
Killer Whales
Second Edition
John K.B. Ford
Graeme M. Ellis
Kenneth C. Balcomb

John K.B. Ford, Graeme M. Ellis, and Kenneth C. Balcomb

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The natural history and genealogy of *Orcinus orca* in British Columbia and Washington

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Contents

This book has its beginnings in the early 1970s. At that time, the late Dr. Michael Bigg, Ian MacAskie, and one of us (Graeme Ellis), working at the Pacific Biological Station in Nanaimo, British Columbia, were studying the population status of killer whales in the province. This proved to be no small task. Conventional census techniques, such as aerial or vessel transect surveys, were not practical because of the vastness of the convoluted British Columbia coastline and the wide-ranging distribution of the whales. A public sighting program using mail-in questionnaires yielded a very rough estimate of the population size, but nothing about birth and death rates, social organization, and other vital aspects of the whales' life history. Clearly another study technique was needed.

By 1973, Mike Bigg, always the inventor and innovator, had discovered a technique that was to revolutionize field studies of killer whales worldwide. Mike realized that the whales were all carrying natural markings on their bodies and that these could be used for the cetacean equivalent of a mug-shot identification system. A good photograph of the dorsal fin and grey "saddle" patch at the base of the fin revealed a unique pattern of nicks and scars that provided a whale's identification. Mike reasoned that if every individual present during repeated encounters with whale groups along the coast was identified photographically, the population could actually be counted rather than estimated, and many other features of the species' natural history could be examined. Many scientists were skeptical about the validity of this new approach, but Mike persisted and demonstrated that photo-identification was indeed the key to understanding this species.

The study continued through the 1970s and expanded as other researchers joined the collaborative effort. Two of us became involved during this period. In 1976, Ken Balcomb formed a research group on San Juan Island and started an intensive multifaceted study of the portion of the population that frequents US waters. This research program, operated by the Center for Whale Research, continues today. In 1977, John Ford began graduate studies at the University of British Columbia, focusing on the underwater vocalizations of the whales and their relationship to behaviour and social structure. This work also continues today.

By the early 1980s, our understanding of the coastal killer whales and our relationship with them began to enter a new era. Scientifically, a most remarkable picture was emerging. Killer whales were far from conventional mammals; indeed, certain aspects of their biology appeared unique. Two different forms of the species – residents and transients – lived in the same waters, yet never associated and seemed to specialize on different prey – fish for residents and mammals for transients. The social structure of the resident whales was exceptionally unusual, with young whales staying in their mother's group well into maturity and probably for their entire lives. Also, each resident killer whale pod was found to have a unique vocal dialect that appeared to encode its relationship to other pods in the population.

During this period, the whales were attracting the attention of more than just researchers. Plans to turn Robson Bight, a sheltered bay on northeastern Vancouver Island, into a log-booming area threatened this important whale habitat. Lobbying efforts by conservationists eventually led to the creation of an ecological reserve for the whales in Robson Bight in 1982, and, in the process, the area became widely known as the best place for the public to view killer whales in the wild. The opening of a road to northern Vancouver Island in 1979 improved access to the area, and Johnstone Strait quickly grew in popularity as a destination for recreational whale watching. In 1980 the first commercial whale-watching excursions began in the Strait, and soon people were travelling from throughout North America and abroad to watch killer whales in this area and, some years later, off southern Vancouver Island and in Haro Strait.

As interest in recreational whale watching grew, so too did the demand from whale enthusiasts for a book containing the latest information on killer whale natural history and a catalogue of photographs to identify individual whales and their family groups. Such a book was co-authored and published in 1987 by Mike Bigg and the three of us, but it was very much Mike's project. Mike Bigg was the pioneer of modern killer whale research, and it was his enthusiasm, cooperative spirit, and love for the animals that was responsible for much of the success of the scientific work, as well as this first book on killer whale natural history and identification. Mike hoped that the book would be updated every four to five years as the population changed and new discoveries were made, and that this might "result in the killer whales of this region becoming one of the best understood of all marine mammals." Sadly, Mike Bigg was not to live to see the next edition of his book. In

October 1990, Mike died at the age of 51, leaving many friends and students to carry on the work that was so important to him.

It wasn't until 1994 that we produced a new and updated version of our original killer whale book, this time published jointly by UBC Press and the University of Washington Press. Much had changed between 1987 and 1994. The killer whale population in the region had jumped from about 350 to almost 700 with the discovery of a new community of "offshore" killer whales. The resident population itself had grown from about 260 in 1987 to about 300 in 1993. The number of identified animals in the transient killer whale population had more than doubled. With such a large number of whales now known, it was impractical to include them all in the photographic registry in a single book. Thus, we chose to produce two separate books, each with a different focus and photographic catalogue. *Killer Whales* describes the natural history of all three populations of killer whales – resident, transient, and offshore – but only includes the more common resident population in the catalogue section. The second book, *Transients,* published in 1999 (see Bibliography), focuses on the fascinating lifestyle of these mammal-hunting whales and contains a catalogue of over 200 transients identified in British Columbia, Washington, and southeastern Alaska. It is likely to be some time, however, before "offshore" killer whales get their own book. We continue to encounter these whales several times a year, but we are still a long way from understanding their natural history and ecology.

Killer whale populations are constantly in flux, and our knowledge of their biology continues to steadily improve. We have thus revised this book to provide readers with the latest information on the current status and understanding of killer whales in British Columbia and Washington. We have also revised the catalogue section to ensure that whale watchers have an up-to-date identification tool for use out on the water. Since publication of the first edition of *Killer Whales* in 1994, there have been 71 births and 64 deaths in the resident population. The appearance of many whales has changed – young whales have grown, and many individuals have acquired new nicks or scars. We have also changed the way we refer to the basic social groups of resident whales, from "subpods" to "matrilines," because social organization of resident killer whales is better defined by genealogical relationships than by association patterns, as has been done in the past.

Like its predecessors, this book is the product of countless people, too numerous to list here. Over the years, the study has involved several thousand people who called us to report whale sightings and over 200 people who took photographs that were used to document whales. For major ongoing contributions to this research, we give special thanks to our colleagues Lance Barrett-Lennard, David Ellifrit, Candice Emmons, and Astrid van Ginneken. For contributions of identification photographs and/or acoustical recordings, sharing of data and ideas, or other special assistance, we thank the following: David Bain, Kelley Balcomb-Bartok, Nancy Black, Prentice Bloedel II, Jim Borrowman, David Briggs, Randy Burke, Diane Claridge, Marilyn Dahlheim, Nicola Dedeluk, Volker Deecke, Brian Falconer, Beverly Ford, Pat Gerlach, Karen Hansen, Kathy Heise, Stan Hutchings, Iain Jones, Bob and Ruth Lamont, Ed Lochbaum, John McCulloch, Iain MacDonald, Bill and Donna Mackay, Rod MacVicar, John Mair, Nancy Marcus, Craig Matkin, Valentina Mendoza, Alex Morton, Linda Nichol, Erin Nyan, Miriam O, Peter Olesiuk, Rich Osborne, Rod and Kechura Palm, Meg Pocklington, Peter Ross, Mark Sears, Val Shore, Paul Spong, Helena Symonds, Robin Taylor, Chris Tulloch, Adam U, Jane Watson, Peter Welk, and Harold Yurk.

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We were fortunate in having dedicated and skilled assistance in the production of this revised edition. Wilf Hatch processed and Elwood Miles printed the majority of the black-and-white photographs. Astrid van Ginneken digitally scanned the identification photographs of southern residents. George Vaitkunas scanned and optimized the remaining photographs and was responsible for the overall design and layout of the book. Lance Barrett-Lennard, Bev Ford, Holly Keller-Brohman, Peter Olesiuk, Peter Ross, and Jane Watson reviewed and offered comments on portions of the revised manuscript. We thank all for their enthusiastic, ongoing support.

The killer whale, *Orcinus orca*, is second only to humans as the most widely distributed mammal on earth. It ranges from the tropical seas through the temperate zones to the edge of the pack ice at both poles. Yet it is only in the last quarter-century that we have begun to learn something about the nature of this remarkable animal. There are several reasons for this. Like all cetaceans (whales, dolphins, and porpoises), killer whales live at sea and spend most of their time underwater and out of sight. Compared to most terrestrial animals, this makes them difficult to observe and study in the wild. Also, the species does not appear to be very abundant in most parts of its range. There are concentrations in certain waters, such as off Antarctica, northern Japan, Iceland, Norway, Alaska, and British Columbia, but killer whales are only sighted sporadically in most parts of the world.

For many years, widespread fear and hatred of the animal also impeded an understanding of killer whale natural history. From ancient times, the killer whale featured prominently in marine folklore as a bloodthirsty, voracious predator that was extremely dangerous to humans. In the first century AD, the Roman scholar Pliny the Elder wrote, "A killer whale cannot be properly depicted or described except as an enormous mass of flesh armed with savage teeth." More recently, in 1874, the whaler, Captain Charles Scammon, wrote that "in whatever quarter of the world [killer whales] are found, they seem always intent upon seeking something to destroy or devour." Even as late as 1973, US Navy diving manuals described the killer whale as "extremely ferocious," warning that it "will attack human beings at every opportunity."

But killer whales have not been universally disliked throughout history. Native peoples of coastal regions in many parts of the world regarded the killer whale with awe and respect rather than hostility. Along the northwest coast of North America, Native cultures held the killer whale in high esteem, and it was featured prominently in their art and mythology. The Tlingit of southeast Alaska, for example, believed that the killer whale would never harm humans, but instead would aid them with gifts of strength, health, and food from the sea, of which the killer whale was custodian. Killer whales remain an important component of Native traditions today.

Killer whales have long been viewed with particular animosity by fishermen, who regarded the whales as threats to

Killer Whales as Nuisances

Killer whales have not always been well liked in British Columbia. In the late 1950s, perceived competition with sports fishermen for salmon, in addition to the general fear of the whales, led to plans by the Federal Department of Fisheries to reduce the number of killer whales in the Campbell River area. The following letter, dated 28 July 1960, is from a report by the committee planning this program:

It is recommended that one .50 calibre machine gun with tripod mounting be used [at Seymour Narrows] with ball ammunition only ... If the whales approach from the westward, the method of attack would be to open fire when they approach ... in an endeavour to turn the herd back and so prevent them from entering Seymour Narrows and continuing on to the Campbell River area ... Should the whales approach from the Campbell River side, it would be preferable to withhold fire until they have passed to the westward of the gun position, to prevent turning back toward Campbell River.

their lives as well as their livelihood. In Norway, it was feared that killer whales were decimating herring stocks, so the government encouraged hunting of the species by whalers, even subsidizing this hunt in some years. Between 1938 and 1980, an average of 57 killer whales were taken each year. In British Columbia, fishermen also considered the whales to be nuisances and unfair competition, and they were frequently shot on sight. About 25% of the killer whales live-captured during the late 1960s and early 1970s carried evidence of having been previously shot and wounded. In 1960, under pressure from sports fishing lodges in the Campbell River area on Vancouver Island, the Federal Fisheries Department developed a program to reduce killer whales by shooting them from a land-based machine gun. Although the gun was mounted, it was never fired; fortunately, the whales had shifted their foraging pattern to areas outside of Campbell River when the culling program was about to begin.

Killer whales have also been taken in some parts of the world for their meat and oil, usually as a bycatch of whaling operations focused on other species. The former USSR typically captured about 25 per season in their Southern Hemisphere whaling operations; then, in the 1979-80 whaling season, they took an unprecedented 916 whales. This raised concern among conservationists, and in 1982 the International Whaling Commission recommended against further killing until more was known about the impact on populations.

Attitudes towards and awareness of killer whales among the general public finally began to improve in the late 1960s. By then, a number of killer whales were being displayed in aquaria around the world, and millions of people were able to see for themselves that the animals were not the ferocious beasts of reputation. Instead, they were intelligent, inquisitive, and cooperative, as were their relatives, the smaller dolphins. This, combined with the emergence of an environmental movement in North America in the 1970s, resulted in a new tolerance and compassion for the species. Interest in viewing killer whales in the wild soon developed, and the first commercial whale-watching excursions aimed at this species began in the Johnstone Strait area of British Columbia in 1980.

Today, killer whales are protected by many countries, and they are safe from exploitation in most parts of the world. None have been taken in commercial whaling operations anywhere since 1981. With the success of captive breeding, live captures for aquaria have become rare. Recreational killer whale watching has grown into a major pursuit, mostly in British Columbia and Washington, where an estimated 100,000 people took a commercial whale-watching excursion in 1999. Killer whale watching has also become a growing industry in northern Norway and Alaska. Fresh bullet wounds are now rarely seen on whales in British Columbia and Washington.

Coincidental with this new respect for the killer whale has come a new scientific understanding of the species. Field studies similar to our own are under way in Alaska, Argentina, Norway, and the sub-Antarctic, and a fascinating story about this intelligent, innovative, and adaptable social predator is emerging. Killer whales have among the richest, most complex, social lives of any marine mammal. Some populations are made up of kin groups that are the most stable of any species, marine or terrestrial. Many of the whales' behaviour patterns, such as foraging specializations, appear to represent traditions that are passed on from generation to generation. Killer whales even have vocal dialects that define their social identity.

Every piece of knowledge that we gain about the killer whale compels us to learn more and adds to our deepening respect for this remarkable animal. Yet, just as we have entered this new era of compassion and understanding, we are threatening the whales in new, insidious ways. Pollution, over-fishing, and industrialization are all having an impact on the whales' habitat, and these pressures are increasing steadily. A recent decline in the southern community of resident killer whales in British Columbia and Washington may be an early indication of these impacts. Only through awareness, understanding, and commitment – both within the public and scientific communities – can we succeed at preserving the whales' habitat and their future.

The following section was written by the late Dr. Michael Bigg for our original catalogue, published in 1987. We have included it here, with only minor updating, as it best describes the history of killer whale research in British Columbia and Washington.

The study began in 1970. At that time, biologists in British Columbia and Washington State were faced with an urgent request. Fisheries managers and the public were concerned about the live-capturing of killer whales for aquaria. The commercial netting of these whales had begun in 1965 and grown rapidly. The questions posed concerned whether the removals were endangering the local killer whale population and what restrictions should be introduced if more whales were to be taken. This required knowing how many killer whales were in the region; whether the whales taken in Washington State were from the same stock as those taken in British Columbia; what the productivity of the population was; and whether the removal of one particular age or sex was detrimental to productivity. Little was known about these topics, and no method of data collection existed to obtain the answers.

We initiated field studies in 1971 by organizing a public sighting program to find out the approximate numbers of killer whales and where these whales could reliably be found. Questionnaires were sent to lighthouses, ferries, fishery patrol boats, tugs, fishermen, and other individuals who lived or worked along the coast of British Columbia. The method usually involves collecting sightings year-round. However, we modified it to take into account the problem of duplicate sightings of the same individuals seen at different locations. We asked sighters to watch on only a few specific days. A total of three censuses were conducted on 26 July 1971, 1-3 August 1972, and 1-2 August 1973, and 15,000 questionnaires were distributed for each. From the 500 or so returns each year, we estimated the population in British Columbia and Washington State at roughly 200-350 whales. This number was much lower than the many hundreds, and even thousands, that most people thought were present. The questionnaires in 1971-73 also indicated that western Johnstone Strait was the best location to study the species in British Columbia. Sighters reported that the whales could be found there during most days in summer.

For the 1972 field season, we went to Johnstone Strait during early August to observe the whales for ourselves. Killer whales were seen every day as expected, and we followed them around by boat, taking many photographs. The pictures revealed several individuals with distinctive nicks and gouges on their dorsal fins. This provided us with natural identification tags. If we could find these whales again, we would be able to learn about their daily lives.

We gambled that we could relocate the "tagged" whales and chartered two boats for studies in Johnstone Strait during August 1973. Within a few days we had found them, but more important, we found that many other individuals were also recognizable by their unique natural markings. The dorsal fin and the saddle patch, which is located at the base of the fin, varied in shape and often bore scars, indentations, and a wide variety of nicks and gouges. We had now discovered a method to study killer whales and could begin documenting the life histories of many individuals. With time we would be able to answer the management questions.

The study area expanded in 1974 to include eastern and southern Vancouver Island. However, unlike Johnstone Strait, we had the problem of how to reliably locate the whales on a daily basis. This was solved by borrowing a technique developed by the local killer whale netters. We organized a network of volunteer observers to call us whenever they saw killer whales, and we would then dispatch a boat and crew to find and photograph the whales.

The first task was to determine the number of killer whales in the region. To do this, we undertook an intensive census during 1-10 August 1974. Boats were stationed at seven strategic sites – Johnstone Strait, Campbell River, Stuart Island, Comox, Vancouver, Active Pass, and Victoria. Newspapers, radios, and marine broadcast stations were asked to announce that the census was in progress and to request that anyone sighting killer whales should immediately call a central dispatch number. The system worked well, and we managed to count all the resident whales off southern Vancouver Island and most of those off northern Vancouver Island. During this period we saw no transient whales, but these are few in number and are seldom seen (see next section).

The study continued to expand over the next few years. Counts were conducted on a year-round basis off eastern and southern Vancouver Island. We went to Fitz Hugh Sound in August 1975, and in 1976 began what has since become an annual census in Washington State. In August 1978, we searched the Prince Rupert area. However, the study had clearly become too large by the late 1970s to carry out over such a wide area every year. This forced us to consolidate our efforts at two main sites, Johnstone Strait in British Columbia and Haro Strait in Washington State. It turns out that Haro Strait, like Johnstone Strait, has killer whales present almost every day in summer. All resident whales off British Columbia and Washington State usually visit one of these sites at some time each summer. Transient whales do not seem to have any particular site that they visit regularly.

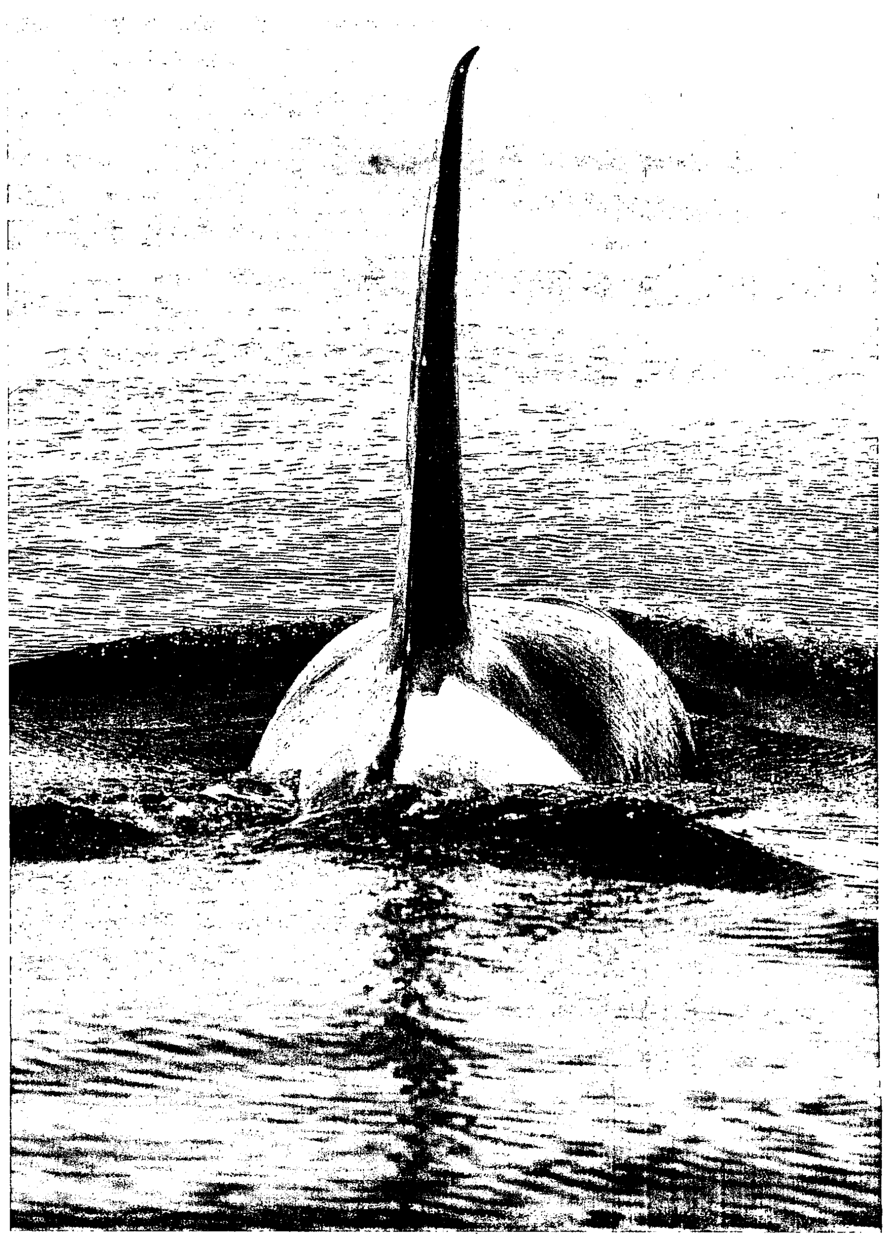
The data-gathering routine has now become standardized. In Johnstone Strait and other areas on the north coast, we locate the whales mainly by boat, often with the aid of a portable hydrophone. Other researchers, whale watchers, and boaters in the area also help to find them. In Haro Strait, they are located visually from the Center for Whale Research on western San Juan Island. Early warning of their approach is received through a permanent hydrophone. A boat is then dispatched to intercept and photograph them. Volunteer sighters living nearby along the waterfront also report whales.

The minimum information that we try to obtain from an encounter with a pod is the identity of all individuals present. We also attempt to determine the sex and travelling companions of each animal and to make a tape recording of their vocalizations for studies of the different sounds made by each pod. Many other kinds of data can be collected, such as travel routes, group mixing, dive times, feeding activities, travel speeds, time spent on various activities, interactions with fishing operations, and so on.

In addition, we collect recordings from permanent hydrophones at Telegraph Cove and other locations, and audiotapes from other sites, such as at Orcalab on Hanson Island, are made available to us. From these, we can identify pods from their dialects. People maintaining the hydrophones often take photographs of the whales that enable us to identify the individual whales that were present. We also receive photographs taken both by naturalists and the public that are used to establish pod composition and distribution. We continue to search for historical photographs and tape recordings to help determine the ages of individual whales and to identify which pods were captured for aquaria during the late 1960s and early

1970s. Finally, we frequently exchange findings with the many researchers working on the species in this region.

We are now able to answer many of the original management questions. As a result of the years of data collection from various localities, information has been compiled on the population size, numbers of pods, pod composition, social organization, genealogy, movement patters, birth and death rates, feeding habits, breeding cycle, impact that captures for zoos and aquaria had on productivity of the population, and many other topics. Although these whales are no longer captured in British Columbia and Washington State, there are now new reasons for studying them. The beauty, size, and intelligence of killer whales makes us want to know more about their life cycle. With this unique research opportunity to look into their world, more can be learned about their society and their adaptations to life in the marine ecosystem. Understanding their biology will help ensure that killer whales will survive humankind's continuing encroachment.



Natural History of the Killer Whale

One might expect that after twenty-five years of field research we would understand all of the important features of the life history and ecology of killer whales in British Columbia and Washington. This, however, is far from the case. We and our colleagues have assembled a considerable amount of detailed information on certain aspects of the whales' biology, but answers to some fundamental questions have eluded us. Where are the whales in winter and what is their diet? Who are the fathers of the calves that we have seen born during the study? In the following sections, we will bring you up to date on what we do and don't know about the answers to such questions.

Distinct Populations: Residents, Transients, and Offshores

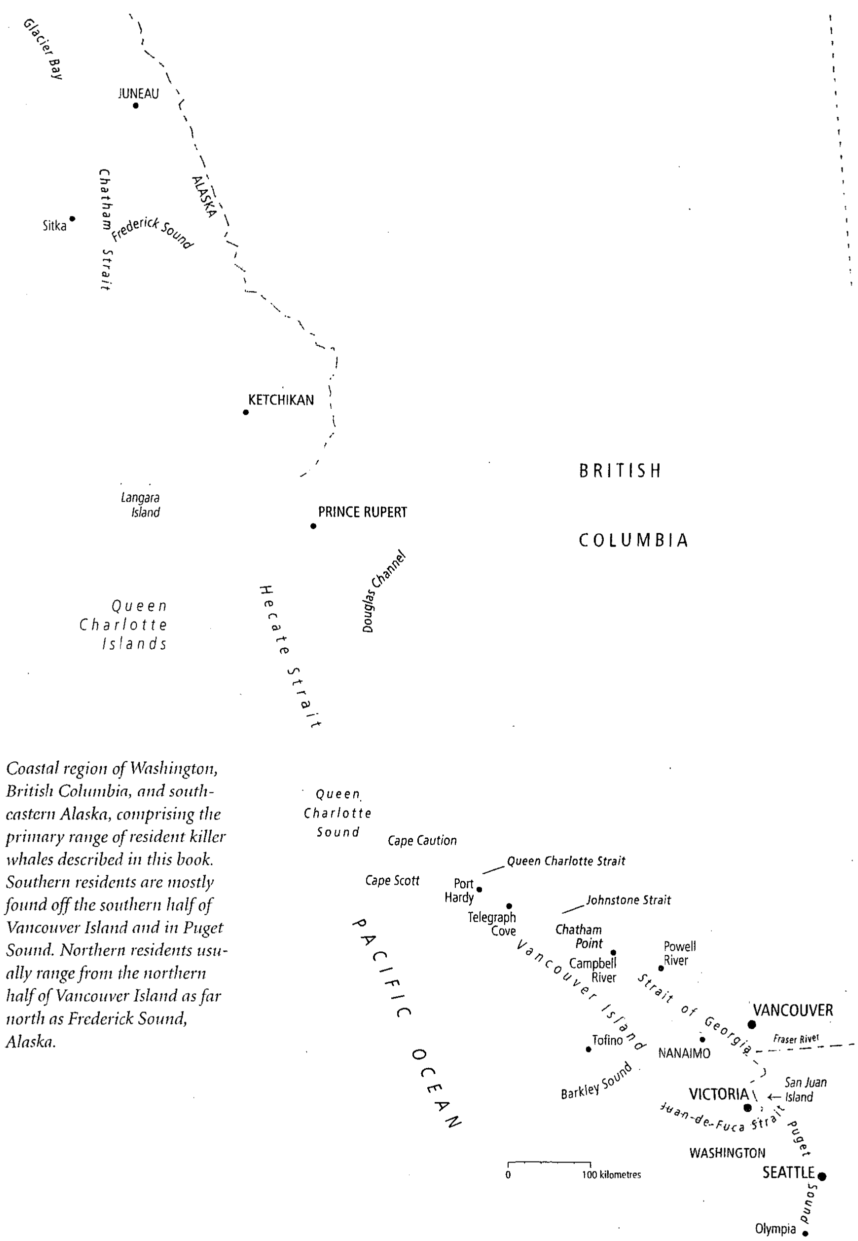
In the early stages of this study, we became accustomed to encountering killer whales in groups, or *pods,* containing 10 to 25 or more whales. These pods displayed certain characteristics that soon became familiar. Most of the time, individuals were dispersed singly or in small subgroups over a wide area, moving in the same direction but surfacing independently. Their movement patterns were fairly predictable, as was their occurrence in certain areas during the summer. Occasionally, however, small groups of killer whales were encountered that differed in appearance and behaviour from the larger pods. Typically the smaller groups contained only two to five whales, and their patterns of occurrence and movement were erratic. We found it curious that these small groups never travelled with the larger pods and speculated that perhaps they were social outcasts in transit to other locations. For this reason, we termed the whales found in these small groups *transients* and those identified in the large, common pods *residents.*

Although we still do not fully understand the relationship between residents and transients, it is now clear that resident whales do not become transients, or vice versa. Instead, the two forms of killer whales are fundamentally different in most aspects of their behaviour, social organization, and ecology. These differences are so profound that the two forms are socially and genetically isolated, despite living in the same waters. One indicator of genetic differences between the two forms is the shape of the dorsal fin, which tends to be pointed at the tip in transients and rounded in residents, especially among mature females (see sidebar, p. 18). Recent DNA analyses have confirmed that residents and transients are genetically distinct and do not interbreed, leading to speculation that they are separate subspecies on the evolutionary path towards becoming distinct species (see sidebar, p. 99). Over the last decade, we have discovered a third population of killer whales on the British Columbia coast, which we have provisionally designated as *offshores*. We have only had about forty encounters with these whales and thus know little about them. Offshore killer whales are often found in large groups of 30 to 60 individuals and are seldom seen in protected coastal waters. Most encounters have taken place near the Queen Charlotte Islands (Haida Gwaii) and 15 or more kilometres off the west coast of Vancouver Island. Our colleagues in California have encountered groups of offshores as far south as Los Angeles, mostly in winter months. Although the ranges of residents, transients, and offshores overlap, they have never been seen to mix. Genetic studies have recently revealed that offshore whales are closely related to residents, but they appear to be a distinct population that spends most of its time on the continental shelf, probably feeding on fish. It may be a decade or longer before we have a clearer picture of their natural history.

As of 1999, the resident killer whale population in British Columbia and Washington was comprised of about 300 whales. These individuals and the groups to which they belong are shown in the catalogue portion of this book. We are less sure of the population sizes for transients and offshores. About 220 transients have been identified in the coastal waters of British Columbia, Washington, and southeastern Alaska, but this may not represent their true population size. Many years may pass between re-sightings of individual transients, so we are uncertain about how many of these remain in this area or are alive today. Also, in most years we photograph several transients that were previously unidentified in the area (for more information on transients, see the recent book *Transients*, listed in the Bibliography). Similarly, we have little idea of what the population size for offshore killer whales may be. Up to 1999, approximately 200 individuals had been identified, and each new encounter adds a number of new whales to the total.

Different Lifestyles

The most important difference between residents and transients, and the one that influences all aspects of their distinctive



Coastal region of Washington, British Columbia, and southeastern Alaska, comprising the primary range of resident killer whales described in this book. Southern residents are mostly found off the southern half of Vancouver Island and in Puget Sound. Northern residents usually range from the northern half of Vancouver Island as far north as Frederick Sound, Alaska.

Distinguishing Resident, Transient, and Offshore Killer Whales

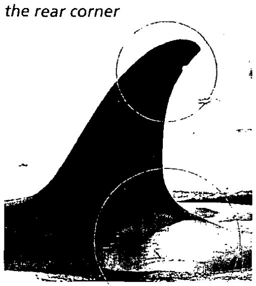
The dorsal fins of resident, transient, and offshore killer whales differ subtly in shape, especially in adult females. With a practised eye, it is possible to determine which form of whale you are seeing based on these differences, with the help of certain other clues. It is important to note, however, that the differences described here are not seen in every individual, but are typical of the majority for each population of killer whale.

In residents, the fin tip tends to be rounded and positioned over the rear insertion of the fin to the back. The leading edge of the fin tends to be straight or curved slightly back. Although the fin tip is generally rounded, this curve ends in a rather sharp angle at the rear corner of the tip. The grey "saddle patch" at the base of the fin may be either uniform in colouration or may contain various amounts of black – the latter known as "open saddles." Residents are usually seen in groups of 6 to 50 or more and tend to surface at intervals of no more than 3-4 minutes.

The tip of the dorsal fin in transient females is typically pointed and positioned in the centre above the front and rear insertions of the fin. Also, the midpoint along the leading edge of the fin sometimes has a slight bulge. The saddle patch is typically quite large compared to residents and offshores, and open saddles are not found. Transients usually travel in groups of 6 or less and often dive for periods of 5-7 minutes.

In most respects, the offshore form of killer whales appears more similar to residents than to transients. The saddle patch is roughly the same relative size as that of residents, and open saddles are occasionally seen. The dorsal fin also tends to be rounded, although the shape of the tip often differs subtly. Rather than ending in a sharp angle at the rear corner of the tip, as in residents, the dorsal fin tends to be continuously rounded over the entire tip. Although there are no measurements available, the body size seems to be somewhat smaller than that of residents or transients. Offshores are usually seen in groups of 25 or more and have diving characteristics not unlike those of residents.

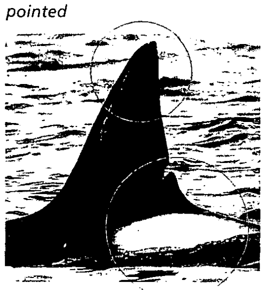
Dorsal fin has rounded tip, but usually with sharper angle at the rear corner



Resident fin

Open saddle, often seen in residents, occasionally in offshores, but not in any transients identified to date

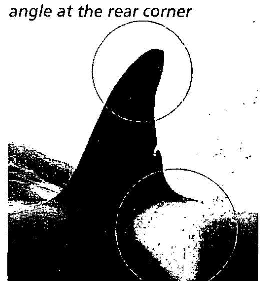
Dorsal fin tip generally pointed



Transient fin

Saddle patch large and uniformly grey

Dorsal fin continuously rounded over tip, usually lacks the sharper angle at the rear corner



Offshore fin

Saddle patch either solid grey or open

lifestyles, is diet. Residents eat predominantly fish, while transients prefer marine mammal prey. Although we long suspected that these preferences existed for the two forms, accumulating enough information to confidently describe the details of each population's feeding habits has taken many years.

In the past, the diet of marine mammals was often studied by killing the animals and examining their stomach contents. In the case of large whales, this was usually done on the flensing deck of factory whaling ships or at shore-based whaling stations. For smaller cetaceans or seals and sea lions, the animals were harpooned, shot, or netted, then dissected. Today, such techniques are not acceptable, and various non-invasive methods have been devised to study a species' feeding ecology. In our study of killer whale diet, we have used two basic approaches: (1) field observation of predation events, and (2) examination and identification of stomach contents of stranded carcasses.

Whenever we encounter killer whales, we keep a sharp lookout for signs of feeding. These can often be subtle – a quick turn at the surface, or a series of short, shallow dives at a single location, can indicate that a kill is taking place. On other occasions, feeding involves a chase with rapid acceleration, porpoising clear of the water, or other high-speed maneuvers. When we see that a kill has likely taken place, we wait until the whale, or group of whales, has left the site, then approach slowly in our boat, looking for prey scraps in the water. If it is a fish kill, silvery scales or bits of flesh are often seen floating beneath the surface. We collect these with a long-handled, fine-mesh net, and have the scales identified to species by the Fish Aging Lab at the Pacific Biological Station, Nanaimo, British Columbia. Other prey remains left behind at kills can be more substantial – lungs or chunks of blubber floating at the surface, for example, in the case of marine mammal kills by transient whales.

We often witness what appears to be an attack, but the potential prey escapes or the whales abandon the animal. In such cases it is not certain that the killer whales are intent on killing and eating the prey – they may simply be playing with the presumed prey rather than attempting to consume it. We record such events as "harassments," although in most cases the whales are likely trying to kill and eat the victim.

