APPLIED
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SCIENCES

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September 28, 1992

To: John Strand

From: Bob Spies

Re: Peer Review of the "Killer Whale Monitoring and Habitat Studies"

As per your request of July 31, 1992 enclosed is a review of the subject report by John Ford. As you can see from the review there are serious questions about the advisability of tagging killer whales. There may be better ways to study winter-time distributions, including extending the photo-identification techniques. I hope that this review is useful to you. Please call if there is further information required. I trust that you will forward this review to the principal investigator through Byron Morris for revision and to other NOAA personnel as appropriate.

CC: Gibbons
Morris

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MEMO

Date: September 26, 1992

To: Dr. Robert Spies
Applied Marine Sciences, Inc.

From: Dr. John Ford
Research Zoologist,
Vancouver Aquarium

Re: Killer Whale Monitoring and Habitat Studies, Prince William Sound

I have reviewed the report entitled:

Killer Whale Monitoring and Habitat Studies; Study ID Number: Marine Mammals Study Number 6

by M.E. Dahlheim, T.R. Loughlin and J.M. Waite. April 1992

This report has two main objectives, the first being to review literature and data related to habitat use by killer whales in Prince William Sound and adjacent waters, and the second being to assess the feasibility of applying satellite tags to killer whales. Although the discussion of satellite tag feasibility explores the topic in reasonable detail, the components regarding habitat use are rather brief overviews. In general, the information presented in the report is accurate. The following are my comments on specific sections of the report.

Objective I: Assessment of Habitat Use.

Population Assessment (p. 3):

There seems to be some inaccuracy in the details of research programs involving photo-identification of killer whales in Prince William Sound (PWS) during 1984-86. The field work in 1984, undertaken on behalf of Sea World, was reported in detail in Leatherwood et al. (1984), rather than Hall and Cornell (1986). The report states that photo-identification studies in 1985-86 were conducted under contract to the National Marine Mammal Laboratory (National Marine Fisheries Service), which is incorrect. The 1985 field work was undertaken by Sea World (Hall and Cornell 1986), and the 1986 photo-identification studies were conducted by the North Gulf Oceanic Society (NGOS), with funding from the University of Alaska Sea Grant Program (Matkin et al. 1987). Minor points, perhaps, but noted here for the sake of accuracy.

I also note that the three post-spill years of photo-identification studies in PWS are referred to only through the NRDA summary reports of Dahlheim and Loughlin (1989, 1990, and 1991). In my experience, it is customary in literature reviews to cite reports written by those who have actually undertaken the research and which contain the original data. This allows the reader to better determine the source of information being used in the review, and to assess its reliability. In this case, the results of field research in PWS during 1989-91 originate from reports by NGOS, specifically by Matkin, Ellis and Saulitis (1989), and Matkin and Ellis (1990 and 1991). Although these references are not in the primary literature, this is true of most of the citations in the report.

Distribution and Seasonality (pp. 3-4):

The discussion on distribution does little more than to acknowledge that killer whales can be seen throughout PWS, and that individual whales photo-identified in PWS have been observed in other regions of Alaska (no reference given). However, it would seem to me that a great deal of useful information on pod occurrence and movements within PWS during May to September, much of it with data on survey effort, is available. This could help identify critical habitats for killer whales in PWS during this part of the year.

It is correct that data on the year-round seasonality of killer whale occurrence in PWS are lacking, due to the absence of information for the winter months. However, it should be possible to obtain from existing data a reasonable understanding of trends through the months of May to September, the period when most surveys have been undertaken.

Prey/Fisheries Data (pp. 4-6)

There seems to be a discrepancy in information on stomach contents reported for three killer whales found stranded in PWS in 1990. The report claims that the stomachs were all empty (p. 5), but Matkin and Ellis (1991) state that two stomachs contained marine mammal remains, and the third contained a halibut hook.

