salmon stocks. The direct effects of acid rain upon marine mammals are unknown, however its effects on salmonid are much more clear. Most fish begin to experience trouble at a pH around 5, this can reach a critical point if the pH becomes as low as 4.7 or lower. The average pH for Southern B. C. coast including Vancouver Island is 5.0.

pH effects on salmon stock

pH < 5.4 = no immediate acidification threat.
pH range 5.1-5.4 = fisheries threatened
pH range 4.7-5.0 = some mortalities likely
pH > 4.7 = no natural salmon reproduction

According to literature published by the Canadian Fish and Game, most of Vancouver Island itself is out of trouble, but the rest of Canada's west coast has lake and stream types that are sensitive to acid rain. (i.e. rock formations other than limestone or other natural buffers.)

An indirect relationship between acid deposition and salmon stocks will become apparent when other areas begin to show a noticable reduction in salmon populations. A reduction in salmon numbers in other areas will cause an increase in the demand for less affected areas; such as Robson Bight. This increase in boat traffic and salmon depletion could make it even more difficult for orcas to sustain themselves within this area.

Oil and Chemical Pollutants

St. Johnstone Strait is a standard coastal route for many oil tankers on their way to and from Alaska. The threat of an oil spill is rapidly increasing with the rise in traffic. How oil tanker noise and chemical pollution effect marine life is just now being understood. When oil is spilled into a marine environment it begins to undergo many immediate processes: spreading to form slicks, evaporation of the more volatile components, solution of some compounds into the water column,

emulsification, photochemical oxidation and sedimentation. Most of the information obtained comes from studies on acute oil spills caused by oil or gas well blowouts, platform fires, tanker accidents

Pollution from tanker operations is serious. One and one-tenth million tons of oil released/dumped into the sea of which 1.5 million tons are non-accidental. The remaining 0.4 million tons results from tanker accidents - many of which are avoidable.

Surface contamination in the form of slicks and floating tar has been found to be most prevalent near major tanker routes. Concentrations of dissolved dispersed petroleum residues have been shown to be present almost everywhere at a depth of one meter in the water column at such polluted sites. The heavy vessel traffic in St. Johnstone Strait due to commercial fishing and recreation has resulted in four days of surface oil at the rubbing beach area alone (Smith, 1987).

Cruise ships and oil tankers have reportedly opened their bilges directly into the St. Johnstone Strait. We observed one such encounter during the summer of 1987. This makes the orcas extremely vulnerable to surface contamination, ingestion or inhalation of oil. Other marine mammal management studies have recognized the consequence of oil spills to their species. Fish and Wildlife Service in California cited a major oil spill as "probably the most serious potential threat to the California Sea Otter". The Council of Europe declared Phocoena phocoena endangered by pollution. Assessments of harbor porpoise populations in U.S. waters near offshore oil and gas development has acknowledged the probability of harbor porpoise encountering oil through contact, inhalation or ingestion of contaminated prey and are concerned that nearshore pollution would have "deleterious effects" on this species (Prescott and Fiorelli, 1980).

Geraci and Smith found that surface contact with oil had a much greater impact on ringed seals than did the ingestion of oil. Six seals exposed in the field showed eye damage and behavioral changes; three seals exposed to oil in a laboratory died within 71 minutes of oil introduction. If an oil spill were to occur in St. Johnstone Strait, the potential physical damage that could effect orcas are:

1. Eye damage.

2. Absorption of oil through the blow hole. The ultimate outcome could be a thin film of oil covering the lungs and respiratory passages. This could have the same effects as pneumonia, including death.

3. Reduction of available food sources at St. Johnstone Strait and/or accumulation of oil by products from ingestion.

Effects of oil sorption and sedimentation are especially important near land or river mouths where suspended particles are concentrated and effective at attracting and absorbing oil. Due to the decrease of winds and currents in these low energy embayments many of the oil soaked particles drift to the bottom where they can accumulate in the sediment and detritus. Detritus is decomposed organic plant and animal matter which collects in embayments, mudflats, eelgrass beds and kelp beds. The oil sorbing ability of deritus is of key importance since it is vital to many food chains.