Stomach contents of dead, stranded whales can yield substantial amounts of feeding information, but it is rare that we are able to recover whale carcasses for study. Our records show that 167 resident whales have died during the 28 years of our study, but only 11 of these have been found on shore and examined (most whales disappear over the winter, probably in remote or offshore waters). Stranded transient whales are similarly rare. When examined, stomachs are often empty or contain few remains, but occasionally there is a bounty of bones or other undigested leftovers. In the stomach of the old female A9, we found 5 litres of fish bones, representing 59 individuals of 13 different fish species.

Using these techniques, we have documented a total of 22 species of fish and one species of squid in the diet of resident killer whales. Despite this diversity of species, residents have a clear preference for salmon prey, at least in nearshore waters during spring through fall. In field observations of feeding, 96% of fish take was salmon. Six species of salmon have been identified, with chinook salmon being the most preferred (65% of the total salmonids taken). Stomach contents also revealed a preference for chinook salmon, but other fish species identified included lingcod, halibut, greenling, and various small flatfish. It was somewhat of a surprise to find that chinook are so prevalent in the diet of residents, considering their overall low abundance compared to other salmon species. However, chinook are far larger than other salmonids and have the highest fat content, which probably make them more desirable than other species. There are only a few examples of resident pods attacking seals or porpoises, but these involved harassments without any clear evidence of the whales actually eating the animals. Residents are often seen in the vicinity of other marine mammal species but typically ignore them.

In contrast to residents, we have found that transients feed almost exclusively on marine mammals or seabirds. Transients have not been observed killing or harassing fish, and no fish remains have been found in stomachs of stranded transients. Instead, harbour seals, sea lions, and porpoises, in that order, are favoured prey of transients, and most other available marine mammal species are taken as well. Seabirds, while occasionally eaten, are usually harassed as a form of play by juvenile transients, then released.

The different prey preferences of resident and transient killer whales dictate different foraging strategies and therefore different group sizes and structures. The social system of transients is more fluid than the stable, multi-generation associations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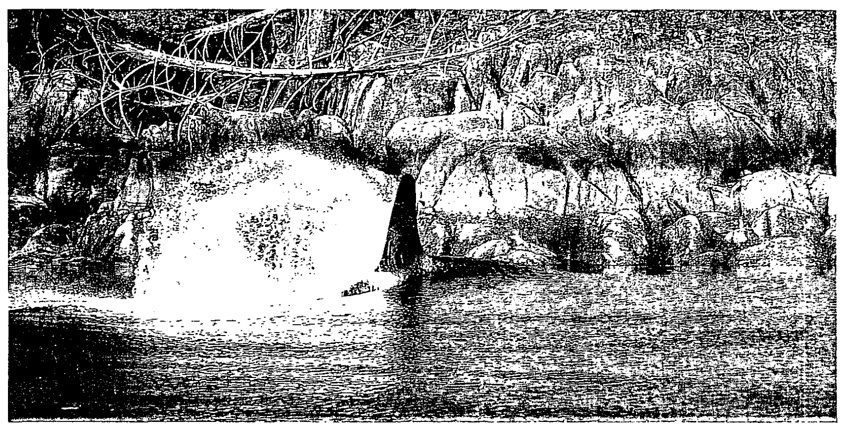
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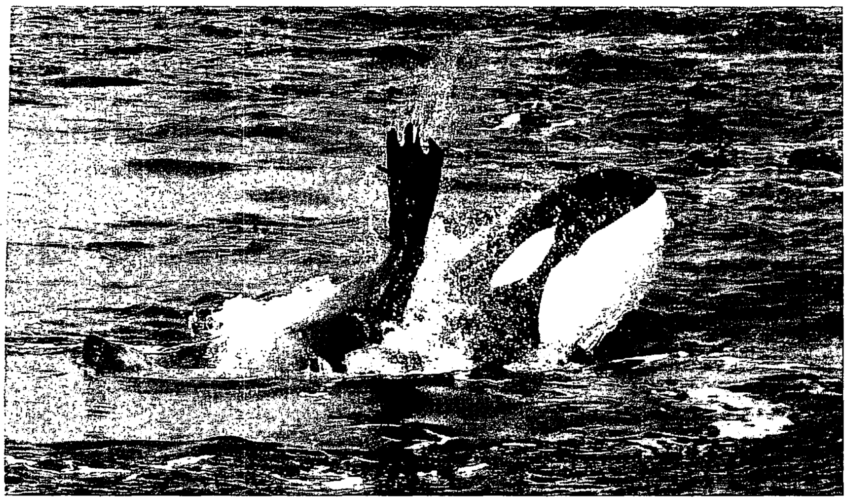
1. Transient killer whales can reach speeds of over 20 knots when chasing prey. This transient, photographed at Chatham Point on Vancouver Island, made several high leaps through the air while attacking a Dall's porpoise, seen as a small burst of spray ahead of the whale.

2. Resident killer whales also show impressive bursts of speed while pursuing salmon prey. Here, the male A32 (A1 pod) is chasing a chinook salmon along a rocky shoreline on the central BC coast.



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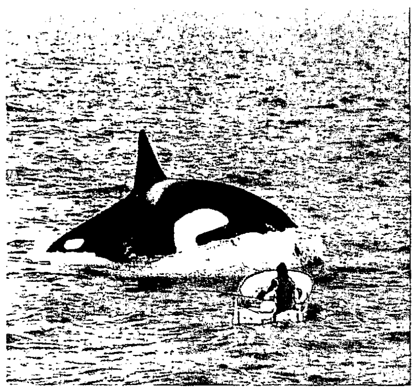

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1. A transient whale rams a Steller sea lion from below. During such attacks, transients may ram or strike their prey with their tail flukes for an hour or more before it is drowned and eaten.

2. A southern resident whale with a half-eaten salmon.

3. A foraging northern resident male, probably in the process of catching a salmon, surprises a lone fisherman.

of residents. A typical transient group might be comprised of a mother and two or three offspring, or perhaps of several adult females of unknown relationship. Some offspring leave their mother's group as adolescents, often following the birth of a younger sibling. Adult males often travel alone but may team up occasionally with other transients to form temporary foraging groups. Adult males are seldom found travelling solely with other adult males. Residents, on the other hand, tend to live in stable groups comprised of several related females and their young. Offspring of both sexes stay with their mother as long as she is alive, with the result that resident pods are often large and may simultaneously contain three or four generations. This social system is very unusual, not only among whales, but among mammals generally (see "Resident Killer Whale Societies," pp. 23-27, for more details).

Resident pods specialize on salmon for most of the year, and the whales' movement patterns coincide with the distribution and timing of salmon migrations. For example, northern residents congregate in the western Johnstone Strait area starting in mid-June, when the first salmon begin arriving on their migration to various rivers and streams, especially the Fraser River. The whales are very common here until late fall, when the last salmon runs pass through the area. When foraging for salmon, resident pods spread out and form a broad front that sweeps along the narrow coastal passages, often from shore to shore. They usually forage in a predictable fashion, moving from one good feeding spot to another. By exchanging underwater vocalizations, pod members keep in contact and possibly alert each other to the presence of prey. The whales produce rapid series of clicks that are used for echolocation of salmon and for navigation. Once a fish is detected, it is usually captured and eaten by single individuals, or occasionally a mother and her young offspring. Living in large pods may benefit each whale by increasing the overall success rate of locating scattered salmon. Making a living on salmon undoubtedly requires specialized knowledge that is passed on from generation to generation, and a whale's survival is enhanced by staying with its pod and taking advantage of these behavioural traditions.

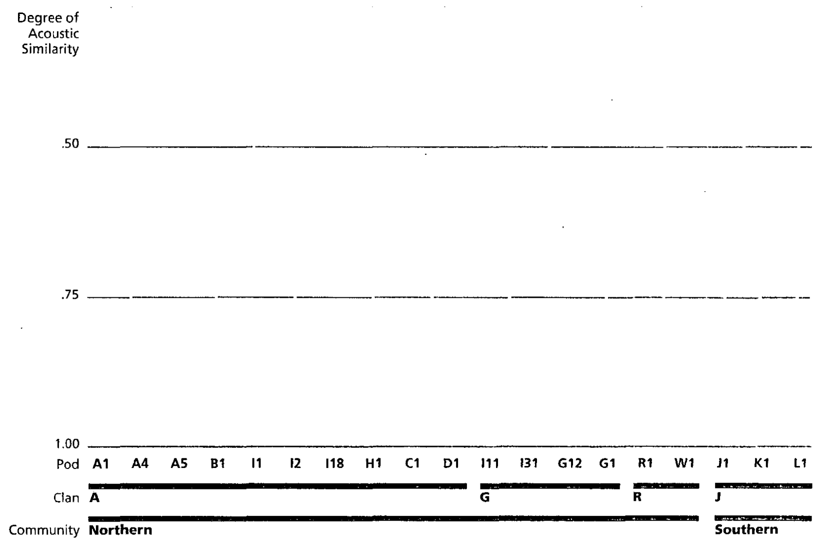
Transient whales employ a very different foraging strategy for their marine mammal prey. Unlike residents, their movements are quite unpredictable. Travelling in small groups, transients roam widely, entering small coves, bays, and channels in search of seals, sea lions, or porpoises. They often dive for more than five minutes, and occasionally in excess of fifteen minutes (residents are seldom underwater for more than three to four minutes at a time). Transients seem to employ a "sneak attack" technique when hunting. Unlike residents, transient groups almost always forage in silence, probably to avoid detection by their acoustically alert mammalian prey. This is even true for echolocation clicks, which would help locate prey but would reveal the whales' presence. Instead, the transients appear to find prey by "passive sonar" – listening for the sounds made by the mammals they are hunting. Transients only vocalize freely once they are in the process of killing or eating prey. Members of a transient group will frequently cooperate to kill a marine mammal, especially the large and physically powerful sea lions. The tail flukes are first used to strike and stun the prey, and then it is drowned. Once killed, the mammal is often shared among group members.

How the newly discovered offshore killer whales may fit into this fish versus mammal diet dichotomy is not yet clear. In many respects, they resemble residents, and we believe that they prey on salmon for at least part of the year. They are frequently vocal and use a great deal of echolocation, which suggests that they are primarily fish feeders. Their tendency to form large groups also point to a piscivorous lifestyle. However, the possibility that offshores also take marine mammals cannot be ruled out.

Dialects and Population Identity

Different killer whale populations can be distinguished by the kinds of underwater communication sounds they produce. These vocal variations, known as *dialects*, can provide important clues about the relationships of groups and populations. Like other toothed whales, killer whales produce a wide variety of acoustic signals that serve various purposes. Rapid series of clicks, mentioned earlier, are used as echolocation or sonar signals for navigation and detection of objects in the whale's surroundings. Other kinds of sounds, mostly whistles and burst-pulsed signals that resemble squeals, squawks, and screams, are used for social communication within and between groups. A large proportion of the social sounds of killer whales are quite stereotyped and distinctive in structure. Each group of whales produces a specific number and type of these discrete calls, which together form its dialect. The group's dialect is apparently learned by each individual, probably by mimicking its mother as a calf. Each pod of resident killer whales has a unique dialect that can be readily identified by the trained ear or sound analyzer – some dialects are so distinctive that even an inexperienced listener can immediately discern the differences.

It may well be that dialects are used by the whales as acoustic indicators of group identity and membership, which might serve to preserve the integrity and cohesiveness of the social unit. Whatever their function for the whales, dialects provide us with insight into the social history of populations. Within the resident population, pods with related dialects belong to a *clan*. Each clan is most likely a continuous lineage that has descended from a common ancestral pod. As pods grew in size over time, they gradually split into new pods, and their common dialect drifted apart. This process may have repeated itself several times within each lineage, resulting in the complex systems of pod dialects we see today. Pods with very similar dialects probably split in the recent past, while



Vocal dialects of resident killer whale pods provide information on how communities have evolved in the past. This diagram shows all 19 resident pods organized according to the degree of similarity in their repertoires of calls. Pods with almost identical dialects are linked with a high index of acoustic similarity, and they in turn are linked to others with less acoustic similarity. Pods that have related dialects belong to the same clan. The four resident clans thus have no acoustic similarity and are not linked together. The degree of dialect similarity between pods probably indicates how closely they are related. The "family tree" shown for each clan reflects its historical genealogy.

Newborn killer whales nurse for at least a year. The minimum interval between calves is three years, although, for some females, a decade or more may pass between successful calves.

others with fewer similarities likely have more distant relationships. Different clans have no dialect features in common and probably have very ancient links. (Communication and echolocation of residents are also described in the sidebar on p. 96.)

Dialects of transients are, predictably, very different from those of residents. Transient dialects are made up of a relatively small repertoire of 4 to 6 different discrete calls, compared to the repertoires of 7 to 17 calls that form resident dialects. No calls are shared by the two types of killer whales. Most significantly, all transient groups recorded to date have the same basic dialect. This homogeneity of calls is probably a reflection of the fluid social system of transients. Because transient group membership frequently changes, there is little opportunity for group-specific sounds to develop within a lineage. The transient dialect is so widespread and distinctive, it has become one of the criteria we use to assign newly identified whales to the transient community.

Killer whales belonging to the offshore population are highly vocal, and preliminary analysis suggests that they produce calls unlike any resident or transient. There is even some evidence of group-specific dialects within this community, but much more research is needed to describe them in detail.

Population Parameters

Detailed documentation of the resident killer whale population over the past 25 years has provided important information on the life history of the species. Although most of the statistics below were obtained from this population, they are probably representative of transients, offshores, and other populations as well.

The timing of many events in a killer whale's life is not unlike that of humans. In most cases, females give birth for the first time at 14 or 15 years, which is also near the age of reproductive maturity in human females. The youngest female we have seen with a calf was 11 years old. Studies of breeding in aquaria indicate that the gestation period is 16 to 17 months. Single young are usually born, although we have recorded one possible set of twins. Calves are about 2.5 metres long at birth and weigh 200 kilograms. For reasons that are not known, the mortality rate of calves is quite high – over 40% of resident calves die in their first six months of life. A typical female produces 4 to 6 surviving offspring over a 25-year period, then stops breeding. Post-reproductive females may live for an additional 30 or more years after giving birth for the last time. The average lifespan of females appears to be about 50 years. However, from the number and age of offspring and descendants of some old females, we estimate that some may reach 80-90 years of age.

Male killer whales begin maturing at 12 to 14 years of age. Over the next few years, they grow very quickly and attain physical maturity at about 20 years. Most males probably reach a length of 8 to 9 metres, while females average about 7 metres. Although we cannot estimate the age of males from the number of their offspring, we know that some live well into their 40s and perhaps to 50-60 years of age. Male longevity, however, typically seems to be less than that of females, averaging about 29 years.

Due to the abundance and predictability of resident killer whales in protected coastal waters and as a result of their unusually stable social system, we have been able to collect considerably more information about this population than for transient and offshore whales. Annual field studies over the past twenty-five years have enabled us to assemble detailed genealogical histories for each of the approximately 300 whales currently inhabiting the coastal waters of British Columbia and Washington. In this section and the next, we describe these resident societies and present a catalogue containing individual photographs and names for every whale in the population.

The social lives of resident killer whales are without doubt as rich and complex as those of the most advanced land mammals. They live in groups that are tightly organized along lines of maternal relatedness. The bonds among females and their offspring are extremely strong and persist throughout the whale's life. It is this long-term relationship between mother and offspring that is the most significant feature of resident societies, and it accounts for the kinds of social structures that we see in the population.

In this study, relationships among individual whales were determined from their associations with each other while travelling. However, this technique only allowed us to identify the maternal lineage, as paternity was unknown. It seemed unlikely that males mate with females in their pod, who are closely related, and thus we speculated that fathers travel in other social groups than their offspring. Recent genetic studies indicate that this is indeed the case (see sidebar, p. 99). Travelling associations were determined by direct field observations as well as through analysis of photographs. The latter method involved two techniques. The first consisted of selecting representative pictures of several whales and determining the level of association by the distance between the whales. The second photographic technique involved the use of over 50,000 photos collected from 1973 to 1987. A computer program was designed to evaluate the number of times individuals appeared together, which resulted in an "index of association." The results of each kind of analysis were largely the same.

All ages and both sexes of whales tend to spend the greatest proportion of their time travelling with their mothers. For its first year of life, a nursing calf seldom strays far from its mother's side. Then, as a juvenile, it will spend more time interacting with siblings and whales in other groups but still swims most frequently close to its mother. As the whale grows older, the association weakens somewhat, especially for female offspring once they give birth to their own young. However, the tendency continues well into adulthood, and we have concluded that a whale will stay primarily in the same social group as its mother as long as she is alive.

As our study is only twenty-five years old, and whales may live sixty or more years, it has taken some extrapolation from our observations to arrive at such a conclusion. First, numerous offspring that were born early in the study have matured during the course of our observations. Many of these are females, which now have their own calves. In all cases, these whales have continued to travel closely with their mothers. Assuming that the adult female accompanying each medium- and large-sized juvenile observed at the beginning of the study was the mother, then these animals have continued to travel with their mothers as adults. No changes in close travelling companions have been observed during the past two-and-a-half decades. Thus, extending this logic, we conclude that resident whales travel primarily with their mothers throughout their lives.

It was not without some surprise that we came to the realization that resident society is so strongly matrilineal. When the study began, many speculated that killer whale pods were the primary breeding units. The mature males in the group were thought to be the "harem masters," and they mated with the pod's cows. The calves and juveniles were therefore their offspring. This was not an unreasonable assumption, however, as many social carnivores live in groups with this kind of social system. But numerous other mammals, including some of the most socially advanced species, such as primates, live in multigeneration, matrilineal societies. However, in most of these matrilineal species, offspring, usually just males, disperse from the group upon reaching maturity and join or form new groups. This is probably also the case for certain other species of toothed cetaceans, such as bottlenose dolphins and sperm whales, which appear to live in matrilineal groups for at least part of their lives. Dispersal is thought to be primarily a mechanism by which the animals prevent excessive inbreeding. We are not certain how resident killer whales avoid the problem of inbreeding, but we believe that males will mate with unrelated females in other pods, perhaps using dialects as a behavioural indicator of relatedness. Genetic studies, soon to be completed, will resolve this question (see sidebar, p. 99).

Definitions of Social Structure

The way we define the various levels of social order within resident societies has evolved over the course of our study. Early in the research, the basic social and travelling unit of resident killer whales was considered to be the pod, a cohesive group of individuals that were always seen to travel together. However, when pods were first defined and identified in the early 1970s, it was during a period of rapid growth in the resident population. As pods grew in size through the late 1970s and 1980s, many gradually split into smaller groups that often travelled independently. We termed these new social groups *subpods*, and these became the basic travelling units for much of the population. Several of the original pods, however, maintained their cohesion during this period of expansion and remained the primary travelling unit for their members.

Over the past decade, it has become increasingly evident to us that because of the dynamic nature of social affiliations among resident groups, subpods and pods cannot be clearly and consistently defined on the basis of their travel patterns. These patterns can change dramatically within a season as well as from year to year and decade to decade, likely as a result of the size and demographics of groups, and possibly ecological factors. To some extent, the definitions of pods and subpods are artificial in that they depend on arbitrary measures of social bond strength and time scales.

To improve the consistency of resident group definition, we have recently begun to define groupings of residents primarily on the basis of their maternal genealogy, as this reflects the true social order and is independent of fluctuating affiliations. Resident societies can be organized into a series of social units, from small to large, on the basis of these genealogical relationships. The maternal relatedness of the whales diminishes as one goes from the smallest kin unit, a mother and her offspring, through increasingly larger units, the *matriline*, the *pod*, and the *clan*. The largest grouping, the *community*, is the only social grouping defined by travel patterns and not on genealogy or acoustics. The general features of each of these social levels are described below.

Matriline. A matriline is a group of closely related whales linked by maternal descent. A typical matriline consists of an older female, or *matriarch*, and her male and female descendants. The matriarch's daughters may be of reproductive age and have young of their own. Because of the long lifespan of matriarchs, some may actually have granddaughters that have young of their own, thus some matrilines may contain four generations. Some matrilines, however, contain only one generation. This often results when a matriarch dies and leaves only sons or daughters that have no young of their own (e.g., A36 matriline, p. 49). Because matrilines are highly cohesive and rarely separate for any significant length of time, the groupings are in most cases the same as those previously referred to as subpods.

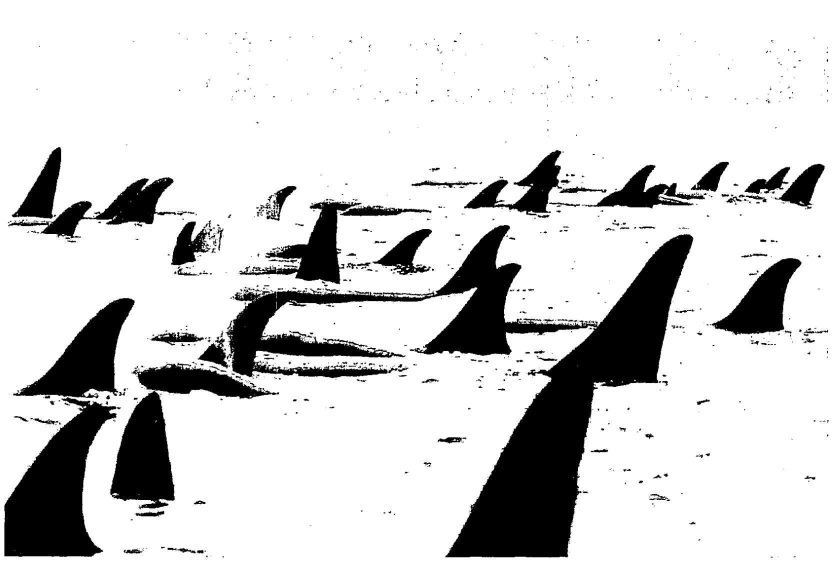
Pod. A pod is a group of related matrilines that likely share a common maternal ancestor in the recent past. Matrilines within pods are thus more closely related to one another than to matrilines in other pods. Pods in the resident population of British Columbia and Washington were identified and named in the 1970s, primarily on the basis of travelling pattern. Some pods are still highly cohesive today (e.g., B1 and J1 pods) and their matrilines are typically seen together. Others have grown over time and are less cohesive than in the past, and their matrilines now regularly travel apart. However, these matrilines still tend to travel more often with others from their pod than with matrilines from different pods. Over three-quarters of pods are comprised of 1-3 matrilines. One pod, L1, is by far the largest in the population, with 12 matrilines. Pods tend to have dialects that are distinctive and thus can readily be identified acoustically.

Clan. The clan is the next level of social structure above the pod, and it is defined by the acoustic behaviour of pods. It is comprised of pods that have similar vocal dialects. All pods within a clan have most likely descended from a common ancestral pod through a process of growth and fragmentation along matrilines. Thus, the related dialects of clan members seem to be a vocal reflection of the common matrilineal heritage of the pods. Those pods with very similar dialects are probably more closely related, and have split more recently, than those with more different features in their dialects. We have no idea how different clans may be related as they have no dialect features in common. It may be that clans are linked through a common maternal ancestor, but one that is more ancient than that linking pods within clans. Alternatively, perhaps each clan represents a separate lineage that, through an ancestral founding matriline, independently colonized this section of the northeastern Pacific.

It is interesting that we often see little indication of the relatedness of pods, as determined from dialects, in their travel associations. Some pods will frequently swim with distantly related groups in preference to their close acoustical relatives. Pods choose different travel associates at different times, based probably on social factors, such as age and sex composition. Dialects are very stable over time, however, and appear to better indicate pod genealogies than do associations.

Community. The top level of social structure is the community, which is made up of pods that regularly associate with one another. The community is thus defined by association patterns rather than maternal genealogy or acoustic similarity. Pods from one community have rarely or never been seen to travel with those from another, although their ranges may partly overlap. There are two resident communities in coastal waters of British Columbia and Washington: the northern and the southern communities. The northern community ranges through coastal waters from roughly the midpoint of Vancouver Island north to southeastern Alaska, as well as around the Queen Charlotte Islands. The range of the southern community includes waters off the southern half of Vancouver Island and Puget Sound, and unknown areas offshore. At last count, the northern community was composed of 16 pods with a total of 216 whales (1998), and the southern had 3 pods with 83 whales (1999). The northern community contains 3 clans and the southern community a single clan. Whales from these two communities have never been seen to mix, although their known ranges overlap. The northern extent of the range of the northern community overlaps with the southern part of the range of another community of Alaskan residents. Pods from these two communities have been observed to travel together in this area of overlap in southeastern Alaska, but it does not seem to take place very frequently.

It is important to note that the social structure of residents is not static. The process of change may be a slow one, but it is



Large aggregations of resident killer whales are common during the summer months, when salmon are migrating and concentrated in coastal channels. Here, several resident pods are resting together.

constantly under way nonetheless. The resident population has grown at a rate of 2-3% per year during our study, and mathematical models tell us that it has probably done so since the 1960s. The northern community, for example, has grown from about 129 in 1975 to an estimated 216 in 1998. As pods defined in the 1970s grew in size, many split into independent matrilines that mostly travel apart today. These splits took place very gradually. Some pods (e.g., pod A1) contain matrilines that spent the majority of their time together in the 1970s, but gradually spent more and more time apart through the 1980s, and now are seen separately more often than together. However, they still tend to associate more with one another than with matrilines from different pods. The death of an old, post-reproductive cow – the matriarch of the group – can destabilize her matriline and trigger the beginning of the splitting process. An example of this effect can be seen in the A11 and A24 matrilines, which always travelled together with their mother, A10, until her death in 1983. In 1986, the two matrilines began to be seen travelling apart, albeit rarely, but the splitting process continued and in the past few years it has become a regular occurrence. Not all pods grow and split along matrilines, however. If a pod has few or no reproductive females, its size may only just be maintained, it may decline, or it may die out altogether (e.g., W1 pod, p. 83). There are indications that the growth rate of the resident population in British Columbia and Washington is beginning to slow, and the communities may be entering a period of reduced social fission.

There are still a number of important gaps in our understanding of resident societies. One of the most puzzling is that individuals never leave the group into which they are born. Whales appear to mate outside their matriline or pod, as mentioned above, to avoid inbreeding. But who do they choose to mate with, and who does the choosing – males or females? We occasionally observe mating in the field, but never with enough confidence to predict when a female will give birth or who the calf's father might be. It is likely that dialects – another very unusual feature of resident cultures – have a role in the mating system. Perhaps whales choose mating partners that sound different from themselves and are thus not close relatives. Whales might favour mating partners in different clans, although this is not an option for the southern community, which consists of a single clan. The results of Lance Barrett-Lennard's genetic studies (see sidebar, p. 99) will finally shed light on the mysteries of paternity and mating systems in resident societies.

Another question that we often ask about resident social organization is simple but difficult to answer: What determines group size and stability? Most likely the answer lies in a combination of social and ecological factors. During the summertime peak of salmon migration, food is abundant for residents, enabling them to form large aggregations, often termed *superpods.* These large temporary groups probably form for social reasons, such as mating. During leaner times, as in winter, the whales spend more time foraging, and matrilines are more likely to travel independently. But why are some pods several times the size of others, and why do some pods fragment into independent matrilines while others rarely or never do so? These kinds of variations are probably determined by the age and sex composition of the group, which in turn influences social dynamics. The numbers of matriarchs, mature males, or young whales may all play some role in determining the social patterns of the pod. For example, we have noticed that matrilines containing more than the average proportion of mature males are more independent in their travelling patterns than those with a balanced sex ratio. The details of the various forces shaping social structures may require decades of additional fieldwork to resolve.

How typical of killer whales around the world is the social organization of our resident population? It is only in the last few years that it has been possible to shed some light on this question. Since the mid-1980s, photo-identification studies have been undertaken in Alaska, and the social structure seen there is very familiar. Between southeastern Alaska and the Prince William Sound region, there is a large community of resident, salmon-eating pods that are each composed of matrilines. Pods from this community have been seen on several occasions to travel with northern resident pods from British Columbia when the latter venture into southeastern Alaska. In Norway, colleagues have recently conducted similar research on a population of herring-eating killer whales, and resident-like, matrilineal social structures seem to be the rule. Killer whales that have been studied by photo-identification in the sub-Antarctic Crozet Islands and Argentina are primarily mammal-hunters and have a lifestyle and social structure more typical of transients. It appears that resident-type societies may only occur in areas where there are abundant and reliable food resources, such as salmon or herring, and where there is an advantage for whales to remain in the same group for life.

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1. Southern resident whales L2 (left) and her son L39 (right) in the San Juan Islands.

2. Southern resident J11 carrying a stillborn or dead newborn calf in the northern Strait of Georgia, 4 December 1998. An estimated 40-50% of resident neonates die in their first six months of life, for reasons that have yet to be determined.

Watching killer whales in the wild in British Columbia and Washington has developed into a popular recreational activity over the past two decades. Nothing quite matches the thrill of witnessing a resident pod cutting through the waters of Johnstone Strait in pursuit of salmon, or seeing a transient group combing the kelp beds in their hunt for seals. Listening to a pod's strident underwater calls as the whales keep in touch in their own dialect enhances this fascinating experience. There are two principal ways to view killer whales in the wild: from land and from boats.

Land-Based Whale Watching

The whales can be seen from land anywhere along the coast, but there are few sites that offer a good opportunity to see them with some certainty. At present, the most reliable and accessible site for public viewing from land is Lime Kiln State Whale Watch Park, located on the west side of San Juan island, overlooking Haro Strait. This park was established in 1984 by the Washington State Parks and Recreation Commission for the purpose of watching killer whales and has become very popular. In 1999, the whale watch park had an estimated 190,000 visitors. Southern resident pods can be seen there on most days during summer, often at close range.

Most of the range of the northern resident community is accessible only by boat. However, there are plans to soon develop a trail from Telegraph Cove east along the Vancouver Island shoreline that will provide good opportunities for viewing whales in western Johnstone Strait. It is also hoped that a land-based whale-watching site will be developed near the Robson Bight (Michael Bigg) Ecological Reserve, which people could access by shuttle water-taxi. As interest in whale watching continues to grow, viewing from shore may be an excellent way to accommodate large numbers of people without adding to vessel congestion around the whales.

Vessel-Based Whale Watching

Whale watching can be done from all types and sizes of vessels, both private and commercial. Many people choose to take one of many tour boats that offer killer whale watching. There are a variety of day-long or half-day excursions operating through the summer months in Haro and Johnstone Straits. Some commercial tour operators also offer longer trips by kayak or sailboat. We recommend that, whenever possible, people choose a whale-watch operator belonging to an association having guidelines or a code of conduct to minimize disturbance to whales. In the core area of the southern resident community, accredited whale-watch companies belong to the Whale Watch Operators Association Northwest. Some people prefer to view whales from their own boat or one they have chartered. Sea kayaks are an economical option, and these can be easily rented and transported by car to good whale-watching areas. Sailboats and motor vessels are also popular. Whale watchers using their own vessels should be aware that it is against the law to disturb whales and other marine mammals and are urged to follow the guidelines set forth in "How to Behave around Killer Whales" (p. 57).

Interpreting Whale Activities and Behaviours

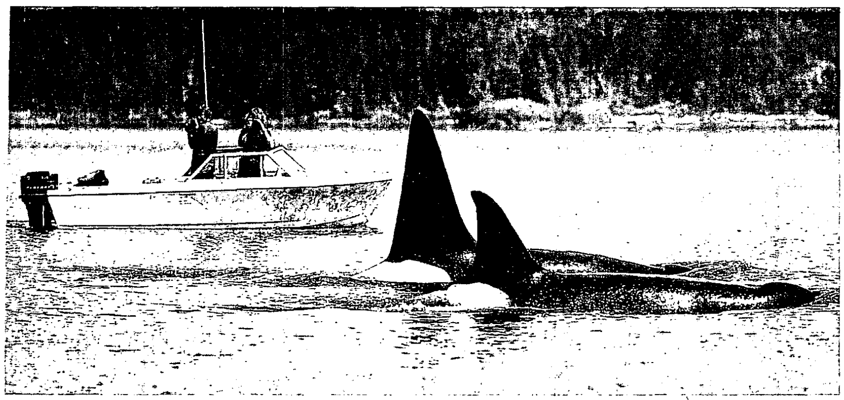
Like all social mammals, killer whales exhibit a wide variety of behaviours as they go about their daily lives. Unlike their terrestrial counterparts, however, these marine mammals spend the majority of their time underwater and thus out of sight of vessel- or shore-based observers. For this reason, we must infer much of the whales' behaviour from relatively short glimpses at the surface and by eavesdropping with underwater hydrophones. Until such time as technology enables us to view wild whales as they swim underwater, the details of their subsurface behaviours are left to the observer's imagination.

The activities of resident killer whale groups fall into four rather broad categories: foraging, travelling, resting, and socializing. Although members of matrilines or pods tend to coordinate their activities, these categories are not entirely exclusive. Some whales in a group may be foraging, for example, while others nearby are socializing or resting. Within specific activity states, the whales tend to exhibit characteristic surface behaviours, but again these are not exclusive. Some behaviours, such as tail slapping, may be observed during all four activity categories. In the following section, we describe each activity state and the kinds of group and individual behaviours that one typically sees. It should be noted that our knowledge of whale activities is based mostly on observations in daylight hours during the months of May through November. We believe that whales behave similarly during the hours of darkness, but their activities during winter are very poorly understood.

Foraging. The most common activity of resident killer whales is foraging. This activity includes all occasions where the whales are feeding or appear to be searching for food. When foraging, members of pods spread out, often over areas of several square kilometres, with individuals or small subgroups diving and surfacing independently while swimming generally in the same direction. The whales often move forward in a loosely organized broad front, as if they are sweeping an area for fish. In narrow passages, such as Johnstone Strait, some individuals can often be found close to the shore on each side of the strait, while others, especially mature males, swim out in the channel. Foraging whales typically make 2-3 short, shallow dives, followed by a longer dive of 1-3 minutes. The whales produce underwater vocalizations frequently during foraging, presumably to keep group members in touch with one another.

The amount of time killer whale groups engage in foraging can vary widely. In areas or at times of the year when salmon are relatively scarce, the whales may spend entire days foraging. During the peak of salmon abundance in Johnstone or Haro Straits, however, bouts of foraging may only last two or three hours before the whales begin a different activity. During the summer, resident killer whales in Johnstone Strait spend about 65% of their time foraging. Visual signs of successful fish capture are often subtle, such as a whale briefly changing direction or making a slight lunge at the surface. Sometimes, however, an individual makes a spectacular dash through the water, culminating in an explosion of spray as it captures its prey. Usually the only evidence of a kill is a few scales or bits of flesh drifting in the water. Whenever possible, we collect such remains and use them to identify the species involved. Almost all resident kills we have documented were of salmon and included all six species found on the coast.