Although more study is needed, it is apparent from field observations by NGOS researchers that resident pods feed primarily on salmon in PWS during the summer months. The movements of these whales in the Sound during this period of the year might thus be expected to correlate with the timing and distribution of salmon migrations. This correlation has been well documented for resident pods in British Columbia and Washington State (Heimlich-Boran 1988; Nichol 1990; Felleman et al. 1991). No detailed analysis of salmon distribution was attempted in this report, because it was concluded that catch numbers are too variable within and between years, and data are only available where fish are landed and not where they are caught. It is my understanding, however, that some potentially useful information on salmon distribution is available, and that further analysis may be warranted. For example, the timing of salmon arrivals at hatcheries is well recorded, which might be compared to whale abundance in the vicinity.

Depth contours and Temperature (pp.6-7)

Extensive analysis of the correlation between killer whale distribution and water depths and temperature would seem unlikely to be of much value. The distribution of killer whales has been shown in other areas to correlate with the distribution of their prey (as noted above), and this is almost certain to be the case for killer whales in PWS. As the authors correctly note, these factors may well influence prey distribution, and there may thus be a secondary, or indirect, correlation.

Objective II: Satellite Tagging

This discussion goes into considerable detail, far more so than do the sections discussed above. I agree that the means of tag attachment remains a problem that may be difficult to solve. Recent studies on belugas and bottlenose dolphins (Geraci and Smith 1990) indicate that subcutaneous implants are unlikely to be successful because of bacterial infection leading to rejection of the tag from the tissue. Dorsal fin attachment of a VHF tag to two temporarily-captive killer whales was successful (Erickson 1978), although the tags eventually tore out or were removed by the animals, causing significant permanent damage to their dorsal fins. Non-invasive dorsal fin attachment without restraint of the animal would be desirable, but it is difficult to envisage how this might be accomplished.

Although I'm sure all would agree that satellite-tagging of killer whales could result in a considerable amount of new information, I wonder whether this should be the future research priority for determining habitat use by PWS killer whales, especially if funds are limiting. Development and ultimate deployment of the tags is likely to be expensive and not without some risk of failure. If successful, it would provide information on the whereabouts of one or, at most, a few individuals over one winter. It would provide data on dive times and depth, but would not reveal much detail concerning the animals' activities.

I disagree with the statement (p. 11) that "useful information on seasonal movements across all seasons can only be obtained by placing satellite transmitters on whales". Much can be learned from alternative research techniques. If the priority for future research is to be the identification of critical habitats for PWS killer whales, perhaps more effort should be devoted to vessel-based studies within the Sound itself. For example, systematic photo-identification surveys throughout the year would determine the extent to which pods use PWS during the winter . When whales are located, behavioural observations would provide information on their activities, and opportunistic sampling of prey remains following kills would shed light on food habits. This latter technique has been shown to be an effective field tool in British Columbia, and is currently being employed in studies of killer whales in PWS during the summer months (C. Matkin, pers. comm.). In addition, hydroacoustic surveys and other techniques could be useful for quantifying prey abundance in areas of whale occurrence (cf. Thomas and Felleman 1988; Felleman et al. 1991).

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RPWG
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July 31, 1992

MEMORANDUM FOR: Bob Spies

FROM: John Strand

SUBJECT: Peer Review of NOAA's Killer Whale Monitoring and Habitat Study

Would you provide the Restoration Planning Working Group with a review of the enclosed report. This particular study assesses the usefulness of killer whale sighting data in establishing "preferred" habitat, and also explores the feasibility of placing satellite transmitters on killer whales to obtain specific information on habitat requirements. This was the restoration science study that you had helped shape. Thanks.

cc: RPWG
Bruce Wright

KILLER WHALE MONITORING AND HABITAT STUDIES

Study ID Number: Marine Mammals Study Number 6

Marilyn E. Dahlheim, Thomas R. Loughlin and Janice M. Waite
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April 1992

INTRODUCTION

Natural Resource Damage Assessment Studies (NRDA) were conducted on killer whale pods occurring in Prince William Sound from May to September for the years 1989, 1990, and 1991 to assess the possible impacts of the Exxon Valdez oil spill on killer whale life history and ecology. An unusually high number of killer whales were reported missing from Prince William Sound soon after the spill. In addition to the missing whales, changes occurred in the social structure of these pods. Differences were noted in the seasonal distribution of whales and there was an increase in the rate of observed strandings.

