Exxon Valdez Oil Spill
Restoration Project

Photographic and Acoustic Monitoring of Killer Whales in Prince William Sound and Kenai Fjords, Alaska

Restoration Project 01012
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report

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Photographic and Acoustic Monitoring of Killer Whales

STUDY HISTORY: The current project was initiated under Restoration Project 95012 (Initially "Comprehensive Killer Whale Investigations" now Photographic and Acoustic Monitoring of Killer Whales"). This is the seventh annual report for this study. Prior to the current year's work, killer whales were monitored in Prince William Sound, Alaska with funding from the *Exxon Valdez* Oil spill Trustee Council in 1989, 1990, and 1991 (Dahlheim, M.E. and C.O. Matkin, 1993) and in 1993 (Dahlheim 1994). The North Gulf Oceanic Society (NGOS) independently maintained a monitoring program in 1994. A peer reviewed 1995 annual report was submitted in April 1996 and annual reports without review comments addressed were submitted in spring 1997, 1998, 1999, 2000 and 2001. An assessment of the status of killer whales from 1984 to 1992 in Prince William Sound was published (Matkin et al. 1994). Feeding habit studies, geographic information system, and genetic studies were initiated in 1995 (95012a) and continued in 1996 (96012a) and 1997 (97012a). Journal articles describing killer whale movement and distribution (Matkin et al. 1997), resident pod genealogies and status of AB pod (Matkin et al 1999a), feeding habits (Saulitis et al 2000) and habitat use (Scheel et al 2001) have been published. Several other papers are in review.

ABSTRACT: Monitoring of killer whales (*Orcinus orca*) was continued in 2001 using photo-identification and acoustic methods. There were two calves recruited and one mortality in AB pod in 2001. AB pod now numbers 26 whales, but has not recovered to the prespill number of 36. Part of AB pod (AB25 subpod) still travels with AJ pod. Population modeling indicates that although the mortality rate in AB pod has remained higher than expected during recent years, the primary reason for the lack of recovery of the pod is the loss of reproductive potential due to the atypical death of reproductive females and juveniles at the time of the spill.

In the genetically unique AT1 transient group, the nine individuals missing since 1990, the two individuals missing since 1992, AT1 stranded in 2000 and AT10 possibly stranded in 2001 are presumed or known dead. Of these, the whales AT19, AT1, and probably AT10 were stranded and known dead. There has been no recruitment in this population since 1984 and no recovery from losses following the spill. Lack of recovery may be a result of several factors including high levels of contaminants (PCBs and DDTs), a region-wide continued decline in numbers of harbor seals (their primary prey), and the genetic/social isolation of the group.

Improved techniques have been developed for acoustic monitoring of whales in winter months. This has permitted tracking of AB, AJ pods and other pods during this period. Field recordings made in 2001 have augmented our acoustic catalogue to include AG and AF22 and AF5 pods and have increased our ability to identify pods by calls.

KEY WORDS: acoustics, biopsy, contaminants, *Exxon Valdez*, Geographic Information System, genetics, killer whales, photo-identification, *Orcinus orca*, Prince William Sound, Kenai Fjords, resident, transient.

PROJECT DATA: Identification data consists of frame-by-frame identifications of individual whales for all exposed films. These identifications are available on computer disk upon request approved by the *Exxon Valdez* Oil Spill Trustee Council from Craig Matkin, North Gulf Oceanic Society (NGOS), 60920 Mary Allen Ave., Homer, Alaska 99603, (907) 235-6590. All field observations, killer whale encounter data, vessel logs and tracklines are stored in a GIS system (Arc/Info) housed at Alaska Pacific University, Anchorage, Alaska (Contact David Scheel) or at U.S. Fish and Wildlife Service, Marine Mammals Management, 1011 Tudor Rd, Anchorage, Alaska. Contact Doug Burn. This data is now available for inspection and use with permission of NGOS.

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EXECUTIVE SUMMARY

Killer whales were monitored in Prince William Sound, Alaska with funding from the *Exxon Valdez* Oil Spill (EVOS) Trustee Council in 1989, 1990, and 1991 (damage assessment) and in 1993 (restoration monitoring). Monitoring was continued in 1995-1999 as part of the EVOS Trustee Council restoration program. The North Gulf Oceanic Society (NGOS) independently maintained a monitoring program in all other years since 1984 (Matkin, et. al. 1994). This report summarizes results of the monitoring of killer whales in Prince William Sound in 2001 using photo-identification and acoustic techniques. The goal of the photo-monitoring has been to obtain identification photographs of all whales in all major resident pods and the AT1 transient group on an annual basis. Photo-identification techniques (after Bigg, et. al. 1990) were used to identify individual whales. The current photographic database includes tens of thousands of frames of film collected from 1984-2001 and is used to provide individual identifications for each encounter with whales. Vital rates for AB pod and all other frequently sighted resident pods have been calculated annually based on the photographic data.

The total number of whales in the seven well-known resident pods other than AB pod has increased from 81 to 118 whales from 1988 through 2001, while AB pod has declined from 36 whales to 26 whales in that same time period. All resident pods other than AB pod have all increased or remained stable since 1984. From 1995 to 2001, AB pod has had a net increase of four individuals, due to recruitment of nine calves and five mortalities. Eight members of the pod (AB25 subpod) still appear to travel with AJ pod a majority of the time, although they maintain their AB pod vocal dialect. Although recruitment rates for AB pod now meet or exceed those of other pods and there are nine reproductive females in the pod, recovery has been hindered by unexpected mortalities. The primary reason for lack of recovery, however, has been the loss of females and juveniles at the time of the spill, resulting in a loss of potential reproduction.

Encounter data for the AT1 transient group (a genetically unique population) was used to update sighting histories for this group in 2001. Despite substantial field effort, the number of AT1 whales sighted each year has declined following 1989 and remains consistently half or less of what it was prior to the spill. We are confident that 12 and possibly 13 of the original 22 whales in the AT1 group have died since the spill. The rate of encounter with members of this group also has declined significantly since 1989. Eight

of the nine known surviving AT1 whales were photographed in 2001. One member of the AT1 group, a young mature male (AT10), apparently stranded and died on Hinchinbrook Island, PWS in late June 2001. Listing of the AT1 group under the ESA or MMPA remains a possibility.

Acoustic monitoring relies on a catalogue of distinct pulsed calls for each resident pod, the AT1 group, and the Gulf of Alaska transients collected from 1984 to 2001. Distinct pod/population repertoires allow identification from recordings collected by remote hydrophones. During winter 2000-2001, a remote hydrophone was operated in Resurrection Bay using a microwave transmission system powered by wind and solar electrical systems and monitored in Seward. Recordings determined that AB, AJ, AN10 and AT1s used the region in fall/winter.

Vessel tracks and maps of whale movements have been logged into a GIS database. Data entry into this database has been completed for all NGOS killer whale records from 1984 to 2001, including a total of 1,978 boat-days of search effort and 914 encounters with whales. In 2001, the GIS database was archived at both Marine Mammal Management, U.S.F.W.S. Anchorage, Alaska at Alaska Pacific University, Biology Department (Dr. David Scheel), Anchorage, Alaska.

Biopsy tissues from free ranging whales were collected on an opportunistic basis in both the Bering Sea and Prince William Sound/Kenai Fjords using a biopsy dart system developed by Barrett-Lennard, et. al. (1996). Preliminary contaminant analysis was conducted on blubber samples collected from the two regions and again indicates very high levels of PCBs and DDTs in the transient whales, from the Bering Sea as well as Prince William Sound.

INTRODUCTION

On March 31, 1989, a week after the *Exxon Valdez* Oil spill (the spill), the AB pod of resident killer whales was observed traveling through oil sheens in western Prince William Sound, and six members of the pod were missing. In the two years following the spill, a total of 14 whales were lost, and there was no recruitment into AB pod. The rate of mortality observed in this pod after the oil spill (19% in 1989 and 21% in 1990) exceeds by a factor of 10 the rates recorded over the past 11 years for the other resident pods in Prince William Sound or over the past 20 years for 19 resident pods in British Columbia and Washington State (Balcomb, et. al. 1982, Bigg 1982, Olesiuk, et. al. 1990, Matkin, et. al. 1994). Following the spill, the social structure within AB pod demonstrated signs of deterioration. Subgroups traveled independently of the pod, and pod members did not consistently travel with closest relatives. The pod was observed less often; prior to the spill, AB pod was the most frequently encountered resident pod in Prince William Sound (Matkin, et. al. 1994). Although AB pod shows a net gain of 4 whales from a low of 22 whales in 1995, it still contained only 26 whales in 2001. There were 36 whales in AB pod in fall 1988 prior to the spill.

No individual resident whale missing during repeated encounters with its maternal group over the course of a summer season has ever returned to its pod or appeared in another pod in all the years of research in Canada and the United States. Subgroups of resident pods may travel separately for a season or longer; however, this has not been observed for individuals. In a few instances, missing whales have been found dead on beaches, but strandings of killer whales are infrequent events and most missing whales are never found. During 1975 to 1987, only six killer whales were found on beaches throughout the entire Gulf of Alaska (Zimmerman 1991). One explanation for the lack of stranded killer whales comes from the observations of early Soviet researchers. Killer whales that were shot for specimens were reported to sink (Zenkovich 1938).

Immigration and emigration may occur among groups of transient whales. In British Columbia, infrequently sighted transients missing from their original groups for periods ranging from several months to several years or more have been resighted swimming with other groups of transient whales (Ellis unpub. data). For this reason, transient whales missing from a particular group over only several years cannot necessarily be considered dead.

Eleven of the 22 whales from the transient AT1 group have not been observed or photo-documented for at least 9 years despite extensive field effort. While mortalities in transient groups cannot be confirmed with the same certainty as for residents, AT1 transients have not been observed in adjacent regions, and in light of sighting records prior to the spill, it is most likely they are dead. Most of these whales (9 of 11) disappeared the year of or the year following the spill. Additionally, two AT1 whales have stranded and died including AT1 (an older adult male in 2000) and AT10 (a young adult male tentatively identified in 2001)

The AB pod and AT1 group appear to have been injured due to the effects of the *Exxon Valdez* oil spill and neither has recovered. Numbers of whales in other well-documented resident pods have increased following the spill. Annual photographic monitoring has been the most effective tool in determination of the recovery status of AB pod and the AT1 group and the status of the entire Prince William Sound killer whale population (Matkin, et. al. 1994). This project continues using photo-identification to monitor changes in resident killer whale pods (including AB pod) and the AT1 transient group in Prince William Sound/Kenai Fjords.

Previous projects examined predation parameters using historical killer whale sighting and behavioral data in a geographic information system (GIS) framework. Predation by killer whales may be a factor in the non-recovery of harbor seals in Prince William Sound following the *Exxon Valdez* oil spill. The decline of harbor seals may also be a factor in the non-recovery of the AT1 group of transient killer whales. At least 300 harbor seals were killed at the time of the spill and the harbor seal population does not show signs of recovery from a decline that began before the spill. Of the two types of killer whales in Prince William Sound, only one, the transient, has been observed preying on marine mammals. Observation of predation and collection of prey remains has indicated harbor seals and Dall's porpoise are the primary food items of AT1 transient killer whales, at least from April to October. These results have been incorporated into models of harbor seal population dynamics (project 064, seal trophics). Coupled with subsistence hunting (350+ seals per year), predation by killer whales could have a significant impact and inhibit the recovery of harbor seals. Current observations of healthy pups and low recruitment rates for harbor seals would seem to support this hypothesis (K. Frost, pers. comm.). Resident killer whales appear to select coho salmon from mixed schools during the July to September period (Saulitis, et.al. 2000) and have been observed preying on Chinook salmon in the May to June period.

A geographic information system (GIS) database was designed and the data from 1984 to 1999 entered into a computer from hand-written data sheets. Sighting records provide considerable behavioral information (travel rates, duration of feeding bouts, etc.). Location of encounters and basic behavioral information (resting, feeding, traveling, etc.)

are available for each sighting. It has been a goal of the GIS project to provide a systematic and easily accessible storage system for geographically referenced data generated by this ongoing project since 1984. The system can be used to address questions of interest to restoration management, and to examine the distribution of whale groups over time in Prince William Sound/Kenai Fjords. Data analysis has provided detailed demographics and spatial distributions of resident and transient killer whales (Scheel, et. al. 2001)

Killer whales are found regularly in Alaskan waters, but only a few locations allow acoustic tracking of animals for purposes of group identification and community assessment. Ambient and anthropogenic noise in some areas precludes use of remote hydrophones and may also interfere with the whales' ability to communicate or hunt and may cause avoidance of those areas. Some parts of Prince William Sound and Kenai Fjords, Alaska are relatively acoustically pristine and allow tracking of killer whales by calls. Since the mid-1980s, during systematic field studies of killer whales of this area, we have opportunistically recorded killer whale vocalizations while identifying individuals photographically. As a result, a relatively large number of acoustic recordings exist in addition to photo-identification pictures of killer whales. Acoustic analysis supports separation of populations described by genetic analysis and demonstrates resident pod specific dialects and acoustic clans, which make possible identification and enumeration of whale pods and groups from calls collected via remote hydrophone stations.

Past projects have examined the separation of marine mammal-eating transient and fish-eating resident killer whales using behavioral data and genetic analysis. Genetic samples were obtained from 103 identifiable whales. Samples were collected using lightweight biopsy darts (Barrett-Lennard, et. al. 1996). The genetic analysis used both mitochondrial DNA (mtDNA) and nuclear DNA microsatellites to separate populations and examine breeding systems. MtDNA evolves quickly, is only passed through the maternal line, and provides a faithful record of female lineages over long periods. MtDNA is considered an appropriate marker for distinguishing well-established populations. Microsatellite analysis has also provided further delineation of populations and examined male mediated breeding patterns (Barrett Lennard 2000).

Contaminant analysis has been completed on blubber tissue collected simultaneously with the genetic samples. The National Marine Fisheries Service Environmental Contaminant Laboratory in Seattle, Washington conducted the analysis using a rapid high-performance liquid chromatography/photodiode array (HPLC/PDA) method. This method has proven accurate in the analysis of very small blubber tissue samples. Patterns in contaminant accumulation suggest the importance of reproductive status and genealogy in determining contaminant levels. Contaminant levels in transient killer whales were 15 to 20 times higher than in resident whales. They are comparable or exceed levels in other marine mammal populations believed to have been negatively impacted by contaminants.

OBJECTIVES

1. To monitor changes in AB pod, the AT1 transient group and the other major resident pods in Prince William Sound.

2. To identify individual whales photographed on a frame-by-frame basis and complete entry of identification data for 2001 into a photographic database.