Travelling. A group of whales is considered to be travelling when it is swimming consistently in one direction at a moderate to fast pace, usually in a relatively tight formation, and there is no sign of feeding. Travelling whales tend to move at speeds of 5 knots or more, compared to the more leisurely pace of 2-3 knots exhibited during foraging. It is not uncommon for a rapidly travelling group to surface and dive in unison, or for individuals to clear the water's surface as they come up to



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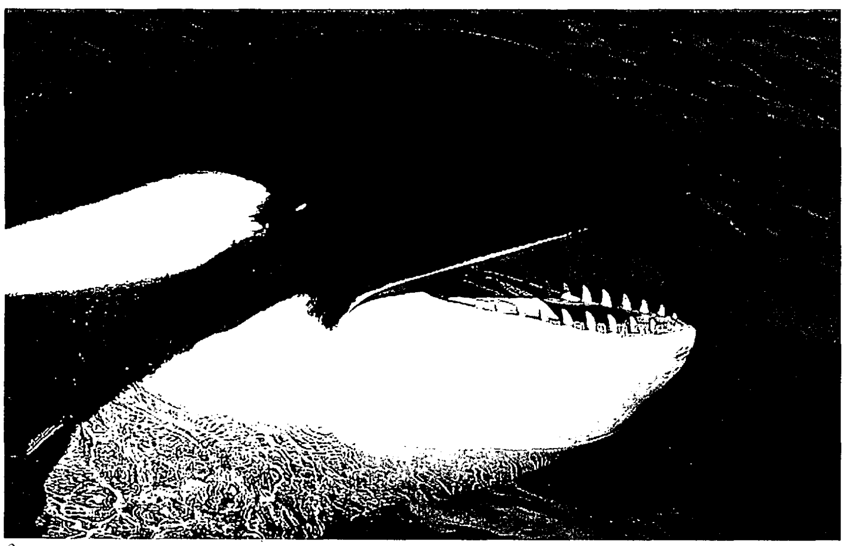


2

1. The male A5 and his mother A9 (deceased, 1990) are photo-identified as they cruise slowly in Johnstone Strait.

2. The conical, interlocking teeth of killer whales are well suited for a wide variety of prey, from small schooling fish to large whales.

breathe. Travelling seems to be simply a means of transiting an area, perhaps to move from one good feeding spot to another. In western Johnstone Strait, travelling activity is fairly uncommon, apparently because the foraging routine of the whales in the area is confined to a small area. Travelling is more often observed among southern resident whales than northern residents. At most times, travelling whales are highly vocal, but occasionally a group will travel in silence.

Resting. Following a bout of foraging, members of killer whale pods and matrilines often get together and begin resting. This activity, the whales' version of sleep, is quite distinctive and easily recognizable at the surface. The whales typically group tightly together abreast, forming a line of animals that dives and surfaces as a cohesive unit. The arrangement of individuals in a resting line is usually determined by genealogy. Offspring tend to cluster around their mother, often appearing to be in physical contact, and surface for air in a characteristic sequence. If many whales are present, they group according to the appropriate matriline or pod. At such times, there may be several resting lines in close proximity.

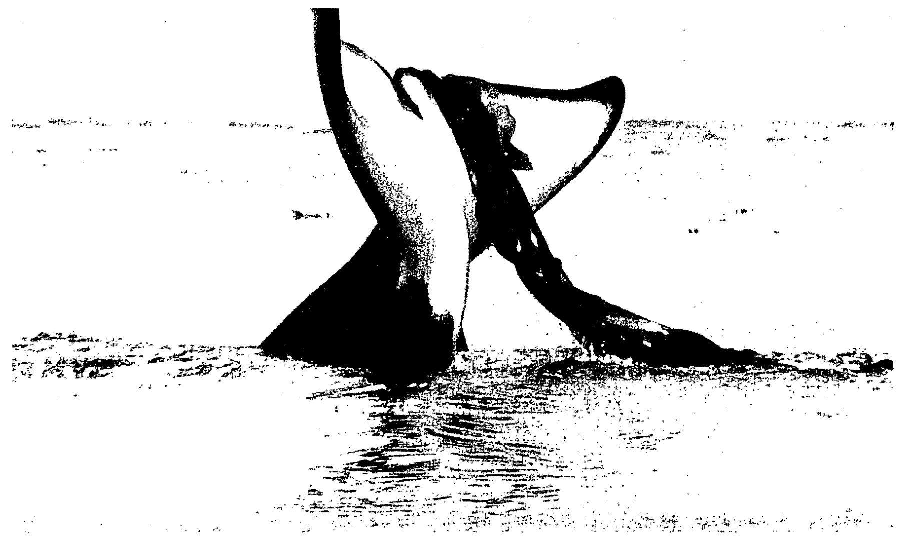
When resting, whales slow down and usually become very quiet underwater. Dives and surfacings become highly regular; the group has several short, shallow surfacings over a period of 2-3 minutes, then dives for 3-5 minutes. Forward progression of the group continues, albeit at a slow pace of 1-2 knots or less. Episodes of resting may last from less than an hour to more than 7 hours, with an average duration of about 2 hours. During the summer months, when most behavioural data have been recorded, resident whales spend about 13% of their time resting.

Socializing. The fourth activity category of residents, socializing, includes a great variety of physical interactions and displays among individuals. An entire group of whales can be simultaneously involved in socializing, or only a few individuals may socialize while others forage or rest. Behaviours seen during socializing episodes include sexual interactions, often among all-male subgroups, and various aerial displays, such as breaching, spyhopping, tail slapping, and flipper slapping. Whales often chase one another, or roll and thrash together at the surface. Individuals may also interact with inanimate objects, such as floating kelp, and will occasionally surf in the wake of passing boats. Socializing behaviours are often most common and vigorous among juvenile whales and seem to represent a form of play.

Periods of socializing activity last about two hours on average and account for approximately 15% of the whale's time during the summer months. Socializing whales often group together and dive for long periods, not unlike the patterns seen during resting activity. However, in addition to the increased levels of excitement, socializing whales tend to be far more vocal than resting whales. The types of vocalizations produced during socializing tend to differ quite markedly from those of foraging or travelling whales. Unlike the repetitive stereotyped calls used in the latter contexts, socializing whales employ a wide range of highly variable squeaks, squawks, and whistles. Although the functions of these unusual signals are not known, they probably serve an important social role when used in conjunction with physical and visual displays during socializing.

One particularly unusual form of socializing activity is beach rubbing. This behaviour takes place only among northern resident whales – the southern residents have never been seen to rub on any beach, nor have transient killer whales. Although several beaches in the range of the northern residents are known to serve as occasional rubbing sites, the behaviour is most common and regular at a series of small beaches within the Robson Bight (Michael Bigg) Ecological Reserve in Johnstone Strait. The whales may visit these beaches several times in a 24-hour period, where they rub their bodies on the small, smooth pebbles for up to an hour or more. Most evidence points to beach rubbing being a social or recreational behaviour, although it may also have some practical application, such as being a way of removing external parasites. Rubbing is usually exhibited in the context of other socializing behaviours or resting and probably represents a behavioural tradition that has developed over generations within the northern resident community but not among the southern residents. If some form of external parasite is involved, presumably this is not a problem in the southern community.

Although southern resident whales do not appear to rub, they have social traditions that differ somewhat from northern residents. When socializing, for example, southern residents appear to exhibit more vigorous and frequent aerial displays, such as breaches, than do northern residents. Also, when southern resident pods meet after a separation of a day or two, they often engage in a distinctive behaviour referred to as a "greeting ceremony." As two pods approach each other, they form two lines and stop at the surface when 10 to 50 metres apart. After less than a minute, the two groups then submerge and a great deal of social excitement and vocal activity ensues as they swim and mill together in tight subgroups. This form of display has occasionally been seen among the northern residents, but it is far more common among the southern whales.

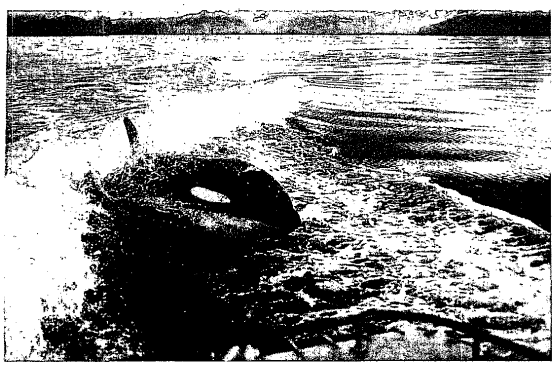


Killer whales occasionally play with kelp by draping it over their dorsal fin or lifting it in the air with their tail flukes.

Does Watching Whales Bother Them?

Many whale enthusiasts are concerned about the potential disturbance to killer whales from whale-watching vessels. This concern is also shared by whale researchers, many of whom have tried to objectively assess the impacts of vessels. Unfortunately, we do not yet have enough clear evidence to determine whether whale-watching boats and other types of marine traffic are detrimental to the well-being of the whales.

Disturbance to killer whales from boats can potentially come in many different forms, some of which are very difficult to measure. The sudden approach of a boat can startle a whale



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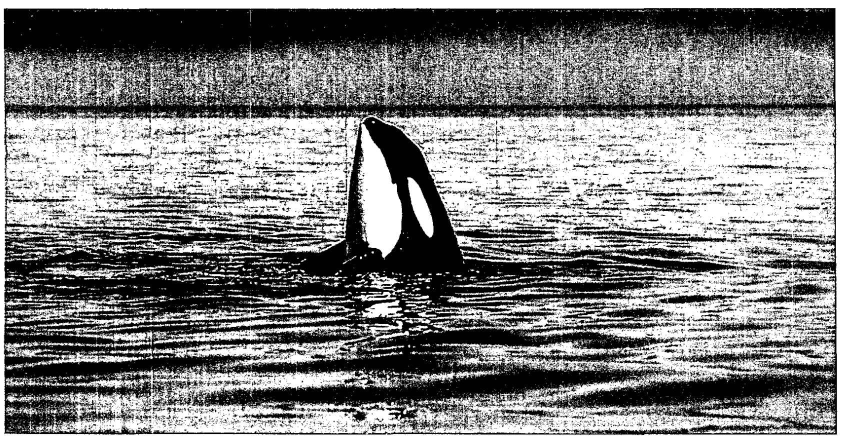
1. A frisky juvenile surfs in the wake of a research boat. Resident whales have been seen riding the wake of all types of vessels, from small skiffs to the largest cruise ships.



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2. Spyhopping is a behaviour where a whale raises its head out of the water, presumably for a look above the surface. Killer whales have good vision both above and below the water.

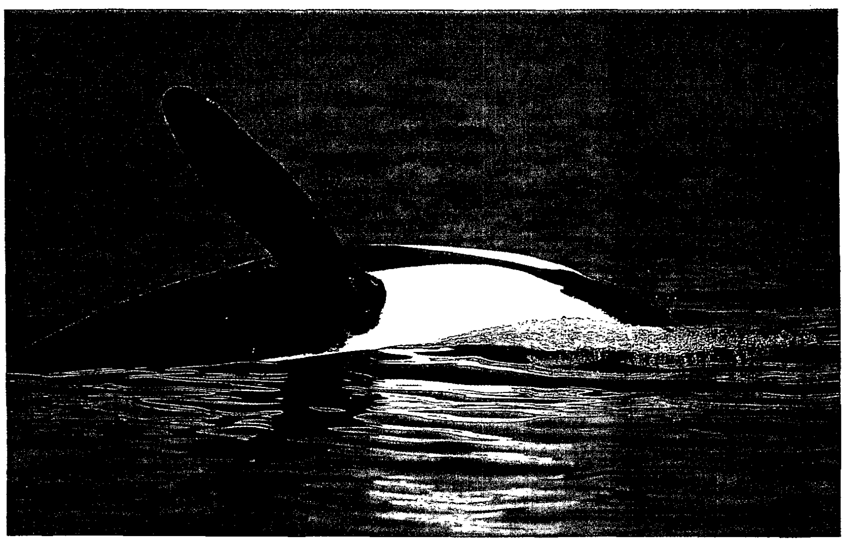
opposite page: A whale throws spray into the air as it raises its flukes after slapping the water's surface. Tail slapping is a behaviour that allows for both visual and acoustic communication, although it is not always clear what the whale is signalling. Whales may tail slap while socializing, after resting, or when disturbed.

or cause short-term disruption of a pod's activities. Typically, the whales seem to recover quickly from such isolated incidents and do not reveal any lasting effect. However, if disruptive encounters take place repeatedly – and they do at certain times in some areas – it seems likely that there will be a cumulative, negative impact. If whales are followed by a number of boats, hour after hour, or have to negotiate a fleet of vessels in their path, this will probably lead to some form of stress. Vessel traffic generates much underwater noise, which may affect the whales' ability to hear the communication sounds of distant companions or perhaps limits their ability to navigate and find food by echolocation.

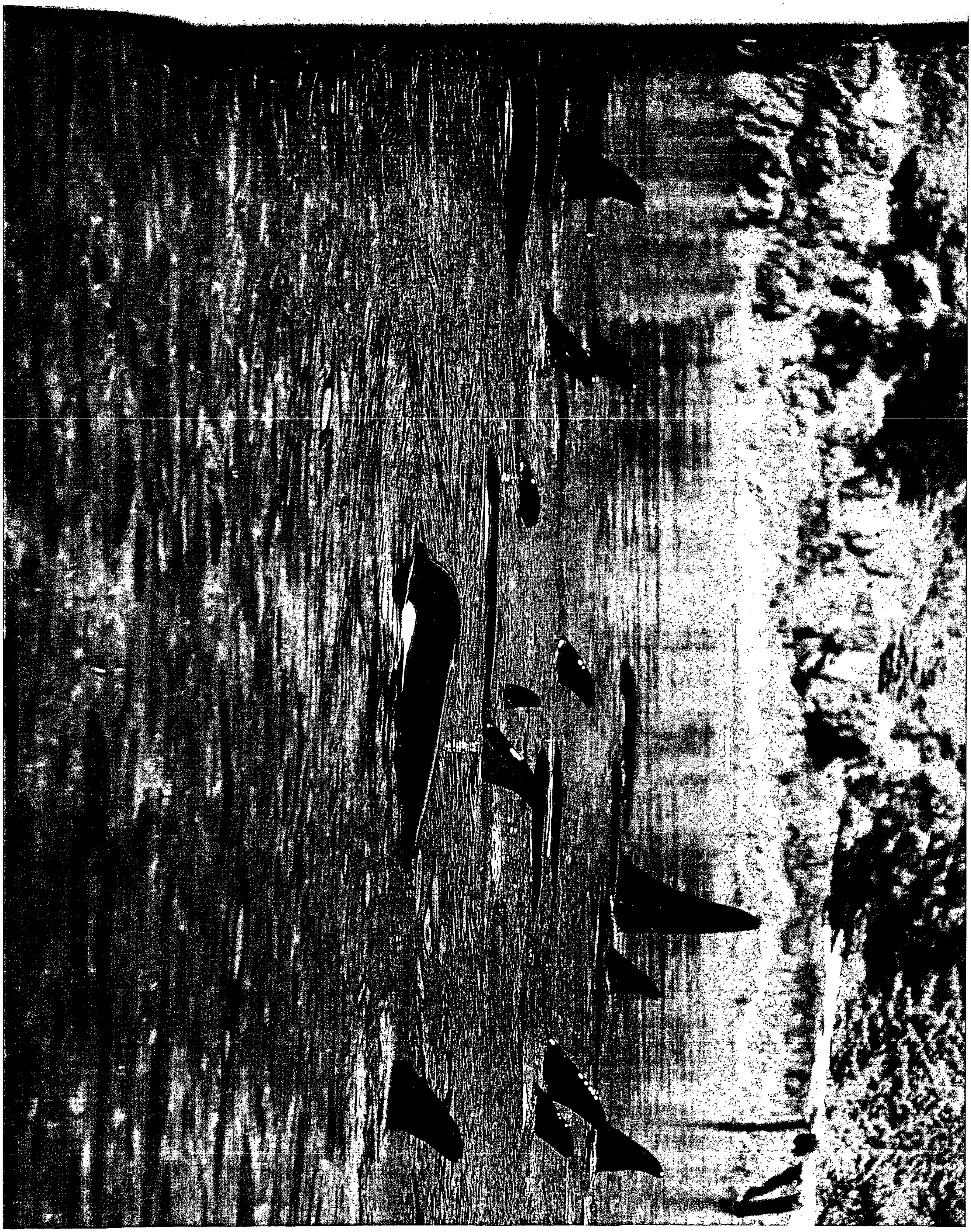
If long-term effects of vessels exist, they have eluded detection by researchers. Resident killer whales have long frequented waterways that are busy with marine traffic, and they seem to have adapted to the underwater noise and commotion. Although survey effort has varied over the years, resident whales appear to use the core areas of Johnstone and Haro Straits about as much now as they did twenty-five years ago, despite steady increases in the amount of whale-oriented boat activity. There are variations in whale presence in these areas from year to year, but these may well be in response to fluctuating abundance and distribution of salmon rather than vessel avoidance. However, we must be vigilant and continue to closely monitor whale occurrence and behaviour in order to detect any signs of possible disturbance. At the same time, it is important that we act in a cautious manner when viewing or studying whales, and that we manage our activities conservatively. Research has confirmed that northern residents are particularly sensitive to human activities at their traditional rubbing beaches in the Robson Bight (Michael Bigg) Ecological Reserve in Johnstone Strait, and for this reason the area is off-limits to whale watchers and researchers without a special permit (see sidebar, p. 57).

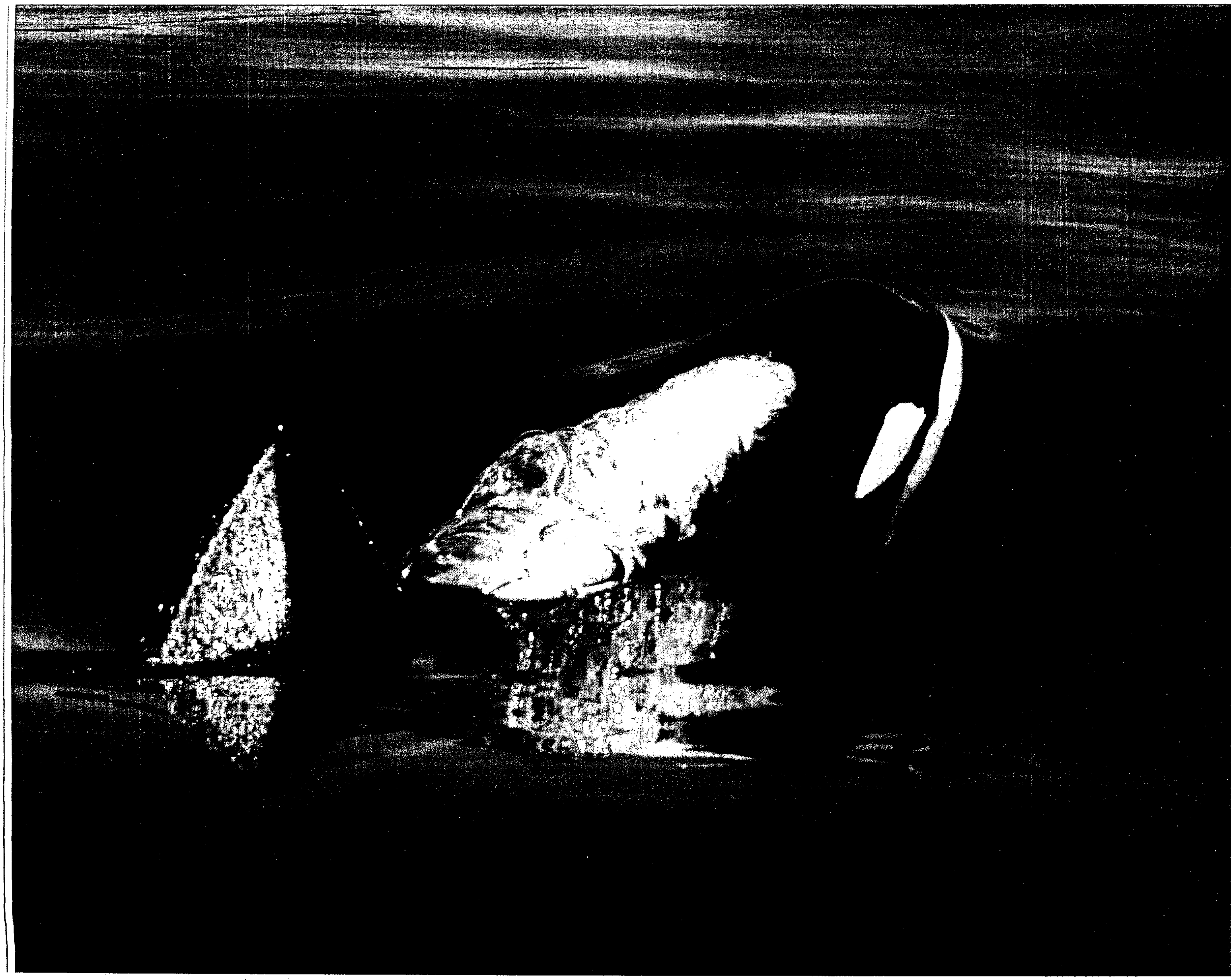
For most people interested in viewing killer whales in the wild, we recommend that they choose an accredited commercial tour excursion, if one is available in the area (see sidebar, p. 53). The operators of these vessels are generally very familiar with the whales and their habits and are careful not to approach them in a manner that might cause disturbance. Most also carry underwater hydrophones for listening in on the whales' vocal exchanges. Watching whales in the coastal waters of British Columbia and Washington is a wonderful experience, yet it is a privilege that we should not abuse. Done properly, future generations will also be able to witness these remarkable animals in their natural habitat.

Resident whales exhibit a variety of behaviours while undertaking their daily activities. Beach rubbing (left) is a common behaviour of northern residents, especially at certain pebble beaches in the Robson Bight (Michael Bigg) Ecological Reserve, but it is not observed among southern residents. Speed swimming (upper right) is often seen when whales are travelling quickly from one feeding location to another. Most of the time, however, whales swim at a more sedate pace while foraging (lower right).

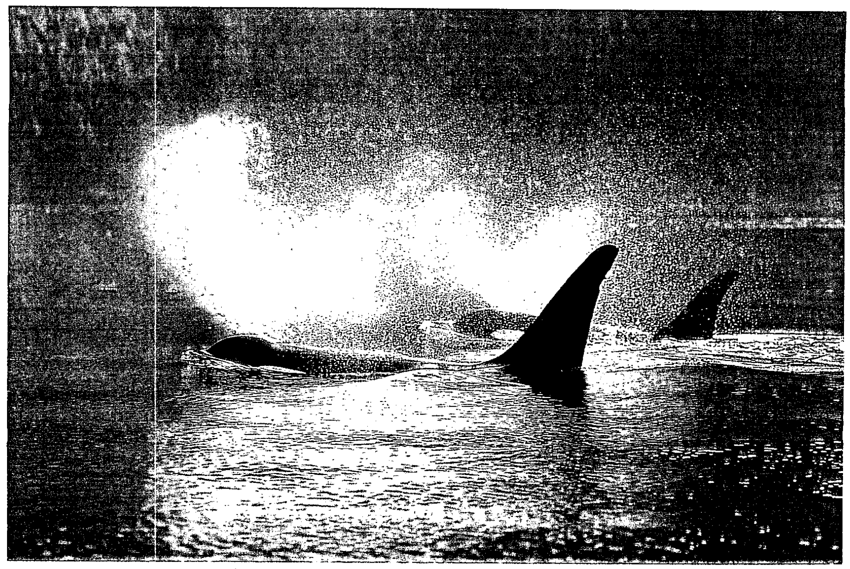


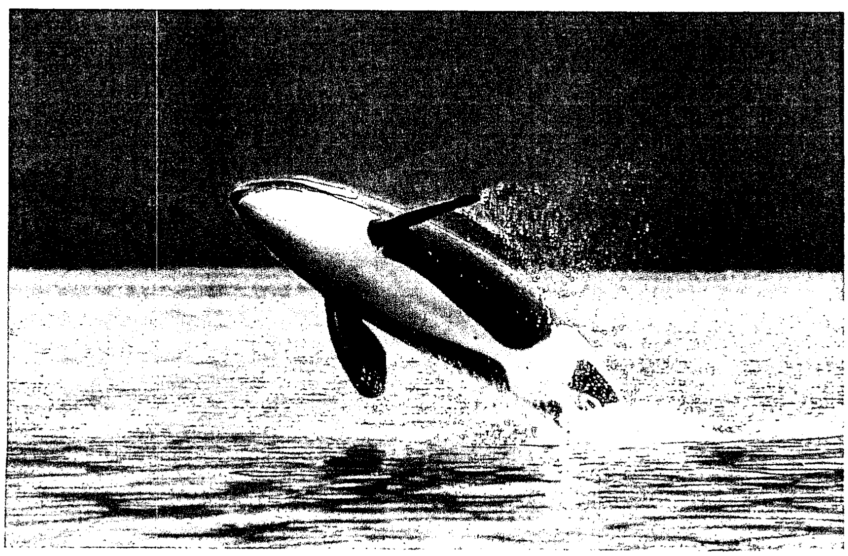
When resting, members of pods or matrilines group closely together and cruise slowly and quietly. The female A28 rests with her two probable uncles, A26 and A5 (upper left). A group of northern residents lazes at the surface near the Robson Bight (Michael Bigg) Ecological Reserve in Johnstone Strait (right). As whales begin "waking up" from a period of resting, they often exhibit aerial behaviours such as flipper slapping, where an individual raises its pectoral flipper above the surface and strikes it forcefully on the water (lower left). Flipper slaps make a loud sound that can carry for up to a kilometre underwater. As with other aerial displays, the function of this behaviour is not certain.

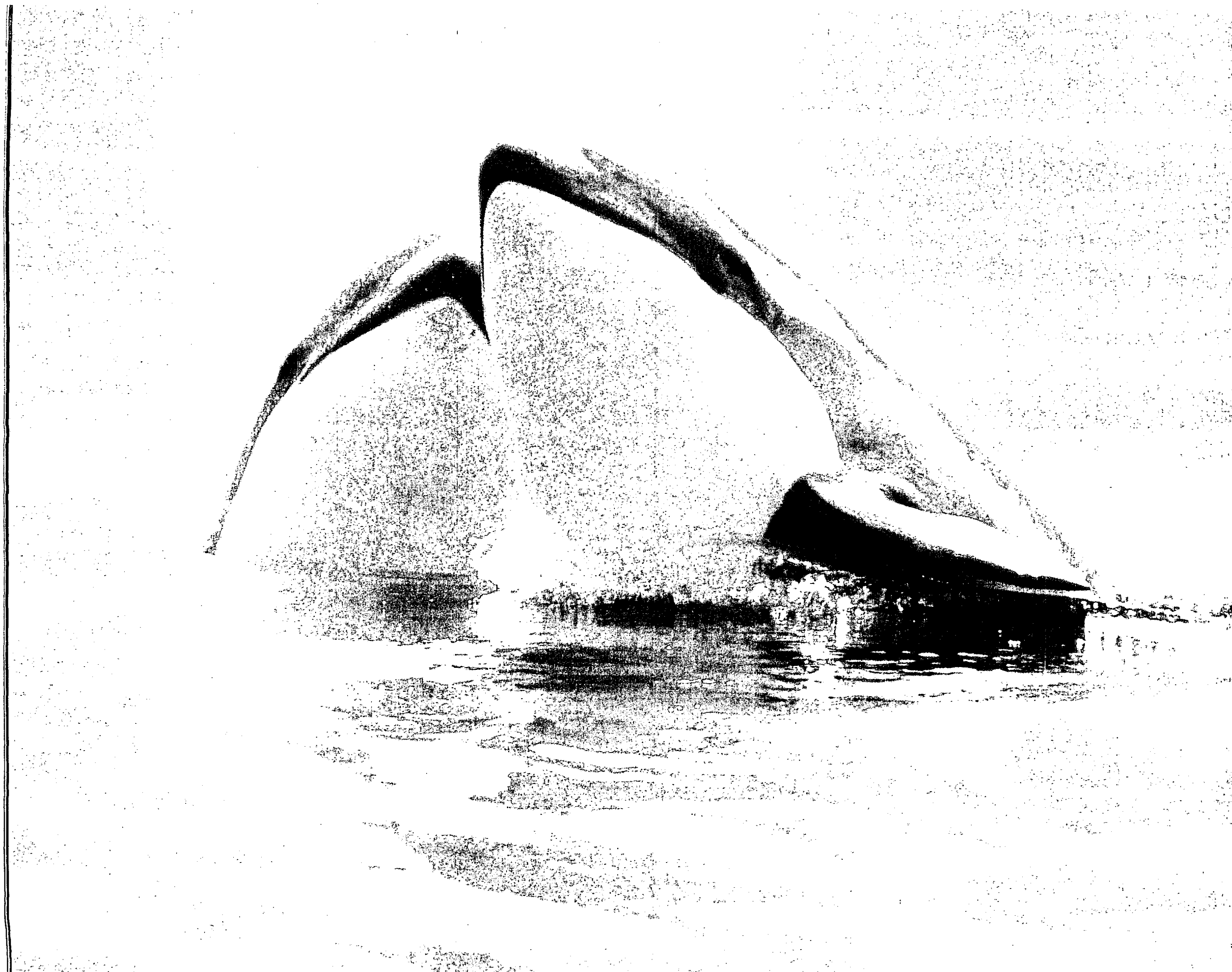




While travelling at high speed, killer whales often begin exhaling before surfacing (left). When swimming at regular speeds, however, they exhale at the surface, creating the plume of fine mist typical of a blow (right). A breach (lower right) occurs when a whale leaps out of the water, exposing two-thirds or more of its body. Breaches may take place at any time when a group is active and are exhibited by all age classes. The function of breaches is not clear, but it probably varies with each situation.







Catalogue of Resident Killer Whales

What follows is an overview of the social composition of the resident killer whales of the northern and southern communities and of the methods used to identify the groups in the field. An identification photograph of each whale is presented, along with the individual's known or estimated year of birth, and its sex, again where known. The whales are arranged according to their position in their matriline, pod, clan, and community. First, however, it is important to have some background on how whales and the various levels of social structure are named, as well as on the technique of individual identification.

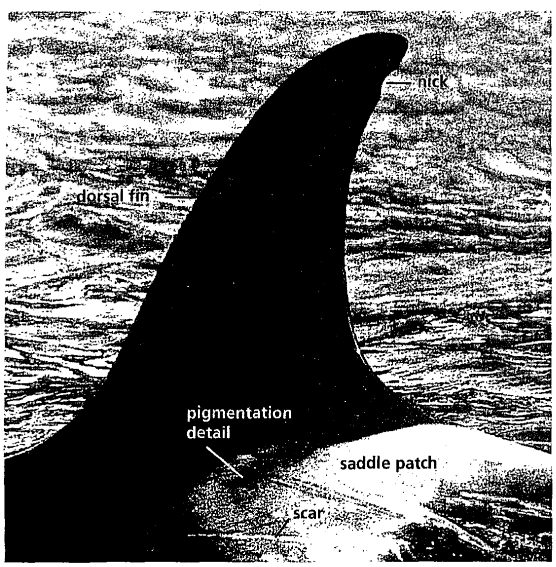
The Naming System

The naming system we use to define social groupings of resident killer whales has evolved over the course of our research. As our understanding of the structure of resident society improved, we realized that a naming system based on genealogy of individuals and groups is more appropriate and useful than our initial system based on social associations or travel patterns. This transition to a genealogy-based naming system is almost complete, although some remnants of the earlier system have been retained for continuity in our catalogues.

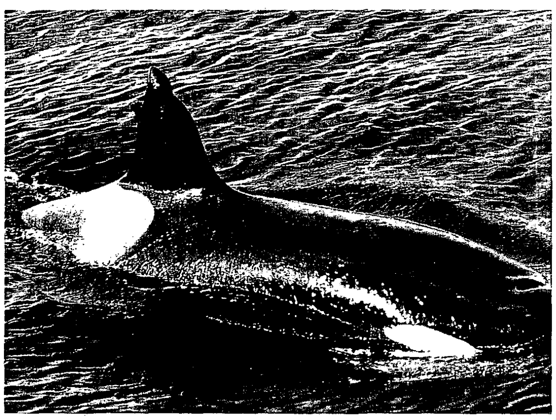
Early in the study, consistent travelling groups of individuals were defined as pods. These were thought to be the basic social unit of resident killer whales. The plan was to assign the same letter to each whale within a pod and then to give each individual whale a number. The following is an historical account of the identification of the first pod, which will explain some of the system's idiosyncrasies.

The first whale recognized was called A1, and because she was so well marked her pod was called A1 pod. As chance would have it, during our first encounters with her pod, we did not realize that the pod actually consisted of three pods that just happened to be travelling together, and we erroneously considered all of the whales to be members of her pod. When we discovered our error, it was too late to change the names of the whales in the other two pods. We simply split A1's group into three pods and called each new pod after its most distinctive member, which in two cases were mature males. The resulting pods were A1, A4, and A5. Each whale in the three pods has the prefix "A" in its name and is numbered according to the order in which it was identified.

Differences in the appearance of the dorsal fin and saddle patch are used to recognize individuals. An identification photo of the female A51 is shown here, along with the features that make her distinctive.



The first resident killer whale to be identified from markings on the dorsal fin was the old female, A1, who died in 1974. Known as "Stubbs," this whale had sustained major damage to her dorsal fin, probably from a collision with a ship's propeller (see sidebar, p. 66). Although A1 was easy to identify visually, the majority of whales have less distinct markings, and a good photograph or close examination with binoculars is needed for a positive identification.



Similar situations arose several times in naming other pods. An important consequence of this naming system is that no significance with respect to genealogy or travel patterns should be given to the fact that pods have the same letter designation. For example, I11 and I31 pods belong to a different clan than I1, I2, or I18 pods, and are probably only distantly related. These pods all share the letter "I" simply because they happened to be together when first photo-identified. Also, some pods were named after whales that have since died.

As the study continued into the 1980s, the resident communities continued to grow in size, and many of the initially designated pods began to gradually fragment into smaller groups, which we called subpods. During this same period, we came to realize that resident society is strongly structured by matrilineal descent. In recognition of this structure, we began to name subpods consistently after the senior matriarch in the group, who may be an old, post-reproductive grandmother or a breeding female, rather than after the most distinctive individual in the group. More recently, we have changed our definitions of social groups to further reflect the genealogical relationships of individuals, which better represent the true social organization of the population than do highly variable travelling patterns (see "Definitions of Social Structure," p. 24, for more details). As a result, pods are now subdivided according to the matrilines that comprise them. Most pods contain between one and five matrilines, except for the unusually large L1 pod, which contains 12 matrilines.