Epibenthic zooplankton which are small deritus consuming animals are very sensitive to the effects of oil and are fed on by many other animals. As juvenile slamon migrate to the Pacific Ocean from surrounding rivers they feed almost exclusively on epibenthic zooplankton that reside in shallow nearshore waters. Due to the sensitivity of fish eggs and larvae to oil and the short spawning period of many species, the survival of one year's offspring could be seriously endangered.

Orcas are nearshore mammals which make them particularly vulnerable to accumulating high concentrations of chlorinated hydrocarbons (PCB and DDE, the main metabolite of DDT, are two examples). Factors that make them susceptible are: they are long lived, ? accumulation, deed high on the food chain, and have blubber layers that attract these lipophillic contaminants (Calambokidis, 1986).

Harbor porpoises in Scotland and the Bay of Fundy have higher concentrations of dieldrin and DDT group residues than any other animal including man. How DDT is passed on due to age and sex is summarized in Prescott and Fiorelli report, "Review of Harbor Porpoise in the U.S. Northwest Atlantic":

> "Subsequent to their 1971 report, Gaskin, Holdvinet, and Frank (1976) noed a correlation in the level of DDT residue with age and sex (reproductive status). The dieldrin-DDT levels in pregnant and lactating females, 60.63 ppm DDT, were less than that in immature or resting (non-pregnant) females (214 ppm DDT), and significantly below the level in males (306 ppm DDT). DDT concentration is correlated with age, and that there is a net uptake in accumulation over an extended period of time. Gaskin et al. (1976) postulated that lower levels and a net loss of DDT residuals occur in females as a result of a transfer of the DDT titre to the fetus during development and to the calf during lactation."

We were unable to find out if there is any pesticide or herbicide runoff

into St. Johnstone Strait from logged areas. Logging companies should be questioned about their practices in order to adequately make this assessment. Although most effects of pesticides on cetaceans are unclear, pesticides are known to be responsible for uterine tract problems in seals, resulting in reproductive failure.

It is speculated that nine grey whales in Georgia Strait died as a result of 45,000 liters of wood preservative lindane (containing PCBs) emptied into the water from a shipping accident (The Cormorant, Nov./Dec. 1987).

Most characteristics of heavy metals favor their accumulation in the food web. Orcas, being top order carnivores, are particularly susceptible to magnification of heavy metals in the food web. Transient orcas have been shown to have higher PCB accumulation in their bodies than residents in St. Johnstone Strait. This is due to the fact that transients feed on marine mammals. As the International Whale Commission states:

> "Cetaceans, as top marine predators with a long life span, exhibit relatively high levels of pollutants in their tissues when compared with their environment. Whether this is a consequence of bio-magnification or bio-accumulation is irrelevant to the fact that relatively high levels of contaminants are recorded, especially in species occuring in coastal waters."

Noise Pollution

Noise pollution has been hypothesized to be one of the greatest disturbances to cetaceans. There are many common noise sources in the Strait: boats, airplanes, helicopters, seismic blasting for logging roads and gun shots. Sounds echo down the strait easily because of the straight, narrow steep geology of the strait.

Air pockets form closely around boats when moving, especially at the bow. It is theorized that these tiny air pockets forced into suspension in the wake waters may interfere by dispersing sonar and sound transmission (Franker, 1977). The abrupt stopping and starting is particularly noisy and disruptive to the orcas.

Most authors agree that cetaceans may be able to habituate to "background" noises from industrial, aircraft or vessels following a constant, predictable course. However, assessing effects of background noises are difficult because long-term effects are often unforeseen. A few studies have shown different marine mammals' intolerance to such background noises. Such a case is the relocation of spinner dolphins in Hawaii, which could not tolerate the presence of a marine construction site (Shallenberger, 1978). Also, harbor seals on Tugidak Island, Alaska reacted increasingly to

aircraft noises by fleeing breeding beaches.

Marine mammals can mask out background and other noises when a pure tone or other sound signal is masked only by noise at frequency near the frequency of the signal (distinguishing problem). Dolphins can distinguish frequencies as close as 0.2 to 0.8%. The critical band width is variable for this masking effect, but is usually about one-third of an octave. The signal may also be detectable if its power equals the noise power, and perhaps even if its power is a few decibels less than the noise power.