3. To complete input of observational data for 2001 into the specially designed GIS system and database housed at Alaska Pacific University and U.S. Fish and Wildlife Service, Anchorage, Alaska.

4. To expand our population dynamics analysis/modeling using data from southeastern Alaska residents and Prince William Sound/Kenai Fjords residents and complete analysis in preparation for publication.

5. To address review comments on paper submitted on the behavior and acoustics of the unique AT1 group.

6. To continue analysis of acoustic data collected from 1984-2001 and develop dialect information for AG and AF pods and to interpret data collected from remote hydrophone in 2000-2001.

7. To continue monitoring killer whales via remote hydrophone system in Resurrection Bay during the fall/winter 2001/2002

FIELD METHODOLOGY

Fieldwork for the 2001 photo-identification study was done aboard the *R/V Natoa,* a 10.3 m inboard diesel powered vessel, capable of 18 knots and sleeping 4 researchers. The vessels operated in both the Kenai Fjords and Prince William Sound region. The twin diesel powered 42' *Mariah* and sister vessel *Misty* were used primarily in conjunction with the Youth Area Watch program in mid May.

Researchers on the *R/V Whale 1* (a 7.8 m light motor-sail vessel with 50hp outboard) also photographed killer whales and kept vessel logs and encounters sheets during surveys primarily directed at humpback whale photo-identification. The daily vessel logs and killer whale encounter sheets for this vessel were included in the GIS database and used in our analysis

Researchers attempted to maximize the number of contacts with each killer whale pod based on current and historical sighting information to insure sufficient photographs of each individual within the pod. Consequently, searches were centered in areas that had produced the most encounters with killer whales in the past, unless sighting information indicated changes in whale distribution. Whales were found visually, or by listening for killer whale calls with a directional hydrophone, or by responding to VHF radio calls from other vessel operators. Regular requests for recent killer whale sightings were made on hailing Channel 16 VHF. In Kenai Fjords, Channel 77 was also monitored. An encounter was defined as the successful detection, approach and taking of identification photographs. Accounts of whales from other mariners (generally by VHF radio) were termed "reports". Although reports were used to select areas to be searched, all identifications were made from photographs taken during encounters. Photographs for individual identification were taken of the port side of each whale showing details of the dorsal fin and saddle patch. Photographs were taken at no less than 1/1000 sec. using Fuji Neopan 1600 high-speed black and white film. A Nikon N70 auto focus camera with internal motor drive and a 300mm f4.5 auto focus lens was used. When whales were encountered, researchers systematically moved from one subgroup (or individual) to the next keeping track of the whales photographed. If possible, individual whales were photographed several times during each encounter to insure an adequate identification photograph. Whales were followed until all whales were photographed or until weather and/or darkness made photography impractical.

A vessel log and chart of the vessel track were kept for each day the research vessels operated. Similar logs were kept for all previous study years and have been placed in a GIS format and used to estimate effort (Scheel et al 2001). On these logs, the elapsed time and distance traveled were recorded. Vessel track was plotted and record was made of time and location of all whale sightings and weather and sea state noted at regular intervals.

Specifics of each encounter with killer whales were recorded on standardized data forms that have been used since 1984. These forms were modified in 1995 to improve collection of data for GIS input (Matkin, et. al. 1996). Data recorded included date, time, duration, and location of the encounter. Rolls of film exposed and the estimated number of whales photographed also were recorded. A chart of the whales' trackline during the encounter was drawn and the distance traveled by the vessel with the whales calculated. Specific group and individual behaviors (i.e. feeding, resting, traveling, socializing, milling) were recorded by time and location when possible. Encounters with whales averaged from 2-5 hours, providing considerable behavioral information (travel rates, duration of feeding bouts, etc.).

Directed observations of feeding behavior and identification and collection of killer whale prey were made when possible during the 2001 fieldwork. Only events that provided positive evidence of a kill were categorized as predation. Evidence included prey observed in the mouth of the whale, bits of hair or other parts, or oil slicks with bits of blubber. Incidents of harassment of potential marine mammal prey were also recorded. This included instances where evidence was not observed but a kill was suspected or when potential prey exhibited fright or flight response or other strong behavioral reaction to killer whales. Harassment was demonstrated by behaviors such as flipper slapping and lob tailing by humpback whales and fleeing behavior by small cetaceans, pinnepeds or mustelids. When predation on fish was observed, scales from the site of fish kills were collected and later identified by species. Scales were individually mounted and identifications were made by the fish scale and aging laboratory at the Pacific Biological Station, Nanaimo, B.C. Canada. Fish scales and marine mammal remains were collected with a fine mesh net on an extendible handle (5 m. maximum extension). The pod or group of killer whales and specific individuals present at the kill or harassment incidents were recorded on the encounter data sheets.

Biopsy samples were collected on an opportunistic basis in 2001 using a pneumatic rifle and custom-designed biopsy darts (Barrett-Lennard, et. al. 1996). A small dart was fired from a specially outfitted rifle powered by air pressure from a .22 caliber blank cartridge. The setup is similar to that used to deliver tranquilizing drugs to terrestrial mammals in wildlife research. A lightweight plastic and aluminum dart (approx. 10cm long by 1.2cm dia.) was fitted with a beveled tubular sterile stainless steel tip that took a small core of skin and blubber (approximately 1.6cm long and 0.5cm dia.).

The sterilized dart was fired from a range of 16-20m. The dart struck the animal in the upper back, excised a small tissue sample, bounced clear of the whale, and floated with sample contained until retrieved with long handled net.

From the biopsy samples, the epidermis, which is heavily pigmented, was separated aseptically from the other layers with a scalpel soon after retrieval. The dermal sample, the source of DNA, was stored at about 4 deg C. in a sterile 1. ml cryovial containing 1. ml of an autoclaved solution of 20% DMSO and 80% sodium chloride saturated with double distilled water (Amos and Hoelzel 1991). The dermis and hypodermis were made up primarily of collagen and lipid, respectively, and were frozen at -20C in autoclaved, solvent-washed vials for contaminant analysis. Contaminant analysis was conducted by the National Marine Fisheries Service, Environmental Contaminant Laboratory in Seattle, Washington using a rapid high-performance liquid chromatography/photodiode array (HPLC/PDA) method. This method has proven accurate in the analysis of very small blubber tissue samples.

Acoustic recordings were made using an Offshore Acoustics omnidirectional hydrophone in combination with Sony Walkman professional tape recorder. The hydrophone had a flat frequency response to signals ranging from 100Hz to 25 kHz. The tape recorder showed a flat response to signals up to 15kHz.

POPULATION STATUS

Introduction

Population monitoring of killer whales in Prince William Sound and adjacent waters has occurred annually since 1984. The existence of pre-spill data made it possible to determine that resident AB pod and the AT1 transient group have declined following the Exxon Valdez oil spill and are not recovering. This project continues using photo-identification to monitor changes in resident killer whale pods and groups including AB pod and the AT1 transient group in Prince William Sound/Kenai.

Methods

Photographic Analysis

All photographic negatives collected during the fieldwork were examined under a Wild M5 stereomicroscope at 9.6 powers. Identifiable individuals in each frame were recorded. When identifications were not certain, they were not included in the analysis. Unusual wounds or other injuries were noted.

The alphanumeric code used to label each individual was based on Leatherwood, et. al. (1984) and Heise, et. al. (1992) and has been continued in the latest catalogue of southern Alaska killer whales (Matkin, et. al. 1999c). The first character in the code is "A" to designate Alaska, followed by a letter (A-Z) indicating the individual's pod. Individuals within the pod receive sequential numbers. For example, AB3 is the third whale designated in AB pod. New calves were identified and labeled with the next available number.

Individual identifications from each roll of film were computerized on a frame-by-frame basis using a specially designed data entry program. From this photographic database, the actual number of whales identified and pods of whales present for each encounter was determined and included with each encounter entered in the GIS database.

Calculation of Vital Rates

Most new calves were already present at the beginning of the field season and exact birth dates could not be determined. We followed the method of Olesiuk et. al. (1990) and placed the birth of all calves in January for calculation of vital rates. Thus, birth rates could not be measured, and recruitment rates represent the survival of calves to about 0.5 years of age. The determination of mothers of new calves was based on the consistent close association of calves with an adult female (Bigg, et. al.1990, Matkin, et. al. 1999a).

If a whale from a resident pod is not photographed swimming alongside other members of its matrilineal group during repeated encounters over the course of the summer field season it is considered missing. If it is again missing during the repeated encounters in the following field season it is considered dead (Bigg, et. al. 1990, Matkin, et. al. 1994, Matkin, et. al. 1999a,b).

Finite annual mortality rates (MR) and reproductive rates (RR) for resident pods were calculated as follows:

where: NM = number of whales missing from a pod in a given year
NP = number of whales present in a pod at end of the previous year
NR = number of calves recruited to 0.5 years in a pod in a given year

then: Mortality rate = NM/NP and Reproductive rate = NR/NP

If the year a mortality or recruitment occurred could not be determined, it was split between the possible years. A mean weighted mortality and reproductive rate for all pods for all years was determined by pooling the data

The sex and age class of missing whales were determined from data collected prior to their disappearance when possible. In some cases sex had been determined by viewing the ventral side of the whale. Reproductive females were identified by the presence of an offspring. Whales of adult conformation at the beginning of the study that had not calved since 1983 and were not accompanied by a juvenile(s) were considered as possibly post-reproductive. Exact ages of whales could be determined only for whales born since 1983. Juveniles born before 1984 were given approximate ages by comparing the relative size of the whale and development of saddle patch and dorsal fin in photographs from 1984. Males are readily identified at about 15 years of age as their dorsal fin grows taller and less falcate than females at that time. At sexual maturity, fin height will exceed width by at least 1.4 times (Olesiuk, et. al. 1990). The fin continues to grow until physical maturity (about 21 years of age).

Sighting data for individual transient killer whales was recorded. The cumulative number of different AT1 individuals was plotted against effort (days in the field) for the 2000 season and compared with similar data averaged for 1984-89 and 1990-1995. AT1 whales that had not been resighted for 6 or more years were considered dead.

Results

In 2001 the 34' diesel powered *R/V Natoa* completed a total of 54 survey days in the Kenai Fjords/Prince William Sound region. The 26' high-speed motor sailer *Whale 1* completed 22 survey days in Prince William Sound, with the primary objective of humpback whale photo-identification. The 42' diesel powered high-speed charter vessel *Misty/Mariah* completed 4 survey days, and the similar *Renown* completed 2 survey days and the 38' diesel powered *Emanuel* completed 4 dedicated survey days. . Effort was divided between the Kenai Fjords and Prince William Sound areas (Figure 1, page 12).

Researchers were on the water a total of 87 days (31 in Prince William Sound) and traveled a distance of 7930 km searching for and traveling with whales

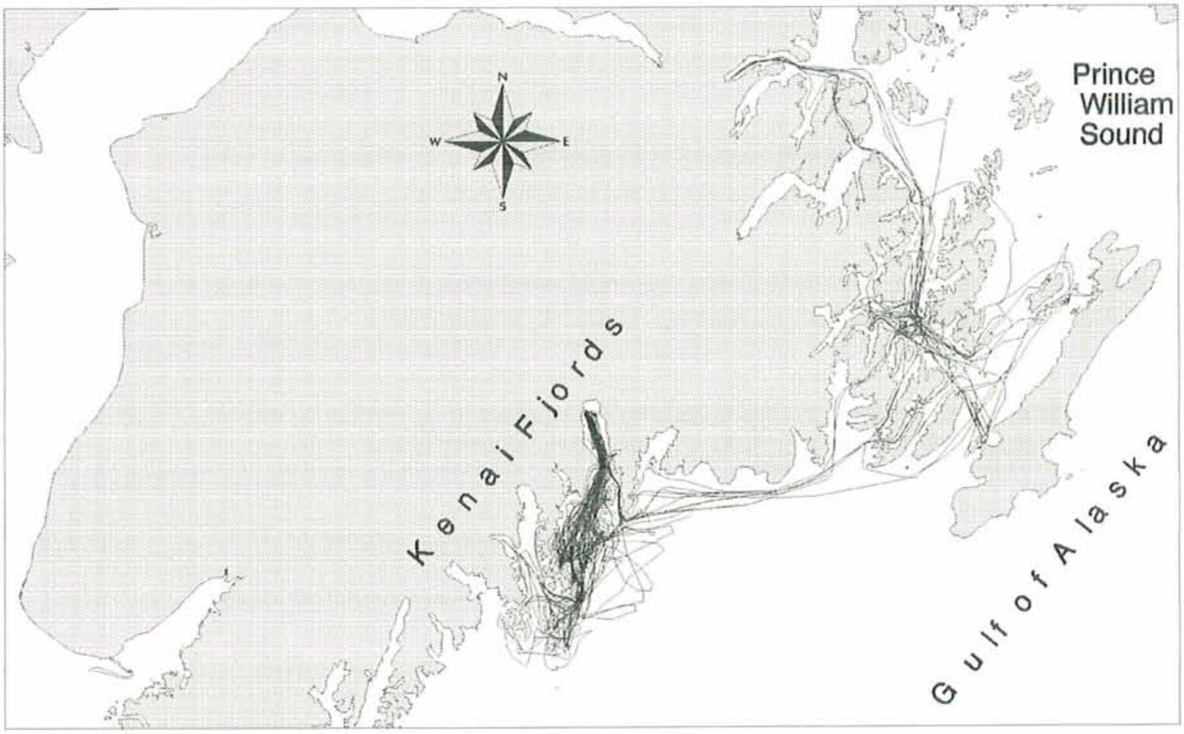
Table 1. Effort by vessels in 2001.

Vessel	# Days	Distance(km)
Natoa	54	5334
Whale 1	22	1750
Emanuel	4	89
Misty/Mariah	4	542
Renown/Viewfinder	2	189
Skiff	1	26
Total	**87**	**7930**

Killer whales were encountered on 59 occasions in 2001 (including one encounter in Kachemak Bay) (Table 2). Researchers traveled 937 km with killer whales.