Matrilines are named first after the senior living matriarch of the group. Thus, as an example, the matriarch A11, her sons and daughters and grandsons and granddaughters, all belong to the A11 matriline. When reference is made to specific reproductive daughters in the matriline, and their offspring, these "submatrilines" are identified with the grandmother and mother's name. Thus, A35, daughter of A11, and A35's offspring are referred to as the A11-A35 matriline. Upon death of the senior matriarch, her name is dropped from the descendant matriline's name, unless sons or non-reproductive daughters of the matriarch survive, in which case the original matriarch's identity is retained in the matriline's name. Once these individuals are dead, the original matriarch's name is retired from the catalogue.

Clans are named according to the first alphabetical designation of a member pod, hence the A, G, R, and J clans.

How Whales Are Identified

As explained earlier, whales are identified individually from unique markings on their dorsal fin and the grey saddle patch at the base of the fin. Other features can also be used, such as the eye patch, but these are not as visible to the surface observer. The markings on the dorsal fin and saddle patch are documented by a high-quality black-and-white photograph, normally of the left side of the whale. The two sides often vary slightly in appearance, but, on occasion, one side is completely different. We arbitrarily chose the left side to simplify and standardize the system.

The unique characteristics of the dorsal fin are its shape, size, and scars. The scars are the result of injuries and are seen as gouges, nicks, and indentations, most of which are located along the rear edge of the fin. These injuries are permanent markings. The saddle patch, particularly its upper half, often has a unique shape. The shape does not change and its scarring and blemishes are frequently permanent. The location of the saddle patch relative to the ridge of the back and the detail of the edge of the pigmentation is also important.

We developed this recognition process over approximately ten years, and we can now distinguish many individuals on sight. However, we still rely mainly on photographs for identification, especially for whales with indistinct markings. The ability to recognize individuals develops with experience and can be classified according to three stages:

Easy. The easiest whales to recognize are those with prominent injuries to their dorsal fin. Such injuries consist of the splitting and curling of the tip of the fin (e.g., C9, p. 58; H4, p. 62), or tears (e.g., C10, p. 59). Spotting these features still requires observers to spend time looking at each whale to see the range of possible fin appearances. Some whales have prominent fin injuries that are quite similar to those of other individuals, and care must be taken not to confuse them. Examples of similarly appearing whales are C10 (p. 59) and D9 (p. 61), or C9 (p. 58) and G11 (p. 70). Saddle-patch shape and details can help distinguish individuals with similar fin injuries. Once recognized, a well-marked whale can be readily distinguished. Most people will be content to reach this level.

Difficult. The majority of whales can only be identified by the examination of small injuries (e.g., G3, p. 68; K7, p. 86), or an unusually shaped saddle patch (e.g., A42, p. 54; L11, p. 88). Sometimes there are fairly noticeable scars on the saddle patch (e.g., A23, p. 55). Close examination of whales using binoculars or good photographs is required to identify these animals. Again, saddle-patch shape can help to confirm identity. Many southern resident whales have very distinctive saddle patches.

Challenging. The most difficult group to identify consists of those whales with no obvious distinguishing marks. The subtle features of dorsal fin and saddle patch shape are used, and a very good photograph is usually needed. Most small juveniles fit into this category. Fortunately, resident whales travel in established matrilines and some individuals can be recognized by identifying their companions. This is especially useful for juveniles, which travel very closely with their mothers. Their identities can be tentatively determined from these associations, then confirmed from photographs.

Catalogue Organization

Identification photographs of individual whales are arranged by known or assumed genealogical relationships. Typically, the oldest whale – the matriarch – in the matrilineal group is placed at the top of the page, and her offspring are positioned below her in order of increasing age from left to right. Below these, third- and fourth-generation offspring, when present, are arranged in the same manner. The catalogue includes photographs of all whales known or, in a few cases, believed to be alive in 1999. Also shown on each catalogue page is a schematic family tree for the matriline(s), which includes whales that died during the study.

To assist in whale identification, we have prepared photographs in three size categories that reflect the body size of individuals:

Calves and small juveniles (height of photograph = 3.5 cm). This category includes young whales 1-3 years of age (born 1997-99). These small individuals are often difficult to photograph and are usually indistinctly marked.

Older juveniles and adult females (height of photograph = 4.5 cm). All whales born in 1996 or earlier, except adult males, are included in this category.

Adult males (height of photograph = 6.5 cm). The dorsal fin of males grows rapidly at the onset of puberty, usually around

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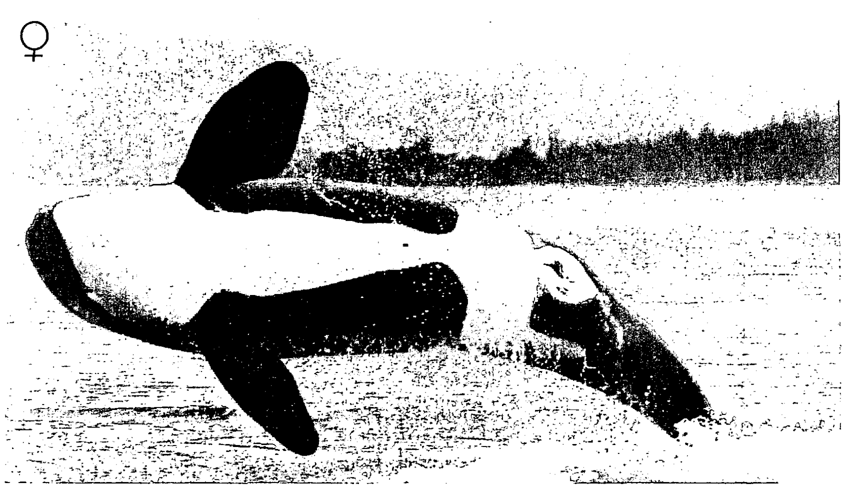

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13-15 years of age, and reaches a height of almost 2 metres at maturity. This category includes males whose fin is part way through this growth spurt or has reached full height.

Lines linking whales in matrilineal groups are of three types, which reflect different levels of certainty in genealogical assignment:

Positive (———). A solid line indicates relationships that we consider to be certain. Most whales born during the study (1973 or later) are linked in this way to their mothers.

Probable (············). Whales born prior to the start of the study, but still juveniles when first seen, are linked with a closely dotted line to the whale that is most likely their mother. Although the adult female with which it was closely associated was assumed to be its mother, the real mother may have died before the study began, and the juvenile may have formed a bond with another adult female.

Possible (· · · · · ·). A line of widely spaced dots is used to indicate the maternal relationship of a whale that was an adult when first seen. Although the association appears to be a strong bond and likely represents kinship, the actual lineage is the least certain. There is a real possibility that the actual mother may have died or that the travel association with the presumed mother may have been formed on some basis other than genealogy.

As the study continues in the future, possible and probable linkages will gradually be replaced with positive relationships as old whales die and new whales are born. Of the 299 resident whales in the population, the mothers of 208 (70%) are positively known. Probable mothers have been identified for 46 whales (15%) and possible mothers for 15 (5%). Mothers of the remaining 30 whales (10%) were probably dead at the beginning of the study and thus are unknown.

Sex and Years of Birth and Death

Above each whale's photograph in the catalogue we have indicated its sex, where known, and its estimated or actual year of birth. The sex of mature whales (over about 15 years old) is easy to determine because of the much larger dorsal fin of males relative to that of females. Establishing the gender of juveniles and calves, however, can be quite difficult. If a small whale happens to roll upside down at the surface, and if we are fortunate enough to get a clear view or photograph of its underside, its sex can be determined from distinctive pigmentation patterns in the genital area and from the presence of mammary slits in females. We know the gender of many juveniles and calves belonging to common pods because such opportunities have arisen. More recently, genetic analyses at the University of British Columbia have determined the sex of numerous subadult whales from DNA (see sidebar, p. 99).

The year of birth given for whales varies widely in precision. For individuals born during the study (1973 and onwards), ages can be considered correct unless noted. About 70% of the resident whales were born during our study, and this proportion will increase with time. We should point out, however, that since most whales are born during the late fall to spring period when little fieldwork is done, we are usually unsure whether a calf was born early in the new year or late in the previous year. To simplify our analysis, we have standardized all winter births to 1 January, except for the few cases where we know a whale was born late in the previous year.

For whales born prior to the beginning of the study, we have had to use various methods to estimate the year of birth. Those individuals that were immature, but not calves of the year when first identified, were aged by their relative size. Juveniles that were older when first seen were aged in reference to the year that they became sexually mature. These birth dates can be considered accurate to within ±2 years. Whales that were mature when identified were aged by indirect methods. For females, year of birth was estimated from the age of their offspring and the average age at which females cease reproduction (around 40 years). These estimates have potential inaccuracies of as much as ±12 years. For mature males without living mothers, it was not possible to estimate the year of birth. Instead, their ages are given as the latest year the whale could have been born (for more details on age estimation, see papers by Bigg et al. [1990] and Olesiuk et al. [1990], listed in the Bibliography). As the proportion of individuals that have been born during our study increases, the overall accuracy of ages will also improve.

The year of death for whales that have died during the study is given in the schematic family trees for each matriline included in the catalogue. Bodies of whales are seldom recovered following death – the whales simply disappear and are never seen again. Most animals disappear sometime between the last sighting of the group in late summer or fall and the first encounter the following year, which for most pods or matrilines is after April or May. Thus, as with winter births, it is not known whether an animal died late in the previous year or early in the next year. In rare cases with northern resident pods or matrilines, several years may pass between complete encounters, during which individuals may disappear. To be consistent, we have standardized the year of death in this catalogue as the last year in which the individual was seen alive.

Northern Resident Community

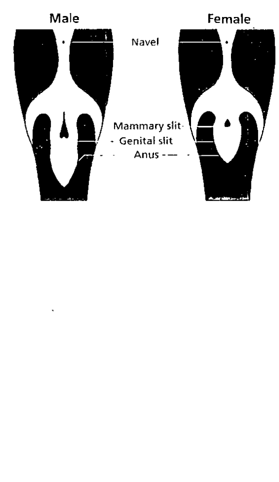
The northern resident community is comprised of three clans A, G, and R, with a total of 16 pods. In 1998, the most recent year with good census coverage, the community was made up of 216 whales. The community has grown by over 60% from an estimated size of 132 whales in 1975.

As mentioned previously, the range of the northern community includes coastal waters from approximately the midpoint of Vancouver Island north to southeastern Alaska. Members of the community are most commonly seen during the months of June through October in the area of western Johnstone Strait and Queen Charlotte Strait, off northeastern Vancouver Island. It is in this region that salmon funnel into narrow channels on their way to spawning rivers, and the whales congregate here to intercept them. Whale researchers also tend to congregate in Johnstone Strait during summer, and, as a result, we know little of the whereabouts of whales outside of this area and season. Even during the peak of whale activity in Johnstone Strait in the summer, it is unusual to have more than 50, and rare to have more than 100, whales present on any given day. In the winter, northern residents turn up in Johnstone Strait periodically, but only in small numbers. Thus, the majority of northern residents are typically located in other parts of their range throughout the year.

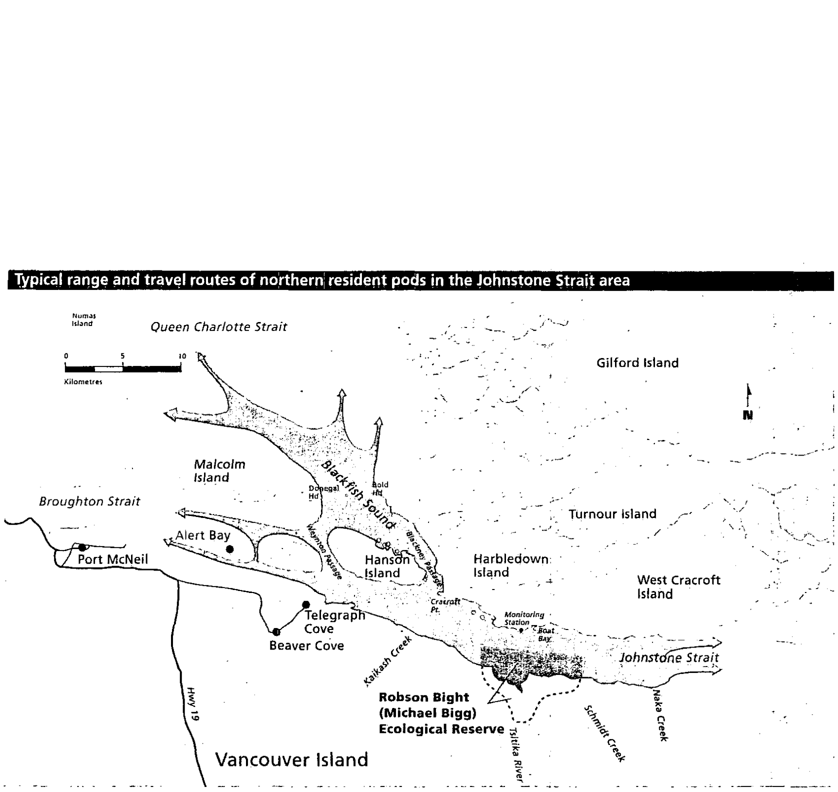
We have observed or received photos of northern residents at many different locations in their range, but in no area are they found as predictably as in Johnstone Strait. Sightings have been made throughout the narrow inside passages of the central and northern British Columbia coast, off the west coast of Vancouver Island, in the middle of Hecate Strait, around the Queen Charlotte Islands, and in the Strait of Georgia. The

Distinguishing Males and Females

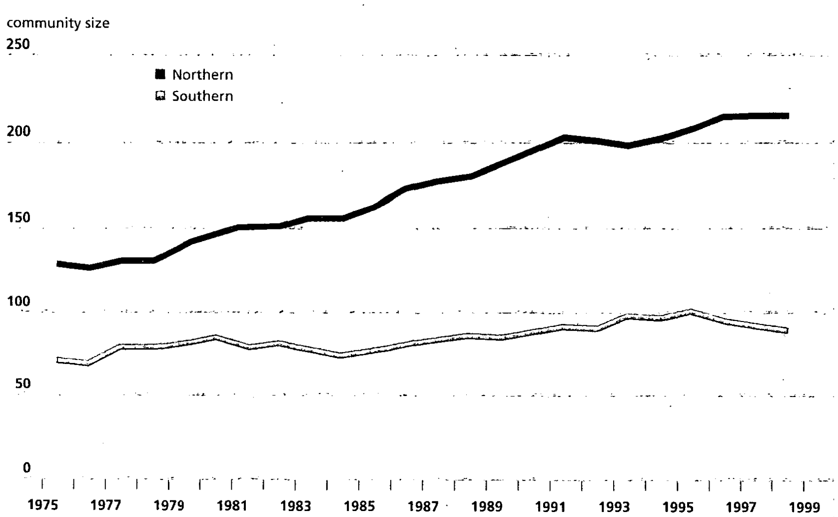
Male and female killer whales can be distinguished by variations in the appearance of the pigmentation in the genital area. Females (upper photo, p. 44) have dark spots marking the two mammary slits, located on either side of the genital slit, which also usually has a dark marking. The genital area is surrounded by a roughly circular or oval white patch. Males (lower photo, p. 44) have a more pronounced dark spot at the genital slit, lack mammary slits, and have a more elongated white patch surrounding the genital slit. Note the long pectoral flippers of the adult male which, together with the large dorsal fin and downward curled tail flukes, are sexual characteristics typical of mature males.



Typical range and travel routes of northern resident pods in the Johnstone Strait area



Size of northern and southern resident communities



range of northern residents includes many thousands of kilometres of inlets, channels, passes, and straits, much of it very remote. Perhaps it is not surprising that we know so little about the year-round distribution patterns of these whales.

Members of each of the three northern resident clans have been observed in most parts of the community range, indicating that there is no clan territoriality. Indeed, all 16 northern resident pods have been observed to travel together at least once, and most on repeated occasions. However, some pods appear to prefer certain portions of the range over others. For example, A1 pod (or one or more of its matrilines) has been recorded in the western Johnstone Strait region on over 1,600 occasions over the past 25 years, but its fellow A-clan member, I18 pod, has been sighted only 35 times in that area. Only with increased study effort in remote parts of the range will we have a clearer picture of distribution patterns at the matriline, pod, or clan level.

The following is a summary of the size and composition of the northern resident clans (as of 1998 census). Further details about pods and matrilines accompany their identification photographs.

A-Clan. The A-clan is comprised of ten pods, A1, A4, A5, B1, C1, D1, H1, I1, I2, and I18, with a total of 108 whales. As with all clans, these pods have dialect similarities, which suggest that they are part of a single ancestral lineage. Within the clan, certain pods are more closely related than others, as shown in the diagram of A-clan dialect similarity (p. 21). Pods A1, A4, and A5 are fairly closely related to one another, and C1 and D1 are also quite closely related. Pods I1, I2, and I18 share essentially the same dialect, although further study may reveal some group-specific features in their sounds.

The A-clan includes the best-known northern resident pods as well as the least-known. Pods A1, A4, A5, and C1 are the most common pods in the Johnstone Strait area, having each been observed many hundreds of times during our study. On the other hand, pods I1 and I18 have been sighted less than 50 times each.

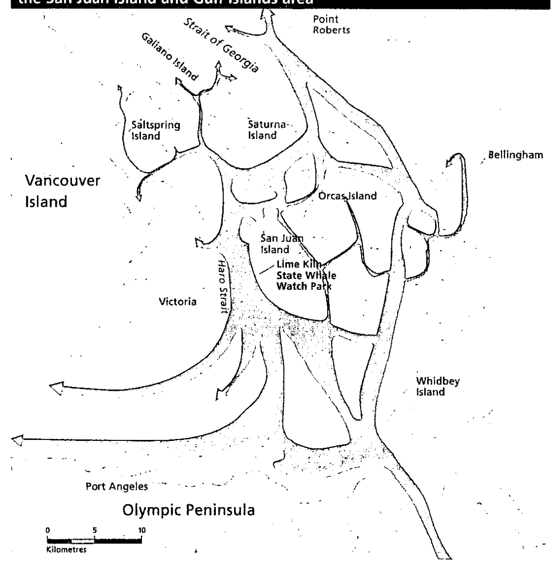
G-Clan. The G-clan contains four pods, G1, G12, I11, and I31, with 76 whales in total. G-clan pods are sighted less frequently than most A-clan pods, but more often than R-clan pods. Pods G1 and G12 formerly were considered to be a single pod but were split into two when it became clear that they spent a significant amount of time apart. Pod G1 is acoustically quite distinct from pods G12, I11, and I31. The latter three pods have very similar dialects and are more difficult to distinguish acoustically. Members of the G-clan are sighted off the west coast of Vancouver Island more often than other northern resident pods. Also, G1 and G12 pods tend to frequent the Johnstone Strait area most often in the late summer and fall.

R-Clan. The R-clan is the smallest clan, containing only 32 members in two pods, R1 and W1. The two have almost identical dialects, although they can be distinguished from subtle differences in call use. Although R-clan pods have been sighted as far south as the Strait of Georgia, there is some evidence that they frequent the northern portions of the community range more often than do other community members.

Southern Resident Community

The southern community is comprised of a single clan, J-clan, which is made up of three pods, J1, K1, and L1. The population totalled 83 at the end of 1999, which is 17% higher than its size of 71 when first censused in 1974. Unlike most northern community pods, all three southern resident pods were cropped during 1967-73 in a live-capture fishery for aquaria. An estimated 47 southern residents, mostly immature whales, were taken during this period, and this probably hindered growth of the population when compared to northern residents. The community reached a peak size of 99 in 1995 and has dropped by 16 members since then. Pod L1, with 46 members, is by far the largest resident pod. Of the three pods, J1 and K1 are more acoustically related to each other than either is to L1 pod. The southern resident pods are seen most regularly during the summer in the protected inshore waters of the Strait of Georgia and Puget Sound, especially in the vicinity of Haro Strait, west of San Juan Island, and off the southern tip of Vancouver Island. Southern residents, especially pods K1 and L1, frequently make excursions out of Juan de Fuca Strait to areas off the west coast of Vancouver Island and Washington. In these areas, they mingle with commercial trollers on the offshore banks to catch salmon headed for the Fraser River. In September and October, all three pods can often be found off the mouth of the Fraser River in the Strait of Georgia, intercepting salmon before they enter the river. During the winter, J1 is the most common pod sighted in inshore waters, while

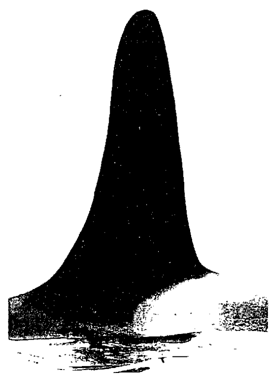
Typical range and travel routes of southern resident pods in the San Juan Island and Gulf Islands area

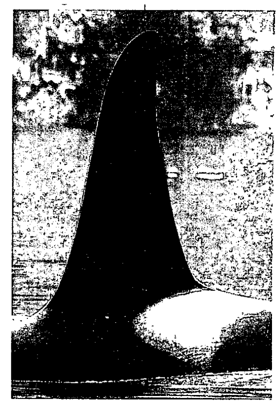


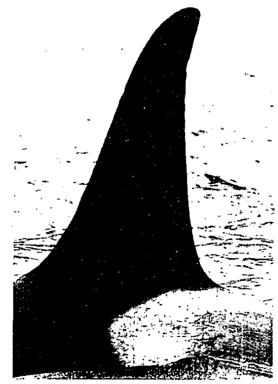
K1 and L1 apparently spend more time in offshore areas. The overall range of these pods in the winter is unknown. The carcass of one southern resident, identified as such by genetic analysis, was found in June 1995 on the west coast of the Queen Charlotte Islands. Whales from K1 and L1 pods were recently encountered by our colleague, Nancy Black, in Monterey Bay, California, on 29 January 2000. This is the first sighting of residents in waters south of Washington.

The known range of the southern residents overlaps with that of the northern residents in the waters off both the west, east, and north coasts of Vancouver Island. For example, both northern and southern residents have been observed in the central Strait of Georgia near Nanaimo, offshore of Barkley Sound on the west coast of Vancouver Island, and in Juan de Fuca Strait. Pods K1 and L1 often enter the Strait of Georgia for the first time in the spring by way of Johnstone Strait, which is the core area of the northern resident community. It is possible that the whales sometimes mix when they are in these overlap areas, but they have never been seen to do so.

A36 Matriline

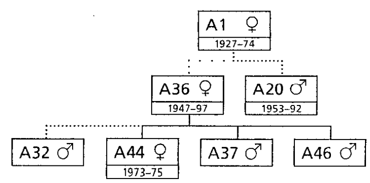






A-Clan

The A36 matriline lost its matriarch, A36, in 1997. It now consists of only three males, and thus will die out in time. Since their mother's death, the three males continue to travel together, either on their own or in the company of other A1 pod matrilines, or other northern community groups. The first known matriarch of this matriline was the female A1, known as "Stubbs" because of her lopped-off dorsal fin (see photo of her on page 42). Identified in 1971, she was the first whale named in this study.

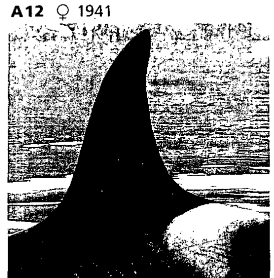


Key

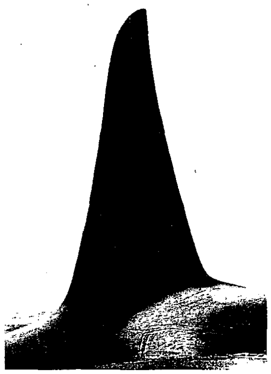
A1 ♀ 1927–74	**Deceased killer whale with estimated or known birth date and date of death**
*	**possibly dead**
c	**live captured**
	Genealogical relationship:
———	**Positive**
·········	**Probable**
· · · · · · ·	**Possible**

A1 Pod
A12 Matriline

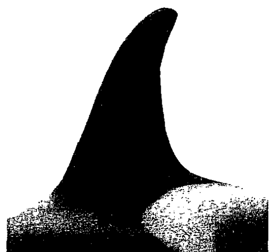
A12 ♀ 1941



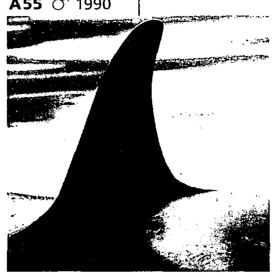
A33 ♂ 1971



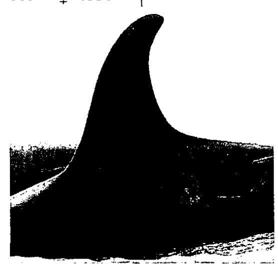
A34 ♀ 1975



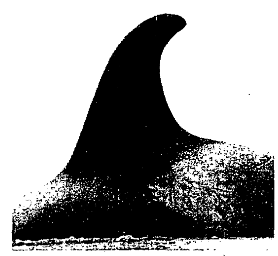
A55 ♂ 1990



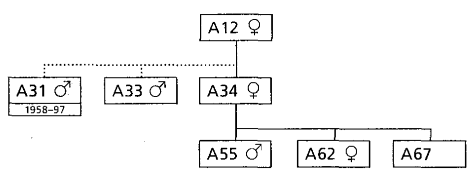
A62 ♀ 1993



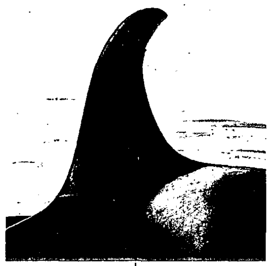
A67 1996



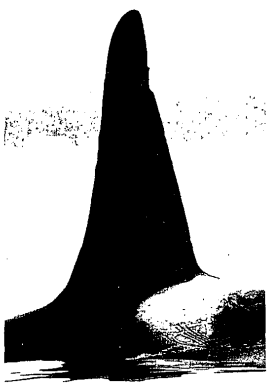
A1 pod was the first group identified in this study. The pod's size has not changed much over the past 26 years – it had 13 members in 1973 and 16 in 1999. However, its three matrilines have steadily been spending increasing time apart over the course of the study. In the 1970s, all three matrilines were together in about 63% of encounters with A1 groups. This dropped to 32% of encounters in the 1980s and 14% of encounters in the 1990s. Although the three matrilines are now usually not seen together, each still tends to travel more with fellow A1 matrilines than any other northern resident group.



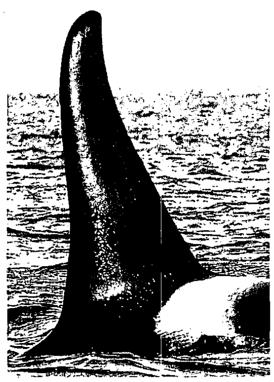
A30 Matriline



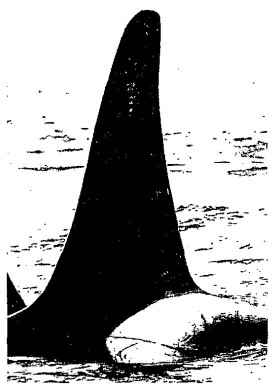
A6 ♂ 1964 *



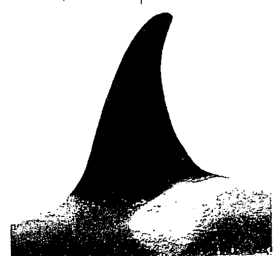
A38 ♂ 1970



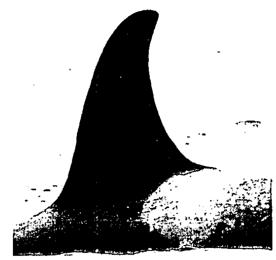
A39 ♂ 1975



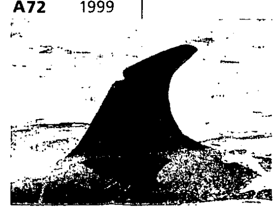
A50 ♀ 1984



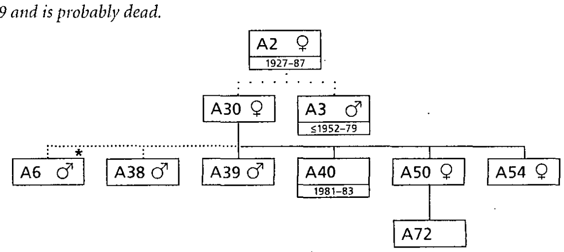
A54 ♀ 1989



A72 1999

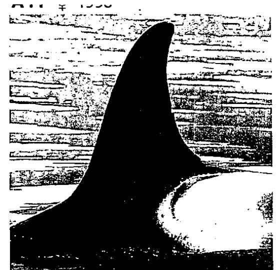


The A30 matriline is the most commonly encountered matriline in the northern resident community, mostly due to its preference for the western Johnstone Strait region. It was present in over 60% of all resident killer whale encounters in this area. Until her death in 1987, the matriarch of the matriline was the well-known whale A2, or "Nicola." The male A6 was missing after August 1999 and is probably dead.



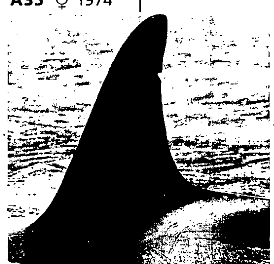
A11 Matriline

A4 pod once travelled as one group with a single matriarch, A10, who died in 1983, along with her young calf A47, after being shot at the rubbing beaches in the Robson Bight (Michael Bigg) Ecological Reserve. Starting in 1986, the pod began splitting into two matrilines, A11 and A24. These two groups still spend the majority of their time together. For the first time in 1999, we observed the A11-A35 matriline travelling well apart from the rest of the A11 matriline.

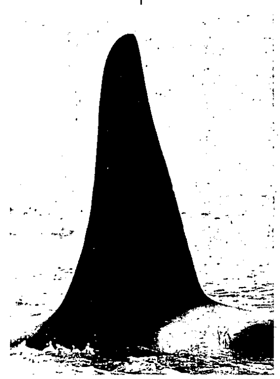


The dialects of A11 and A24 matrilines cannot easily be distinguished from each other. They are acoustically more closely related to A5 pod than to A1 pod.

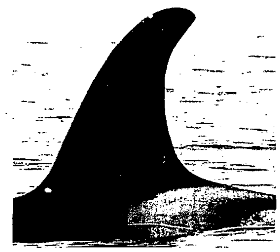
A35 ♀ 1974



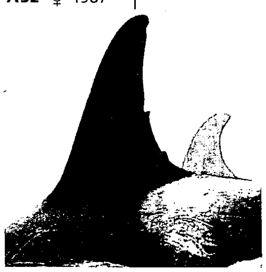
A13 ♂ 1978



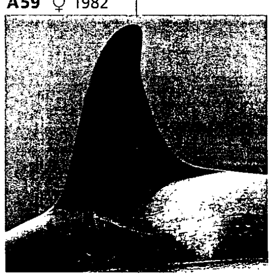
A56 ♀ 1990



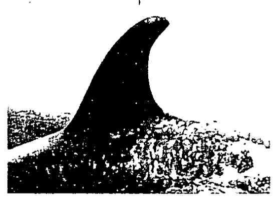
A52 ♀ 1987

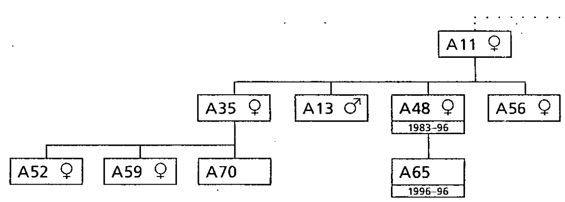


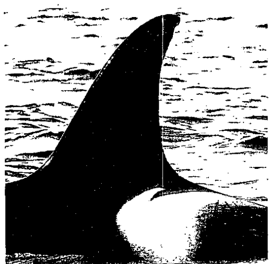
A59 ♀ 1982



A70 1999

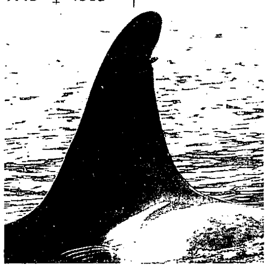




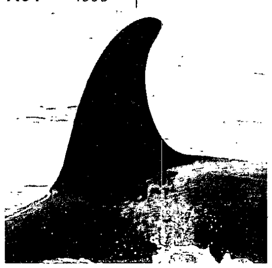


A24 Matriline

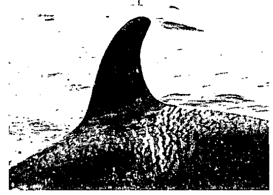
A45 ♀ 1983



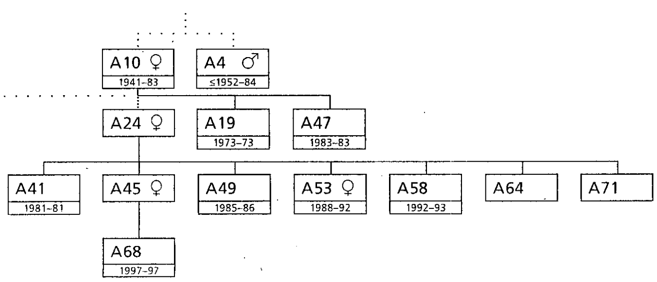
A64 1995



A71 1999



The A24 matriline has had many young whales die. Two of A24's siblings died as calves, as did four of her own offspring. A71, first sighted in June 1999, is A24's seventh known calf.



A-Clan

The growing interest in whales has led to increasing numbers of people wanting to view them in the wild. As numbers of whale watchers grow so too do concerns about the potential negative effects of vessel disturbance and boats.

Whale watching from one's own boat is unlikely to cause significant disturbance if the guidelines given in "How to Behave around Killer Whales" (see sidebar, p. 57) are followed. However, as vessel congestion continues to increase in popular whale-watching areas, such as Johnstone and Haro Straits, joining an established whale-watching tour is a better option for both people and whales. Operators of accredited tours are careful to follow industry standards and government regulations to avoid disturbing the whales. Also, the large vessels used by many operators have the advantage of carrying many passengers, which is preferable to having a few whale watchers on many small boats. Most tours have onboard naturalists to explain killer whale biology and conservation. They also carry hydrophones for listening underwater and provide good opportunities for taking photographs.

There are now many tour operators offering whale-watching excursions in both British Columbia and Washington. Most operate only during the months of May through September, when resident whales can be found reliably. Full- or half-day excursions are the most popular, although some companies offer longer trips of a week or more.