Orcas hear between 65 and 100 kHz (Norris, pers. comm., 1987), with the highest sensitivity being in the middle of this range. Dolphins can discriminate tones with frequencies between 0.2% and 0.8%. Directional masking effect is expected to be less if the signal and noise source are in different directions.

Many researchers at St. Johnstone Strait have commented that orcas stop vocalization in the presence of boat sounds when listening via the hydrophones. Whether orcas stop vocalizing or whether they changed vocalizations to a frequency out of observer hearing range in order to communicate around a masking interference of boats are unknown.

It is generally accepted among authors that marine mammals do not always habituate to noise sources when being actively pressured or when sudden changes in direction occur. Behavioral whale/boat interaction studies in St. Johnstone Strait support this (Kruse, 1984; Briggs, 1987; Duffus and Dearden, 1986).

Sue Kruse's study concluded there was no difference in behavioral responses of orcas exposed to inboard or outboard motor types at Robson Bight whereas other cetacean studies have.[4] Oops! Foot note is on next pg.

Acoustic data has been collected in St. Johnstone Strait for years. This data would be valuable for management plans but as of yet, a study of such has not been tackled and the effects of noise pollution are largely left unknown.

Logging Perspectives

McMillian Bloedel Ltd., one of Canada's largest logging companies, owns a small amount of land at the base of the Tsitika River and has the timber license for the entire Tsitika watershed. McMillian Bloedel is currently conducting sporatic clearcutting techniques through the watershed during the winter months.

Western Forest Products holds the timber license east of the reserve. Western Forest Products' new logging road has reached Fine Creek, less than a mile from the rubbing beaches. Blasting at the east end of the reserve continued all summer. Seventy-five blasts were heard on 23 days, usually

echoing west down the strait (D.Smith, 1987). These blasting sounds were recorded from the rubbing beaches, although no observations of whale reactions were made.

Western Forest Products' and McMillian Bloedel's logging procedures are as follows: clear cut the entire base leaving a shallow (approximately 20 foot) strip of forest along the coastal shores and surrounding the river basin. There are several alternative log handling options. These options include truck transport either to Naka Creek or Eve River, bundle booming to either West Delta or Miles West sites, or barging from either the West Delta or Miles West sites.

The best option of the three would be truck transport outside Robson Bight. There would be no direct impact to the whales in the Robson Bight area from the trucking process itself to Eve River if a suitable buffer from the haul road is established. Truck transport to Naka Creek is close to the whale core area and there is potential for debris carried by the prevailing

Oops! Foot note for pg 20.

---

[4]For example, Beluka whales head out of rivers into open water when outboard motors are heard. Bottlenose dolphins flee from shallow grass flats into deep channels in response to engine sounds from a boat used in a capture the year before.

southeast and easterly winds to degrade prime rubbing beach habitat.

Bundle booming and barging log handling options would be disastrous both directly to the orcas and their habitat. Implications of bundle booming include building a floating or land-fill breakwater, leveling, dredging, or filling to construct a dry land sort and a log storage area. Additionally there would be marine traffic from tugs, boom boats, and vessels which service the facility. This would also open the area to non- related marine traffic using the breakwater for night anchorage for protection from bad weather. Booms would be moving around the estuary and out of Robson Bight. There would also be on-shore machinery noise from trucks, heavy sorting equipment and loading cranes.

Direct impacts to orcas from bundle booming processes are:

1. Physical displacement of whales by the booms and breakwater, since orcas are known to spend part of their resting time in the vicinity of the two sites identified.

2. Dispersal of resting orcas out of the area as a result of vessel traffic, as is observed to occur now when boats approach orcas in this area.

3. Increased underwater and airborne noise from vessels and

land-based machinery.

4. Visual effects to orcas due to buildings and new domineering shoreline structures.

5. Accumulation of debris (bark and wood) in adjacent rubbing areas and on the ocean floor.

6. Destruction to the fragile estuary due to siltation from land filling and dredging and wood bark litter on the ocean floor. This would have irreversible effects on the salmonid and therefore the orcas.