Restoration of cetaceans could be enhanced through protection of sensitive habitats, minimizing fishery interactions, reducing or redirecting other human-use impacts, and promoting public education. At present, little or no quantitative information exists on habitat needs for killer whales in Prince William Sound and adjacent waters on which to base a recommendation to limit or otherwise change human-use activities.

Objective I of this study was to review all available killer whale literature and sighting data from Prince William Sound and adjacent waters to determine if existing data were sufficient to assess habitat use by killer whales.

Objective II was to explore the feasibility of placing satellite transmitters on Prince William Sound killer whales to determine if this technique could be used to obtain specific information on habitat requirements.

MATERIALS AND METHODS

Objective I: All available literature and sighting data on Prince William Sound killer whales were reviewed to assess and summarize existing information on killer whale population levels, distribution, and seasonality patterns. Known researchers at federal and state wildlife agencies, as well as independent researchers, were requested to supply information on killer whales.

NOAA's Platforms of Opportunity (POP) database for killer whales was examined for Prince William Sound and adjacent waters and sightings were plotted. Marine mammal sighting data for the POP program have been collected from scientists aboard dedicated research vessels and from observers aboard various types of vessels from 1956 to the present time. Marine mammal sightings are contributed by professional marine mammal observers under contract to NOAA and occasionally by marine mammal and boating enthusiasts. Trained foreign and domestic fisheries observers also contribute sightings from Alaskan waters and waters off the U. S. west coast. Trained Japanese and U. S. observers report sightings from high-seas salmon and squid fishery vessels.

In addition to our review of available sighting data, we also searched for information concerning water depth, sea surface temperature, and fishery catch data which might help understand movements of killer whales in Prince William Sound.

Objective II: To determine habitat use and overall distribution and movements of killer whales, we explored the feasibility of placing satellite transmitters on Prince William Sound killer whales. A NOAA sponsored national tagging meeting (held in Warrington, Virginia, in February 1992) was attended. Scientists with satellite tagging expertise were consulted regarding the feasibility of placing satellite tags on killer whales. Throughout the year, meetings were conducted with numerous environmental groups and members of the killer whale research community to discuss the proposed satellite tagging program (Appendix I). The National Marine Fisheries Service, Office of Protected Species, in Washington, D. C. was contacted regarding the issuance of permits for tagging research.

RESULTS/DISCUSSION

Population Assessment

Hall (1981) conducted vessel and aerial surveys in 1976 to investigate population levels of cetaceans in Prince William Sound. He noted groups of approximately 70 killer whales in Knight Island Passage during June through September. Vessel surveys continued through 1982 which yielded a minimum population estimate of 80 killer whales (Leatherwood et al., 1984b). In 1984, Sea World conducted photo-identification studies in the area and reported a total of 185 whales (Hall and Cornell, 1986). In 1985 and 1986 photo-identification work was continued by researchers under contract to the National Marine Fisheries Service/National Marine Mammal Laboratory. Leatherwood et al. (1990) summarized the photo-identification efforts from 1976 through 1987 noting a population estimate of 232 killer whales in 17 pods. Minimal effort was expended in 1987 and again in 1988 by independent researchers in an attempt to provide continuity to the database. Beginning in 1989 and continuing into 1991, NOAA contracted for work on killer whales related to the Exxon Valdez oil spill. The most current population estimates of Prince William Sound killer whales are available from NOAA's 1989-1991 investigations (260 whales representing approximately 20 pods). Results of these 3-year investigations have been reported in the annual NRDA reports by principal investigators (Dahlheim and Loughlin, 1989, 1990, 1991).

Distribution

Braham and Dahlheim (1982) used the POP database to plot killer whale distribution in Alaska and found that killer whale sightings occurred primarily inside the 200 m contour line. A closer look at the POP sightings in Prince William Sound shows that killer whales

are seen in all parts of Prince William Sound (Fig. 1). Sightings are especially concentrated along shorelines and in Hinchinbrook Entrance. A systematic survey also had sightings distributed throughout Prince William Sound (Leatherwood et al., 1984b).

Some additional sighting information (< 15 sightings) was available on killer whales from the Alaska Department of Fish and Game and the U. S. Fish and Wildlife Service. Distributional patterns of killer whales were similar to those available from NOAA's POP Program thus these data added no new information on overall distribution of killer whales.