We recommend that whale watchers in the southern Vancouver Island area or Washington choose a tour operator belonging to the Whale Watch Operators Association Northwest. This association has in recent years worked closely with whale researchers and government regulators to develop a code of conduct to minimize disturbance to killer whales. For additional information, and for a listing of member companies, see their website at www.nwwhalewatchers.org. For other information on whale-watching tours, contact:

In British Columbia:

Tourism BC
1-800-663-6000
www.hellobc.com

Travel BC
www.travel.bc.ca

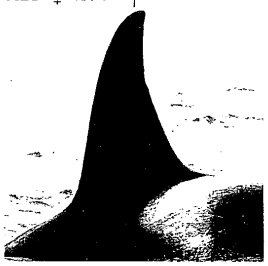
Tourism Vancouver Island
www.islands.bc.ca

In Washington:

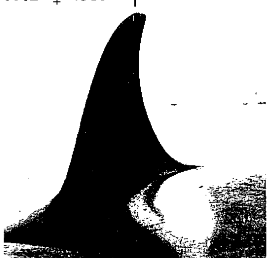
Washington State Tourism
1-800-544-1800
www.tourism.wa.gov

A8 Matriline

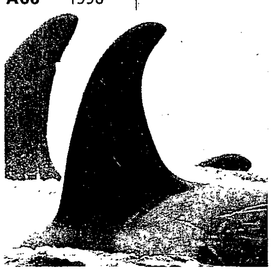
A28 ♀ 1974



A42 ♀ 1980



A66 1996

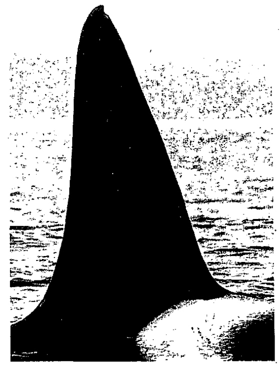


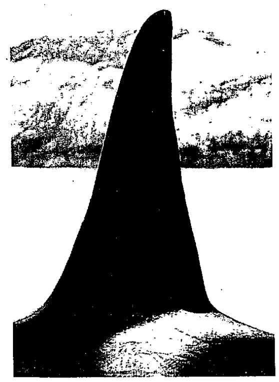
A28 is one of the few females in the resident population that has been sexually mature for many years but has never been seen with a calf.

A42's first offspring, A57, was found alone and very ill on the morning of 16 December 1996 in a bay south of Powell River, BC. She died later that day. Necropsy results indicated that she died of erysipelas, a bacterial infection.

A9 Matriline

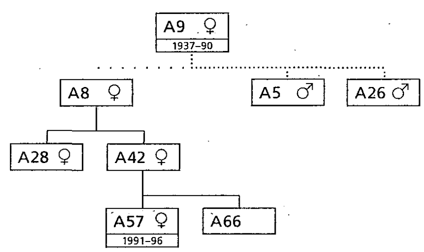
A5 pod is one of the few northern resident pods that makes occasional forays into the northern Strait of Georgia. It was captured there twice, in 1968 and 1969, and a total of 12 whales were taken into captivity. One of these is still alive in a US oceanarium. The pod was only three members larger in 1999 than when first censused in 1973.





The A9 matriline began spending time away from the rest of the pod in the mid-1980s, when A26 became mature. The matriarch, A9, died in late November 1990, and her body was recovered shortly thereafter from a beach in the Johnstone Strait area. Her stomach contained 5 litres of fish bones, representing 13 different species. Most common were salmon and lingcod, but also present were remains of various species of sole, flounder, greenlings, sculpins and sablefish.

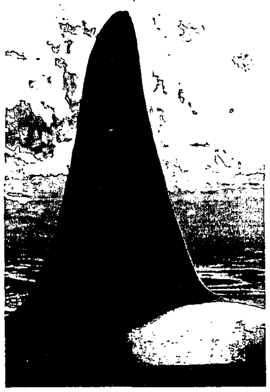
As the A9 matriline contains only males, in time it will die out. Following their mother's death, A5 and A26 spent considerable time apart from other groups. When not alone, they travel most consistently with the A8 matriline.



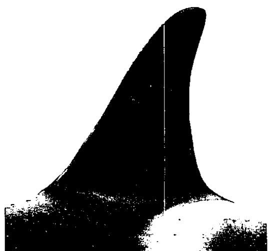
A23 Matriline

A23 is probably the mother of A16, also known as "Corky," who was captured at Pender Harbour in 1969 and presently lives at Sea World, San Diego.

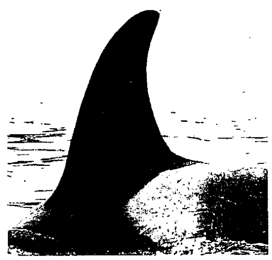
A27 ♂ 1971



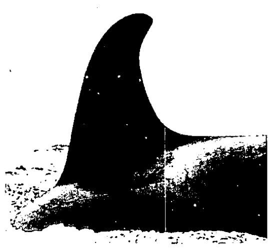
A43 ♀ 1981



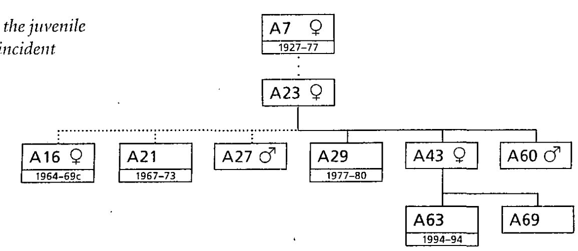
A60 ♂ 1992



A69 1996



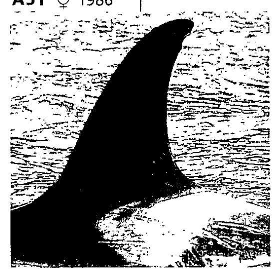
The whale A21 may be the juvenile struck by a ferry in an incident described on page 66.



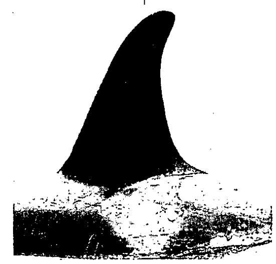
A25 Matriline

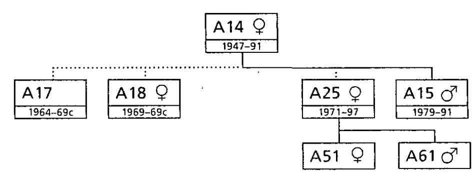
An early matriarch of this matriline was A14, also known as "Saddle" because of her distinctively pigmented saddle patch. Her only surviving offspring was A25, called "Sharky" because of the distinctive shape of her dorsal fin. Two of A25's siblings were taken into captivity in 1969, and another, A15, vanished at the same time as their mother. A25 died as a young mother in 1997.

A51 ♀ 1986

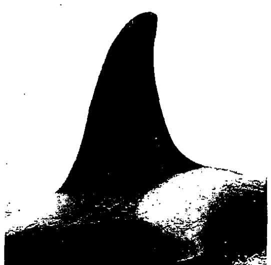


A61 ♂ 1994

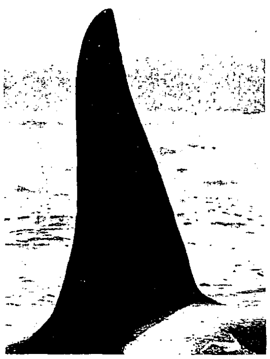




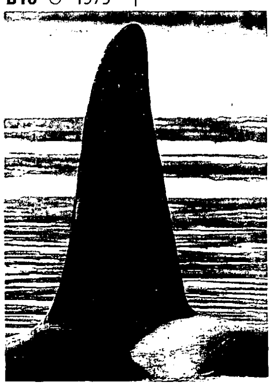
B7 Matriline



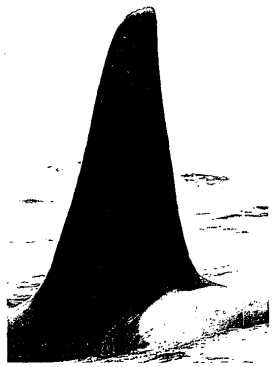
B8 ♂ 1964



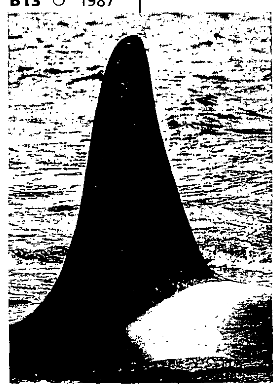
B10 ♂ 1979



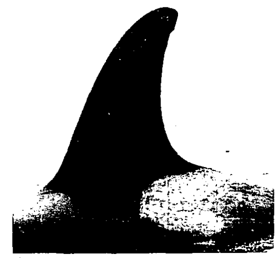
B12 ♂ 1984



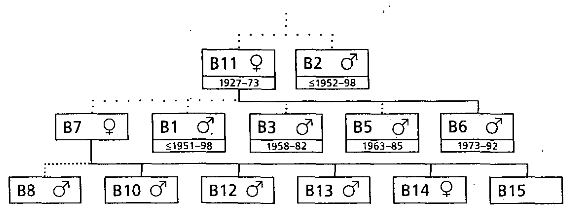
B13 ♂ 1987



B14 ♀ 1991



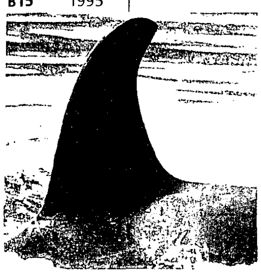
B1 pod was long known for its unusually high number of males. Although two old males, B1 and B2, died in 1998, the pod is still comprised mostly of males. The pod travels alone more than any other northern resident group, perhaps due to its preponderance of males.



When a boater encounters killer whales, either intentionally or by chance, the question immediately arises: How can I get the best view of them? More and more, people are also asking: How can I get a good view without disturbing the whales?

Killer whales tend to travel in a particular direction, usually at a speed of 2-4 knots, and are likely to continue to do so if undisturbed. The dive pattern of residents usually consists of a long dive of 3-4 minutes, followed by several short dives of about 15 seconds each. A pod may travel in a tightly packed group for a while and then disperse into small groups over a wider area, usually to forage. Transient whales tend to dive longer and to be more unpredictable than residents. For more detailed guidelines on watching transient whales, see the book *Transients*, listed in the Bibliography.

B15 1995



The following guidelines allow boaters to view whales in the least obtrusive way:

1 From a distance, determine the travel direction and diving sequence of the whales.
2 Approach whales from the side, not from the front or the rear. Approach and depart slowly, avoiding sudden changes in speed or direction. Do not "leapfrog." Accelerating or fast-moving boats create considerable underwater noise.
3 Maintain low speeds and constant direction if travelling parallel to whales. When whales are travelling close to shore, avoid crowding them near shore or coming between the whales and shore. Avoid disturbing groups of resting whales.
4 Approach no closer than 100 metres and idle along at the speed of the whales, or shift your motor into neutral. Keep noise levels down – no horns, whistles, or racing motors. Start your motor only after the whales are more than 150 metres from your vessel. Leave the area slowly, gradually accelerating when more than 300 metres from the whales.
5 Limit the time spent with any group of whales to less than 30 minutes at a time when within 100 to 200 metres of the whales.
6 Be considerate of other whale watchers so that all have a chance to view without disturbance. If several boats are following one group of whales, check the surrounding areas with binoculars to see if other groups are nearby. If possible, decrease boat congestion by following an unwatched group.
7 If a group of whales changes direction repeatedly or changes behaviours quickly (e.g., from slow travelling to fast travelling), these are signs of possible disturbance and the group should be left alone.
8 Aircraft should maintain an altitude of 1,000 feet or more above whales. Float planes should refrain from landing in the vicinity of whales.

Robson Bight is located on the typical foraging route of resident whales in Johnstone Strait and is the site of several beaches that are frequently used by these whales for rubbing (see map, p. 46). The Robson Bight (Michael Bigg) Ecological Reserve was established in 1982 by BC Parks as a sanctuary for killer whales and to protect these important rubbing beaches. It includes 1,248 hectares of marine area and 505 hectares of upland buffer zone.

Ecological reserves are intended for conservation, research, and educational purposes, and are not intended for recreation. At Robson Bight, a number of restrictions are currently in place to better protect the area, and further restrictions may be applied as required. The area is monitored daily during summer months by wardens who can provide detailed information to boaters. The key restrictions are as follows:

1 Land access is now restricted in the ecological reserve and the landing of vessels is prohibited.
2 Recreational activities, such as whale watching, should not take place in the reserve. Boats requiring sheltered waters, such as canoes and kayaks, should cross over to West Cracroft Island, where there are good anchorages and camping is permitted.
3 Commercial fishing activity in the reserve is currently under review.
4 As with all ecological reserves, camping, campfires, and discharge of firearms are prohibited.

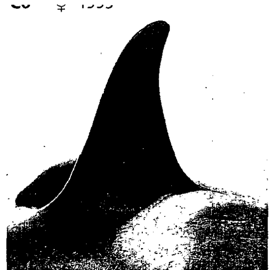
Regulations and Licensing

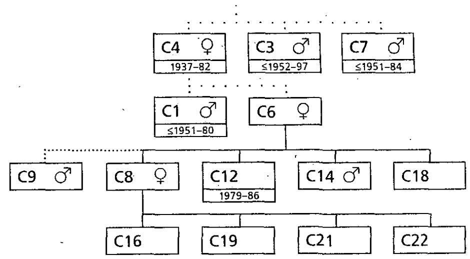
In Canada, the Department of Fisheries and Oceans is responsible for the management and protection of marine mammals, including killer whales. In the United States, the responsible agency is the National Marine Fisheries Service. In both countries, regulations specifically prohibit disturbance of whales. Infractions are subject to fines and/or imprisonment.

Activities such as research or commercial photography may require a licence or permit to approach whales. Individuals wishing to carry out such activities should contact the Department of Fisheries and Oceans in Canada, or the National Marine Fisheries Service in the US, to ensure that their proposed activity is permissible and to determine whether or not they will require a scientific permit. For research activities that may require entry of the Robson Bight (Michael Bigg) Ecological Reserve, researchers must contact BC Parks.

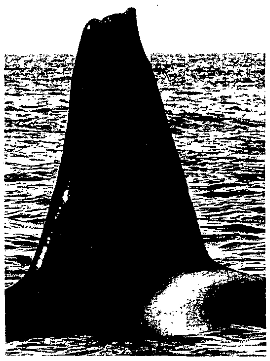
C6 Matriline

The C10 and C6 matrilines share a dialect that is very similar to that of D1 pod. The two matrilines are mostly encountered separately – in only about 20% of encounters in the 1990s were the two groups together.

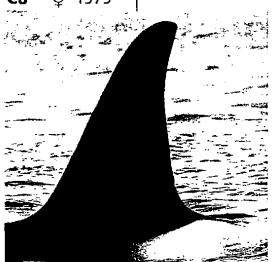




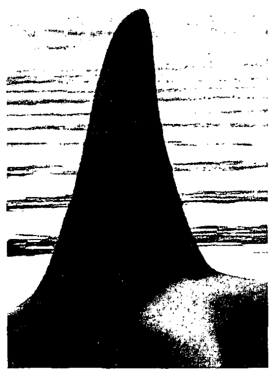
C9 ♂ 1971



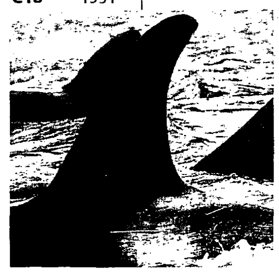
C8 ♀ 1975



C14 ♂ 1985

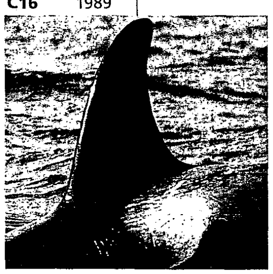


C18 1991

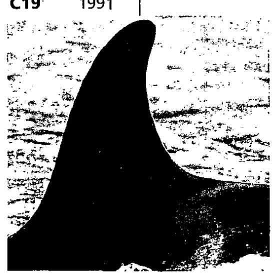


The dorsal fin of the male C9 sustained a major injury in 1993. Likely caused by a bite from another killer whale, or possibly a gun shot, this kind of injury can take many years to heal, during which time the fin may continue to crumple and collapse. C9 can be confused with H4 (p. 62), G11 (p. 70), or G33 (p. 73).

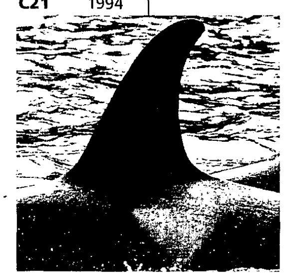
C16 1989



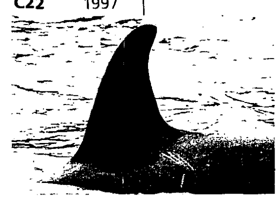
C19 1991



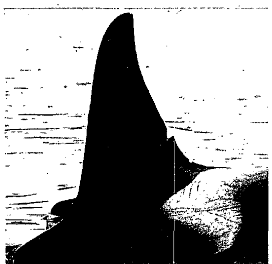
C21 1994



C22 1997



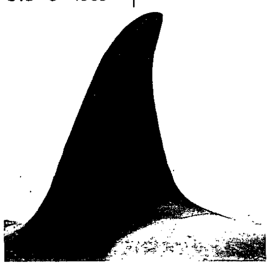
C10 Matriline



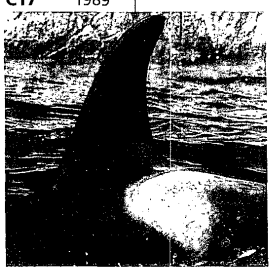
The former matriarch of this matriline, C5, was most likely the mother of C11, widely known as the whale "Namu." This male was captured near the town of Namu on the central BC coast in 1965 and transported to Seattle in a floating pen. "Namu" became known around the world through magazine articles, books, and a movie.

A-Clan

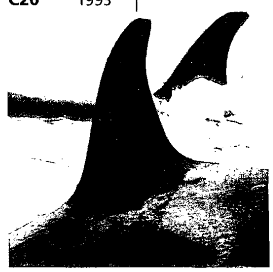
C13 ♂ 1985



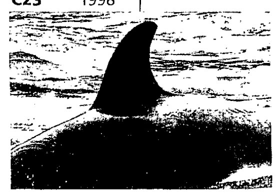
C17 1989

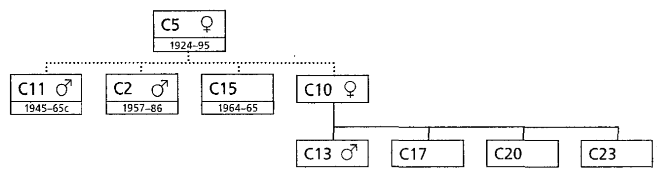


C20 1993

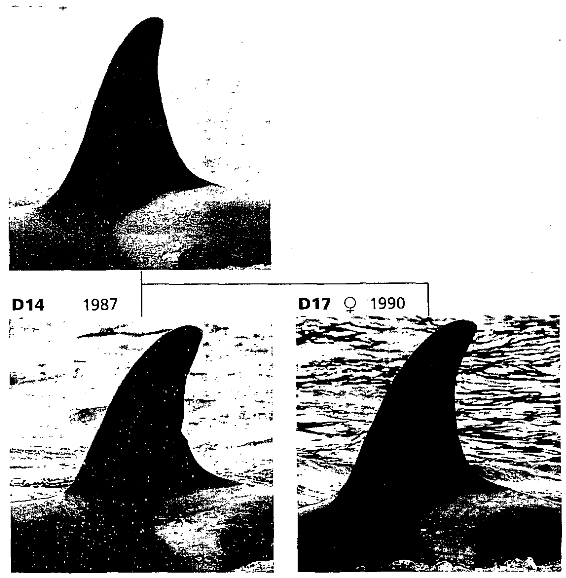


C23 1998

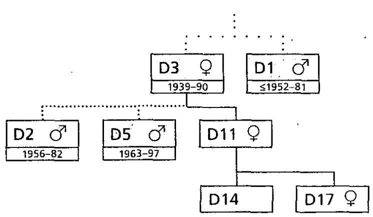




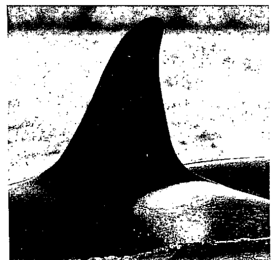
D11 Matriline



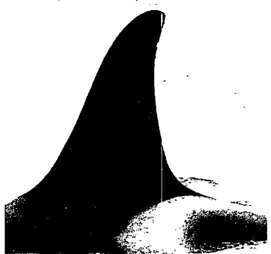
D1 pod was once quite common in Johnstone Strait but only occasionally visited this area during the 1990s. The two matrilines, D11 and D7, typically travel together (in about 80% of encounters). The last complete census of this pod was in 1998.



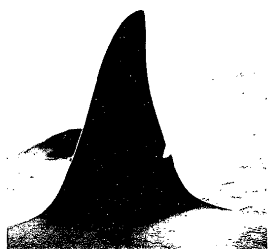
D7 Matriline



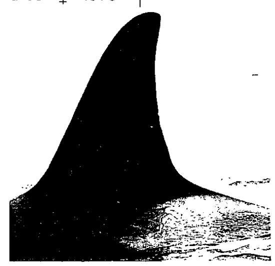
D8 ♀ 1967



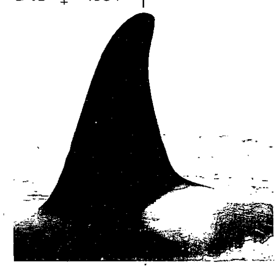
D9 ♀ 1971



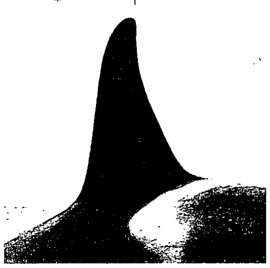
D10 ♀ 1978



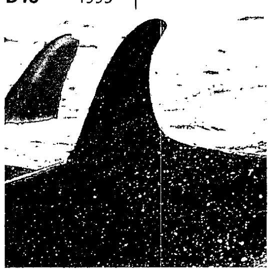
D13 ♀ 1984



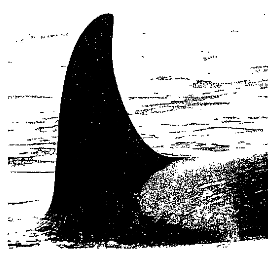
D12 ♀ 1982



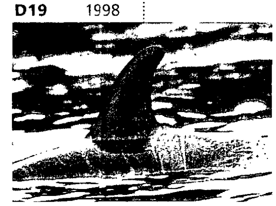
D18 1995



D15 1987

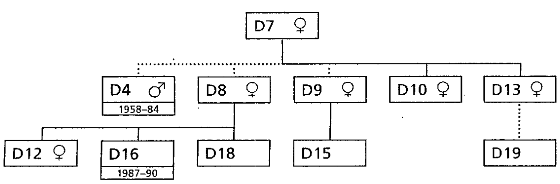


D19 1998



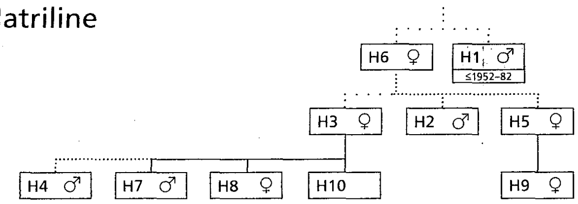
D10 has a small hole through her dorsal fin, apparently caused by a bullet.

D9 can be easily confused with the female C10 (p. 59), as they have very similar dorsal-fin nicks, although their saddle-patch shapes are quite different. In an encounter in July 1998, D13, previously thought to be a male, was seen accompanied by a very young calf, D19. D1 pod has not been seen since then to confirm this relationship and apparent sex change, but we consider it most probable.



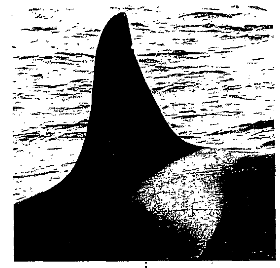
A-Clan

H6 Matriline

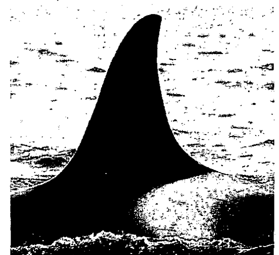


H1 pod once travelled as a cohesive group, but this appears to have changed. Recently, H3 and her offspring have been seen on a number of occasions, whereas since 1993 only H5, from the other half of the pod, has been accounted for in a couple of incomplete encounters.

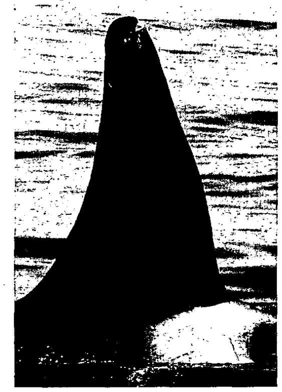
H1 pod has a very distinctive dialect that is related to those of B1, I1, I2, and I18 pods.



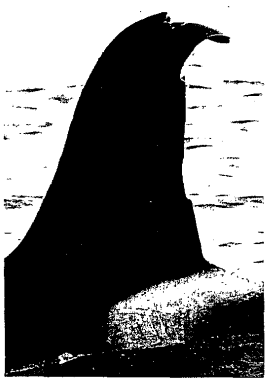
H3 ♀ 1959



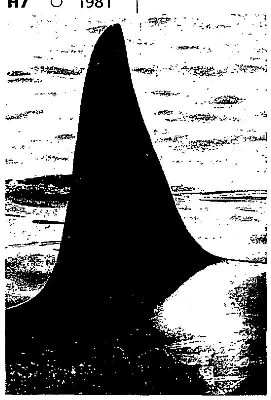
H2 ♂ 1965



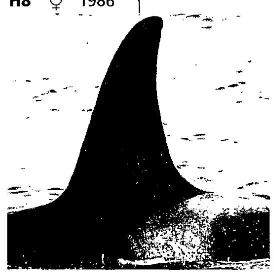
H4 ♂ 1974



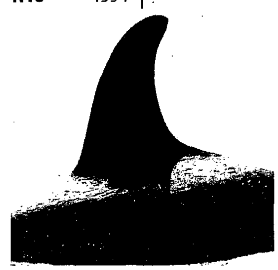
H7 ♂ 1981



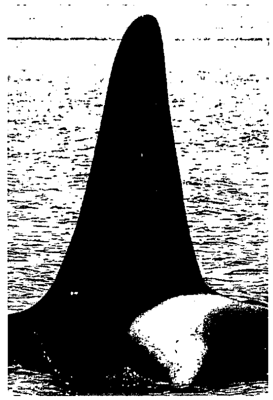
H8 ♀ 1986

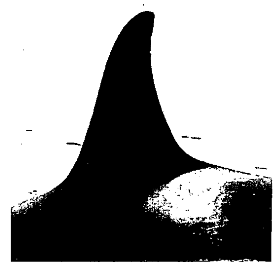


H10 1994

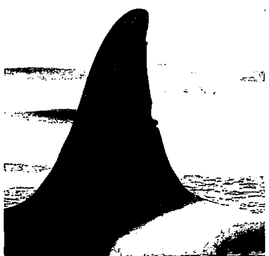


I1 Matriline



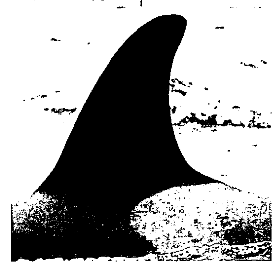


H5 ♀ 1973

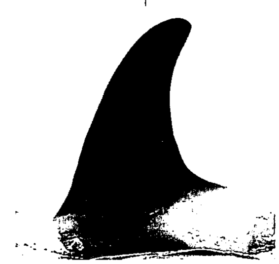


I54 ♀ 1983

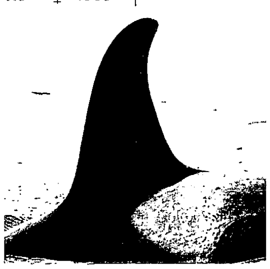
I69 1991



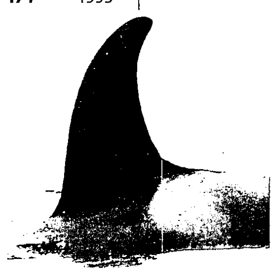
I82 1994



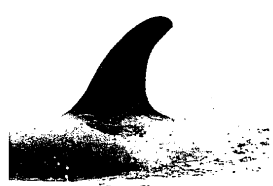
H9 ♀ 1988

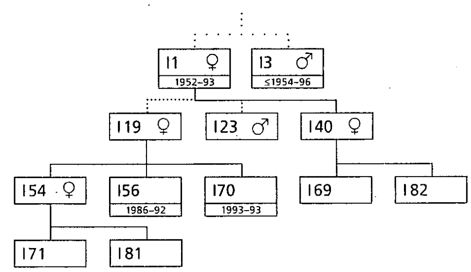


I71 1993



I81 1997





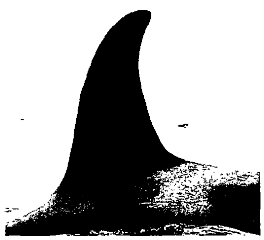
I1 pod is one of the least commonly encountered northern resident groups, having been seen only 33 times in 25 years. It appears to spend more time off northern and western Vancouver Island and along the north coast of BC than in the more frequently surveyed waters of Johnstone Strait.

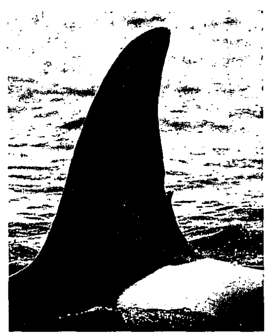
The matriarch, I1, died in 1993, but in keeping with matriline naming protocol, her name is retained because she still has surviving offspring of both sexes.

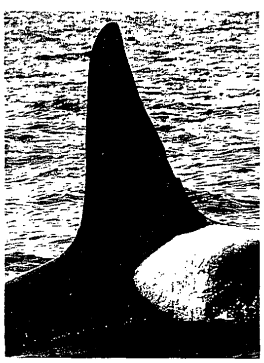
Although a photograph can provide a reliable identification of a whale, the appearance of an individual's dorsal fin can change dramatically over the years. As a whale grows, the shape and size of its fin changes, especially in males, whose adult fin height can be ten times its height at birth. Over time, dorsal fins also acquire new nicks, tears, and gouges, and saddle patches often receive new scars from teeth rakes and other natural causes. It is for this reason that we photograph whales at regular intervals, ideally every year, so that such changes can be catalogued. This is especially important over the first few years of a whale's life, because a juvenile's fin and saddle can change quickly from being non-descript to distinctively marked.

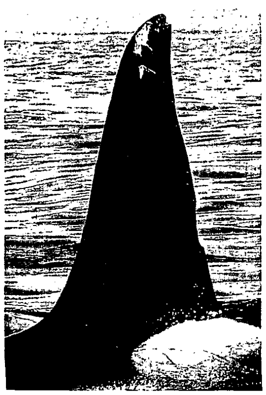
The changes in the fin and saddle of some whales are far more prominent than in others. The whale H4 is a good example of an individual whose appearance has changed significantly over its life. Shown here is a series of identification photographs spanning H4's growth from calf to mature male.

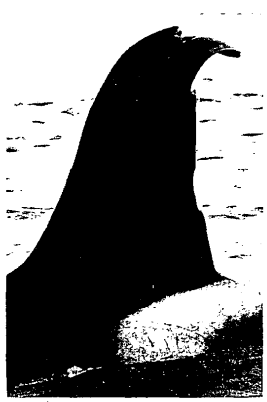

July 1975


July 1980

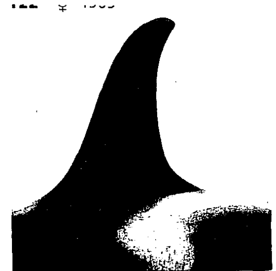

July 1985


August 1986

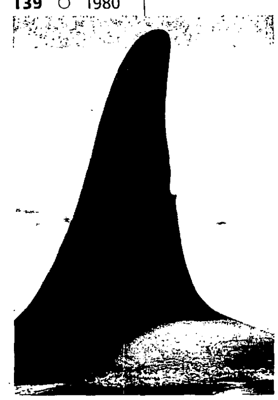

August 1993


August 1998

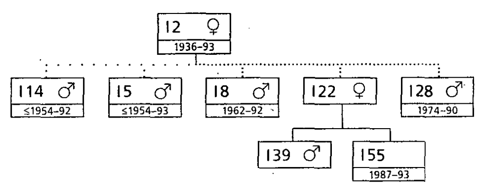
I22 Matriline



I39 ♂ 1980

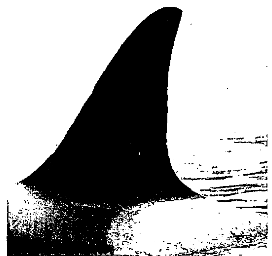


I2 pod is now down to two individuals, from a peak of seven in the early 1990s. The pair is seldom sighted and prefers to travel with equally uncommon pods I1 and I18.



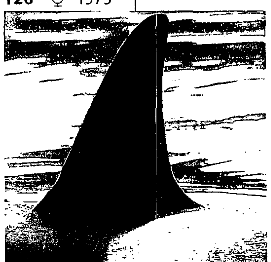
I18 pod contains two of the least-known matrilines in the northern resident community. The two matrilines, I17 and I18, have been encountered only 48 times over the 25-year-long study. They were together on about one-third of these encounters. It is a burgeoning group, however, increasing from 5 whales in 1975 to an estimated 17 in 1999 (a more precise count awaits a good and complete encounter in the future). Acoustically, I18 pod is very closely related to I1 and I2 pods.

I17 Matriline

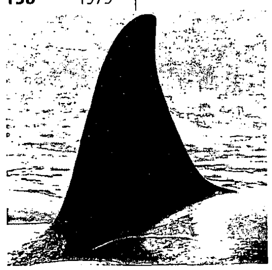


I17 matriline has been partially accounted for a few times in recent years but unfortunately not in enough detail to confirm the relationship of new calves and juveniles. It appears that since the group was last well documented in the early 1990s, they have produced approximately 4 new calves.