Table 2. Encounters with killer whales by vessel in 2001

Vessel	# Encounters	Distance (km)
Natoa	39	769
Whale 1	7	35
Emanuel	4	44
Mariah/Misty	6	61
Renown/Viewfinder	2	19
Skiff	1	9
Total	**59**	**937**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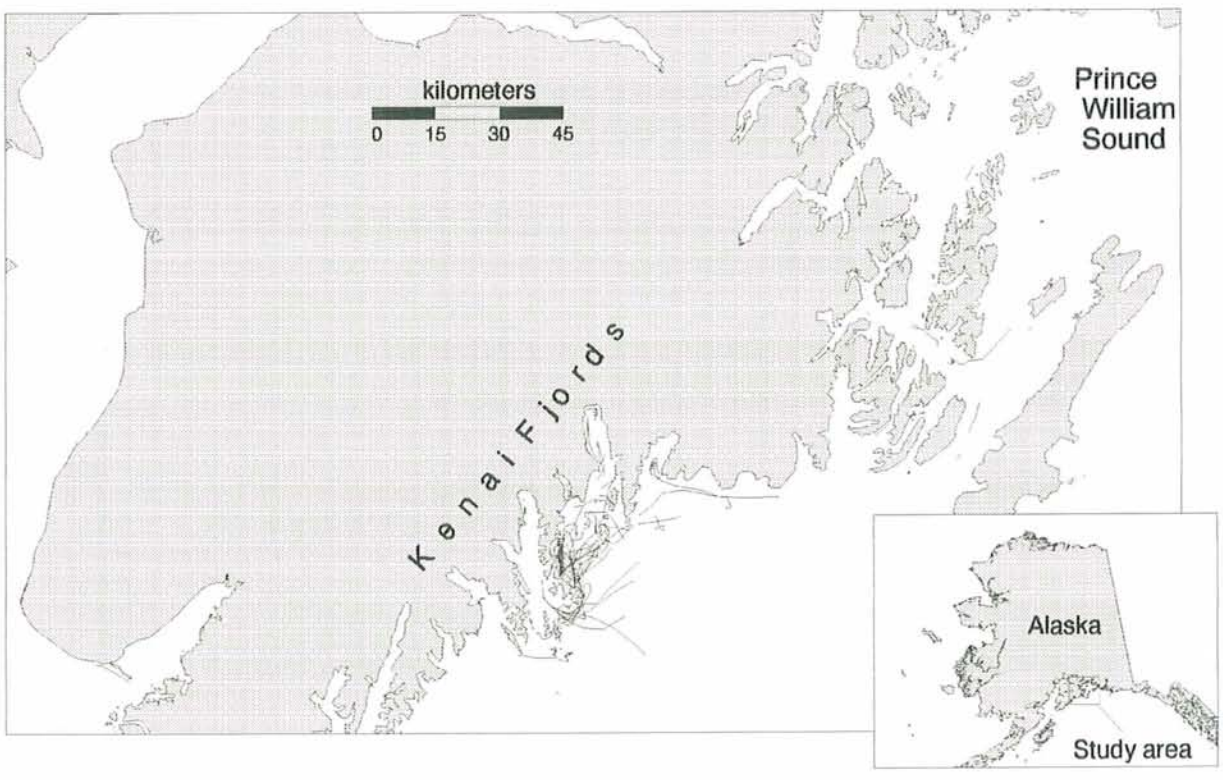

kilometers
0 15 30 45
Prince William Sound
Kenai Fjords
Alaska
Study area

In 2001 there were 47 encounters with resident killer whales and one encounter with unknown "probable" residents. There were only five encounters with members of the AT1 transient group, and six encounters with known or probable Gulf of Alaska transients (Table 3, page 14).

Overall we had more encounters (59) in 2001 than in 1997 (50), 1998 (48) 1999 (50) or 2000 (44). This was due primarily to the very high encounter rate for residents in May and early June in Kenai Fjords which averaged over one encounter per field day. In Prince William Sound we had a total of 8 encounters. Encounter rates were considerably lower in Prince William Sound than in Kenai Fjords in 2001; however, the encounter rate in Prince William Sound was over three times higher in 2001 than in 1999. In 2001 in Kenai Fjords, there were 50 killer whale encounters during 55 vessel days for an average of 0.91 encounters/day compared to an average of 0.68, 0.71, 0.63, and 0.79 encounters per day in 2000, 1999, 1998 and 1997 respectively. This was the highest overall encounter rate we have recorded in Kenai Fjords. In Prince William Sound in 2001, there were eight killer whale encounters in 31 vessel days or 0.26 encounters per day compared to 0.33, 0.09, 0.29, and 0.14 encounters per day in 2000, 1999, 1998 and 1997, respectively. The encounter rate for all areas of 0.70 encounters per day was substantially higher than the 0.53, 0.51 and 0.49 encounters per day for 2000, 1999 and 1998, respectively and was the highest overall rate we have recorded to date and was do to the exceptionally high number of encounters in the May-June period.. In 2001, for the first time, we recorded 5 superpod encounters in late May and early June in Kenai Fjords. Participating pods included the infrequently seen AS and AY pods as well as a new pod (AH1) and the well known AD05, AD16 and AK pods. In 2001 we had only 3 encounters with three or more resident pods ("superpods") from late July to September (Table 3) as was the case in 2000. This is far fewer superpod encounters than in some previous years. However, superpod aggregations were reported during early September by transiting vessels 8-12 miles offshore between Kenai Fjords and Prince William Sound. Unfortunately, sea conditions in this open ocean area were not conducive to photoidentification work during much of this period.

Encounters with transient whales were rare (0.12 encounters/day) and scattered throughout the season. This rate was comparable to the 0.09, 0.10 and 0.07 encounters per day with transients in 2000, 1999, and 1998, respectively. This includes several encounters with AT109 (Matushka) who repeatedly patrolled the Chiswell Island rookery in the late July and August period and was observed killing at least one Steller sea lion.

Table 3. Summary of 2001 Encounters with Killer Whales in Prince Willliam Sound (PWS) and Kenai Fjords (KF)

DAY/MO/YR	BEGIN LOCATION	END LOCATION	PODS	REGION	#WHALES	RECORDING?
5-Jan-01	2.5 mi N of Caines Head	1 mi NE of Caines Head	AB25,AJ	KF	47	N
25-Jan-01	1 mi NW can off Homer Spit	1 mi W of Bishops Bch	AG	KBAY	30	N
27-Jan-01	.25 mi S of RR dock	0.5 mi S Harbor	AC22,23,24	KF	3	N
5-Mar-01	S end of Lowell Point	2.8 mi s of Lowell Point	AT13?AT17?	KF	2	N
10-Apr-01	S end of Lowell Point	1.2 mi W of Thumb Cove Pt	AD5	KF	14	N
24-Apr-01	Head of Resurrection Bay	2 mi S of head of R Bay	AD5	KF	14	N
12-May-01	1 mi S Rugged Island	1 mi N Natoa	AD5	KF	14	N
14-May-01	3 MI S of Shiplift	Beach betw. Calisto & Caines	AK	KF	6	N
14-May-01	1 mi N Chevall	3 mi E Chevall	AD5	KF	14	N
15-May-01	1.5 mi SE Porcupine	1.5mi N Cheval Is	AD5	KF	14	N
16-May-01	Chevall Narrows	E Side Chevall Island	AK	KF	6	N
16-May-01	Mouth of Agnes Bay	4 mi N of Agnes Bay	AD5	KF	14	N
17-May-01	Pony Cove	N end Chevall Narrows	AD5	KF	14	Y
18-May-01	.5 mi NE No Name Island	S end Chevall Narrows	AD5	KF	14	N
18-May-01	S end Chevall Narrows	2.5 mi E Natoa	? probable residents	KF	6	N
18-May-01	2.5 mi N Chevall	.5 mi N Chevall	AD16	KF	6	Y
19-May-01	Mouth Agnes Bay	Bay just N of Agnes	AD5	KF	14	Y
24-May-01	Pony Cove	Mouth Agnes Bay	AD5	KF	14	N
24-May-01	B/t Bear Cove & 3 Hole Bay	Just N of Bear Cove	AK	KF	6	N
25-May-01	NW side Chat Island	S end Dora Passage	AH20, AD16	KF	18	N
29-May-01	Off Cape Resurrection	Cove N of Bulldog Cove	AY,AH1,AD5,AD16,AK	KF	54	Y
30-May-01	1.25 mi N of Chevall	N end Pete's Pass	AY,AH1,AD16	KF	27	Y
30-May-01	Agnes Bay	same	AD5	KF	14	N
31-May-01	Mid Chevall Narrows	Mouth Agnes Bay	AY,AH1,AD5,AD16,AK	KF	54	N
2-Jun-01	Cove S of Porcupine	2.5 m S Porcupine	AK	KF	12	Y
2-Jun-01	N of Chiswell Island	S side Granite Island	AX	KF	19	N
4-Jun-01	Off Sunny Cove	2.5 mi S Bear Glacier	AK	KF	12	N
5-Jun-01	B/t Hive & Fox	B/t Porcupine & Agnes	AY,AS,AK,AX,AD16+	KF	61+	Y
6-Jun-01	E side No Name Island	4.5 mi S Rugged Island	AS,AY,AX	KF	56+	N
6-Jun-01	Sunny Cove	2 mi W Halibut Cove	AD16,AK	KF	18	Y
7-Jun-01	2 mi N Agnes	Cape Aialik	AD16,AK	KF	18	N
13-Jun-01	2 mi S Mary's Bay	5mi SE of Cape Res.	AX	KF	12	N
14-Jun-01	Agnes Bay	Outside Rugged Island	AD5	KF	14	Y
26/6/2001	Squire Rock	same	AT105,122,123	PWS	5	N
27/6/2001	Mid KNIP off Mummy Bay	same	AT6	PWS	1	N
1-Jul-01	KNIP Lower Passage	Upper Passage	AE	PWS	18	Y
11-Jul-01	S of Dutch Group Islands	same	AB	PWS	17	N
16-Jul-01	S end Montague Strait	same	AI, AD16	PWS	12	N
17-Jul-01	Lower Knight Is Passage	S end Prince of Wales Pass	AI, AK	PWS	13	N
23-Jul-01	2 mi S McMullen Cove	.5 mi S Holgate Arm	AT2,3,4,6	KF	4	N
23-Jul-01	N end Natoa	E side No Name	AY,AD16	KF	19	N
24-Jul-01	Off Three Hole Point	4 mi SE Pilot Rock	AT2,3,4,6	KF	4	N
26-Jul-01	3.4 mi E Cape Resurrection	4.5 SE Cape Resurrection	AT9, 18	KF	2	N
29-Jul-01	Off Little Bay	2 mi S L. Green Island	AB	PWS	17	N
4-Aug-01	6 mi E Cape Resurrection	1 mi E Cape Resurrection	AI	KF	6	N
6-Aug-01	1 mi NE Grotto	6 mi SE Barwell	AG	KF	30	N
7-Aug-01	Chiswell Island	same	AT109	KF	1	N
7-Aug-01	1 mi SE Rugged Island	N end Pete's Pass	AG,AI,AW	KF	38	Y
8-Aug-01	B/t Barwell & Hive	Just S Calisto	AJ (partial)	KF	22	Y
9-Aug-01	1 mi NE Rugged Island	1 mi S Rugged Island	AJ (partial)	KF	22	N
18-Aug-01	B't Barwell & Cape Res	1 mi S Mary's Bay	AB,AJ	KF	64	N
19-Aug-01	.5 mi N Mary's Bay	1 mi NE Halibut Cove	AB,AJ	KF	64	N
22-Aug-01	Chiswell Island	same	AT109	KF	1	N
23-Aug-01	Chiswell Island	same	AT109	KF	1	N
25-Aug-01	Montague Strait	same	AN10	PWS	24	N
31-Aug-01	Chiswell Island	same	AT109	KF	1	N
2-Sep-01	3 mi NE Cape Res	4 mi SW Cape Junken	AN10,AK,AJ	KF	74	N
3-Sep-01	3 mi S Cape Fairfield	Day Harbor	AN10,AK,AJ,AB25	KF	82	Y
19-9-01	1 mi NW Cliff Bay	2.5 mi SE Cape Aialik	AJ+ (visual)	KF	38+	N
	Total encounters: 59 Kenai Fjords: 50 Prince William Sound: 8 Kachemak Bay:1					

Resident pods

The total number of whales in the 7 well-known resident pods that we have monitored since 1984 increased from 81 to 118 whales from 1988 through 2001, while AB pod declined from 36 whales to 26 whales in that same time period (Figure 2). All well known resident pods have increased or are at the same numbers as in 1984 except AB pod (Figure 3). Three resident pods, (AG, AF05, and AF22) that apparently center their range in southeastern Alaska also increased in number during this period. They totaled 47 whales in 1988 and 85 whales in 2001 (Figure 2).

From 1995 to 1998, AB pod showed a net increase of three individuals, due to recruitment of five calves and two mortalities. In 1999 AB pod decreased to 24 whales due to two mortalities and the recruitment of one calf. There was one recruited calf and no mortalities in AB pod in 2000. In 2001 we observed two new calves and one new mortality, all in the AB25 subpod which travels with AJ pod. The whale AB57 was a new calf to AB33 (2001) and AB58 was a new calf to female AB25. The mortality, AB51 (born in 1996) was the juvenile offspring of AB25. The total number of whales in AB pod is now 26.

Members of AB pod were encountered on only 6 occasions in 2001. The entire pod (both the AB17 and AB25 subpods) was encountered and photographed only once, on August 18 in Kenai Fjords. The first encounter with the pod was on 5 January, and they were last photographed on 3 September. The AB25 subpod was not encountered without AJ pod present in 2001. As has been the case in recent years, AB pod was not present during most of the summer field season (May, June and July).

In 2001 our first encounter with AJ pod was on January 5 when they were traveling with AB pod in Resurrection Bay, and our last encounter was on September 3 in Kenai Fjords. In the 7 encounters with AJ pod in 2001, the AB25 subpod was present in 4, while the remainder of AB pod was present in 2. This has been the typical pattern since the oil spill. AJ pod is currently the largest well-documented resident pod with 38 members. In over half the encounters only part of AJ pod was recorded as present; a subpod numbering 23 individuals. This subpod includes the AJ14, AJ23, AJ18, AJ20 matriline.

A total of nine new calves were recruited into the well-known resident pods other than AB pod in 2001 (Table 4, page 17), the largest number recorded in a single year. These were AJ 46, calf of AJ27; AJ47 calf of AJ28; AK17 calf of AK6; A57 calf of AN10; AN58 calf of AN12, AN59 calf of AN35, AN60 calf of AN41; and AD34, calf of AD11 and AD35 calf of AD8. There were no new mortalities in these pods. AE pod was not included in this analysis because of incomplete identification of individuals in the pod.

Mortalities observed in 2000 were confirmed in 2001 for all pods. Births and deaths are listed by pod for 1984-2001 in Table 4 and annual mortality and recruitment rates are listed in Table 5 (page 18).