Movements of killer whales from Prince William Sound to the waters surrounding Kodiak Island and from Prince William Sound to Southeast Alaska have been documented through photo-identification studies. Current killer whale studies by the National Marine Mammal Laboratory off Kodiak Island and Southeast Alaska may supply additional information regarding the movements of Prince William Sound killer whales into other areas.

Seasonality

Boat surveys in Prince William Sound found a shift in whale concentrations from the west-central Sound (Smith Island and Naked Island region) in April through mid-May to the southwest region (Knight Island Passage and Montague Strait) after mid-May (Leatherwood et al., 1984a). Hall (1986) suggested that Knight Island Passage may be a seasonal home range for killer whales.

Leatherwood et al. (1984b) noted that killer whale numbers appear to increase in Prince William Sound (PWS) in the summer months. This assertion cannot be supported since effort is not consistent among all seasons. The POP sighting data shows a decrease in killer whale numbers in the winter months but again effort is reduced during this time period. Although these sighting data are useful in showing general distribution of killer whales, they are not adequate to be used to predict seasonal patterns of killer whales (Figs. 2-5).

Prey/Fisheries Data

Killer whales are known to eat a large variety of prey, including large and small cetacea, pinnipeds, fish, birds, sea turtles, and cephalopods. Most evidence of killer whale feeding habits in Prince William Sound has come from observational data. The occurrence of killer whales in Prince William Sound has been tied to the large runs of summer salmon. von Ziegesar (1984) reported observations of killer whales feeding on schooling salmon (Onchorhynchus sp.). Hall (1986) reported that biologists from the Alaska Department of Fish and Game observed killer whales feeding on Steller sea lions in mid-winter. During photo-identification efforts in 1985, Hall and Cornell (1986) observed six attacks on

marine mammals by killer whales including two harbor porpoise, two Dall's porpoise and two harbor seals.

Few reports are available on the analyses of food items through examination of stomach contents. Rice (1968) reported that the remains of a Pacific halibut was found in the stomach of a male killer whale found near Kodiak Island. During the National Marine Mammal Laboratory's (NMML) studies in 1990, three killer whales were found stranded in Prince William Sound. The stomachs were empty in all cases. A large male killer whale was found stranded at Cape St. Elias (spring 1991) which had remains of a Steller sea lion, harbor porpoise, and harbor seal.

Prince William Sound has a rich diversity of fish species. Besides salmon, possible killer whale prey items include several species of nearshore fishes. Fish abundance is highest in the summer. During the winter fish move offshore or to deeper waters (Hood and Zimmerman, 1987) making them less available to killer whales.

A large database exists on the commercial harvest of salmon in Prince William Sound from the Alaska Department of Fish and Game. The number of different species of salmon caught is recorded for eight districts of Prince William Sound and surrounding waters. Catch numbers are highly variable depending on the number of fishing vessels involved. Catch data reflect only months that were fished which varies between years ranging from May through September. This makes the data unreliable for correlating fish numbers with whale sightings. Fisheries data are also misleading because, although catch numbers are split up into districts, the data only reflect where fish were landed but not necessarily caught. Therefore, the data may not accurately reflect fish distribution and limits the possibility of correlating whale locations with salmon abundance. However, from the data it appears that at least one or two salmon species are always available in PWS as killer whale prey during the summer months.

Many species of both cetacea and pinnipeds are known to inhabit Prince William Sound; all potential prey of killer whales. Dall's porpoise and harbor porpoise are present throughout the year (Hall, 1981). Whales found seasonally in or near Prince William Sound include gray whales, humpback whales, fin whales and minke whales (Hall, 1981, von Ziegesar, 1984).

Harbor seals are found throughout Prince William Sound in the summer (Pitcher, 1989). High numbers of harbor seals probably occur throughout the year (Hoover, 1988). Steller sea lions haulout year-round in Prince William Sound (Calkins and Pitcher, 1977, Hoover, 1988). Seal Rocks (six miles southwest of Cape Hinchinbrook) is the largest Steller sea lion rookery in the Prince William Sound area (1,220 counted in June, 1991; Merrick et al., 1992). It appears that while fish numbers are lower in Prince William Sound in the winter, there are many marine mammals present

that might serve as killer whale prey.