Barging logs from Robson Bight would result in many of the same problems to orca habitat and direct health as the booming operation. If logs were loaded directly from dry land storage on to the barge, and care was taken in the operation of upland facility, the amount of debris entering the water could be substantially reduced. Also, essential traffic could be limited to one or two barges a week and tugs and boom boats could be banned from Robson Bight. On the other hand, an existence of a dock suitable for accommodating a barge would create a major visual site as well as a lot of loading and equipment noise to the orcas.

Regardless of which of the three log transportation options is chosen, McMillian Bloedel Ltd. intends to practice clearcutting methods. Previous studies have shown that clearcutting practices have devastating irreversible effects to the ecosystem chosen. If even a good portion of the Tsitika valley is clearcut, the present buffer zones are not large enough to withstand flooding and siltation movements. The proposed narrow buffer left along the coastline and river valley will be subject to climatic changes unnatural enough to damage the buffer forest sector.

Specific considerations to the Tsitika watershed area in light of clearcutting techniques are as follows:

1. High amount of annual rainfall and snow melt dramatically increases flooding activities.
2. Tsitika river shorebanks are unstable: The braided pattern of the river and present log jams indicate that the river is fragile and potentially very unstable to even natural flooding.
3. Tsitika Valley slope increases siltation movement and flooding into the river.
4. Because of the harsh climate and tidal changes, the estuary is already not as productive as its potential. The dramatic environment has simplified species diversity with respect to the food web.

5. Due to extreme diurnal tides and coastal eddies in Johnston Strait, flooding and siltation movement from the river would pass through the estuary to the kelp beds, ell grass beds and rubbing beaches. Flooding and siltation would damage immediate health to orcas and the salmonid and destroy adequate habitat for rehabilitation.
6. The nearest suitable river for the salmonid is Keogh River, which does not have the potential large enough for present Tsitika salmonid populations.

As stated in An Inventory of Salmonid and Marine Resources by Bill Harrower to the Dept. of Ecological Reserves:

> "It is readily conceivable that even standard logging practices could result in sufficient alteration to drainage patterns to wipe out salmonid production in the lower river. In addition, I suspect that upstream logging activity will have detrimental effects in terms of siltation. Again, I must stress that the area of overall high productivity is so limited in area that it must be protected."

Recent studies of harbor porpoise by Prescott and Fiorelli (1980) stated the following:

> "The apparent disappearance or decline in abundance of harbor porpoise in such areas as Long Island Sound and Cape Cod and Massachusetts Bay has been postulated to be a result of an increase of such human activities as dredging and/or filling of bays and estuaries. Similar declines in abundance have been discussed relative to San Francisco Bay, California."

Management Suggestions

Recognize the importance of the resident northern St. Johnstone Orca community as an isolated population: an important factor to species survival.

Habitat

A. Complete protection of salmonid habitat. This includes protection of the Tsitika River from siltation and flooding from logging practices. Complete protection would also include estuary, eel grass and kelp bed habitats as well as over exploitation of salmonid due to fishing

industries.

B. Complete protection of rubbing beach habitats.
   1. Logging roads should not be considered if debris or noise can enter the area. (Current blasting has already proven to be heard loudly!)
   2. No shore camping near or accessible to rubbing beaches.
   3. Close area to all boat types (including commercial fishing to kayaks).
   4. No research or photography at beaches.
      a) Heaps of unused photographs have already been accumulated.
      b) Added publicity about the beach area will draw more people to this sensitive area.
      c) Researchers and photographers can possibly have long as well as shot term disturbance that may discourage the use of the beaches by some animals.

C. Recognize the different needs and habitat protection of the resident and transient communities.

D. Reserve
   1. Identify and explain permit system and flags.
   2. Increase size and visibility of pennants.
   3. Increase size of shoreline boundary signs, with explanation of reserve regulations, dimensions and the exception granted to fishing boats.

<u>Boat Users and Impacts</u>

A. Proper whale watching techniques should be told to all boats by education officer and posted on reserve boundary signs.
B. Educate the boaters to research and photographer identification so that behavior of researchers/photographers will no be duplicated.
C. Restrict all boat types from the reserve waters, shore and camping so that a protected area for the orcas would be provided.

<u>Researchers and Photographers</u>

A. The final outcome of research and photography projects should be submitted to the Dept. of Ecological Reserves by December of the same year. This will allow time for their work to be evaluated before another permit is given.
B. Research and photographers should be restricted from the rubbing beach areas.