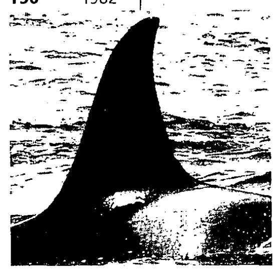
I26 ♀ 1975



I38 1979

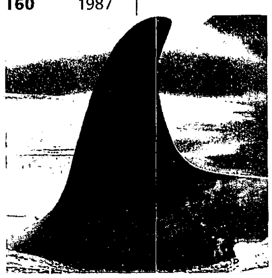


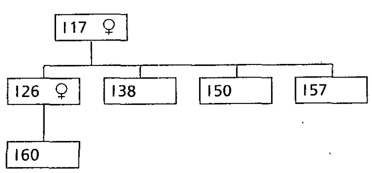
I50 1982



I57 1989

I60 1987





Killer whales are clearly very accustomed to swimming close to power boats and ships without striking and injuring themselves on the vessels' propellers. But collisions sometimes take place and may cause serious injury or death. Two whales, the northern residents A1 and A9, were both apparently injured in this way, but survived. The wounds on these old females – both of whom are now dead – were fully healed at the start of our study in the early 1970s. The whale A1 was known as "Stubbs" because all that remained of her dorsal fin was a ragged stump about half the normal height (see photo, p. 42). The other female, A9, the matriarch of A5 pod, had major pieces of flesh missing from her dorsal ridge between her dorsal fin and tail flukes. Although healed, the wounds extended almost to the backbone in several places.

One often wonders how whales can survive such major physical trauma. It is very likely that without the strong drive of these animals to aid distressed companions, most would die. The following is an account of a collision between a ship and a killer whale that demonstrates the persistence of the whales in helping one of their pod mates. It is drawn from a letter written by Captain D. Manuel of the M/V *Comox Queen*, a ship that is part of the BC Ferries fleet. The ship was en route from Comox to Powell River on 26 December 1973, when it encountered killer whales:

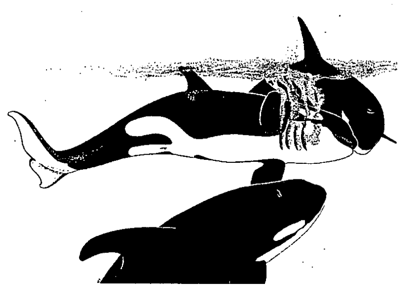
The Quartermaster and I were discussing some subject or other and watching for drift. There was quite a lot of it around, due to the high tides at that time.

At 3:45 there was a crunch at the after end of the ship, as if we had struck a small log. I went and looked out the window at the back of the wheelhouse and noticed a reddish-brown discolouration in our wake. My first impression was that we had struck a butt-end of a dead-head just below the surface of the water. Then four killer whales surfaced about two to three ship lengths astern.

The first thing I noticed about these four surfacing whales was that one was bleeding profusely. I told the Quartermaster to bring the ship hard around and we steamed up to within ten feet of the whales. The pod consisted of a bull, cow and two calves. It was one of the calves that had been struck by the ship's propellers. It was a very sad scene to see. The cow and the bull cradled the injured calf between them to prevent it from turning upside-down. Occasionally the bull would lose its position and the calf would roll over on its side. When this occurred the slashes caused by our propeller were quite visible. The bull, when this happened, would make a tight circle, submerge, and rise slowly beside the calf, righting it, and then proceed with the diving and surfacing. While this was going on the other calf stayed right behind the injured one.

We stayed with the whales for about ten to fifteen minutes; there was no fear of the ship being too close (about ten feet at times). I felt at the time that there was very little we could do to alleviate the obvious pain and suffering that was taking place and that the calf could not survive for too long.

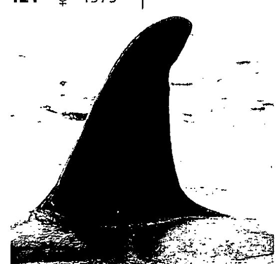
It appears that the young whale did live for at least fifteen days. We later received a report from a resident of Powell River, who, on 10 January 1974, observed "two whales supporting a third one, preventing it from turning over." We do not know whether the whale survived after this, as we received no further sightings or photographs from which we could identify the individual. We suspect, however, that it might have been a young A5-pod whale identified as A21, which was last seen in 1973. Serious injuries from collisions with vessels are probably rare events, as none have been observed among the known whales in British Columbia and Washington during the past twenty years.



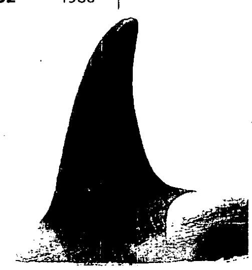
Greg Davies

I18 Matriline

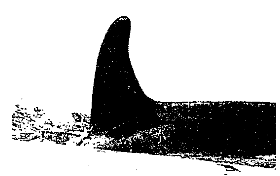
I21 ♀ 1979

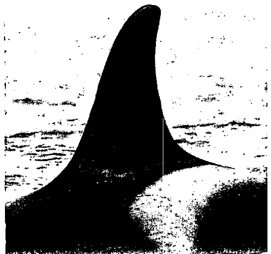


I52 1986

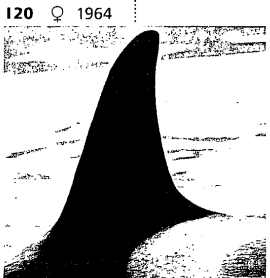


I84 1996

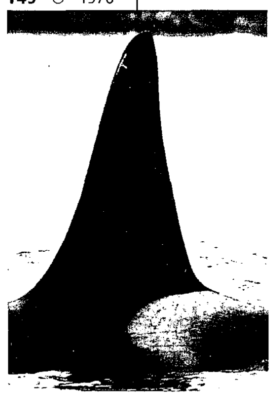




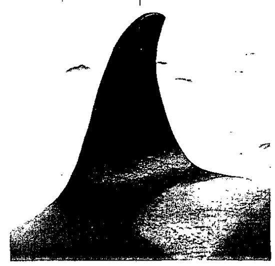
I20 ♀ 1964



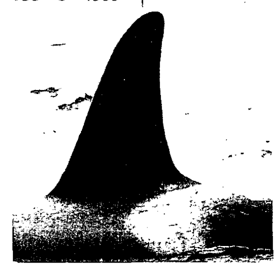
I49 ♂ 1976



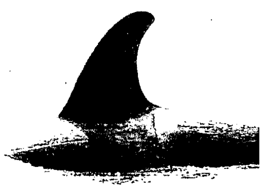
I24 ♀ 1980



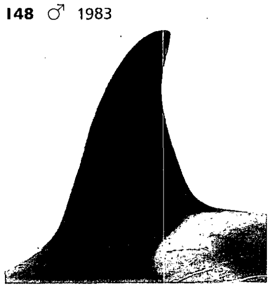
I53 ♂ 1986

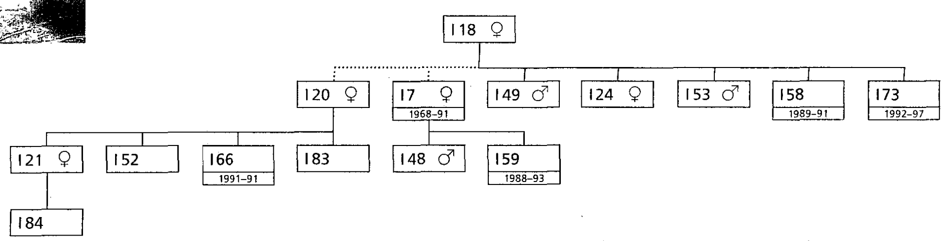


I83 1997



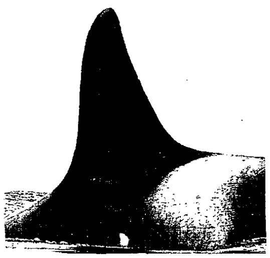
I48 ♂ 1983

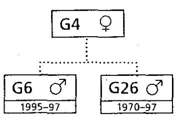




G1 Pod
G4 Matriline

G4 ♀ 1948



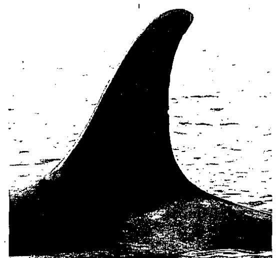


The matriarch G4 lost her two sons, G6 and G26, in 1997, and now, as the sole member of her matriline, has mostly been seen travelling with G17 matriline.

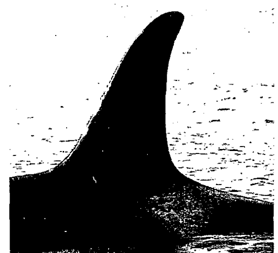
G1 Pod
G3 Matriline

With 29 members, G1 pod rivals R1 pod as the largest northern resident pod. It frequently splits into smaller units, comprising five matrilines.

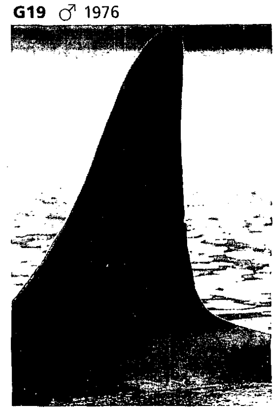
G3 ♀ 1956



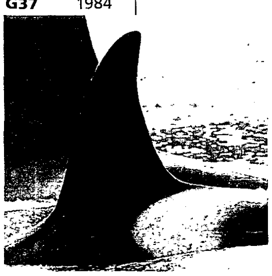
G20 ♀ 1972



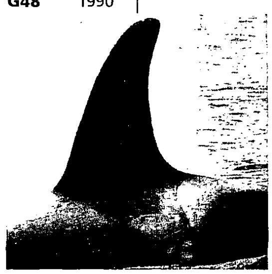
G19 ♂ 1976



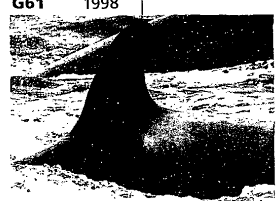
G37 1984

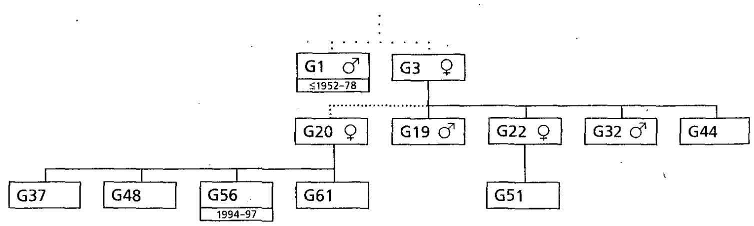


G48 1990



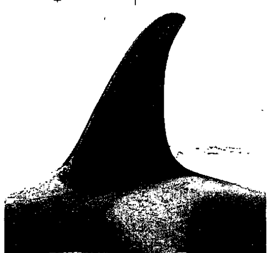
G61 1998



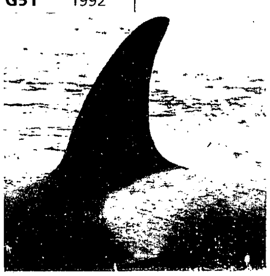


The G-clan contains some of the most rapidly growing resident pods. The clan has doubled in size over 23 years, from 32 whales in 1975 to 75 in 1998. Although members of all three northern resident clans have been observed off the west coast of Vancouver Island, G-clan groups are seen in this area most often.

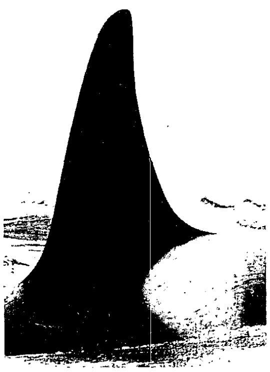
G22 ♀ 1979



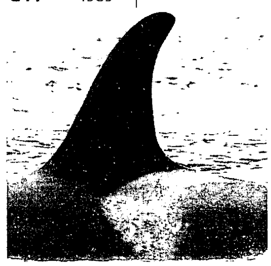
G51 1992



G32 ♂ 1982



G44 1989



Key

A1 ♀ 1927–74 — Deceased killer whale with estimated or known birth date and date of death

* possibly dead

c live captured

Genealogical relationship:

——— Positive

········ Probable

· · · · · · Possible

Although killer whales are found in all the world's oceans, only a single species, *Orcinus orca*, is recognized. Over the past two centuries, a number of different taxonomic forms of killer whale have been proposed, some with interesting names, such as *Orca gladiator*, but these have not been accepted in the scientific community. Recently, Russian biologists suggested that a new species, which they named *Orcinus glacialis*, existed in Antarctic seas. This proposed species was characterized as having a smaller size and a variety of differences in diet, reproduction, appearance, and behaviour, but this classification, too, has not met with general acceptance. More likely, such variations represent racial differences, such as those seen locally between residents and transients.

Orcinus orca is the largest member of the Family Delphinidae, which includes all the world's marine dolphins. For this reason, its common name might be more appropriately the "killer dolphin," but its large size has led to it being called a whale. The distinction between "dolphin" and "whale" is not a scientific one, but relates mostly to relative size, much like the distinction between "boat" and "ship."

Because the species has such a cosmopolitan distribution, it has many common names in different parts of the globe. In some Native cultures, it is known as:

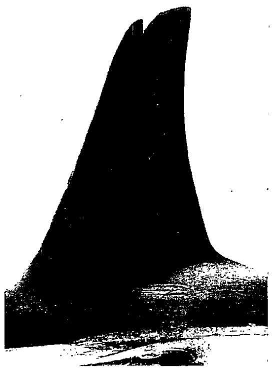
max'inux (northern Vancouver Island Kwakiutl)
ska-ana (Haida of the Queen Charlotte Islands)
arluq (eastern Arctic Inuit)
dukulad (Ainos of the Kuril Islands)
shamanaj (Yahgan of Tierra del Fuego, South America)

In other languages, it is called:

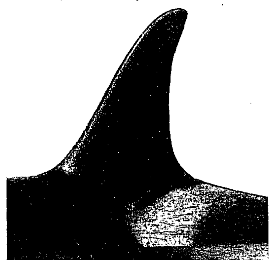
épaulard (French)
hahyrningur (Icelandic)
shachi (Japanese)
kasatka (Russian)
schwertwal or *mörderwal* (German)
spekkhugger (Norwegian)

Many of these common names refer to the killer whale's deserved – but sometimes exaggerated – reputation as the top predator in the sea, and reflect fear or respect. Even the widely used *orca*, has sinister connotations, as it is derived from the species' scientific name, which uses the Latin word *orcinus*, meaning "of or belonging to the kingdom of the dead." For many years, the species was called *blackfish* by coastal mariners and fishermen in BC, despite the fact that they are black and white. Within the English-speaking scientific community, "killer whale" is the common name used most often today.

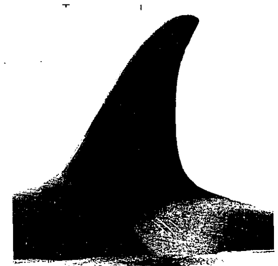
G18 Matriline



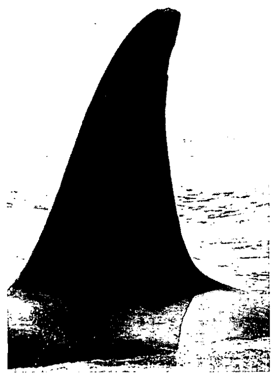
The male G11 can be easily confused with other males having similar fin wounds, especially C9 (p. 58), H4 (p. 62), and G33 (p. 73).



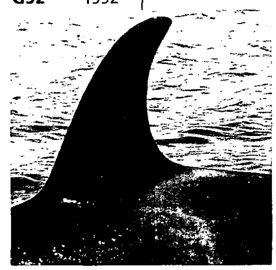
G16 has not been seen for several years, but encounters with her pod have been rather poor. We consider her missing and possibly dead.



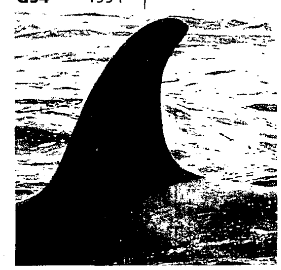
G39 ♂ 1986

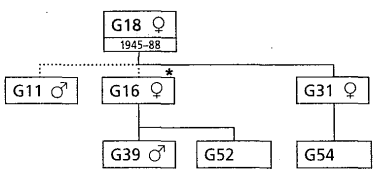


G52 1992



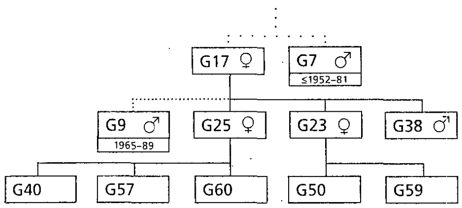
G54 1994

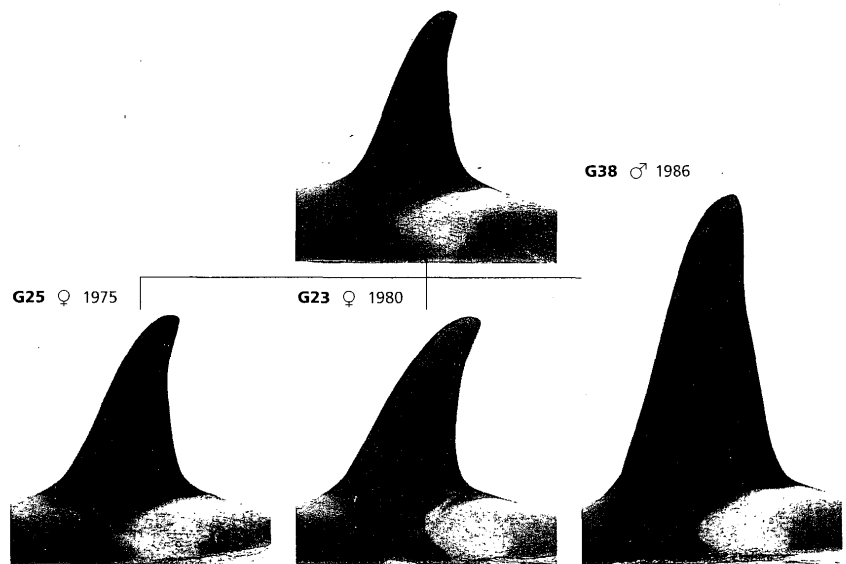


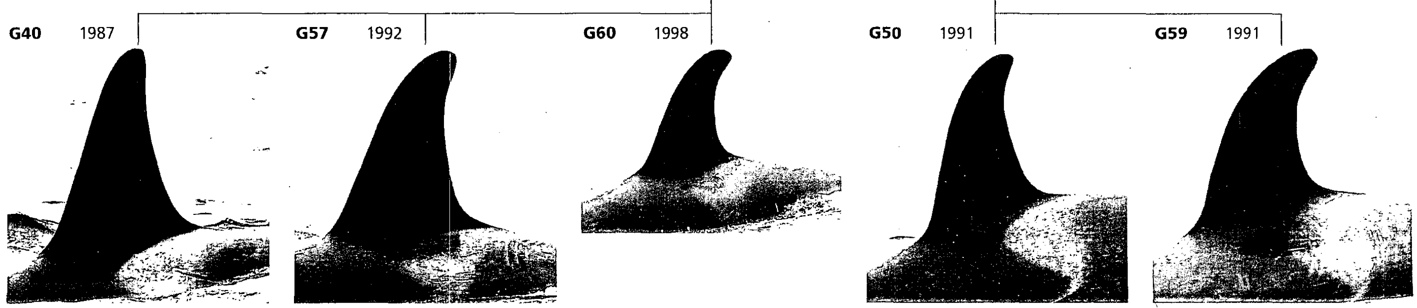


G17 Matriline

After several years of infrequent and incomplete encounters, this matriline was one of the most frequently encountered northern resident matrilines in the 1999 field season.

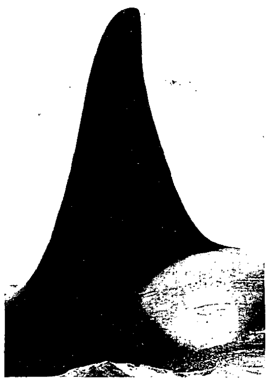




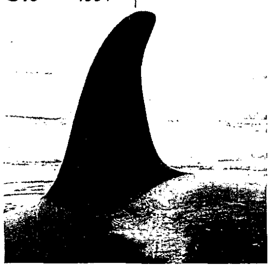


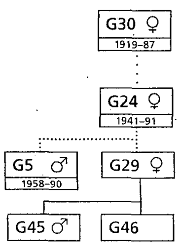
G29 Matriline

G45 1988



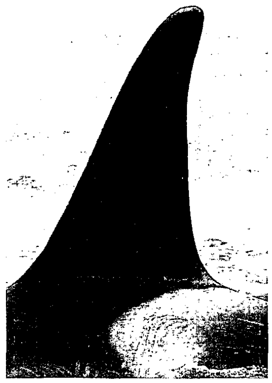
G46 1991



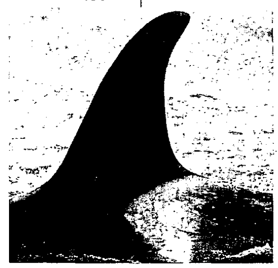


G12 Matriline

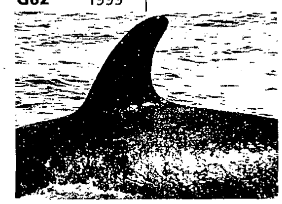
G35 ♂ 1985



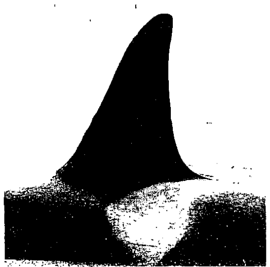
G47 1990



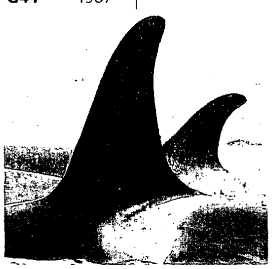
G62 1999

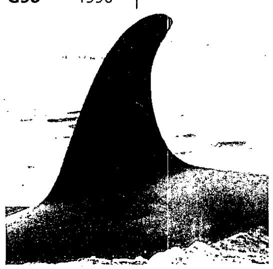


It has taken many years to sort out the acoustical relationships among G-clan pods. They usually travel together in various combinations, which makes it difficult to attribute vocalizations to particular groups. Recent encounters, however, have confirmed that G12 pod has a dialect that is very similar to those of I11 and I31 pods and quite distinct from that of G1 pod.

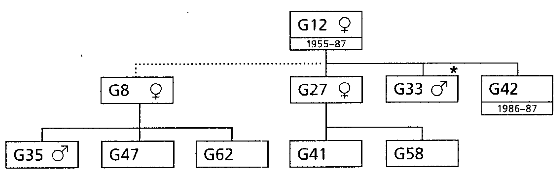


G41 1987 **G58** 1996





G33 was missing when this matriline was last encountered in 1999. With the birth of a third calf in 1999, the G12-G8 matriline was seen to travel separately from the rest of the G12 matriline.



If you have taken photographs from which individual whales can be identified, or have observed an unusual event or incident, you may have useful scientific information that could assist us in our ongoing research program.

Photographs of killer whales in remote locations are particularly helpful, as they may reveal a new group or extend the range of known groups. Areas for which we especially need information include the west coasts of Washington and Vancouver Island, areas north of Vancouver Island, the Queen Charlotte Islands, and any offshore waters.

We are also very interested in any observations of unusual behaviours or incidents, such as:

- dead killer whales, either floating or stranded
- cases of killer whales taking fish from fishing gear
- observations of killer whale predation

Please call us as soon as possible to report observations. If you have photos that you believe may be useful, please send them to us. The photographs and identifications will be returned, usually in a week or two. Each set of photos should include the name of the photographer, date, locations, and the number of whales present. Our contact information is:

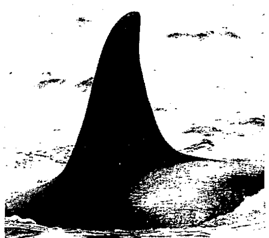
Marine Mammal Research
Department of Fisheries and Oceans
Pacific Biological Station
Nanaimo, BC V9R 5K6
Phone (250) 756-7245
E-mail: ellisg@pac.dfo-mpo.gc.ca
or
Center for Whale Research
P.O. Box 1577
Friday Harbor, WA 98250
Phone: (360) 378-5835
E-mail: orcasurv@rockisland.com

G2 Matriline

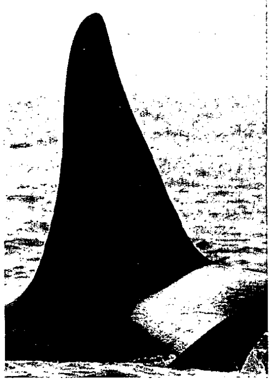
G2 ♀ 1961

This matriline was seen throughout coastal waters from Langara Island in the Queen Charlotte Islands to Juan de Fuca Strait, between July and October, 1999.

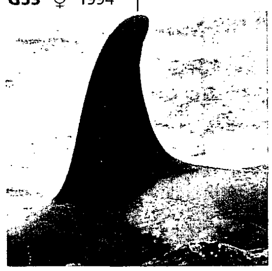
G34 ♀ 1977



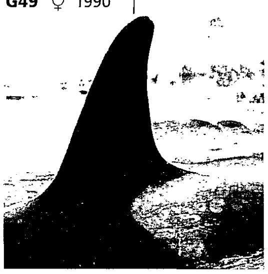
G28 ♂ 1981

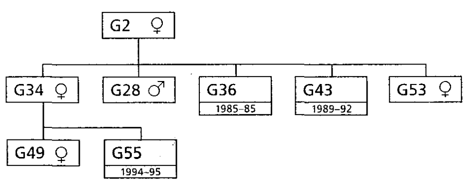


G53 ♀ 1994



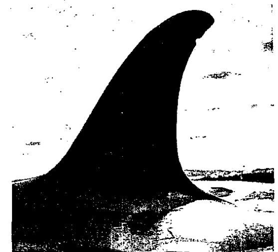
G49 ♀ 1990



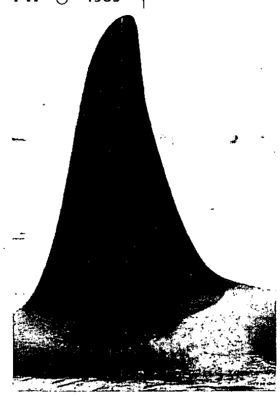


I11 Matriline

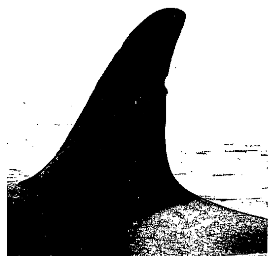
I12 ♀ 1970



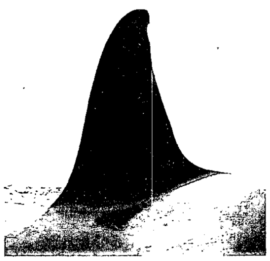
I47 ♂ 1985



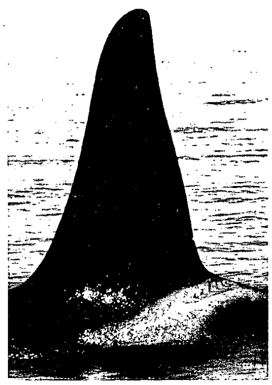
I11 ♀ 1954



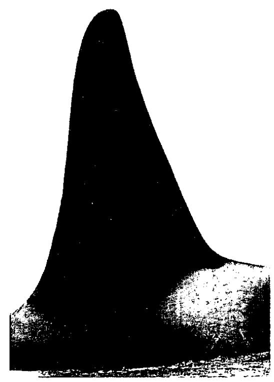
I13 ♀ 1974



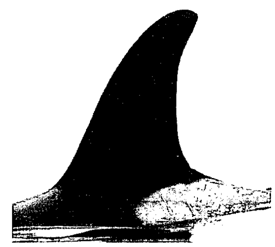
I37 ♂ 1979



I42 ♂ 1983

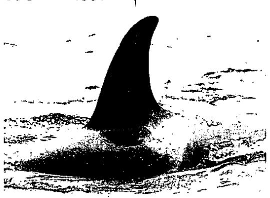


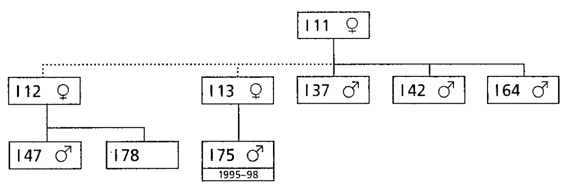
I64 ♂ 1990



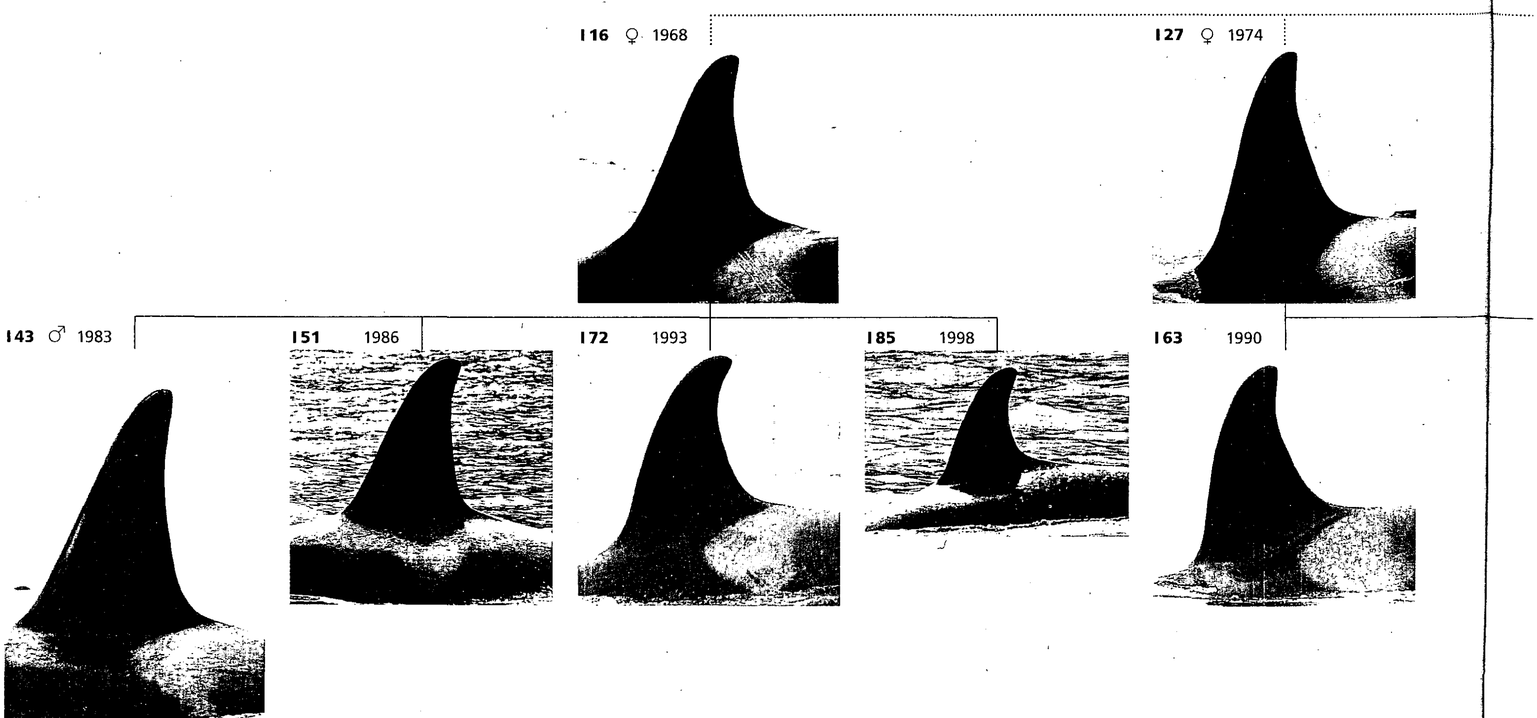
The female I12 and her juvenile I47 have distinctive "open" saddles. The female I13 did not produce a surviving calf until she was 21 years old, and it only lived for 3 years.

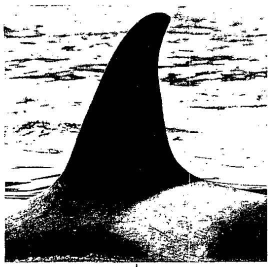
I78 . 1997



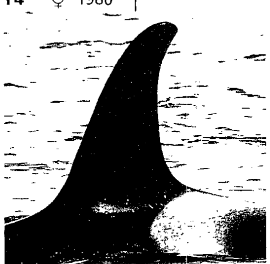


I11 Pod
I15 Matriline

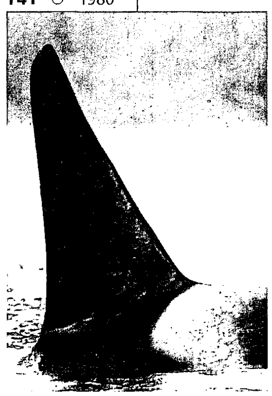




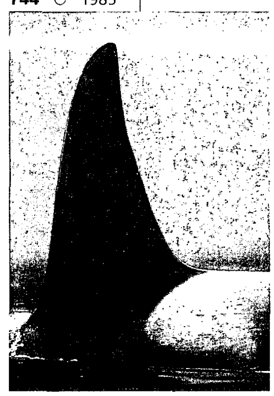
I4 ♀ 1980



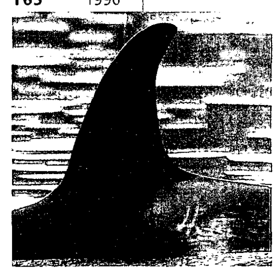
I41 ♂ 1980



I44 ♂ 1985



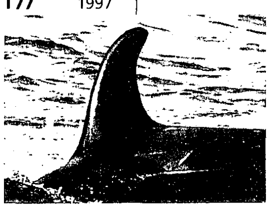
I65 1990



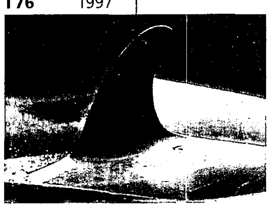
G-Clan

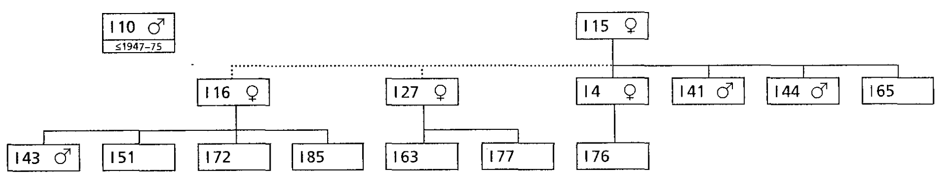
I4 and I41 may be twins born to I15 in 1980, but recent genetic evidence does not support this. Since the group was poorly known prior to that year, it is possible that one of the two lost its (unidentified) mother as a calf and was adopted by I15. Adoptions of very young calves have yet to be confirmed in killer whales.