It has been proposed that there are two types of killer whale pods in Prince William Sound termed resident and transient (Leatherwood et al., 1990). These types are believed to differ morphologically and behaviorally, including differences in prey preferences. Residents are thought to specialize on fish prey, while transients are thought to specialize on marine mammals. If this is true, resident pods may leave Prince William Sound in response to a decline in salmon. Based on the numbers of pinnipeds and cetaceans in Prince William Sound year-round, there is no obvious reason based on prey abundance why transient pods would also need to leave Prince William Sound.

Investigations have been made on the foraging behavior of killer whales in Puget Sound, Washington (Felleman, 1986; Heimlich-Boran, 1988). Felleman (1986) suggested that killer whale populations specialize on preferred prey and shift preferences as prey abundances change seasonally. The resident pods of Puget Sound were found to feed in areas along salmon migratory routes (Heimlich-Boran, 1988). He noted that whales might use the high relief subsurface topography along these routes to increase feeding efficiency (i.e., herding fish). Transient whales were found to feed in shallow protected areas near harbor seal haul-out sites. Foraging studies on Prince William Sound killer whales have not been conducted. It would appear that movements of these killer whale populations would be based on the location of their food resources.

Depth contours

Killer whales have been sighted in areas representing all depths of Prince Williams Sound. This includes the shallowest areas such as Orca Bay (< 100 fathoms), inlets and open areas of moderate depth (< 250 fathoms), and the deepest channel, Knight Island Passage (> 250 fathoms). This limits any meaningful correlations that can be made between killer whale distribution and depth. The area which has been proposed as a possible seasonal home range for killer whales (i.e., Knight Island Passage) does have the greatest depths in Prince William Sound. However, the whales may be there as a direct result of greater fish numbers rather than because they prefer deeper waters.

Temperature

The temperature of PWS surface water changes from season to season. Oceanographic seasons lag behind climatological seasons by two to three months because of the extra time water takes to respond to surface cooling or heating. Surface temperatures in Prince William Sound are lowest in the winter (December to March) ranging from <1° C to 2.4° C (Muench and Schmidt, 1975). During the spring,

waters begin to warm up, ranging from 9°C to 11°C. The maximum temperatures are reached (>12.5°C) during August to September in the eastern central portion of the Sound. A cold tongue of water (<10°C) in the north end is probably due to glacial melt waters. A sharp decrease in the temperature of surface water occurs after September (Muench and Schmidt, 1975).

Because of the lack of consistent killer whale sighting data throughout the year, it is not possible to correlate surface temperatures with killer whale distribution. But, considering that killer whales are marine mammals designed to deal with cold temperatures, it is not likely that the surface water temperature itself strongly affects killer whale distribution. Killer whales are found in many cold water regions around the world. However, killer whale distribution may be affected if water temperature affects prey distribution.

Satellite Tagging

Satellite telemetry is a means to overcome the high costs and logistical programs of conventional VHF (very high frequency) radio-telemetry systems. Detailed locational and behavioral data on animals have been obtained using the Argos Data Collection and Location System (DCLS). The Argos system, a cooperative project of the Centre National d'Etudes Spatiales of France, NOAA, and NASA, is designed to acquire environmental data on a routine basis from anywhere on earth. Signals from transmitters are received by Argos DCLS instruments aboard two Tiros-N weather satellites in sun-synchronous, near-polar orbits. Data from the satellites are received at tracking stations, transferred to processing centers in Maryland and France, and are made available to users via computer tape, printouts, or telephone links. Representatives from Service Argos have indicated that their system would be readily available for killer whale investigations using satellite telemetry. All background information, including required applications, and costs involved have been received by NMML and are also readily available through Service Argos.