Fig. 2. The number of killer whales in AB pod, in seven other Prince William Sound pods, and in three Southeastern Alaska pods.
<u>1984-2001</u>

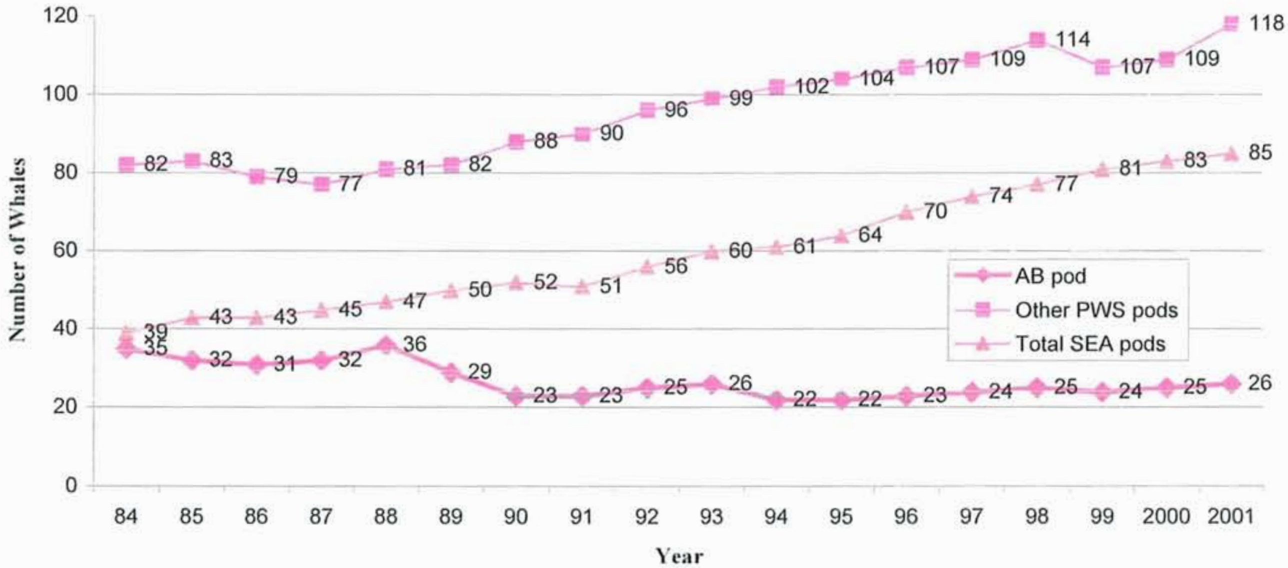


Figure 3. Number of whales in AB pod and in seven other major resident pods
1984-2001

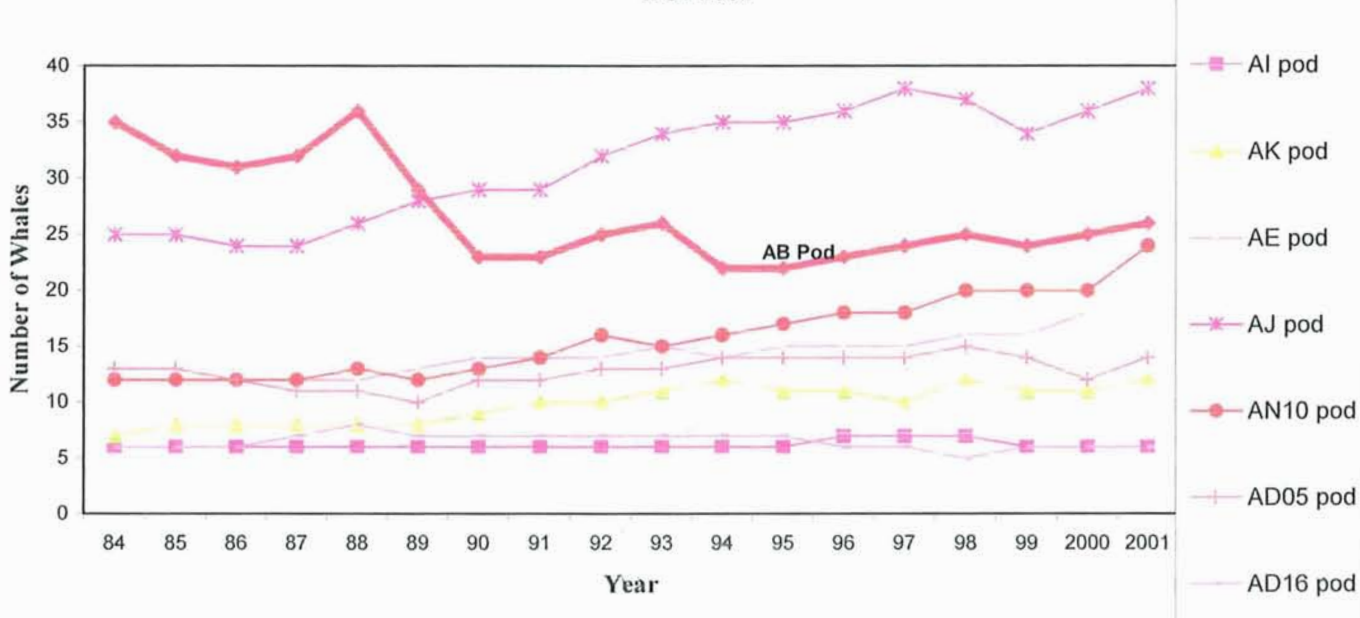


Table 4. Recruitment and mortalities in Prince William Sound resident pods.

	Recruitment in Prince William Sound/Kenai Fjords Resident Pods [whale#(mothers#)]									**Southeast Alaska Resident Pods**		
POD	**AB**	**AI**	**AK**	**AE**	**AJ**	**AN10**	**AD05**	**AD16**		**AF05**	**AF22**	**AG**
YEAR **85**			8(6)	13(11)							24(6)21(8)	18(8)19(11)
86	**36(23),37(6)**		9(2)									
87	**38(31),39(25)**					38(10)				31(20)29(15)		
88	**40(14), 41(8) 42(32)**			15(10)	26(22)27(20)	40(35)		20(16)		33(11)	28(4)	16(11)
89	**43(17), 44(22)**			16(2)17(5)	28(24)29(8)		26(11)			36(5)	27(7)26(8)	17(5)
90			10(2)	18(11)	30(3)	41(8)	21(5)24(7)			35(20)	30(10)	20(4)21(10)
91	**45(16)**		11(6)			45(35)				38(11)		
92	**46(25),47(32)**				31(24)32(22)33(13)	46(10)47(11)	22(7)			34(15)	44(6)40(22)	22(5)23(15)
93	**48(26)**		12(7)	19(11)	34(3)35(8)36(4)					37(5)51(20)55(11)42(13)	48(4)	24(11)
94	**49(22)**		13(2)		37(18),38(20)	48(8)	23(8)				39(16)	25(8)
95				20(2)		49(11)	25(5)	28(16)		43(11)41(25)		26(6)
96	**50(26),51(25)**	7(4)			39(13)	50(35)51(12)	27(11)			54(20)49(23)	45(6)46(10)47(8)	27(15)28(5)
97	**52(33), 53(27)**				40(3)41(4)	54(10)		29(18)		50(11)		29(4)30(11)31(10)
98	**54(17)**	8(3)	14(7)15(9)	21(5)		55(8)56(11)	30(7)			52(12)		
99	**55(39)**				42(24)43(22)		31(8)	32(16)		53(13)56(20)57(15)	64(10)	33(6)
2000	**56(22)**		16(2)	22(10) 23(11)	44(13)45(3)			33(20)		58(25)60(11)59(23)	65(4)	32(19)
2001	**57(33),58(25)**		17(06)	**	46(27),47(28)	57(10)58(12)59(35)60(41)	34(11)35(8)			61(17)	63(16)67(8)	34(15
	** not completely photographed											
	Mortalities in Prince William Sound/Kenai Fjords Resident Pods [by whale number]									**Southeast Alaska Resident Pods**		
POD	**AB**	**AI**	**AK**	**AE**	**AJ**	**AN10**	**AD05**	**AD16**		**AF05**	**AF22**	**AG**
YEAR **85**	**9,15,34**			8-								
86	**1,7,12**		5-	4-	23-		9-	17-				
87	**28-**					6-	1-	15-				
88	**6-**			7-								1-
89	**13,18,21,23,30,31,37**			12-		2-	3,10				2-	
90	**8,19,20,36,42,44**										1-	9-
91	**29-**										3,7	
92												
93					5-	5-						7,16
94	**2,16,38,41,48**			13-	11-					55-		
95			4-				23-					
96	**4-**					1-	26-			43-		
97	**3-**		11-			49-						
98		8-			6-							
99	**5,52**	1-	3-		9,12,16,17,18		12,4	18,29		36-		
2000			8-				7,30	14-		38,53,54		
***2001**	**51-**			**							39*,48*	
	*to be confirmed in2002		** not completely photographed									
[#84/#01]	[35/26]	[6/6]	[7/12]	[13/18]**	[25/38]	[12/24]	[13,14]	[6/6]		[12/30]	[12/25]	[15/30]

Table 5. Mortality and recruitment rates in Prince William Sound/Kenai Fjords resident pods.

	Recruitment rates in PWS/KF Resident Pods										Southeast Alaska Resident Pods			
	AB	AI	AK	AE	AJ	AN10	AD05	AD16	non-AB total		AF05	AF22	AG	Total SEA
85	**0**	0	14.3	7.7	0	0	0	0	2.4		0	16.7	13.3	7.7
86	**6.3**	0	12.5	0	0	0	0	0	1.2		0	0	0	0
87	**6.4**	0	0	0	0	8.3	0	0	1.3		16.7	0	0	4.7
88	**15.6**	0	0	8.3	8.3	8.3	0	25	6.5		7.1	7.1	5.9	6.7
89	**0**	0	0	15.4	7.7	0	9.1	0	6.2		6.7	13.3	5.9	8.5
90	**0**	0	12.5	7.7	3.6	8.3	20	0	7.3		6.3	6.3	11.1	8
91	**4.3**	0	11.1	0	0	7.7	0	0	2.3		5.9	0	0	1.9
92	**8.7**	0	0	0	10.3	14.3	8.3	0	6.7		5.6	14.3	10.5	9.8
93	**4**	0	10	7.1	9.4	0	0	0	5.2		21.1	6.3	4.8	10.7
94	**3.8**	0	9.1	0	5.9	6.7	7.7	0	5.1		0	5.9	5	3.3
95	**0**	0	0	7.1	0	6.3	7.1	20	3.9		9.1	0	4.8	4.9
96	**9.1**	16.7	0	0	2.9	11.8	7.1	0	4.8		8.7	16.7	9.1	10.9
97	**8.6**	0	0	0	5.4	5.5	0	16.7	3.7		4	0	12.5	5.7
98	**4.2**	14.3	20	6.7	0	11.1	7.1	0	6.4		3.8	0	0	1.4
99	**4**	0	0	0	5.4	0	6.7	14.3	3.5		11.1	4.3	3.7	6.5
2000	**4.2**	0	0	12.5	5.9	0	0	16.7	5.6		10.3	4.1	3.6	6.2
2001	**8**	0	9.1		5.5	20	15.4	0	10.3		3.4	8	3.4	4.8
	Mortality rates in PWS/KF Resident Pods										**Southeast Alaska Resident Pods**			
	AB	**AI**	**AK**	**AE**	**AJ**	**AN10**	**AD05**	**AD16**	**non AB total**		**AF05**	**AF22**	**AG**	**Total SEA**
85	**8.6**	0	0	7.7	0	0	0	0	1.2		0	0	0	0
86	**9.4**	0	12.5	7.7	4	0	8.8	16.7	6		0	0	0	0
87	**3.2**	0	0	0	0	8.3	8.3	20	3.8		0	0	0	0
88	**3.18**	0	0	8.3	0	0	0	0	1.3		0	0	5.9	2.2
89	**19.4**	0	0	8.3	0	7.7	18.2	0	4.9		0	6.7	0	2.1
90	**20.7**	0	0	0	0	0	0	0	0		0	6.3	5.6	4
91	**4.31**	0	0	0	0	0	0	0	0		0	11.8	0	3.8
92	**0**	0	0	0	0	0	0	0	0		0	0	0	0
93	**0**	0	0	0	3.1	6.3	0	0	2.1		0	0	9.5	3.6
94	**19.2**	0	0	6.7	2.9	0	0	0	2		4.3	0	0	1.7
95	**0**	0	8.3	0	0	0	7.1	0	2		0	0	0	0
96	**4.5**	0	0	0	0	5.9	7.1	0	1.9		4.3	0	0	1.6
97	**4.3**	0	9	0	0	5.5	0	0	1.9		0	0	0	0
98	**0**	14.3	0	0	2.6	0	0	0	1.8		0	0	0	0
99	**8**	14.3	8.3	0	13.5	0	13.4	28.6	9.8		3.7	0	0	1.3
2000	**0**	0	9.1	0	0	0	13.3	16.7	3.7		10.3	0	0	3.7
2001	**4**	0	0	*	0	0	0	0	0		0	8	0	2.4
# in pod84/0	**[35/26]**	[6/6]	[7/12]	[13/18]	[25/38]	[12/24]	[13/15]	[6/6]	**[82/118]**		[12/30]	[12/25]	[15/30]	**[39/84]**
	*entire pod not photographed													

We encountered members of 15 different resident pods in 2001 (Table 6), a total of 253 individuals. Pods that were completely photographed in 2001 included AB, AD16, AD05, AJ, AI, AK, AN10, AS, AY and AG. Also, three of the four matrilines that compose AX pod (see 1999 catalogue, Matkin et. al. 1999) were photographed in addition to two new resident pods, AH1 and AH20. AF22 and AF05 pod were encountered and identified in southeast Alaska (as part of another project) and that data used in our expanded population analysis

Table 6. Resident pods: number of whales and number of encounters in 2001.

Pod	#Whales	#Encounters
AB	26	6
AJ	38	7
AN10	24	3
AI	6	4
AE*	18	1
AK	12	12
AD16	6	9
AD5	14	13
AX*	22	4
AY	13	6
AS	23	2
AH1 **	8	3
AH20 **	12	1
AW*	21	1
AG	30	3
TOTAL	**253**	**75**

* pod not completely photographed
** new pod

Transient whales

A total of eight of the original 22 whales from the genetically unique AT1 group were photographed during 5 encounters in 2001. Whales photographed included AT2, AT3, AT4, AT6, AT9, AT13, AT17, and AT18. Identifications of AT13 and AT17 are uncertain because of poor photographs.

Twelve whales in the AT1 group have been missing for ten years or more or have been found dead and stranded and are considered dead. The group numbers only 9 individuals as of late 2001 (Table 7, Figure 4). Since 1989, the number of AT1 individuals identified annually has been 12 or less despite a field effort that exceeded 200 vessel days in 1990 and totaled 120 days in 1997, 98 days in 1998, 83 days in 2000 and 87 days in 2001. There were no new calves identified in the AT1 group in 2001, and there has been no recruitment observed in this group since 1984.