I77 1997



I76 1997



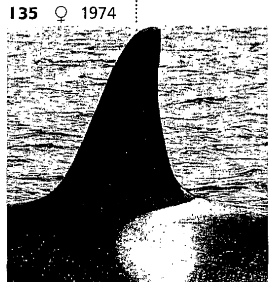


I31 Pod

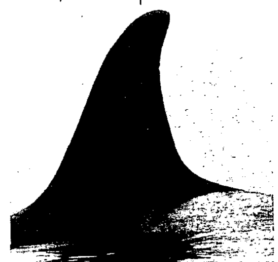
I31 Matriline

The matriarch of this pod and matriline, I31, died in 1994, leaving a two-year-old calf, I68. Calves orphaned at such a young age often do not survive.

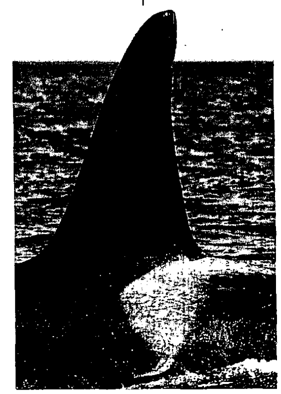
I35 ♀ 1974



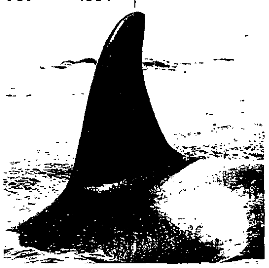
I36 ♀ 1980



I46 ♂ 1985

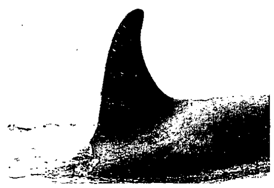


I67 1991

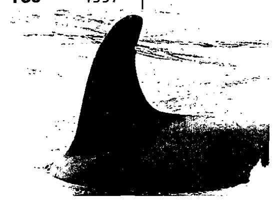


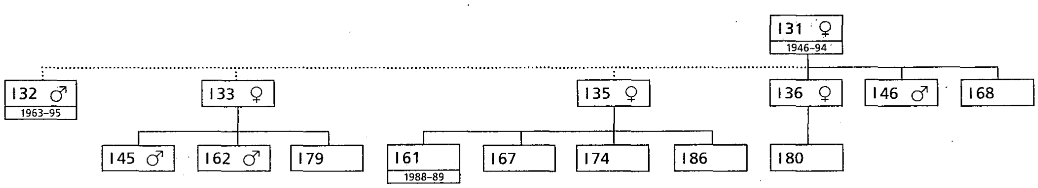
I74 1994

I86 1998



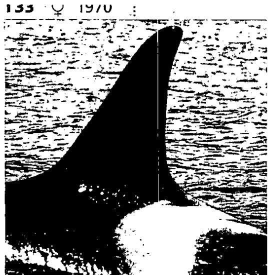
I80 1997





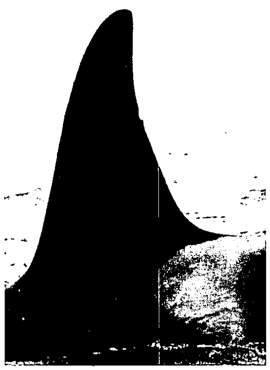
I68 1992

I33 ♀ 1970

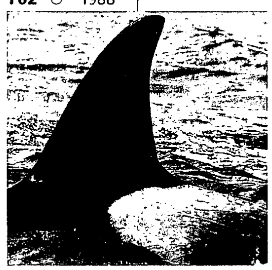


I33 and her offspring are occasionally seen travelling apart from the rest of the matriline.

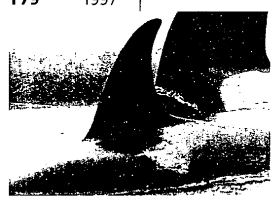
I45 ♂ 1985



I62 ♂ 1988



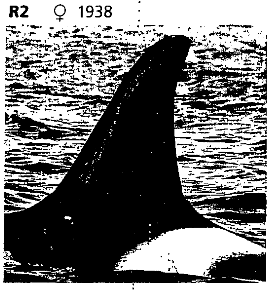
I79 1997



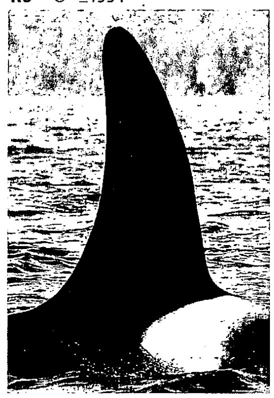
R1 Pod
R2 Matriline

R2 and R6 are believed to be siblings, but because their presumed mother died before the study, the matriline is named after R2. Having no living mother, the male R6 frequently wanders from the matriline for significant periods of time.

R2 ♀ 1938

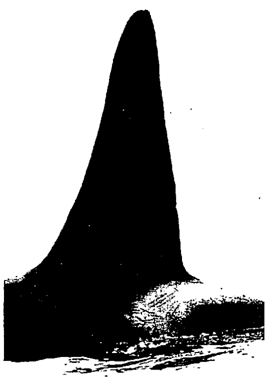


R6 ♂ ≤1954

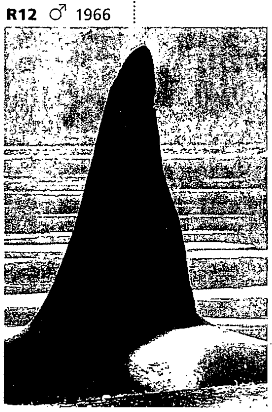


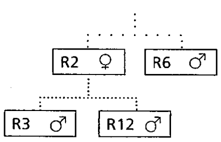
R6's dorsal fin has a forward hook, an attribute sometimes seen in old males.

R3 ♂ 1956



R12 ♂ 1966





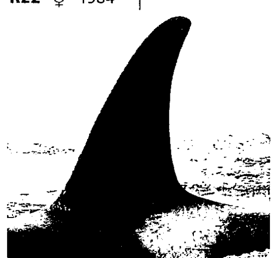
R1 Pod
R5 Matriline

The two R-clan pods have nearly identical dialects, which can be easily distinguished from other clans even by an untrained ear, but not from each other. Despite the apparent close relatedness of R1 and W1 pods, they seldom travel together. W1 pod is only present in about 10% of encounters with R1 matrilines. R1 pod is one of the largest northern

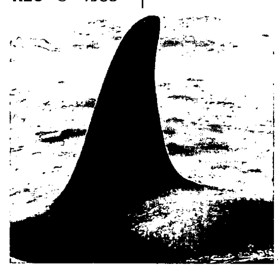
R4 and her offspring occasionally travel separately from the rest of the matriline. R22 was found to have been incorrectly sexed as a male in our previous catalogue when she gave birth in 1994. This burgeoning group has had seven surviving calves since 1993.

R4 ♀ 1964

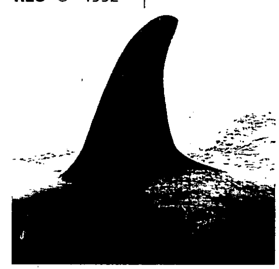
R22 ♀ 1984



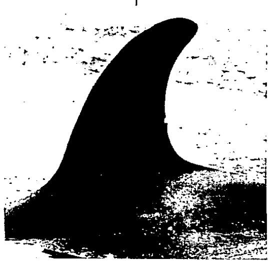
R26 ♂ 1988



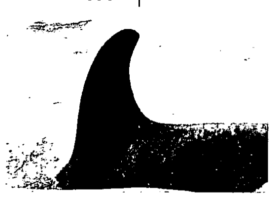
R28 ♂ 1992



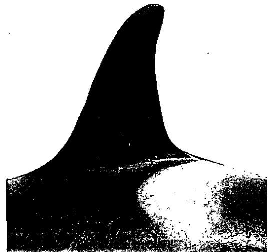
R29 1994



R35 1998



resident pods, thanks to the high productivity of the R5 and R17 matrilines in recent years.
The distribution patterns of R-clan pods seem to have undergone a shift over the course of the study. In the 1970s, these groups were extremely rare in the western Johnstone Strait region. W1 pod was first discovered off Port Hardy in 1979 and did not make its first appearance in Johnstone Strait until 1981. In more recent years, the two pods have become fairly common visitors to this area. We believe that the pods may prefer the northern portions of the community range, as they are sighted there more often than other northern residents.

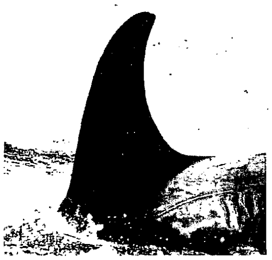


continued on next page

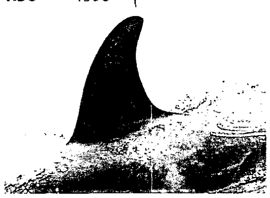
R18 ♀ 1967

R-Clan

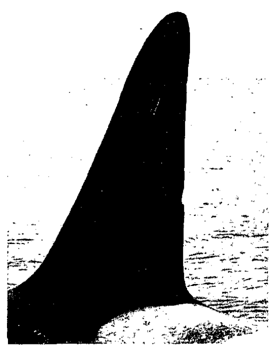
R33 1995



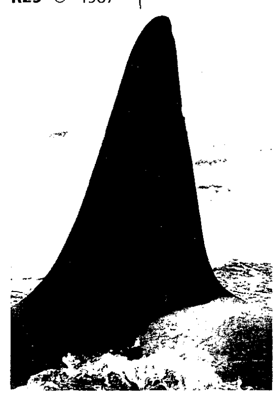
R36 1998



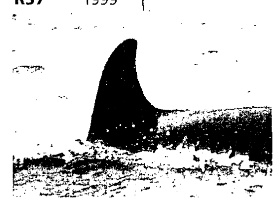
R21 ♂ 1982



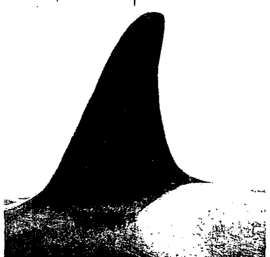
R25 ♂ 1987



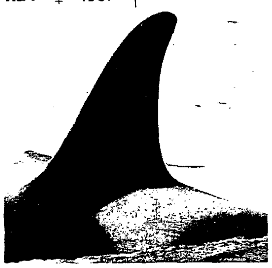
R37 1999



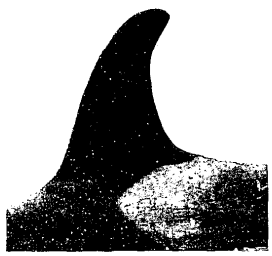
R20 ♀ 1979



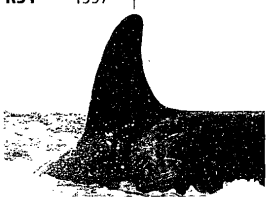
R24 ♀ 1987



R30 1994



R31 1997

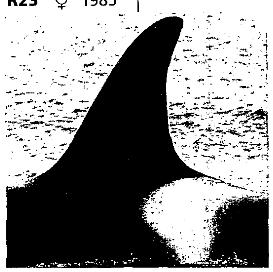


R17 Matriline

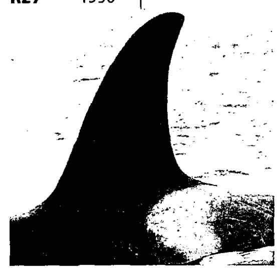
The R17 matriline almost always travels with the R5 matriline.

R17 ♀ 1965

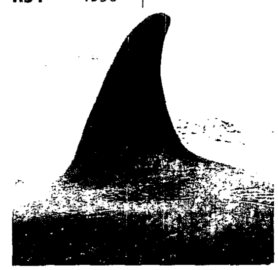
R23 ♀ 1985

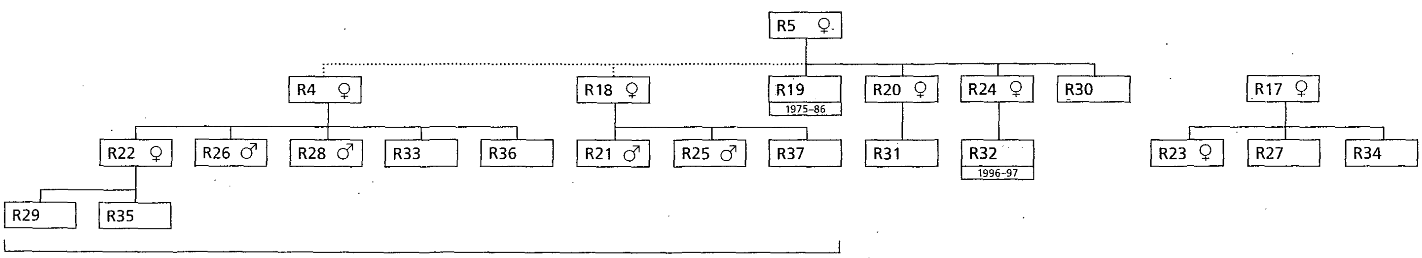


R27 1990



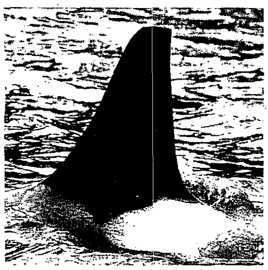
R34 1996





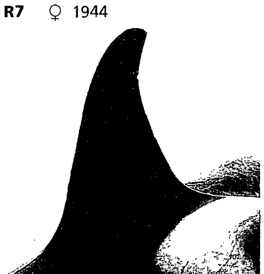
photos on pages 80-81

R9 Matriline

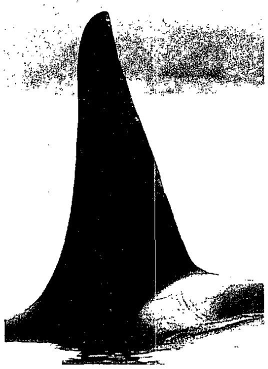


Relationships in the R9 matrline are unclear. Recent genetic data indicate that R7 and R1 are not offspring of R9, as once thought. The relationship of R15 to the matriline is similarly unknown.

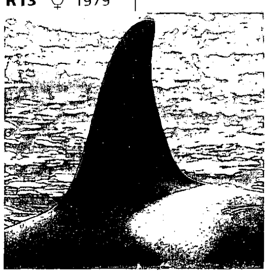
R7 ♀ 1944

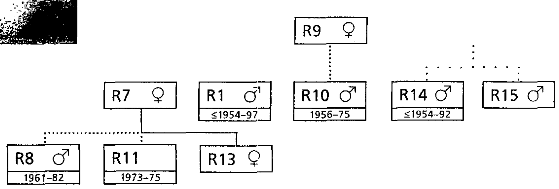


R15 ♂ 1963

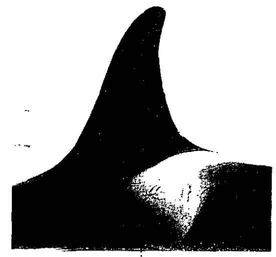


R13 ♀ 1979

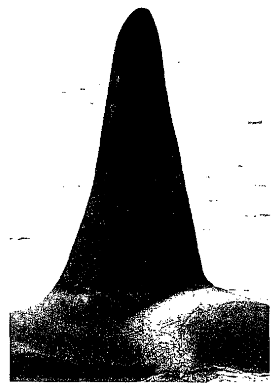




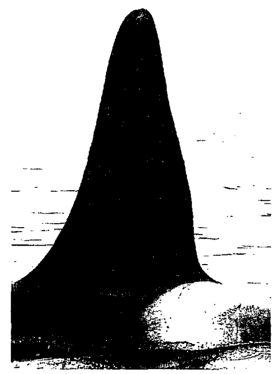
W3 Matriline



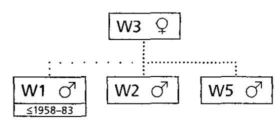
W2 ♂ 1960



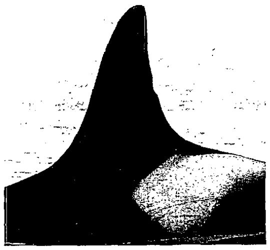
W5 ♂ 1974

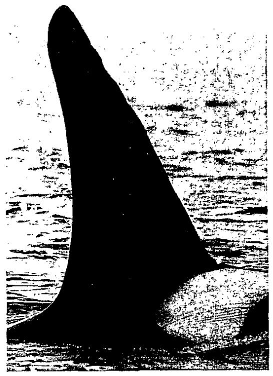


W1 is one of the smallest resident pods, with only three members. It is comprised of a single matriline that will in time die out, as W3 is now post-reproductive.

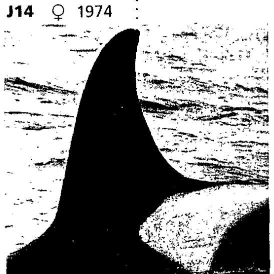


J2 Matriline

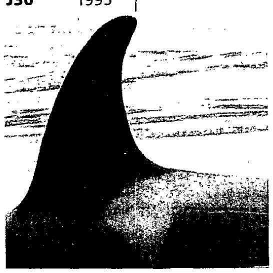


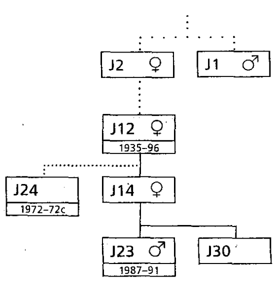


J14 ♀ 1974

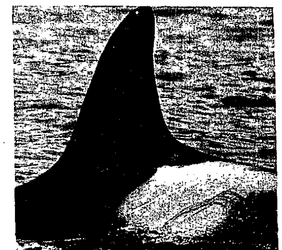


J30 1995

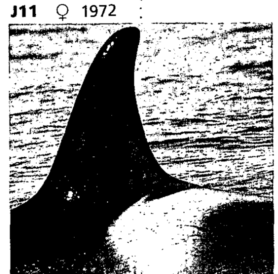




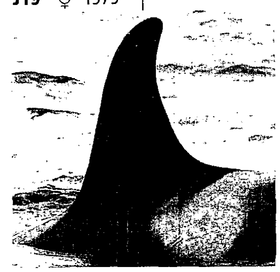
J8 Matriline



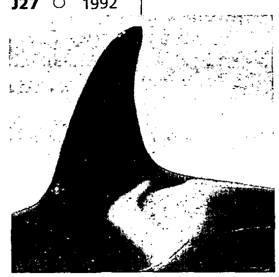
J11 ♀ 1972



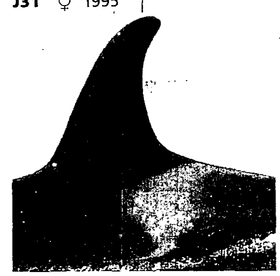
J19 ♀ 1979

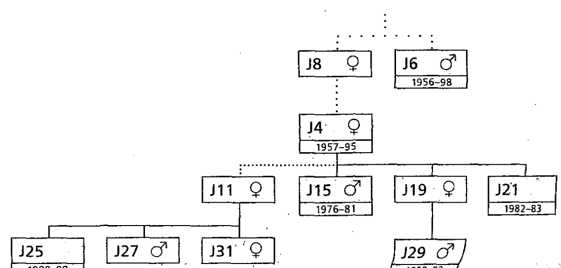


J27 ♂ 1992



J31 ♀ 1995





J16 Matriline

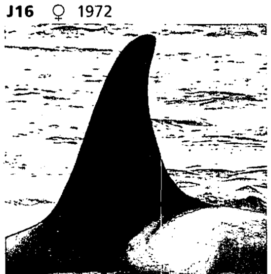
J1 pod's vocal dialect has changed little over the years. Canadian Navy recordings of killer whales near Victoria in the late 1950s contain the J1 dialect in generally the same form as today. In 1964, the first killer whale ever displayed in captivity, "Moby Doll," was captured at Saturna Island. Recordings of this whale's dialect indicate that it was from J1 pod.

J9 Matriline

The 22-year-old male J18, son of J10, died and washed ashore in Boundary Bay on 18 March 2000. Post-mortem examination indicated that he died a day or two before being found on the beach from a severe bacterial infection (*Edwardsiella tarda*).

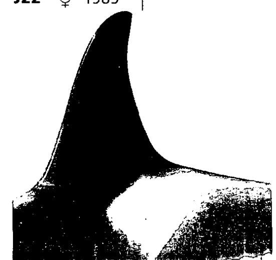
J10 ♀ 1962

J16 ♀ 1972

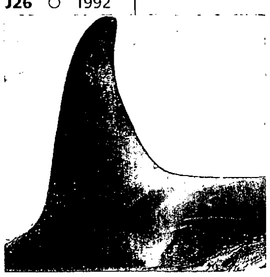


J17 ♀ 1977

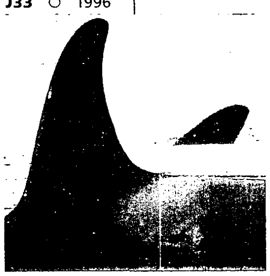
J22 ♀ 1985



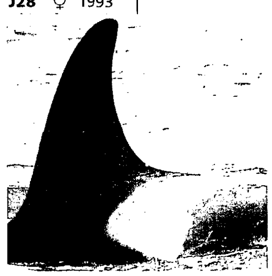
J26 ♂ 1992



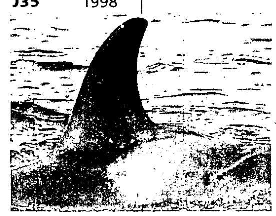
J33 ♂ 1996



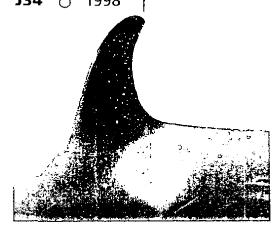
J28 ♀ 1993



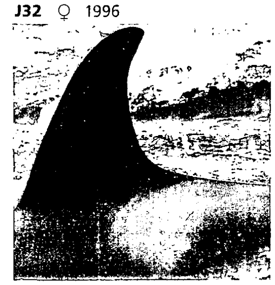
J35 1998

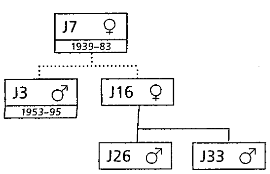


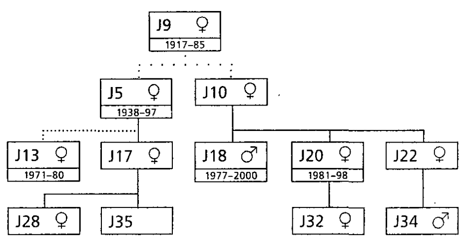
J34 ♂ 1998



J32 ♀ 1996



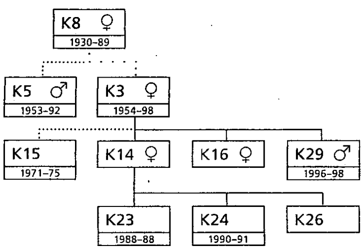




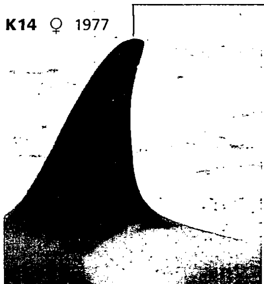
J-Clan

K3 Matriline

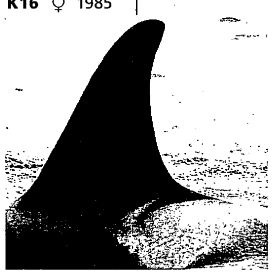
Highly distinctive, "open" saddle patches are far more common among southern residents than northerns. These patterns can be a very useful aid to visual identification of individuals. It should be noted that the pattern on a whale's right side often differs from the left side.



K14 ♀ 1977



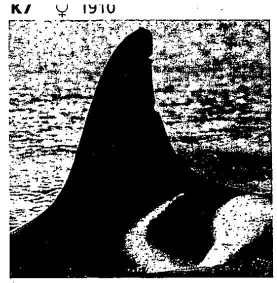
K16 ♀ 1985



K26 1993

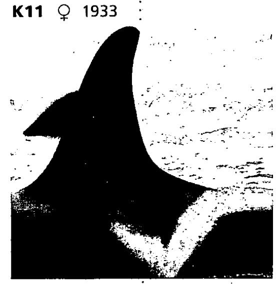
K7 Matriline

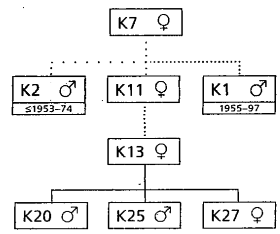
K7 ♀ 1910



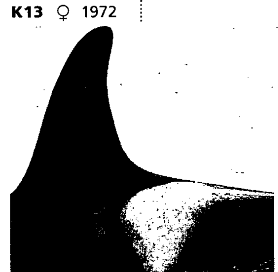
It is estimated that the whale K7 was born in 1910, based on the estimated age of her presumed offspring K11. If this presumption is incorrect, she could be considerably younger than this. However, her estimated age is within the 80-90 year range calculated for maximum longevity from computer simulations. More details on longevity calculations are given in the section, "Sex and Years of Birth and Death," on p. 44.

K11 ♀ 1933

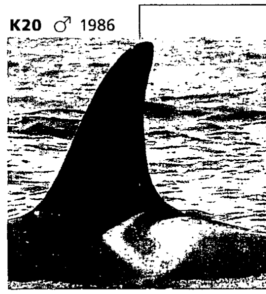




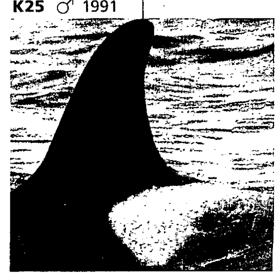
K13 ♀ 1972



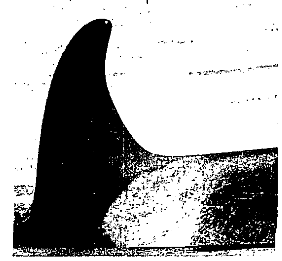
K20 ♂ 1986



K25 ♂ 1991

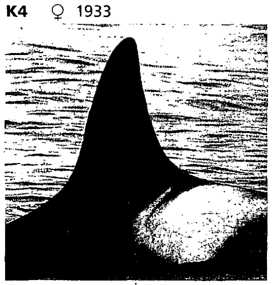


K27 ♀ 1994

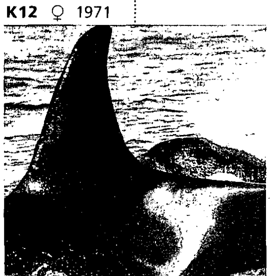


K1 Pod
K4 Matriline

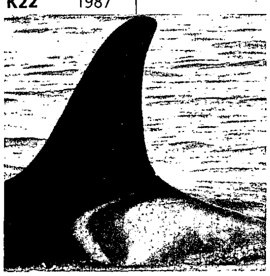
K4 ♀ 1933



K12 ♀ 1971

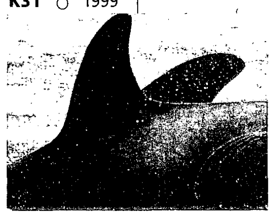


K22 1987



K28 ♀ 1994

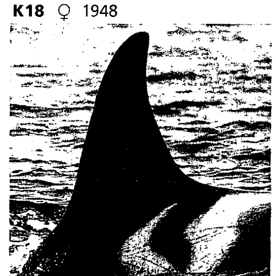
K31 ♂ 1999



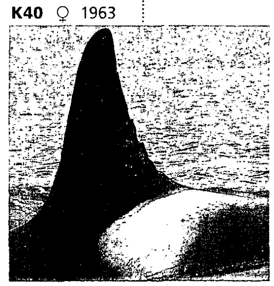
K4 ♀
K12 ♀
K22 | K28 ♀ | K31 ♂

K1 Pod
K18 Matriline

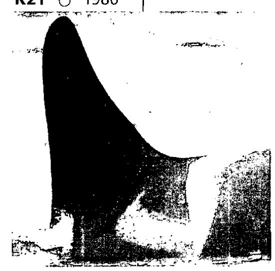
K18 ♀ 1948



K40 ♀ 1963



K21 ♂ 1986

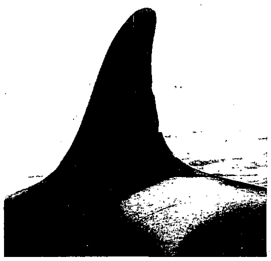


K18 ♀
K40 ♀ | K17 ♂ 1966–94 | K46 1974–81 | K21 ♂

K30 ♀ 1929–82
K19 ♂ ≤1953–84

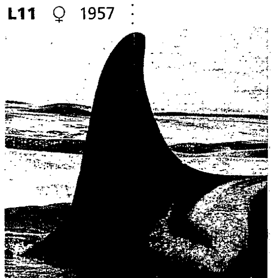
L1 Pod
L12 Matriline

L12 ♀ 1933

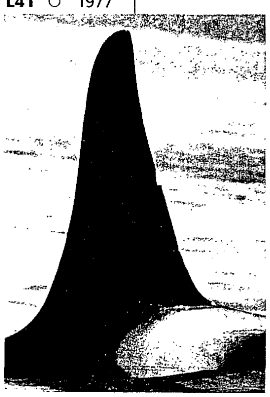


L1 pod spends more time in "outside" waters than either J1 or K1 pods. These waters include western Juan de Fuca Strait and off the west coast of Vancouver Island.

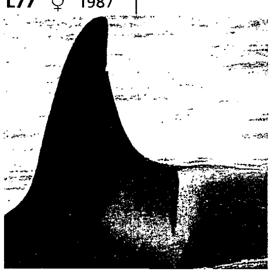
L11 ♀ 1957



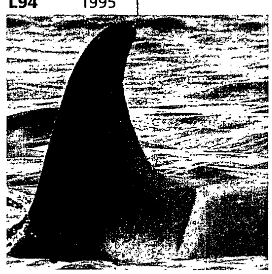
L41 ♂ 1977

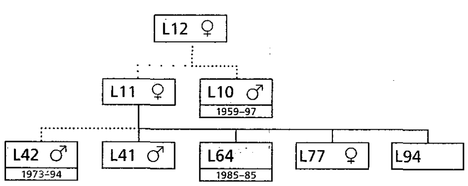


L77 ♀ 1987



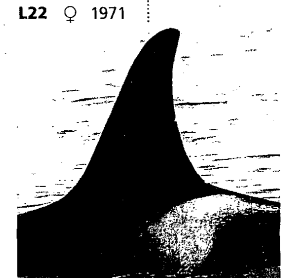
L94 1995



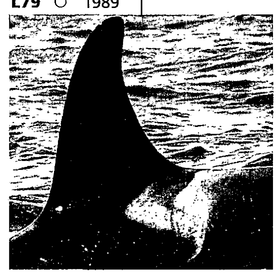


L1 Pod
L32 Matriline

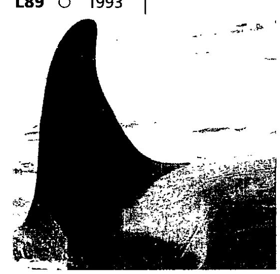
L22 ♀ 1971



L79 ♂ 1989



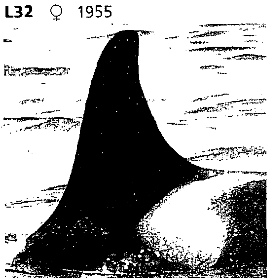
L89 ♂ 1993



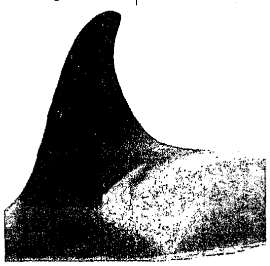
L1 Pod
L28 Matriline

L28, who died in 1994, was initially believed to be the mother of L32. However, a reassessment of this and other associations in the matriline has resulted in the current genealogy for this group, which differs somewhat from that shown in the 1987 catalogue.

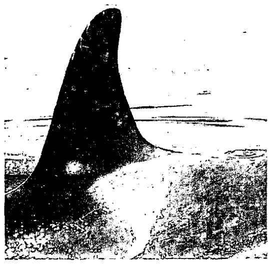
L32 ♀ 1955

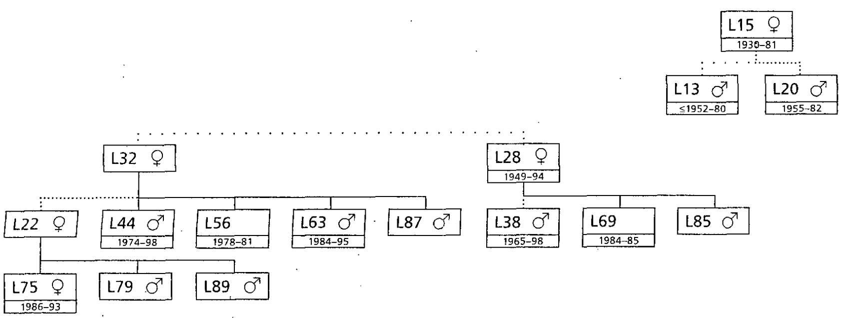


L87 ♂ 1992



L85 ♂ 1991





Eavesdropping on Killer Whales

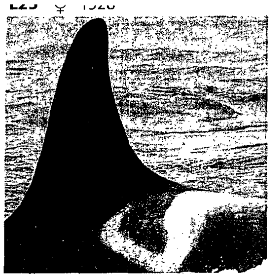
Listening to an underwater microphone, or *hydrophone*, allows the surface-bound whale enthusiast to aurally experience the fascinating, sonically rich world of killer whales. Sound behaves very differently underwater than in air – it travels almost five times faster and much further than airborne sounds of the same energy. For whales, underwater sound is the primary medium for social communication, navigation, and orientation, as it is far more efficient and effective than vision underwater (see sidebar, p. 96).

Most whale-watch operators carry a hydrophone, which they put over the side of their boat to listen underwater while drifting quietly in the vicinity of whales. Some private boaters also carry hydrophones to eavesdrop on whales, or just to listen to the intriguing sonic environment in a quiet anchorage (for a source of hydrophones, see Other Resources, p. 103). But for the casual kayaker or mariner who would like to listen to the underwater conversations of whales in Johnstone Strait off northeast Vancouver Island, a new radio station has been established just for this purpose.

ORCA FM is a solar- and wind-powered radio station that continuously broadcasts the sounds picked up from a bottom-mounted hydrophone in the area of the Robson Bight (Michael Bigg) Ecological Reserve. The station is part of WhaleLink, a project of the Vancouver Aquarium Marine Science Centre, which involves the development of a network of underwater listening stations to track the movements of resident killer whales by monitoring and interpreting their unique group-specific vocal dialects. Officially known as CJKW FM 88.5, it is the world's first station licensed to broadcast underwater sounds. Any boater within a 10-kilometre range of Robson Bight can tune into the station, at 88.5 MHz on the FM radio dial. Visitors to the Vancouver Aquarium Marine Science Centre can also listen to a live feed from the radio station. The live sounds are also available on the WhaleLink website at www.whalelink.org.