Commercial Fishing

A. Educate fishermen about orca natural history and current studies. Encourage the idea that fishermen and orcas are fighting for a mutual cause: protection of the strait and salmonid habitat (i.e., protection from logging practices).
B. Educate fishermen about reserve and sensitive areas like the beaches.
C. Enforce fines for fishermen who either abuse orca habitat or welfare.
D. Reward fishermen by recognition or bonuses for helping protect orca and salmonid habitat via fishermen involvement in education and enforcement of boating distance for tourists.

Pollutants

A. Protect water quality in St. Johnstone Strait. This can be done by limiting the number of motorized boats (keep gas and oil out of the strait) and use only safe logging practices. Also, spot check aboard oil tankers while in the Strait to check up on safety standards and practices. Discourage tanker traffic through St. Johnston Strait.
B. Educate fishermen and recreationalists about the non-biodegradable trash problems.
    1. Plastics not biodegradable.
    2. Plastics and ghost nets may harm or destroy marine life.
C. Study effects of boat noise on orcas (outboard motor types). Paul Spong has hydrophone tapes that can be analyzed to compare engine noise level with orca vocalizations and movements.
D. Monitor salmonid stocks in British Columbia for signs of acid rain. Be aware of fishery information.
E. Limit noise pollution within Robson Bight. Noise pollution has been identified as potentially the worst disturbance to cetaceans. Noise pollution can be controlled by:
    1. Limiting the number of boats in Johnstone Strait.
    2. Enforcing boat distance to whales. One way to do this is to hire a warden and/or educate boaters to noise sensitivity.
    3. Banning target practice by fishermen in Johnstone Strait. (This would also be safer for orcas, other wildlife and researchers.)
    4. Prohibiting booming and barging operations if logging plans are carried out. (Use truck transport instead.)

Logging

A. Consider complete protection of logging practices for Tsitika watershed area or at least more suitable logging plans. Current logging practices are intolerable to ecosystems. Alternative plans could involve:

1. Realistic buffer zones surrounding river, estuary and coast while:
   a) Using alternative logging methods such as the long rotational island method presented by Larry D. Harris in The Fragmented Forest. This methodology would be better for overall biotic diversity and preservation of original forest sector. Also, such a plan would provide McMillian Bloedel Ltd. with a slow but consistent and renewable economy. Operational cost would be considerably less because smaller amounts of land could be leased for periods of logging time.
   b) Limiting selective logging, restricting to level areas.
2. Prohibit any booming or barging log transport plans.

Appendix A
Summary of Rubbing Beach Data
Dave Briggs and Crew personal communication, 1987
(unpublished as of 11/15/87)

The beaches were observed for a total of 61 days between June and September. Observations were taken around the clock: nighttime data was taken from the use of hydrophones. Total data times are quantified from two beaches. Some amount of whale time was spent in the area between the two beach sites, especially in the month of August. This time was not quantified in the following data. Therefore, time totals are conservative due to the lack of data in this "middle beach" area.

Totals by month (time totals are % time in a 24 hour day):

I. Total number of days whales were sighted at beaches:

June 26-30	3 out of 5 days (60%)
July 1-31	29 out of 31 days (94%)
August 1-27	100%
Average	59 out of 63 days (94%)

II. Total percentage of individuals sighted at beaches from a population of 173 whales.

June 26-30	17%
July 1-31	80%
August 1-27	68%
Average	41%

III. Total percentage of known time (24 hrs./day) whales were present in Strait:

June 26-30	35%
July 1-31	51%
August 1-27	64%
Total average	50%

IV. Total % time (spent in the Strait - not % of day) whales were present at beach:

June 26-30	21%
July 1-31	11%
August 1-27	13%
Total Average	15%

V. Total % of time (24 hrs./day) whales spent at beaches:

June 26-30	26.3%
July 1-31	15%
August 1-27	19%
Total Average	20%

Bibliography

Annex, M.
1985 "Report of the Working Group on Whale Habitats and Pollution." Thirty-sixth Report of I.W.C., 1984-1985.

API
Effects of Offshore Petroleum Operations on Cold Water Marine Mammals.