The average number of different AT1 individuals sighted per field day of effort for 1990-1997 was considerably lower than for 1984-1989. In 2001 the individuals sighted per effort was slightly below the average for the 1990-1997 period.

Both before and after 1989, all of the AT1 whales photographed in a particular year were generally seen in the first 20 to 60 days of the field season. This was the case in 2001. In 2001, there were no sightings of individuals not previously photographed after the first 40 days of the field season (Figure 5).

Seven non-AT1 transients made appearances in the study area. The transient whales AT105, AT122, and AT123 were photographed on June 26, and AC22, AC23, and AC24 were photographed on January 27. The transient AT109 was seen on three occasions during the July/August period, each time near sea lion haulouts or rookeries.

Probable stranding of AT10

On 3 July 2001 we performed a partial necropsy on a killer whale that had stranded and died near Johnstone Point on Hinchinbrook Island, Prince William Sound. . The dead whale was first spotted on June 24 and it appeared at that time to have very recently stranded and died. Identification could not be determined for certainty from photographs taken by Steve Raney about 10 days prior to necropsy or by inspection on site. We suspected the whale was AT10, a mature male estimated 21 years of age in 2001 that typically traveled with his mother AT9 and another female, AT18. Although it was a mature male, the dorsal fin was relatively small (52 inches) for a physically mature male and resembled photographs of AT10s dorsal fin in size and shape. DNA evidence suggests that this whale is an AT1 whale (analysis is incomplete). AT9, the mother of AT 10, and AT18 were observed and photographed without AT10 present on July 23 in Resurrection Bay.

The cause of death was not determined. The stomach and intestines were extracted from the animal in sections and examined. The forward section contained numerous pieces of bull kelp (*Nereocystis leutkeana*) and harbor seal (*Phoca vitulina*) hair, nails, whiskers, and a single, intact flipper from a juvenile harbor seal. Materials found in other parts of the digestive tract included harbor seal hair, nails and whiskers. There were no identifiable marine mammal parts that did not come from harbor seals. This confirms field observation that indicated this whale (if AT10) was a harbor seal specialist. Members of the AT1 group have been observed to eat primarily harbor seals and Dall's porpoises.

Table 7. Sighting histories for all AT1 transient whales for years with effort greater than 40 days.

	AT01	**AT02**	**AT03**	**AT04**	*AT05*	**AT06**	*AT07*	*AT08*	**AT09**	**AT10**	*AT11*	*AT12*	**AT13**	**AT14**	*AT15*	*AT16*	**AT17**	**AT18**	*AT19*	*AT20*	*AT21*	*AT22*
YEAR																						
84	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
85	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
86	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
88	X	X	X	X				X	X	X	X	X	X	X	X		X	X		X	X	X
89	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-	X
90	X	X	X	X	-	X	-	-	X	X	X	X	X	X	-	-	X	X	O	-	-	-
91	X	X	X	X	-	X	-	-	X	X	-	X		X	-	-		X	O	-	-	-
92	X	X	X	X	-	X	-	-	X	X	-	-	X	X	-	-	X	X	O	-	-	-
93		X	X	X	-	X	-	-	X	X	-	-			-	-	X	X	O	-	-	-
94	X				-		-	-	X	X	-	-		X	-	-		X	O	-	-	-
95	X	X	X	X	-	X	-	-	X	X	-	-	X	X	-	-	X	X	O	-	-	-
96	X	X	X	X	-	X	-	-	X	X	-	-		X	-	-		X	O	-	-	-
97	X	X	X	X	-		-	-			-	-	X		-	-	X		O	-	-	-
98	X				-	X	-	-	X	X	-	-	X	X	-	-	X	X	O	-	-	-
99		X	X	X	-	X	-	-	X	X	-	-			-	-		X	O	-	-	-
2000	O				-		-	-			-	-	X	X	-	-	X		O	-	-	-
2001	O	X	X	X	-	X	-	-	X	O	-	-	X		-	-	X	X	O	-	-	-

X whale present

\- whale missing, believed dead

0 whale known dead

Figure 4. Number of Whales in the AT1 Transient Group 1984-2001

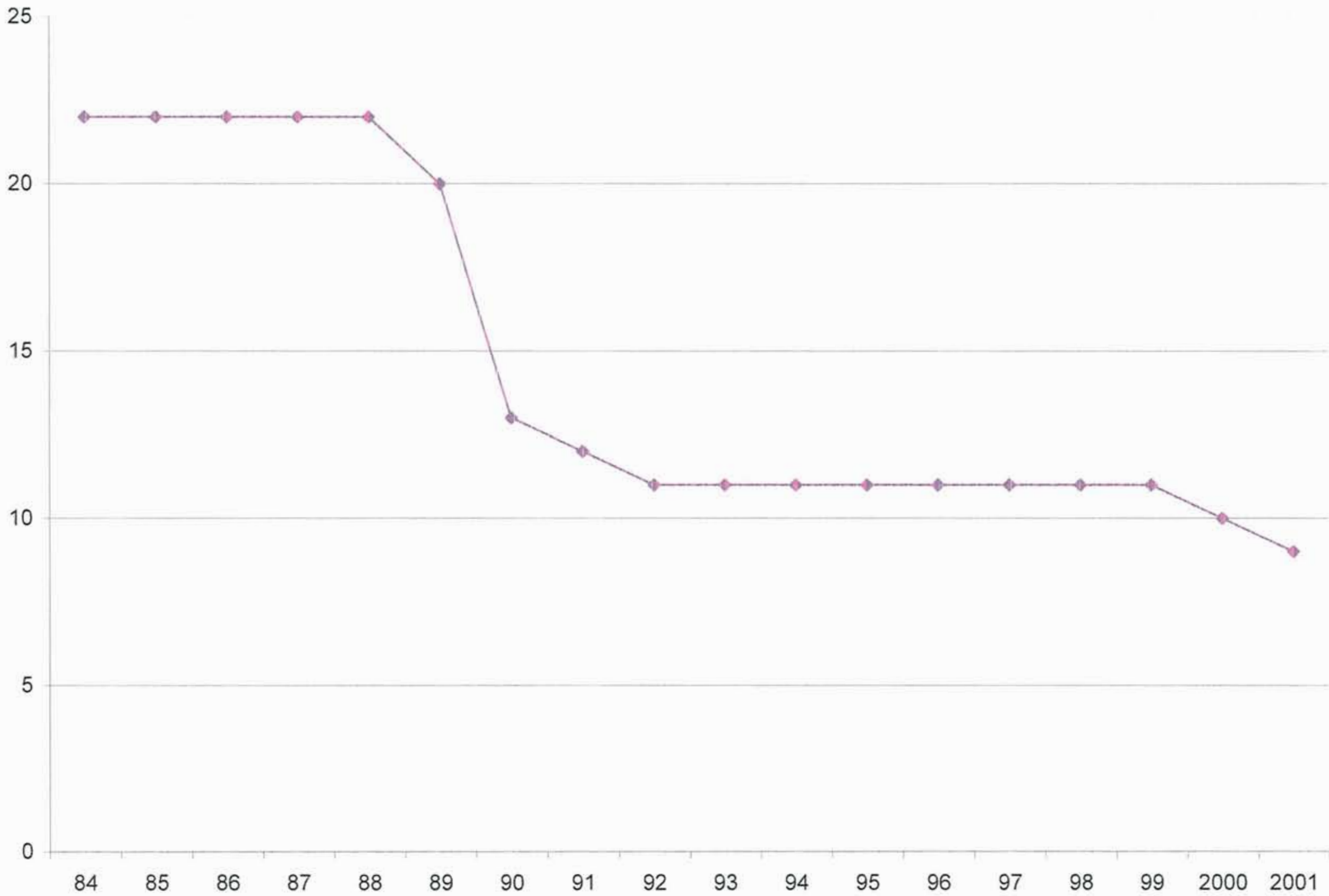
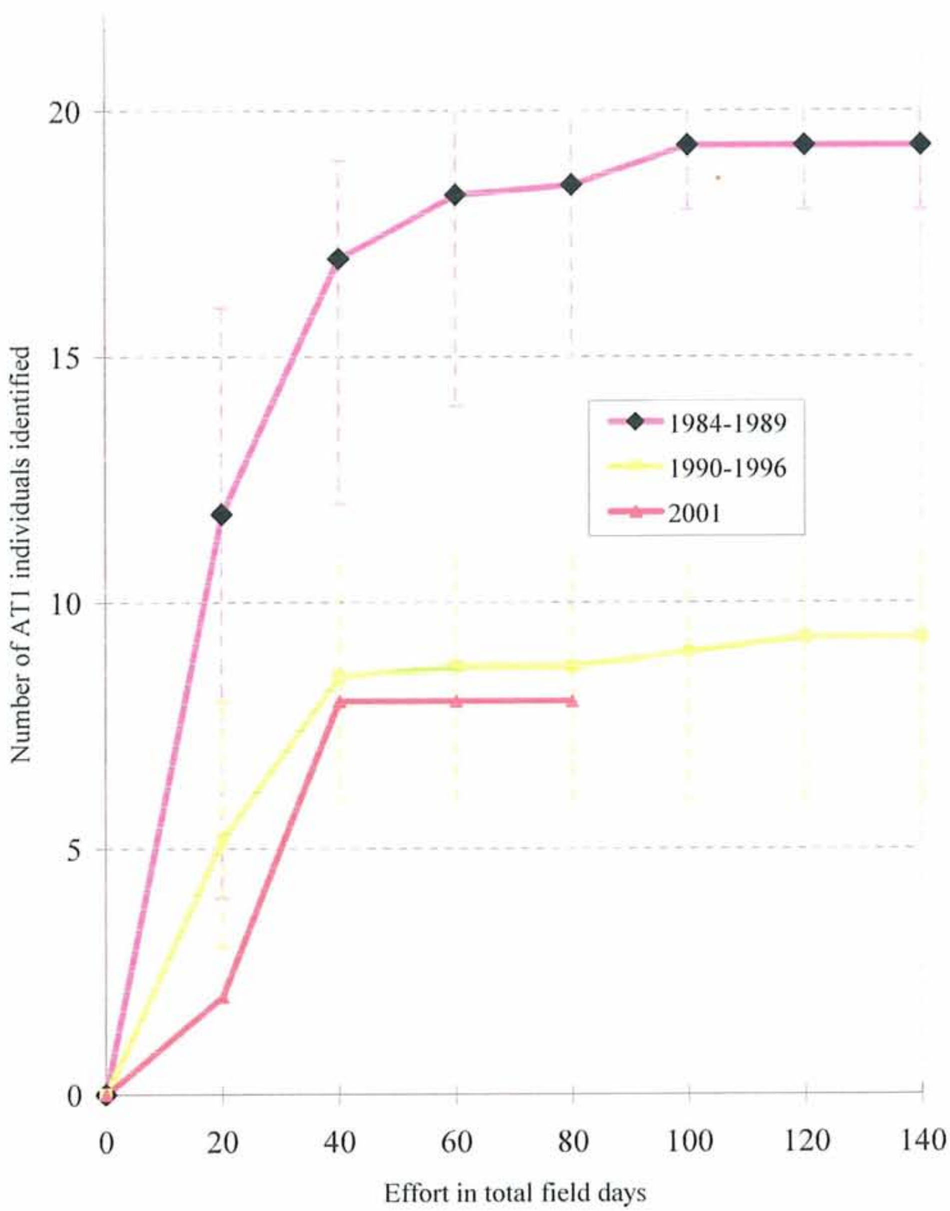


Figure 5. Average number of AT1 transient group whales identified for years with effort greater than 60 field days and actual number of whales identified in 2001
(error bars = range)



Discussion

There was a net gain of one individual in AB pod in 2001. Two new calves were recruited and there was one mortality, all in the AB25 subpod which has traveled primarily with AJ pod since the oil spill. AB25 subpod still spends most of its time in the company of AJ pod, although it maintains the AB pod dialect. There was no change in the larger AB17 subpod or AB10 subpod in 2001; these subpods constitute the independent core of the once cohesive AB pod. With 26 whales, the pod is far from recovery to the prespill level of 36 whales; however, recovery appears to be underway. Our population analysis indicates that recovery can not be expected for some time. Using the intrinsic rate of increase of 2.4% developed for all pods other than AB pod in our population analysis (Matkin et. al. 2001), we would not predict recovery to the 1988 level of 36 whales until 2015. This is over twice as long a recovery time as we estimated immediately following the spill. Although there were additional mortalities due to changes in social structure following the spill (i.e. death of orphaned calves), the extended recovery time is primarily due to the very atypical loss of reproductive females and juveniles at the time of the spill. As indicated by our population modeling (Matkin et al 2001), AB pod would have recovered by 2001 had it not been for the loss of reproductive females and juveniles at the time of the spill. The modeling also suggests that conditions in the northern Gulf of Alaska (including southeastern Alaska) have been near optimal for resident killer whales during the past decade as evidenced by the rate of increase in Prince William Sound/ Kenai Fjords pods (2.8% since 1987), and the continued steady growth of the population in 2001. If conditions were not optimal, the recovery of AB pod would likely be extended beyond our current projection. This underscores the difficulty resident killer whale pods have recovering from anthropogenic or natural disasters, particularly those that involve loss of reproductive females and/or juvenile females, even during periods that are optimal for population growth

Following the summer field season, AB pod appeared to be using the Resurrection Bay/Kenai Fjords on a regular basis in fall and early winter 2000 (see Acoustics section--tapes from 2001 and 2002 will be analyzed for the 2002 final report). As is typical, they were not sighted in May and June in either Kenai Fjords or Prince William Sound, although effort was minimal in the Sound. However, they were encountered in the Sound in July and in late August in Kenai Fjords.

Although we did not observe large late summer groupings within Kenai Fjords as in some in previous years (Matkin et al 1998), groupings that included AN10, AK, AJ, and the AB25 subpod were encountered offshore of Cape Mansfield, where they were difficult to access due to oceanic conditions. Although the whales may use Prince William Sound and Kenai Fjords for their late summer and fall superpod social aggregations in some years, in other years they may occur in adjacent areas in open waters where we do not observe them.

For the first time, we had superpod aggregations in the spring (late May-early June) in Kenai Fjords. Although these included some regular members of fall superpods (AK pod), they primarily were made up of pods that we often see in the region in the spring (AD05, AK16, and AX) with some infrequently seen (AS and AY) and new pods (AH1, AH20). The larger pods seen in late summer and fall superpods (AB,AJ, AN10, AG) were noticeably absent. The mixing of pods and individuals that occurs during the fall aggregations was noted, but pods were also observed traveling alone; there was often more than one encounter per day.