There may soon be other hydrophone signals available for monitoring in the region. The Whale Museum in Friday Harbor plans to place hydrophones along the west side of San Juan Island that would pick up the underwater vocalizations of the southern resident whales as they travel in Haro Strait. Live signals from at least one of these hydrophones will be broadcast on a low-power FM station to give boaters, local residents, and visitors to the Lime Kiln State Park the opportunity to eavesdrop on the underwater soundscape of the whales.

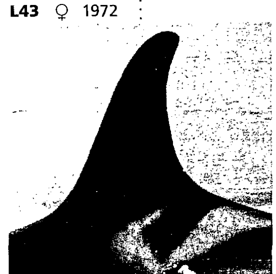
L25 Matriline



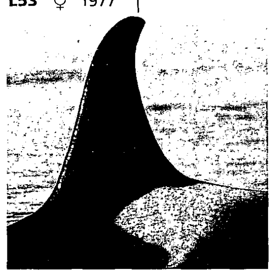
L37 Matriline

L7 ♀ 1961

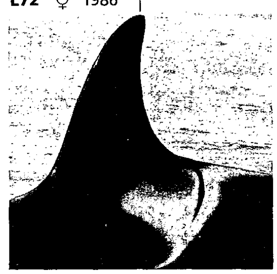
L43 ♀ 1972



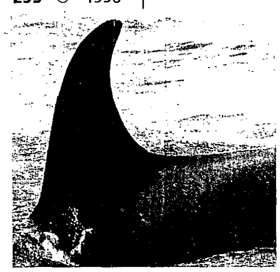
L53 ♀ 1977

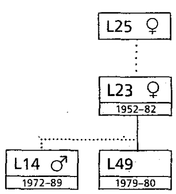


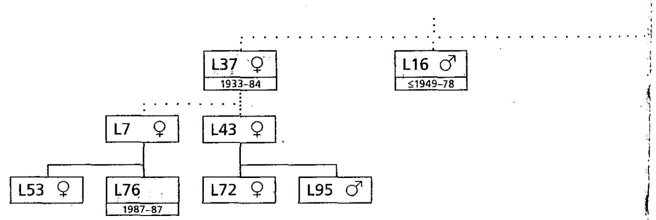
L72 ♀ 1986



L95 ♂ 1996



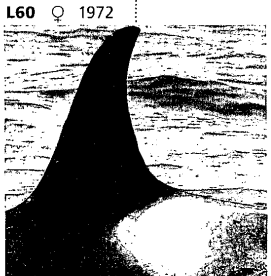




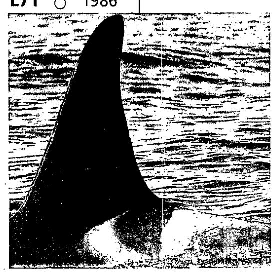
L1 Pod
L26 Matriline

L26 ♀ 1956

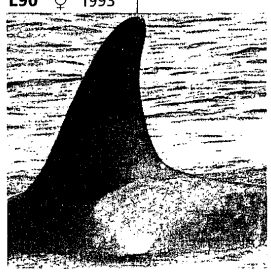
L60 ♀ 1972



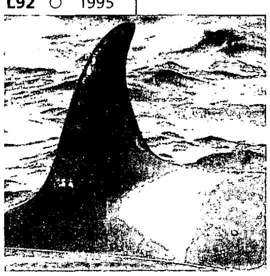
L71 ♂ 1986

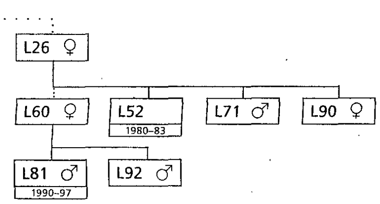


L90 ♀ 1993



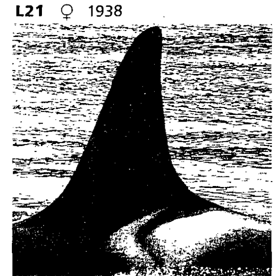
L92 ♂ 1995



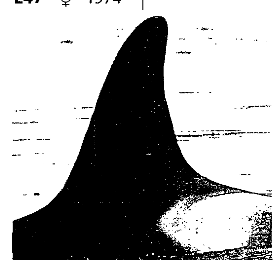


L1 Pod
L21 Matriline

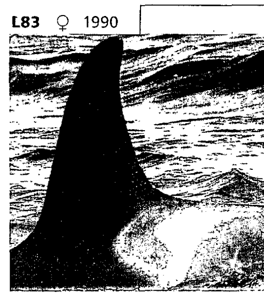
L21 ♀ 1938



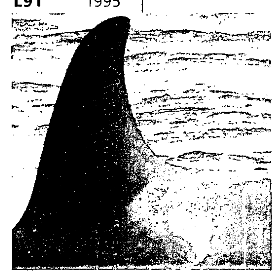
L47 ♀ 1974

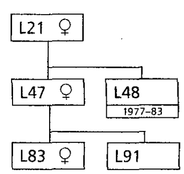


L83 ♀ 1990



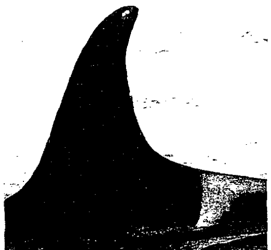
L91 1995



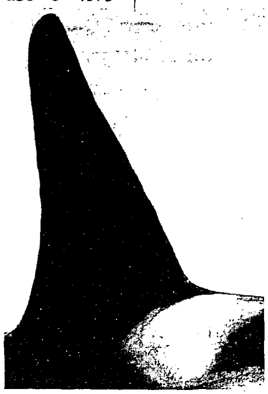


L1 Pod
L2 Matriline

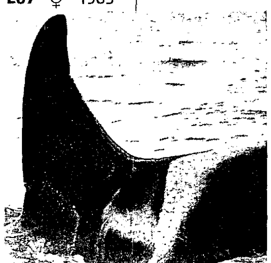
L2 ♀ 1945



L39 ♂ 1975



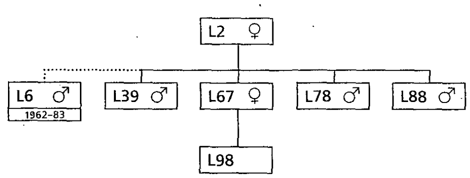
L67 ♀ 1985



L78 ♂ 1989

L88 ♂ 1993

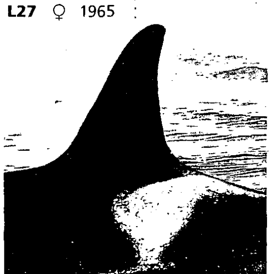
l98 1999



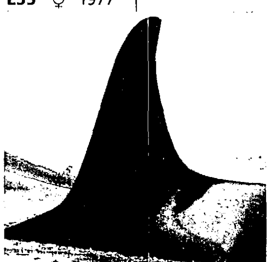
L1 Pod

L4 Matriline

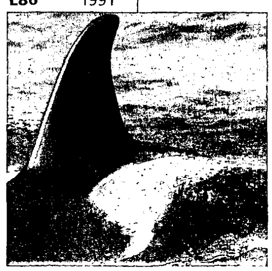
L27 ♀ 1965



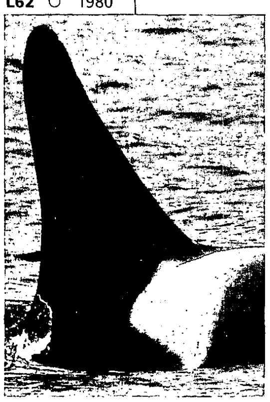
L55 ♀ 1977



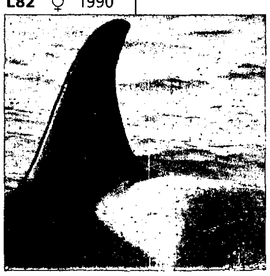
L86 1991

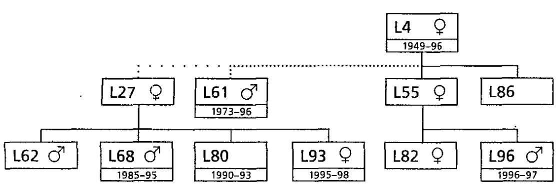


L62 ♂ 1980



L82 ♀ 1990





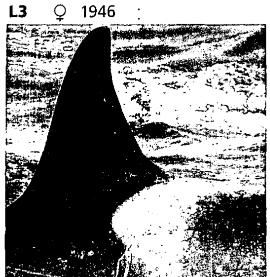
L Clan

L1 Pod
L9 Matriline

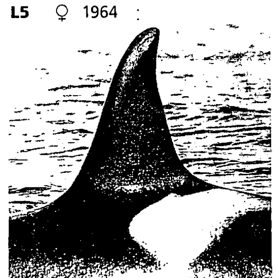
The female L51 was found dead on a beach west of Victoria in late September 1999. Her young orphan, L97, was seen travelling with her brother L84 and uncle L74 for several weeks following L51's death. However, the calf appeared weak and emaciated, and disappeared by mid-October.

The female L5 and her offspring have occasionally been observed attacking or harassing marine mammals, which is very unusual for resident whales. Usually the victim is a juvenile porpoise or harbour seal. There has been no confirmation that the animals are consumed, although they may be killed.

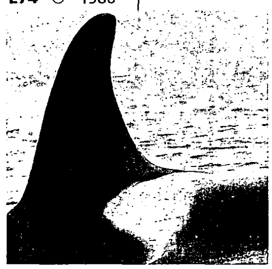
L3 ♀ 1946



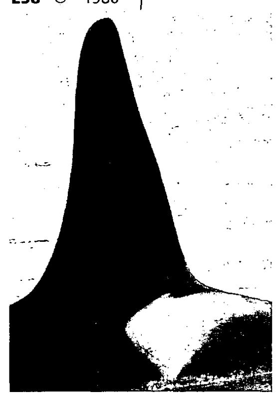
L5 ♀ 1964



L74 ♂ 1986

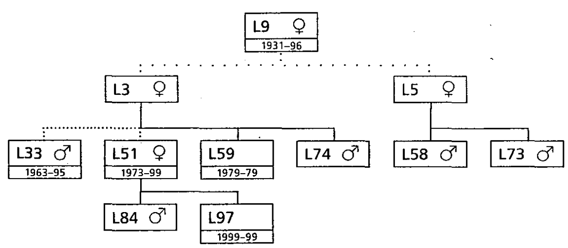


L58 ♂ 1980



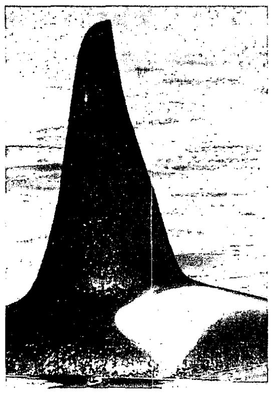
L73 ♂ 1986

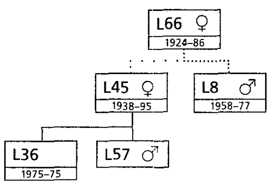
L84 ♂ 1990



L1 Pod
L45 Matriline

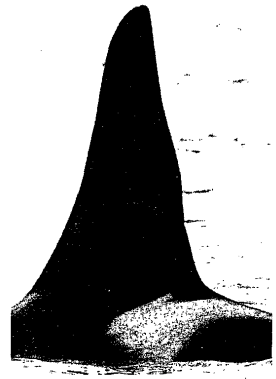
L57 ♂ 1977



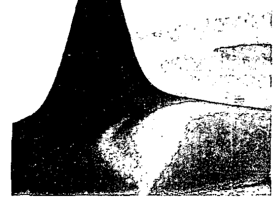


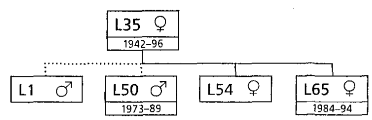
L1 Pod
L35 Matriline

L1 ♂ 1959



L54 ♀ 1977





Communication and Echolocation

Like all members of the dolphin family, killer whales rely heavily on underwater sound for both navigation and communication, and with good reason. Sound is by far the most efficient and reliable medium for collecting sensory information about a whale's surroundings and for social communication with other whales. The whales' eyesight is good, but underwater visibility is usually less than 50 metres, and at night it is negligible. Underwater sound, on the other hand, travels farther and faster than it does in air, and is equally effective day or night.

By forcing air through structures in the nasal passage beneath the blowhole, a killer whale can generate ultrasonic clicks less than a millisecond in duration, long canary-like whistles, or loud, complex calls that may be heard for 10 kilometres underwater. A special body of fat within the melon, the fleshy bulge atop the animal's head, has acoustic properties that focus the higher-frequency sounds into a directional beam ahead of the whale. Killer whales can hear with exceptional sensitivity and directionality. Incoming sound is received mostly through the whale's lower jaw, then is conducted directly to the middle ear.

Lowering an underwater microphone, or hydrophone, into the water near killer whales provides a means of eavesdropping on their acoustic world. When listening to a group of resident killer whales, one usually hears staccato snaps, clicks, and pops of echolocation, punctuated every so often by strident, often metallic-sounding calls being exchanged within the group. The echolocation signals produced by the whales are referred to as "click trains," which are short-duration pulses given in repetitive series that may last for 10 seconds or more. Echoes from these clicks allow the animals to form an acoustical image of their surroundings. The repetition rate of clicks varies from a few to more than 200 clicks per second, probably in relation to the range of the target being acoustically examined. Slow click trains are probably used for navigation and orientation to distant objects, such as seafloor features or other whales. Higher repetition rates seem to be used to investigate closer objects at ranges of 10 metres or less.

The signals used for social communication within and between pods consist of calls and whistles. Calls are more common than whistles, dominating vocal exchanges in most contexts. Typically less than two seconds long, calls are made up of bursts of pulses generated at rates of up to several thousand per second. Such pulse bursts produce high-pitched squeals and screams, not unlike the sounds made by rusty hinges on a quickly closing door. By varying the timing and frequency structure of these bursts, the whales can generate a variety of complex signals.

Most calls produced by resident pods can be classified by ear or with the aid of a sound spectrum analyzer into a number of distinctive categories, or types of *discrete calls*. Each resident pod has a repertoire of about a dozen different discrete call types, although some have as few as 7 and others have as many as 17 call types. Each whale seems to share the entire call repertoire of its pod. These calls appear to serve generally as contact signals, coordinating group behaviour and keeping pod members in touch when they are out of sight of each other. While spread out during foraging, the whales regularly exchange sounds, 90-95% of which are from their repertoire of discrete calls. Most calls contain sudden shifts or rapid sweeps in pitch, which give them distinctive qualities recognizable over distance and background noise.

As described in "Dialects and Population Identity" (p. 21), the call repertoire of each resident pod has unique features that allow the group to be identified acoustically. These dialects may enhance the contact function of the calls by acting like an acoustic "family badge," allowing individuals to easily differentiate the calls of their fellow pod members from those of other whales. Dialects may also serve as indicators of relatedness of pods and might thus have some role in determining association or mating patterns.

It is not yet clear why pods have so many calls in their repertoires or whether any call has a specific meaning. Different calls do not appear to be given in sequences that resemble a syntax, such as in human languages. Rather, call types seem to be contagious – if a whale emits a particular call, others in the pod often respond with the same call type before moving on to another. No call appears to be associated exclusively with any particular activity or behaviour. However, certain calls in a pod's repertoire do tend to be given more often in some circumstances, such as resting or socializing, than in others.

Most likely, the emotional state of an individual is reflected in the call types it chooses to use and also in the way each call is given. For example, when whales are excited, they will often increase the pitch and shorten the duration of a call from its standard format. It is also probable that each whale produces calls in a consistent but subtly different way from others in its pod, thus encoding its identity in the signal. With this communication system, resident whales seem able to transmit their individual and pod identity, location, and mood to others in their pod, thereby maintaining the behavioural coordination, cohesion, and integrity of the group.

Conservation Concerns and Future Prospects for Killer Whales

The last twenty-five years were mostly good ones for killer whales in the coastal waters of British Columbia and Washington. Shootings by disgruntled or fearful fishermen and other mariners have largely become a thing of the past. Live captures for aquaria – which were removing far in excess of what could be sustained by the population – came to an end by the mid-1970s. This fishery was replaced in the 1980s by commercial whale watching, and people came from around the world in ever-increasing numbers to view and appreciate killer whales in the wild. Salmon, the favoured prey of residents, was plentiful. The resident population has been increasing since the first census in the mid-1970s at rates that were at or close to the maximum possible for the species, around 2-3% per year. By the mid-1990s, the resident population size was over 300, more than 100 whales larger than in 1975. Transients also seemed to be doing well. Populations of their mammalian prey, especially harbour seals, were burgeoning. Although more difficult to census than residents, transient numbers also appeared to be on the rise. All seemed well in the world of west coast killer whales.

Unfortunately, this is no longer so. Over the past five years, the status of resident killer whales, especially the southern community, and the state of their environment appear to have changed for the worse, and their long-term well-being suddenly seems less secure. After two decades of growth, numbers have recently levelled off in the northern community and dropped by 15% in the southern community. It is not yet clear if this is the beginning of a long-term trend or whether it is just a temporary phenomenon. With such small populations, a few extra deaths or a few less births can make the difference between growth and decline – and these may simply result from events that occur by chance, or from slight shifts in age and sex demographics. But it is possible that resident killer whale productivity and future survival are being threatened by one or more external factors, and this might also be the case for transients.

Food Supply

High on the list of potential problems for resident killer whales is their food supply. In recent years, stocks of most species of salmon in the coastal waters of British Columbia and Washington have declined dramatically. This is due to many factors, including degradation of spawning habitat, reduced ocean survival, and over-fishing. In particular, returns of the residents' preferred salmonid species, the chinook, have been poor in many coastal spawning streams and rivers. It is difficult to say how reduced salmon availability may affect residents. They may switch their diet more to other fish species, such as lingcod or other bottom-dwelling species, but stocks of these have also been much reduced in nearshore areas. They may well shift their distribution patterns to other areas where food is more plentiful. We know that residents eat mostly salmon during the summer and fall, but their diet during winter, and the whereabouts of the whales themselves, are largely unknown. For transient killer whales, marine mammal prey in the region are plentiful, so transients should not be facing prey scarcity. However, in western Alaska and the Aleutians, populations of seals and sea lions have declined precipitously, which may be affecting transient-type whales in that area.

A conservation issue related to food is the removal of fish from commercial- and sports-fishing lines by killer whales. We have been receiving more reports of such incidences in recent years, which may indicate that this activity is on the rise. Isolated occurrences may not represent a concern, but it can become a serious problem when particular groups of whales come to depend on this strategy for their food. This took place in Prince William Sound, Alaska, in the 1980s, when a pod began stripping commercial longlines of blackcod (or sablefish). Soon the pod was taking a significant portion of the catch and damaging much gear in the process. The fishermen tried various methods of dissuading the whales, but none were effective. Eventually, they resorted to explosive charges and shooting, which likely killed several whales in the pod. Temporary closure of the fishery and other factors resolved the situation in Prince William Sound, but it has become a major problem in longline fisheries in the Bering Sea.

Environmental Contaminants

Killer whales in British Columbia and Washington have recently been found to carry dangerously high levels of PCBs and other contaminants in their blubber, high enough to rank them as one of the world's most polluted cetacean populations. New research by our colleague, Peter Ross, of the Institute of Ocean Science (Fisheries and Oceans Canada), has revealed that killer whales carry surprisingly high levels of toxic pollutants in their tissue. Using blubber samples taken from biopsies collected as part of Lance Barrett-Lennard's genetic studies (see sidebar, p. 99), Ross investigated the levels of fat-soluble organochlorines in both resident and transients, as well as in whales of various age and sex categories. The story that has unfolded from this analysis is both intriguing and alarming.

As top-level predators in the food web, killer whales ingest a variety of human-made industrial pollutants through their diet. The most tenacious and toxic of these are the organochlorines – PCBs, dioxins, and furans. PCBs were produced primarily for use in electrical transformers, and although they have been banned for many years in this region, they continue to find their way into the marine habitat from old storage sites and environmental cycling. Unfortunately, PCBs have not been banned in certain other parts of the world, particularly in industrialized areas in Asia, and these too enter the marine food chain in our region. These persistent chemicals find their way into the atmosphere, where they are transported thousands of kilometres across the Pacific, eventually falling as rain or snow and entering the oceans directly or by runoff from land into coastal waters. The other organochlorines, dioxins and furans, result primarily from the chlorine-based bleaching process used until recently in local pulp mills.

Molecules of these toxic chemicals bind to small particles in the water column or muddy sea bottoms, then work their way slowly up the food chain, from plankton to fish to marine mammals. At each higher trophic level, the concentration of pollutants increases through the process of *bioaccumulation*. Thus, although pollutant levels may be low in individual schooling fish, predators such as harbour seals and resident killer whales feed on many of these, and the fat-soluble chemicals become stored in increasing concentrations over time in the mammals' blubber.

Overall, transient killer whales were found to have the highest levels of pollutants, which no doubt result from their almost exclusive marine-mammal diet. Residents feed on a lower trophic level in the food web – primarily on salmon and other fishes – and thus accumulate pollutants more slowly than transients. PCBs occur at much higher concentrations in killer whales than do dioxins or furans, apparently because the whales are able to metabolize the latter two chemicals and not PCBs. The least polluted whales were found to be the northern residents, which had the lowest levels of PCBs. Southern residents, interestingly, had PCB levels between 3 and 6 times higher than northern residents, presumably because they are feeding on different, more toxic, prey. Transients had PCB levels that were higher still, up to 8 times those of northern residents. It should be noted that these kinds of PCB levels are extremely high for any animal – they are among the highest recorded in cetaceans and are more than 250 times higher than levels usually found in humans.

Levels of PCBs in killer whales were found to also vary substantially with the age and sex of individuals. Concentrations increased steadily with age in males, which one might expect, as the cumulative number of ingested prey items grew. In young females, PCB concentration increases at the same rate as males but drops sharply when the female begins to reproduce. Because these chemicals are fat soluble, they are mobilized from the mother's blubber during lactation and concentrate in her fat-rich milk, then are transferred directly to her offspring through nursing. It is only when a female becomes post-reproductive, at around 40 years of age, that PCB levels begin to rise once again.

Are such high levels of PCBs a serious threat to the health and survival of killer whales? It is not yet possible to answer this question directly for this species, but there is good reason for concern. Studies on harbour seals in Europe have shown that high levels of PCBs and related contaminants can cause hormonal and reproductive dysfunction and suppression of the immune system, which leads to increased susceptibility to disease. PCB-induced immunosuppression has been implicated in a mass die-off of Mediterranean striped dolphins from a viral disease several years ago. Levels of PCBs in southern residents and transients are in the same range as these dolphins and are higher than levels found to cause serious health problems in European harbour seals. Of special concern are first-born killer whale calves, which receive a very high dose of PCBs from their mother through nursing, and older males, who have no way of ridding themselves of these toxins.

Fortunately, PCBs are no longer produced or used in North America. However, because the safe disposal of these toxic chemicals is difficult and expensive, over 90% of all PCBs ever produced are still held in storage – and the security of many of these storage facilities is questionable. It seems likely that these toxic pollutants will continue to seep into the whales' habitat for years to come, unless serious international efforts are made to control and eventually eliminate them.

Genetic Testing: Shedding New Light on Killer Whale Biology

Modern DNA analysis techniques are making it possible to answer many of the fundamental questions about killer whale population structure and breeding systems that have long eluded us. Several researchers over the past twenty years have examined various aspects of killer whale population genetics, but the most comprehensive and revealing study to date is nearing completion. Since 1994, our colleague Lance Barrett-Lennard has been undertaking a PhD research project at the University of British Columbia, focused on determining genetic relationships among and within the various killer whale populations in the northeastern Pacific, as well as on mating patterns within resident communities.

The key to Barrett-Lennard's study was the development of an "ultralight" darting system to obtain small samples of skin from whales in a minimally invasive way. The system used a small biopsy dart weighing only a few grams, which was projected from an air rifle. The dart would hit the whale's back or side behind the dorsal fin, then bounce off and float until retrieved by boat, complete with a small sample of skin and underlying blubber. Even a skin sample of a few milligrams can yield a remarkable amount of genetic information, and the blubber accompanying the skin sample can be used to determine the levels of environmental contaminants in the whales. When biopsied, most whales gave no more than a slight shake, and many showed no visible reaction. The sampling system was found to be more effective, precise, and benign than older darting techniques using bow-and-arrow and has yielded samples from over 275 whales along the west coast from British Columbia to Alaska.

Although the detailed results of Lance Barrett-Lennard's analyses await the completion of his study, some fascinating preliminary findings are available. Genetic sequences in mitochondrial DNA, which is passed on only by mothers, as well as microsatellite analysis of nuclear DNA, which is not dependent on maternal descent, confirm our earlier suspicion that residents and transients represent distinct lineages with little or no exchange of individuals or interbreeding. The differences are so great between these two forms that they have likely been isolated genetically for many thousands of years.

Within the resident populations, some intriguing patterns have emerged. Northern and southern resident communities have distinct mitochondrial DNA haplotypes – that is, they have unique genetic sequences indicating that each is a completely separate maternal lineage, which is supported by our observations of the lack of mixing between the two communities. Interestingly, within a different community of residents in southern Alaska (Prince William Sound and southeastern Alaska), some pods have the same haplotype as our northern residents, and others have the southern resident haplotype. These different genetic patterns in Alaska might reflect separate historical colonization of the area by different pods from the south.

Genetics are also helping us to understand the resident breeding system. We have long wondered how residents avoid the potentially harmful effects of inbreeding – the mating of close relatives. Because resident matrilines are permanent social units from which offspring never leave, or disperse, we have suspected that inbreeding is avoided by whales mating between pods during temporary associations. Paternity tests from microsatellite DNA analysis has shown that this is indeed the case – matings do not normally occur within pods, and there is no evidence of past inbreeding.

Finally, skin DNA has given us a new tool to determine the gender of many subadult whales, which are difficult to sex unless they roll over to show their ventral sides (see "Sex and Years of Birth and Death," p. 44). A simple genetic test reveals whether the young whale is a male or a female.

The female L53, born in 1977, breaching in Haro Strait.

Vessel Disturbance

Increasing marine traffic of all kinds, including commercial and recreational whale-watching vessels, is creating more and more noise and disturbance in the resident whales' core areas, Johnstone Strait and Haro Strait. Recent studies have shown that close approaches by boats can cause short-term disruption of whale activities, but it is the potential for long-term, cumulative effects that are of greatest concern. Multiple disruptions may make it difficult for the whales to function normally in congested areas, causing them to move to less populated waters. Adherence to whale-watching guidelines and regulations may help to reduce physical disturbance by boats, but underwater noise from vessels is more difficult to control. Noise has the potential to interfere with the whales' ability to communicate with one another and coordinate their activities while spread out during foraging. It can also mask the echolocation signals or passive acoustic cues the whales use to navigate and locate prey. Such interference may reduce foraging success and cause other behavioural effects.

Population Status and Future Outlook

It is possible that no single factor is harmful enough to cause a decline of resident killer whales, but together they may create conditions leading to reduced productivity and survival. In response to the recent decline in the southern resident community, and in recognition of reduced salmon availability and other forms of habitat degradation, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recently listed resident killer whales in British Columbia as "threatened." This designation refers to a species (or population) that is "likely to become endangered in Canada if limiting factors are not reversed." In listing resident whales, COSEWIC chose to lump the southern and northern communities together, but it seems clear that the southerns are more at risk than the northerns. The larger northern resident community has been increasing at its maximum potential for years, and only recently has this growth appeared to slow or stabilize. The smaller southern community carries higher loads of toxic chemicals, spends the critical summer feeding season in more polluted, industrialized waters, and has declined in numbers during each of the past four years. Efforts by conservationists are under way in the United States to have southern residents listed as a threatened or endangered population. Transient killer whales, for which no reliable population trend data are available, are also considered "vulnerable" in Canada.

It is possible that the decline of southern residents will turn around and the community will begin to grow once more, or at least hold its own. But the long-term prospects are not particularly encouraging. Projections for human population trends over the next 30 years indicate that most of the land area surrounding Puget Sound and the southern Strait of Georgia will be highly urbanized, and, as a result, inshore waters will become increasingly noisy, congested, and polluted. Recent studies of the potential effects of global warming predict that if water temperatures increase by only a few degrees, salmon may not be able to survive in the region. Hopefully, the recent decline of southern residents will serve as a "wake-up call," triggering concern and action at all levels of society and government to ensure the future survival of killer whales.

The following are definitions of some of the terms used in killer whale research and in this book.

breach
occurs when a whale leaps out of the water, exposing two-thirds or more of its body.

calf
a young-of-the-year, typically born in fall-winter.

clan
one or more pods that share a related dialect; pods within a clan have probably descended from a common ancestral group and therefore are probably more closely related to each other than to pods from other clans.

community
comprises all pods that travel together; pods from different communities have never been seen together.

dialect
a unique set of discrete calls made by an individual whale and fellow pod members; dialects of most resident pods can be distinguished either by ear or with a sound analyzer.

discrete call
a type of communication vocalization that sounds the same each time it is produced; on average, resident pods produce about twelve different types of discrete calls.

echolocation
the process by which killer whales and other toothed cetaceans use vocalizations to obtain information about their surroundings; similar to SONAR, echolocation involves the production of rapid, high-frequency clicks that echo off objects in the whale's path.

eye patch
the elliptically-shaped white patch located above and behind a whale's eye.

flukes
the horizontal projections forming the tail of the whale.

hydrophone
an underwater microphone used to listen to and record whale vocalizations.

juvenile
an immature whale of either sex.

maternal genealogy
a family tree showing the ancestry of an individual through its mother's relatives; also known as a matriline.

matriarch
the eldest female in a matrilineal group, pod, or subpod.

matriline
the basic social unit of resident killer whales, composed of a mature female and her immediate descendants; descendants may include mature males and mature daughters and their offspring.

offshore killer whales
a little-known population of killer whales, found mostly in offshore waters off British Columbia; appear to travel in generally larger groups than residents or transients.

pod
one or more matrilines that usually travel together; term relevant only to resident whales.

resident killer whales
a form of killer whales that feeds preferentially on fish, especially salmon, and has a very stable social structure.

saddle
the grey pigmented area at the posterior base of the dorsal fin.

sprouter
an adolescent male whose fin is undergoing a rapid spurt of growth.

spyhop
a behaviour where a whale raises its head vertically above the water, then slips back below the surface; a spyhop seems to be a means of obtaining a view above the surface.

transient killer whales
a form of killer whales that feeds preferentially on marine mammals and has a looser social structure than that of residents; transients also differ from residents in dorsal fin shape, group size, behaviour, and vocalizations.

whale encounter
an occasion when one or more identifiable individuals have been located.

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Videos

Island of Whales (National Film Board, Vancouver, 1989)
Killer Whales: Wolves of the Sea (National Geographic Society, Washington, DC, 1993)
These films contain accurate natural history information and scenes of killer whales in British Columbia and other regions. They are available on videotape from the sources shown or from the Vancouver Aquarium Marine Science Centre (website: www.clamshell.org or P.O. Box 3232, Vancouver, BC V6B 3X8).

Sound Recordings

Blackfish Sound: Underwater Communication of Killer Whales in British Columbia (Vancouver Aquarium Research, 1992)
This recording features examples of pod dialects and vocalizations recorded during various activities of resident killer whales. It is available in CD or audio-cassette formats from the Vancouver Aquarium Marine Science Centre (website: www.clamshell.org or mailing address above) or from Holborne Distributing Co. Ltd., P.O. Box 309S, Mt. Albert, Ontario LOG 1MO).

Hydrophones

Reliable portable hydrophones, ideally suited to listening to killer whale sounds, can be obtained from Offshore Acoustics, 5454 Indian River Dr., North Vancouver, BC V7G 1L3 (website: www.offshoreacoustics.com).

Whale Adoption Programs

Programs to symbolically adopt whales are an interesting and popular way for people to learn about killer whales. At the same time, they provide funding for field research and conservation. Proceeds from the following two adoption programs directly support the annual photo-identification studies described in this book.

For northern resident and transient killer whales, contact:
BC Wild Killer Whale Adoption Program
Vancouver Aquarium Marine Science Centre
P.O. Box 3232
Vancouver, BC V6B 3X8
Phone: (604) 659-3430, fax: (604) 659-3515
Website: www.killerwhale.org

For southern resident killer whales, contact:
Orca Adoption Program
The Whale Museum
P.O. Box 945
Friday Harbor, WA 98250
Phone: (250) 378-4710, fax: (250) 378-5790
Website: www.whale-museum.org

Research, Conservation, and Education Organizations

The following organizations have programs in research, conservation, or public education involving killer whales.

British Columbia:

BC Parks, Strathcona District
Rathtrevor Beach Park
Parksville, BC VOR 2SO
Website: www.elp.gov.bc.ca/bcparks/

Johnstone Strait Killer Whale Interpretive Centre Society
P.O. Box 3
Telegraph Cove, BC VON 3JO

Orcalab
P.O. Box 258
Alert Bay, BC VON 1AO
Website: www.orcalab.org

Pacific Biological Station
Department of Fisheries and Oceans
Nanaimo, BC V9R 5K6
Phone: (250) 756-7245, fax: (250) 756-7053
Website: www.pac.dfo-mpo.gc.ca/sci/

Raincoast Research
Simoon Sound, BC VOP ISO

Sidney Museum
2440 Sidney Avenue
Sidney, BC V8L 1Y7
Phone: (250) 656-1322, fax: (250) 655-4508
Website: www.sidneybc.com/museum/

Marine Mammal Research Unit
Fisheries Centre
University of British Columbia
Vancouver, BC V6T 1Z4
Phone: (604) 822-8181, fax: (604) 822-8180
Website: www.marinemammal.org

Whale Research Lab
Department of Geography
University of Victoria
Victoria, BC V8W 2Y2
Phone: (250) 721-7344, fax: (250) 721-6216
Website: office.geog.uvic.ca/dept/whale/wrlmp.html

Vancouver Aquarium Marine Science Centre
P.O. Box 3232
Vancouver, BC V6B 3X8
Phone: (604) 659-3400, fax: (604) 659-3515
Website: www.killerwhale.org

Washington:

Center for Whale Research
P.O. Box 1577
Friday Harbor, WA 98250
Phone: (360) 378-5835, fax: (360) 378-5954
Website: www.rockisland.com/~orcasurv/

The Whale Museum
P.O. Box 945
Friday Harbor, WA 98250
Phone: (360) 378-4710, fax: (360) 378-5790
Website: www.whale-museum.org

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We are grateful to the friends and colleagues who have contributed photographs for this book. They are listed below.

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20 (top)	Jim Borrowman
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27 (bottom)	Graeme Ellis
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