Bower, Michael
1987 "Plastic Trash in the Ocean is Killing Millions of Creatures Each Year." The Cormorant, Nov./Dec. issue, Ocean Society, S.F. Bay Chapter.

Calambokidis, John
1986 Chlorinated Hydrocarbons in Harbor Porpoise from Washington, Oregon, and California: Regional Differences in Pollutant Ratios. Administrative Report LJ-86-35C, Southwest Fisheries Center (P.O. Box 271, La Jolla, CA 92038).

Darling,James
1986 Robson Bight Ecological Reserve Management Plan: An Assement of the Impacts of Human Activities on the Killer Whales of Robson Bight Ecological Reserve with Management Guidelines

Dept. of Fisheries and Oceans, Habitat Protection Division
1980 Preliminary Results of a Baseline Study of the Lower Tsitika River and Estuary, May, June and July, 1979.

Duffus,D. and Dearden,P.
1986 Preliminary Report:"Non-consumptive Use and Management of Whales, Robson Bight Study Area,1986"

Ellis, Richard.
1982 Dolphins and Porpoises. New York: Alfred A. Knopf.

Ellis, Balcomb, McSweeney, von Ziegesar, Goodwin, Matkin.
1986 "The Population Biology of South Alaskan Killer Whales." Cetus 6(1).

Fellerman, Frederic
1986 "Progress Report on Feeding Ecology of Killer Whales." Cetus 6(1).

Franker, M.A.
1977 The 1977 Whale Monitoring Program -- MacKenzie Estuary, N.W.T.F.F. Vancouver, Canada: Stanley and Co., Ltd.

Geraci, J.R. and T.G. Smith
1976 "Direct and Indirect Effects of Oil on Ringed Seals (Phoca hispida) of the Beautiful Sea." Journale of fisheries Research Board of Canada, 33:9.

Harris, Larry D.
1984 The Fragmented Forest. Chicago: University of Chicago Press.

International Whaling Commission.
Report of the Sub-Committee on Small Cetaceans. J.W.C. 34: 144-160.

Kopenski, Ronald P. and Edward R. Long
1981 An Environmental Assessment of Northern Puget Sound and the Strait of Juan de Fuca: A Summary. Seattle, Washington: National Oceanic and Atmospheric Administration, Office of Marine Pollution Assessment, U.S. Dept. of Commerce.

Kruse, Sue
1984 The Interactions between Killer Whales and Boats in St. Johnstone Strait, B.C. (1st draft).

Levy, Eric M.
1984 "Oil Pollution in the World's Oceans." AMBIO, 13(4).

Lyrholm, Thomas.
1986 "Orcas off Norwegian Coast," Cetus 6(1).

OCS Gas and Oil Development as it Relates to Marine Mammals. Marine Mammal Commission.

Osborne, Fellerman and Heinlich-Boran.
1986 "A Review of Orca Natural History," Cetus 6(1).

Prescott, John H. and Patricia M. Fiorelli
1980 "Review of the Harbor Porpoise (Phocoena phocoena). The U.S. Northwest Atlantic. Washington, D.C.: U.S. Marine Mammal Commission.

Reeves, Randall R. and Stephen Leatherwood.
1984 "Line-Capture Fisheries for Cetaceans in USA and Canadian Waters,

1973-1982." Report of the International Whaling Commission 34: 497-506.

Rennie, Frances.
1984 An Assessment of the National Significance of Robson Bight, British Columbia. Parks System Planning Division, National Parks Branch, Ottawa, Canada, 1984.

Robson Bight Preservation Committee of the Top Island
1980 The Lower Tsitika River and Robson Bight Area: An Inventory of Salmonid and Marine Resources. S.E.P. Public Participation Study.

Robson Bight Study Team
1981 Killer Whales and Coastal Log Management: An Overview of Future Uses of Robson Bight, British Columbia. Victoria, B.C.: British Columbia Ministry of Environment, Assessment and Planning Division.

Spong, Paul and Helena
Orca workshop, Orca Lab 1987

Taylor, Robin
1986 "The Use of a Marine Mammal Reserve by Researchers and Photographers" (draft).

Wood, George A.
1981 Notes on Planning Considerations for the Lower Tsitika Watershed, June.