Again, the most commonly observed feed for residents whales in spring was Chinook or king salmon. In 2001 we observed numerous kills of king salmon by killer whales and recovered scales for the site of a number of kills. Also observed was prey sharing between females and calves in AD05 pod. There are serious conservation concerns for Chinook salmon. Last year, 38,000 king salmon were taken as bycatch in Bering Sea trawl fisheries (up from 7,500 in 2000). The Alaska Board of Fisheries is currently proposing severe sport fishing bag limits for king salmon in many areas of southcentral Alaska. Although we have had high rates of encounters with killer whales in May and June in other years in Kenai Fjords, we have never observed such large and diverse groupings of animals. This generated very high encounter rates in the spring that resulted in the highest annual rate of encounter for killer whales in the Kenai Fjords region to date (0.96 encounters per day). It is not clear exactly what the function of these groups was, although there was extensive social/sexual behavior observed at times, as well as feeding. The presence of poorly known and heretofore unknown pods suggests the groups were distantly related whales (nuclear DNA analysis has not been completed due to lack of funding). Acoustic analysis could not clearly isolate and develop repertoires for the new and seldom observed pods (i.e. AH1, AH20, AS) because they were never recorded alone.

The rate of encounter with killer whales in Prince William Sound was higher than it had been in most years (0.26 encounters per day) but still far below the rate in Kenai Fjords. Although these rates are not strictly comparable since the vessel spending the most time in Prince William Sound (Whale 1) is primarily searching for humpback whales and the sighting network in the Sound consists of far fewer vessels, it is still clear that there is less killer whale activity in the Sound than there was in years prior to the spill.

Another possible mortality (the male AT10) occurred in the AT1 transient group, which would reduce the number of whales in the group to 9, compared to a total of 22 prior to the 1989 spill. Again, there has been no observed recruitment into the AT1 group in 2001 and has not been since 1984. It is uncertain if any of the AT1 whales are capable of recruiting a calf since there has been no recruitment in 16 years. The suspected female AT3, born in 1984, may be the only potential for reproduction in the group. High contaminant levels in this group could interfere with reproduction

The surviving members of the AT1 group are seen less frequently than in pre-oil spill years, and we suspect they now are forced to range more widely in search of prey because of the severe reduction in harbor seal numbers in the region. They may also be forced to forage further offshore for porpoises, reducing our ability to locate them. Although we no longer observe and photograph all of the remaining 11 whales in a given year, we have not received photographs of these whales from adjacent areas and suspect that they do not range far from the Prince William Sound/Kenai Fjords region. This group has been determined genetically distinct by mtDNA and nuclear microsatellite DNA analysis and is acoustically distinct from all other pods and groups sampled. (Saulitis et al., in review). Despite the fact that the AT1 group continues a slow decline, the steep decline at the time of the oil spill (loss of nine of 22 individuals in 1989 and 1990) is unlikely an event that was simply coincidental considering: 1) the lack of mortalities in this group in the five years they were studied and enumerated prior to the spill. 2) the presence of several of the missing whales in the slick alongside *the Exxon Valdez* at the time of the spill. 3) the repeated presence of many individuals in the spill zone in 1989 and 4) The availability of oiled harbor seals following the spill. Although other factors such as high contaminant levels and the continued decline of their harbor seal prey may be contributing to the decline and lack of recovery, the major factor in the overall decline of the AT1 group since 1988 appears to be the effects of the *Exxon Valdez* oil spill.

POPULATION MODELING

After preliminary modeling and presentation of those results as a paper at the 2001 Biennial Conference on the Biology of Marine Mammals in Vancouver, B.C., we were able to use additional data from this past field season to construct a complete killer whale model for the resident killer whale population of southern Alaska that does not rely on other models for comparative purposes. Although the additional analysis has been completed we are still involved in the write-up and publication of a major paper that will be the result of the modeling exercise. It is expected that this paper will be submitted to *Marine Mammal Science* by late this year.

ACOUSTICS

Introduction

In previous reports (Matkin et. al. 2001, 2000, 1999) we showed that the pod specific call repertoires of seven pods, AB, AD (now AD5 and AD16), AE, AI, AJ, AK, AN (now AN10 and AN20) form two distinct vocal clans in the Southern Alaska resident community (SAR): AB-clan (AB, AI, AJ and AN pod) and AD-clan (AD, AE, and AK pod). Calls are not shared between clans (Yurk et. al. in press). Repertoire exclusiveness among pods of different clans matches their genetic distinction based on mitochondrial and nuclear DNA (Barrett-Lennard 2000). Previously we presented the results of an analysis of inter-observer reliability in recognizing killer whale call-types. This analysis showed that qualitative structural analysis is a valid method to classify killer whale call types and repertoire similarities (Yurk et. al. in press). In this report we present partial repertoires of two more pods of the Southern Alaskan residents (SAR) and attempt to determine to which clan the pods belong or whether they form a separate clan.

Also, in three previous reports (Matkin et. al. 2001, 2000, 1999) we analyzed recordings from a remote listening station in Prince William Sound and Resurrection Bay, and were able to identify all the pods that were present on several days during the winter of 1997-1998 and 1999-2000. In the current report, we will present the results of an analysis of recordings made in Resurrection Bay between October 2000 and December 2000.

Methods

Analytical techniques are the same as in Yurk et. al. (in press) and are based on those developed by Ford (1984) to analyze calls from resident killer whales in British Columbia. The same techniques have also been applied successfully to vocalizations of resident-type killer whales in Norway (Strager 1995), and to vocalizations of an isolated transient group of killer whales called AT1 in Prince William Sound, Alaska (Saulitis 1993). Originally, we combined a qualitative structural analysis of call types with a quantitative call-type frequency analysis (Matkin et. al. 1998) to assess pod identity in remote hydrophone recordings. However, better resolution of the qualitative analysis showing structural differences in calls between closely related pods allows us to determine pod identity based on call structure alone (Figure. 6).

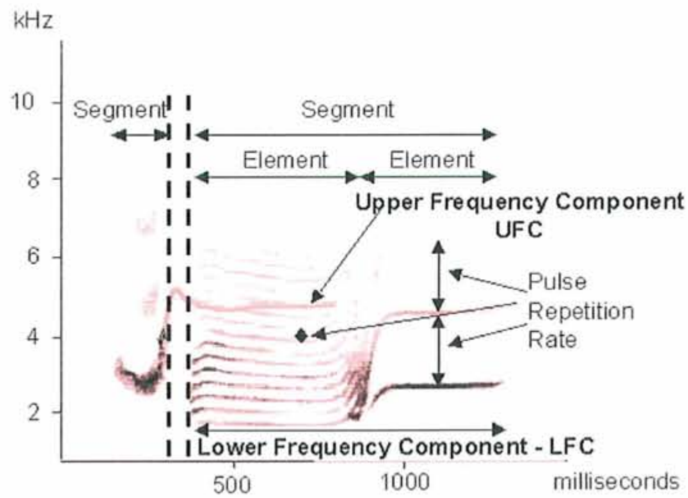


Figure 6: Calls are often composed of two components.

Following Miller and Bain (2000), components with lower sound frequency (lowest band in spectrogram being 0.5 kHz to 3.5 kHz) were called lower frequency components (LFC), and components with higher sound frequency (lowest band always above 3.5 kHz) were called upper frequency components (UFC). LFCs consist of rapidly produced broad-band pulses that overlap to produce the equivalent of sine wave tones. The distance between spectrogram bands reflects pulse repetition rate (Watkins 1967), although intensity differences due to super-positioning of pulse tones may reduce the number of bands in the spectrogram. For example, when the pulse rate is a 2^n multiple of the pulse frequency, the harmonics of the pulse frequency will show up as stronger bands in the spectrogram, and bands in between may disappear completely. Both the pulse repetition rate and pulse frequency are usually modulated over the duration of the call. UFCs often have no sidebands but have true harmonic bands and can then be better described as narrow band signals, such as whistles, produced simultaneously to LFCs. Furthermore, many LFCs of calls can be divided into elements separated by rapid shifts in pulse repetition rates. Some calls may also be segmented, with parts separated from each other by silent intervals.

Call-type categorization

We categorized call-types by ear and by visual inspection of the sound spectrogram. Categorization was based on the distinctive audible characteristics of the calls, which appeared as distinguishing structural differences in the frequency/time contours of a call's spectrogram. Particular attention was given to call duration, segmentation, element structure of LFCs, and the existence of UFCs (Figure 6). A similar method was described by Ford and Fisher (1982) and Ford 1984. Ford 1984 found no significant difference between the categorization of killer whale calls based on a statistical comparison of certain sound parameters and the categorization using aural and spectrographic comparison. Bain (1986), comparing sound and visual appearance of calls, obtained similar call categories from two captive killer whales of the same population that Ford (1984) described. Deecke, Ford, et. al. (1999) compared the results of call similarity analyses from neural networks with those made by humans that have been trained to distinguish between calls and found no significant difference in the results of the types of analyses. Our categorization method differed slightly from the one Ford (1984) used to define stable call variants. Our definition of a call variant was based on contour variations within elements and not on occurrence of elements within a call. Calls that had different numbers of elements but were otherwise similar were categorised as two distinct call-types. This allowed for a greater structural resolution of call-types in the categorization process.

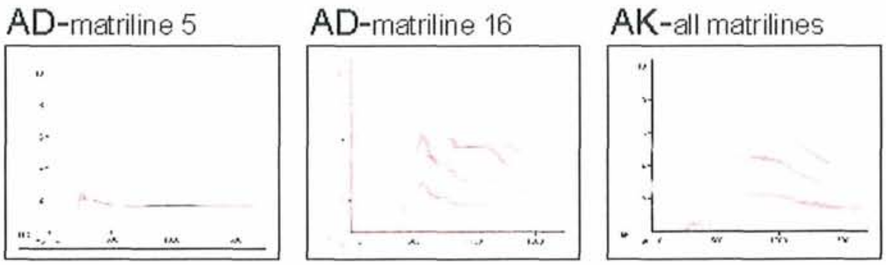


Figure 7. Three distinct variants of call type AKS 01 produced by three matrilines belonging to two pods.

Results

1. Call type classification of two Southern Alaskan resident pods

Aside from the seven pods described in previous reports and which regularly frequent the waters of Prince William Sound and the Kenai Fjords, two more pods, called AF and AG pod, visit the area less frequently. Call classifications based on structural features as described above showed that the two pods appear to have distinct call type repertoires. Our current set of recordings however, does not allow a complete determination of those repertoires. A preliminary analysis of calls taken from the existing recordings allowed us to classify 11 call types of which one, AKS19 had two distinct variants (Table 8). Six of these 11 call types are shared with AB-clan whales, while no AD-clan call type was identified in the recordings.

Pod Names	AF	AG
# Matrilines	8	5
AKS 10	X	
AKS 11iii	X	X
AKS 13	X	
AKS 16i	X	X
AKS 17iii	X	
AKS 19i	X	X
ii	X	X
AKS 20	X	X
AKS 22	X	
AKS 26		X
AKS 33		X
AKS 34		X
TOTAL	9	8

Table 8. List of all identified call types of AF and AG pod and their variants in alphanumerical order. (An X in the appropriate column indicates call types produced by an individual pod. Pods that share call types are grouped together)

2. Analysis of remote hydrophone recordings

The remote hydrophone at Thumb Point in Resurrection Bay was monitored on 49 days between October 10, 2000 and December 20, 2000 for a total of 458 hours and 34 minutes. Resident killer whales were heard on 6 days for a total of 18 hours. During eight different sessions, 480 minutes of recordings were made from resident killer whales.

Date	Whales recorded (min)	Call Types (AKS)	Pods (Groups) present
Oct. 24, 2000	125	11i, 11ii 14, 22, 23, 25	AB, AJ, AN
Nov. 03, 2000	80	21, 22	AB, AN
Nov. 10, 2000	30	AT-4	AT1
Nov. 11, 2000	70	13, 17ii, 17iii, 17iv, 21, 22	AB, AN
Nov. 14, 2000	80	11i, 11ii, 11iv (new variant) 13i, 13ii, 14, 18, 23	AB, AJ, AN + unkown pod
Dec. 12, 2000	80	09i	prob. AK*

Table 9. Dates of recordings and recorded call-types with acoustically identified pods.

*Because of a low signal-to-noise ratio we cannot conclude that AK pod was the only pod present on this date.

Discussion

The acoustic distinctiveness of call types that are shared among pods can be accurately established by describing differences in some acoustic variables such as the one depicted in Figure 7. Call-types can be described by their *gestalt* (Katz 1950, Deecke pers. comm., Ford, et. al. 1999), where gestalt means that acoustic similarities and differences of calls can be distinguished by humans without previous experience in categorizing calls (Yurk et. al. in press). Furthermore, gestalt differences and similarities can be more effectively described by humans that are trained to distinguish between call-types by listening to a great number of different calls (Deecke pers comm., Ford et. al. 1999, Yurk et. al. in press). This method also allows experienced observers to discriminate between variants of call types that are shared among several pods.

On November 14, 2000, an unknown pod was recorded with three pods of AB-clan. This unknown pod appeared also to be a member of AB-clan because of its use of AKS11, a call type that is shared by all other AB-clan whales. Considering the results of previous analyses of recordings from remote hydrophones in Prince William Sound and in Resurrection Bay it appears that during winter months only pods of the same clan associate. Prey availability might be considerably reduced during the winter months, which could result in a segregation of un-related pods to increase inclusive fitness. Mating appears to take place mainly during the late summer and predominantly between members of different clans (Barrett-Lennard 2000).

Call type usage by the two pods AF and AG allows the cautious prediction that these two pods are also members of AB-clan. This result would match the genetic analysis of those pods, which revealed that AF and AG have the same mtDNA haplotype as other AB-clan whales (Barrett-Lennard 2000).

TOUR BOAT AND MARINE MAMMAL INTERACTIONS: FIELD OBSERVATIONS 2000-2001

Background

The viewing of sea otters, harbor seals Steller sea lions, killer whales, humpback whales, gray whales and occasionally fin whales has become an important component of Kenai Fjords National Park/Resurrection Bay vessel tours that now attract in excess of 90,000 patrons annually. Sightings of whales in the area, particularly killer whales and humpback whales, have increased in recent years along with the increased public desire to view them. As commercial whale watching vessels maximize viewing opportunities, there is increasing pressure on all species of marine mammals, particularly killer whales and humpback whales. In light of the impact of the Exxon Valdez oil spill on both resident (AB pod) and transient (AT1 group) killer whales, additive impacts of tourboat activities should be monitored and assessed From 1997-99, we began working informally and opportunistically with operators and owners of tour boats on the water during our field research and dockside after hours. In 2000, a formal training program for non-invasive whale viewing and visitor education was conducted during a spring workshop. Operator developed guidelines were produced and revised in 2001. In addition, a systematic monitoring of vessel-whale interactions was initiated in 2000 to observe the behavior of operators when in the proximity of whales and assess their adherence to the operator developed and NMFS guidelines.

In 2001, we organized a refresher workshop with tour boat operators to review and amend the behavioral code that they developed in 2000 and determine whether it was still reasonable, effective, and compatible with NMFS guidelines and regulations. In addition, we continued monitoring vessel-whale interactions in the Kenai Fjords region and occasionally in Prince William Sound.

Methods

Data was collected from the research vessel R/V *Natoa*, a 10m-diesel inboard powered vessel, in conjunction with other field research activities (see other sections of this annual report). Data included date and time, whale species, location, type and name of vessel, the operators name if known, duration of interaction with the whales, estimated distance of the vessel from the whales, and manner of approach.

Vessels were classified in two categories: the commercial tour boats, hereafter referred to as "tourboats"; and the sportfish/pleasure boats, small charter boats and kayaks, hereafter referred to as "other boats". An interaction was considered to occur when a vessel took notice of whales and altered either course or speed to view the whales. The viewing time (also called interaction time) included the time the boats spent viewing whales within an estimated 500m distance.

The closest distance of active approach was defined as the closest distance that the vessel actively moved toward the whales. We also noted if whales approached the vessel, and the final distance of the whales from the vessel. Because observations were not made from a fixed land-based post, distances were necessarily estimations based on the known lengths of the vessels under observation.

Results

We observed 213 vessel-whale interactions spread over 31 non-consecutive days between 14 May and 3 September 2001. Several interactions were not fully documented. Table 1 presents the number of interactions observed by boat category and by whale species.

Table 10. Number of interactions by categories

	SPECIES			
VESSEL TYPE	Fin whales	Humpback whales	Killer whales	TOTAL
Other	0	0	35	35
Tour boat	2	29	147	178
TOTAL	2	29	182	213

A total of 178 interactions involved 21 different commercial tour boats and 35 interactions involved other boats. A total of 29 of the observations were with humpback whales, 182 with killer whales and two with a single fin whale (Table 1). The research vessel was present during 3467 minutes of whale-watching effort during 213 interactions, including 2930 minutes for tour boats and 537 minutes for other boats. The average viewing time of whales by tour boats was 17.4 minutes (range 3-60, n=168) and for other vessels, 15.8 minutes (range 2-107, n=44). Tour boat operators exceeded the agreed maximum viewing time of 20 min on 56 occasions (33.3% of the interactions observed), and the 30 minute NMFS guideline on 18 occasions (10.7% of the interactions observed). Other boat operators exceeded the NMFS guideline on four occasions (11.7% of the interactions observed). On 19 August 2001, the peak day in terms of interactions, we observed 29 overlapping visits from 1226 to 1640. They involved 24 different vessels (11 different tour boats and 13 other boats) and two killer whale pods (AB and AJ pods). During this time, the boats spent a total of 9.30 vessel hours viewing the animals.

On 37 occasions (27.2% of our observations), tour boats actively approached killer whales closer than 100 estimated meters, and on four occasions (14.8% of our observations) did so with humpback whales. For all whale species, other boats made close approaches less than 100 meters on 16 instances (45.7% of the observations). Most of the time (119 occasions, 86.9% of our observations), tour boats slowly approached the whales. Similarly, other boats' approaches were slow or moderate on 22 occasions (81.5% of our observations).

The mean number of tour boats watching a same group of whales simultaneously was 1.56. On 23 occasions (13.7% of the observations), more than two tour boats were watching a same group at one time, and once there were five simultaneously watching the whales. The total time killer whales were observed in presence of one or more tour boats was 2046 minutes, and the total number of visits recorded was 147 (Table 11) during a total of 26 days. On average, killer whales were visited 78.69 minutes per day with an average of 5.65 tour boat visits per day.

Table 11. Vessel-whale interaction summary table for 2000 and 2001

INTERACTION PARAMETERS	2000*	2001
Tour boats and all whale species		
% (#) boats viewing more than 20 min	31.7% (44)	33.3% (56)
% (#) boats viewing more than 30 min	5.0% (7)	10.7% (18)
% (#) boats actively approaching within 100 m	10.2% (13)	24.8% (41)
mean boat viewing time (minutes)	15.60 (n=139)	17.44 (n=168)
- range (minutes)	2 - 55	3 - 60
mean # boats watching simultaneously	1.68	1.56
max # boat watching simultaneously	6	5
% (#) interactions with more than 2 boats at one time	16.5% (23)	13.7% (23)
Tour boats and killer whales		
# boat-whale interactions observed	131	147
whales in presence of one or several boats (minutes)	1502	2046
# days with boat-whale interactions	16	26
mean daily disturbance time (minutes)	93.88	78.69
mean # of daily visits to whales	8.19	5.65
% (#) boats actively approaching within 100 m	9.2% (11)	27.2% (37)
Tour boats and humpback whales		
% (#) boats actively approaching within 100 m	25.0% (2)	14.8% (4)
Other boats and all whale species		
mean boat whale-watching time (minutes)	7.46 (n=39)	15.79 (n=44)
- range (minutes)	2 - 20	2 - 107
% (#) boats viewing more than 30 min	0.0% (0)	11.7% (4)
% (#) boats actively approaching within 100 m	41.0% (16)	45.7% (16)
Peak days	25 July '00	19 Aug '01
# whale-vessel interactions observed	33	29
combined vessel viewing time during (hours)	5.88	9.3

*Updated from Matkin et. al. 2000.

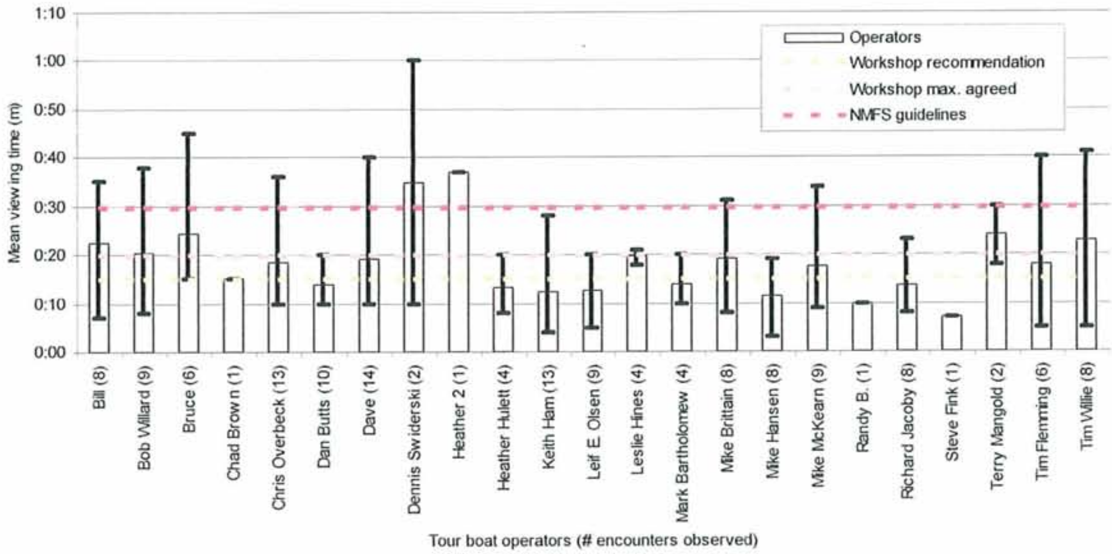


Figure 8. Tour boat operators mean (bars), minimum and maximum (segments) whale viewing times in 2001*.

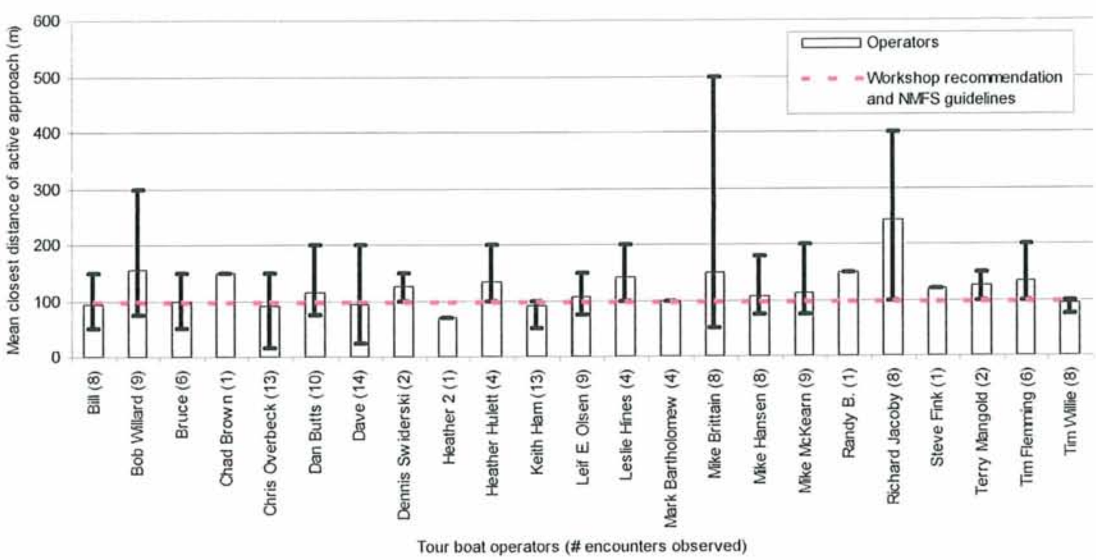


Figure. 9. Tour boat operators mean (bars), minimum and maximum (segments) closest distances of active approach of whales in 2001*.

* Caution should be used in interpreting graphs when less than 6 observations were made of an operators behavior. Data may not be representative of operators overall behavior.

Discussion

These observations had the dual purpose of developing a comparable, systematically collected database that would give an indication of the level and type of whale interactions currently occurring in the Kenai Fjords and reinforce the importance of guidelines and methods for low impact whale observation developed in the workshop and training sessions held in 2000.

Although the presence of the research vessel may have influenced the behavior of other vessels during our field observation of vessel-whale interactions, we believe the data collected does give a good general picture of the interaction of vessels with whales (particularly killer whales) in the Kenai Fjords region.

The mean daily time during which tour boats interacted with whales was less in 2001 than in 2000. This was not due to any reduction in the desire to view whales but more likely associated with reduced accessibility. A greater percentage of killer whale encounters occurred outside the Resurrection Bay waters and the whales were not as accessible to many of the tour boats conducting shorter trips. The increased desire to view whales was evidenced by the trips as far as 12 miles west of Resurrection Bay (Cape Mansfield) that were made late in the season by the larger tour boats capable of transiting the open waters of the Gulf of Alaska.

Although there were as many as five tour boats viewing the whales at one time, most often there were not more than two simultaneously, complying with the 2000 workshop recommendations. Tour boats generally made an attempt not to box in the whales or pin them against shorelines.

Tour boats were likely to take a slow approach that was initiated 300 m or more from the whales and ended not closer than 100 m. However, there were a greater percentage of active approaches less than 100 m in 2001 than in 2000 for killer whales (□^{2} test: $p<<0.01$), with approaches within 50 meters documented on 15 occasions. The percentage of close approaches (less than 100 meters) declined with humpback whales (25.0% in 2000 and 14.8% in 2001), which may have been due to the new regulations (issued in July 2001) that made it illegal to approach within 100 meters. Charter and sport boats generally took a slow or moderate approach; however, fast approaches occurred occasionally with quick course changes to get into viewing position. These boats were also more likely to approach closer than the 100 m guideline and to as close as 10 m or less on three occasions. Because the distances estimated are somewhat subjective, and because the estimates were made by different individuals, the data on closeness of approach must be viewed cautiously.

Although the time range that individual tour boats spent with whales varied widely (up to 60 min for one "whale-watching" cruise), the average time was within the 20 minutes maximum agreed to by operators during the 2000 workshop and therefore within the National Marine Fisheries Service guidelines of less than 30 minutes. This average was 11.8% greater than in 2000 and significantly different between the two years (t test, $p=0.07$). In both years, tour boats exceeded 20 minutes of viewing on one third of the occasions observed. Although violations of the 30 minutes NMFS guideline remain rare, their frequency doubled between last year and this year and the difference is statistically significant (□^{2} test: $p=0.07$). Charter and sport boats generally watched the whales for less than 30 minutes, although on one occasion a charter boat followed them for 107 min. Interest in watching whales seems to be increasing as evidenced by the increasing average interaction times (Table 11).

During the 2000 workshop, tour boat operators had agreed to make a single visit per trip to view a particular group of whales; however, this guideline was not always adhered to. As in 2000, and particularly in the later part of the season, second viewing of whales often occurred on the return trip to town if whales were within range.

Either due to training and/or experience, the tour boat operators were generally more aware and considerate of the whales than sport/charter operators, although there were some obvious violations of NMFS and workshop guidelines by both groups, and particular operators appeared less sensitive to the guidelines and the possibility of harassment (Figures 8 and 9). (Results from this work are being presented at the European Marine Mammal Conference, 2002)

Conclusions

Without additional data it is not possible to determine whether vessel activities are negatively impacting killer whales or humpback whales in the region. However, there is no doubt that harassment does occur on occasion and may at times alter the animals' behavior. Measures that minimize or reduce potential damaging effects of harassment are recommended. As a prescriptive measure, the NMFS guidelines presented as their "Marine Mammal Code of Conduct" should become regulation and serve as a clear baseline against which any Alaskan vessel operator's behavior can be judged. The creation of specific humpback whale watching guidelines that took effect in midseason, 2001 was a step in that direction. It is noteworthy that approaches closer than 100m decreased for humpback whales with the new regulations prohibiting approach closer than 100m; however, for killer whales with no regulation, the approaches closer than 100m increased.

Spring refresher workshops should be held for tour boat operators that stress the guidelines developed by the operators in the 2000 workshop and NMFS guidelines and regulations, and that review previous years observations. Tour company owners should make it mandatory for their captains to attend such workshops. An educational program similar to the 2000 tour boat operators workshop should be conducted for sport and charter boat operators, as it appears that their interest in whale viewing is increasing and because their behavior is often more aggressive. Since it seems difficult to assemble such a group at a single time and place, it might be worthwhile to set up an information campaign (free field guides?) stressing the negative impact of aggressive whale watching and providing the regulations and guidelines.

The opportunistic monitoring of vessel-whale interactions should be continued in the course of other field research to examine changes in activity or behavior of vessels viewing whales across the years. This will also serve as a reminder to operators that NMFS is concerned about marine mammal-vessel interactions.

Again we recommend that a NMFS enforcement officer make at least two trips per season into waters of the Kenai Fjords region to demonstrate that NMFS is concerned about adherence to viewing guidelines/regulations and in maintaining a code of conduct that prevents harassment of marine mammals.

GIS DATABASE

Vessel logs and killer whale encounter sheets were entered into the GIS database, held at both U.S. Fish and Wildlife Service, Marine Mammal Management in Anchorage, Alaska (contact Doug Burn) and at Alaska Pacific University, Anchorage, Alaska (contact Dr. David Scheel). No analysis other than data summaries and mapping were performed on the data in 2001. In 2002 habitat use by resident and possibly transient killer whales in the Kenai Fjords over the past eight years will be examined using GIS techniques and included in the close out report. The annually updated GIS database will serve as an important long-term baseline in the event of future perturbations in the environment and against which long-term changes in distribution can be assessed. The database is now opened for use by other agencies (i.e. USFWS and NMFS). A copy of the entire database was provided to Exxon Inc. in 1999 in response to their request filed under the Freedom of Information Act.

CONTAMINANTS

Although there has been no directed funding for contaminant sampling under this project since 1998, contaminant analysis was provided by the NMFS Environmental Contaminant Laboratory, Seattle, WA on the 10 samples collected in 2001 and the raw data presented in Table 12. The results are comparable to levels found in residents and transients in previous years(the last three samples in Table are transients) although not directly comparable because they are presented as raw data and wet weights. Two samples, from stranded whales (AKW01-05, BS08-01), had very low per cent lipid readings which confound conversion to lipid weight values. Additional blubber will be provided to the contaminant lab so these samples can be rerun and the conversions for all samples presented in a later report. It is clear that samples from the Bering Sea (field numbers marked "BS") follow the pattern we have seen in Kenai Fjords/Prince William Sound with much higher levels in probable transients than residents.

Table 12. Preliminary contaminant analysis of 2001 biopsy samples.
(parts per million wet weight):

FIELD NO.	DESCRIPTION OF ANIMAL(S)	% LIPID	PCB	PCB TEQ	PCB DDT
AKW99-7	AJ41, 2nd calf of AJ4, brn98	35	2100	23	2400
BS03-01	Resident ad. Female?	43	2300	22	1400
BS02-01	Resident ad. Female?	30	3800	50	3600
AKW01-01	Resident adult male, new pod	22	5000	64	5500
AKW01-04	Resident adult male, new pod	22	7700	84	9500
AKW01-03	Resident, young male, new pod	25	12000	120	12000
BS04-01	Juvenile, new resident pod	27	3800	47	4100
AKW01-05 PWS	Stranded probable AT1 transient	8.7	140000	450	160000
BS08-01	Stranded probable transient	6.3	57000	350	34000
BS01-01	Probable transient	32	110000	650	180000

OVERALL CONCLUSIONS

1. AB pod numbered 26 whales in 2001, a net increase of four whales since a low of 22 members was recorded in 1995. The two calves and single mortality recorded this year were in the AB25 subpod which has traveled with AJ pod since the spill. It appears that although a slow recovery is underway, it will likely not be complete until 2015. We recommend the pod be listed as recovering.
2. All major resident pods were thoroughly photographed in 2001, including the southeastern Alaskan pods (AG, AF05, AF22) except for AE pod in Prince William Sound. This has enabled construction of complete population model for the southern Alaskan resident population that extends from southeast Alaska through Kenai Fjords.
3. The AT1 population appears to have lost another individual in 2001, the young male AT10, and produced no new calves. There are now nine individuals in this group that numbered 22 whales in 1998 and no indication of potential recovery. Although other factors may be contributing to the lack of recovery, the nine mortalities following the *Exxon Valdez* oil spill have been the primary factor of the decline.
4. For the first time we had superpod aggregations that formed in late May and early June in Kenai Fjords. These aggregations consisted of frequently observed AD5, AD16, and AK pods as well as AX and AS pods and the newly named AH1 and AH20 pods. Although there were superpod aggregations in late summer (with AJ, AB, and AN10 pods), they occurred primary in the open waters between Kenai Fjords and Prince William Sound and were difficult to access.
5. The remote hydrophone at Thumb Point documented the presence of AB, AJ, ANs and AK pods and members of the AT1 group in Resurrection Bay in fall/winter 2000. Improvements in transmission technology have increased signal quality and reliability of the remote hydrophone. Interruptions in the signal in 2001/2002 were all a result of failed power supply; wind generators have not withstood Alaskan conditions.
6. Although most tour vessels operated within the 30 minute NMFS viewing guideline for marine mammals, interaction times with whales for both tour and charter boats increased in 2001. This seems symptomatic of the growing interest in the whales. When guidelines are changed to regulations, behavior of the operators improves (i.e. approach distances for humpback whales increased with the 100 yard regulation in 2001). This indicates the need for clear reasonable regulations as well as education.
7. Preliminary contaminant analyses of new blubber biopsies continued to show very high levels of contaminants in transient whales, including animals sampled in the Bering Sea.

As a result of the long-term investigations reported here, as well studies in adjacent regions, it is clear that even the resident killer whale populations identified to date in the Eastern North Pacific number only in the hundreds of individuals. Transient populations appear to be much smaller. These populations should be considered at all times "vulnerable" because of their low numbers, low reproductive rates, and susceptibility to anthropogenic as well as natural environmental perturbations. Because these small populations occupy a position atop the marine food chain and because of their potential to accumulate toxic contaminants, killer whales, particularly transients and specific resident populations should be considered a sentinel species that warrant careful long-term monitoring.

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LITERATURE CITED

Bain, D.E. 1986. Acoustic behavior of *Orcinus orca*: sequences, periodicity, behavioral correlates and an automated technique for call classification. In Behavioral Biology of Killer Whales (B.C. Kirkevold, & J.S., Lockard, Eds.). New York. pp.335-371

Bain D.E. 1988. An evaluation of evolutionary processes: Studies of natural selection, Dispersal, and cultural evolution in killer whales (*Orcinus orca).* Ph.D. Dissertation at the University of California, Santa Cruz

Balcomb, K. C., J. R. Boran and S. L. Heimlich. 1982. Killer whales in Greater Puget Sound. Reports of the International Whaling Commission 32:681-686.

Barrett-Lennard, L.G., Smith, T.G., Ellis, G.M. 1996. A cetacean biopsy system using lightweight pneumatic darts, and its effect on the behaviour of killer whales. Marine Mammal Science 12:14-27.

Barrett-Lennard, L.G. (2000). Population structure and mating patterns of killer whales, *Orcinus orca*, as revealed by DNA analysis. Ph.D. Dissertation, University of British Columbia, Vancouver, Canada

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb III. 1990. Social organization and geneaology of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Reports of the International Whaling Commission. Special issue 12 :386-406.

Bowles E.B., Young G.W., & Asper E.D. 1988; "Ontogeny of stereotyped calling of a killer whale calf, *Orcinus orca*, during her first year", Rit Fiskideildar, J. Mar. Res. Inst. Reykjavik, Vol XI, pp.251-275

Dahlheim, M.E. and C.O. Matkin. 1994. Assessment of Injuries to Prince William Sound Killer Whales in: Thomas Loughlin, ed. Marine Mammals and the ExxonValdez, AcademicPress.

Deecke, V.B., Ford, J.K.B. And P. Spong 1999. Quantifying complex patterns of bioacoustic variation: use of a neural network to compare killer whale (*Orcinus orca*) dialects. Journal of the Acoustical Society of America 105: 2499-2507

Deecke, V.B., Ford, J.K.B. And P. Spong 2000. Dialect change in resident killer whales: implications for vocal learning and cultural transmission. Animal Behaviour 60 (5): 629-638

Ford, J. K. B. and H. D. Fisher (1982). "Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia." Report of the International Whaling Commission 32: 671-679.

Ford, J.K.B. 1984. Call traditions and dialects of killer whales (*Orcinus orca*) in British Columbia. Ph.D. dissertation, University of British Columbia, Vancouver.

Ford, J.K.B. 1991. Vocal traditions among resident killer whales (Orcinus orca) in coastal waters of British Columbia. Canadian Journal of Zoology 69:1454-1483.

Frost, K.J, Lloyd F. Lowry and Jm Ver Hoof. 1999. Monitoring the trend of harbor seals in Prince William Sound, Alaska, after the *Exxon Valdez* oil spill. Marine Mammal Science15:2 p494-506

Heise, K., Ellis, G., Matkin, C. 1991. A Catalogue of Prince William Sound Killer Whales. North Gulf Oceanic Society, Homer, Ak. 51 pp.

Janik, V.M. And P.J.B. Slater 1997. Vocal learning in mammals.

Advances in the Study of Behavior, 26: 59-99
Janik, V.M. And P.J.B. Slater 2000 The different roles of social learning in vocal communication. Animal Behaviour 60 (1):1-11
Jurk, H., Barrett-Lennard, L., Ford, JKB., Matkin, C.M., Saulitis, E., And K. Heise. 1998. Clans among resident killer whales (Orcinus orca) in Prince William Sound. Oral presentation to the Word Marine Mammal Conference, Monaco. Abstract, Society for Marine Mammalogy.
Katz, D. (1950). Gestalt psychology, its nature and significance. New York, Ronald Press.
Krahn, M.M., G.M. Ylitalo, J. Buzitis, C.A. Sloan, D.T. Boyd, S.L. Chan, and U. Varanasi. 1994. Screening for planar chlorobiphenyls in tissues of marine biota by high-performance liquid chromatography with photodiode array detection. Chemosphere. 29:117-139.
Environmental Contamination and Toxicology. 25:227-233.
Leatherwood, S., Kenneth C. Balcomb III, Craig O. Matkin, and G. Ellis. 1984. Killer whales (Orcinus orca) in southern Alaska. Hubbs Seaworld Research Institute Technical Report No.84-175. 54pp.
Matkin, C.O., G.M. Ellis, P. Olesiuk, E.L. Saulitis. 1999a. Association patterns and genealogies of resident killer whales (*Orcinus orca*) in Prince William Sound, Alaska. Fisheries Bulletin 97: 900-919.
Matkin, C.O., Scheel, D., Ellis, G.M., Barrett-Lennard, L.G., Jurk, H., And E. Saulitis (1998). Comprehensive killer whale investigation. *Exxon Valdez* Oil Spill Restoration Project (Restoration Project 97012). Annual Report. North Gulf Oceanic Society, Homer, Alaska
Matkin, C.O., Ellis, G.M., Barrett-Lennard, L.G., Jurk, H., Scheel, D., And E. Saulitis 1999b. Comprehensive killer whale investigation. *Exxon Valdez* Oil Spill Restoration Project (Restoration Project 98012). Annual Report. North Gulf Oceanic Society, Homer, Alaska
Matkin, C.O., Ellis, G.M., Barrett-Lennard, L.G., Jurk, H., And E. Saulitis 2000. Photographic and Acoustic Monitoring of Killer Whales in the Prince William Sound/Kenai Fjords. *Exxon Valdez* Oil Spill Restoration Project (Restoration Project 99012). Annual Report. North Gulf Oceanic Society, Homer, Alaska.
Matkin, Craig O., G. Ellis, E. Saulitis, L. Barrett-Lennard, D. Matkin. 1999c *Killer Whales of Southern Alaska.* North Gulf Oceanic Society. 96pp
Matkin, C.O., Matkin, D.R., Ellis, G.M. , Saulitis, E. and McSweeney, D. 1997a. Movements of resident killer whales in Southeastern Alaska and Prince William Sound, Alaska. Marine Mammal Science, 13(3):469-475.
Matkin, Craig O., Scheel, D., G. Ellis, L. Barrett-Lennard, E. Saulitis. 1997b. Comprehensive killer whale investigation, *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 96012), North Gulf Oceanic Society, Homer, Alaska.
Matkin, C.O.,G.E. Ellis, M.E. Dahlheim, and J.Zeh. 1994. Status of killer whale pods in Prince William Sound 1984-1992. in: Marine Mammals and the *Exxon Valdez,* Thomas Loughlin, ed., Academic Press.
Matkin C.O., Saulitis E.L. 1994. Killer Whale (*Orcinus orca*) Biology and Management in Alaska, NGOS Report, prepared for the Mar. Mamm. Comm.,
Miller, P. J. O. and D. E. Bain 2000. "Within-pod variation in the sound production of a

pod of killer whales, Orcinus orca." Animal Behaviour 60(5): 617-628.
Olesiuk, P.F., M.A. Bigg and G.M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Reports of the International Whaling Commission Special Issue 12 :209-244.
Saulitis, E.L., C.O. Matkin, K. Heise, L. Barrett Lennard, and G.M. Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. Marine Mammal Science 16(1):94-109.
Saulitis E. 1993; The behavior and vocalizations of the "AT" group of killer whales (*Orcinus orca*) in Prince William Sound, Alaska, M.Sc. Thesis, University of Alaska Fairbanks
Scheel, D., C. Matkin, E. Saulitis. In press 2001. Distribution of killer whale pods in PrinceWilliam Sound, Alaska over a thirteen-year period, 1984-1996. Marine Mammal Science 17(3): July 2001.
Strager, H. 1995. Pod specific call repertoires and compound calls of killer whales, *Orcinus orca*, Linnaeus, in waters of Northern Norway. Canadian Journal of Zoology 73:1037-1047
Ylitalo, G.M., C.O. Matkin, J. Buzitis, M. M. Krahn, L. L. Jones, T. Rowles, and J. Stein. 2001. Influence of Life-History Parameters on Organochlorine Concentrations in Free-Ranging Killer Whales (*Orcinus orca*) from Prince William Sound, AK. Science of the Total Environment
Watkins, W. A. (1967). "The harmonic interval: fact or artifact in spectral analysis of pulse trains." 15-42.
Yurk, H., Barett-Lennard, L.G., Ford, J.K.B. And C.O. Matkin In press. Parrallel cultural and genetic lineages in resident killer whales off the coast of Southern Alaska, Animal Behavior.
Zenkovich,B.A. 1938. On the Kosatka or whale killer (*Grampus orca*) Priroda 4:109-112 (Translated by L.G. Robbins).
Zimmerman, S. 1991. A history of marine mammal stranding networks in Alaska with notes on the most commonly stranded cetacean species, 1975-1987. in: Marine Mammal Strandings in the U.S. Proceedings of the 2nd Marine Mammal Stranding Workshop.