Between 11-13 February 1992 (Warrington, Virginia), NMFS, Office of Naval Research and Minerals Management Service sponsored a workshop on satellite tagging methodology as applied to cetaceans. In attendance were scientists with past tagging experience, biologists currently involved in telemetry efforts, representatives from industry and several government agencies, and veterinarians. Three working committees were formed to discuss: 1) tag attachment and release systems, 2) electronics and sensors and, 3) data acquisition. Existing technology with regards to electronics, sensors, and data acquisition systems for satellite tagging cetaceans is adequate. Existing sensor packages would need to be modified or a new package design would have to be developed if killer whale satellite investigations were supported. The greatest

problem facing cetacean biologists today is the actual delivery and attachment systems to place the instruments on the animals. For the purpose of this report only those findings from the working committee on tag attachment and delivery systems as applied to killer whales will be discussed since this is the area where major problems exist that could delay satellite tagging research on killer whales. The strengths and weaknesses of various types of attachment methods were discussed to include harnesses, adhesives, suction cups, surgical implants, caudal peduncle mounts, ingested instruments, and dorsal mounts.

Harnesses were not recommended since they were shown to increase drag, respiration rates, and lactate levels. Skin mitosis is so fast on most cetaceans (we assume that killer whales have fast skin mitosis) that any type of surface adhesions tend to be short lived (4-17 hours). Suction cups could be used for short-term instrument deployments (1-4 days) on smooth-skinned cetaceans having slow skin mitosis. Suction cups, however, tend to migrate and pressure necrosis may occur. Suction cups should have built-in release devices to prevent pressure necrosis. Currently, NMML is providing partial support to an existing project occurring in the waters off the southern coast of Vancouver Island where suction cups are being placed on killer whales. Suction cups have been attached to three animals. In all cases, the suction cup only stayed attached to the whale for less that 3 hours. The cup rapidly travelled from its original tagging position (upper mid-body directly beneath the dorsal fin) posteriorally to the tail stock. The response of the three whales to tagging operations varied considerably from no overt reaction (juvenile, transient whale) to an obvious change in behavior (fast porpoising away from its pod to a position approximately one mile ahead -- adult male, resident animal). An annual report on these suction cup investigations will be available in the fall of 1992 from Robin Baird. Surgical implants and ingested instruments can only be used in limited situations (i.e., captivity where animals can be fully restrained) and are not considered a viable option in Prince William Sound killer whale studies. The deployment of caudal peduncle mounts is not recommended since these devices cause drag and abrasion due to the motion of the flukes.

Currently the best method of attaching instruments to a cetacean appears to be by a dorsal mount. A dorsal mount would bolt through a dorsal structure, such as a fin or ridge. Using this method, the animal would have to be captured. Holes would be cut through the fin using a coring device that removes tissue. The bolts should be made of Delrin or some similar plastic rather than metals (testing of materials is needed), and steel or magnesium nuts should be used which eventually corrode thus releasing the package. Bolts should be threaded only on their ends, not where the bolt touches cored tissue. Multiple bolts sites are recommended (five versus two). The actually site for coring and bolting could be determined by infra-red thermography, or by probing with a hypodermic needle prior to coring. Saddles should be made of PVC, Teflon or other

materials that resist biological fouling. Saddles could be lined with neoprene to reduce chafing. Tightness of the saddle is of critical importance. Mounts that are too tight may cause pressure necrosis, while those that are too loose may cause tissue damages in the attachment holes.

A killer whale would be an ideal animal to place a dorsal mount on due to the large size of the dorsal fin and overall size of the animal. However, capturing a killer whale may not be an viable option given the political sensitivity that this type of research on killer whales would raise. Permits may be difficult to obtain as well. If capture is not feasible, a method of delivering a tag to a killer whale's dorsal fin would have to be devised. Although preliminary discussions regarding such delivery systems have occurred, nothing of value has been developed.

Other tag attachment methods are available when capture is not an option. Currently subdermal attachments delivered by shotgun or crossbows are used to attach instruments to large cetaceans. These methods should be used with extreme caution and only after extensive training and experience because such mounts are potentially lethal to the animal. Two systems are currently available -- the "Watkins" system and the "Goodyear" system.

The Watkins system involves a rigid, tubular dart which is fired from a shotgun into the whale's blubber. Depth of penetration is regulated by a stop. All instrumentation is included inside the shaft of the dart. The size of the dart is currently too long for placement into killer whales. However, scientists from Iceland are currently modifying this dart for placement in minke whales. If successful (within the next two years), the minke whale dart could potentially be available for our killer whale investigations. However, blubber thicknesses of minke whales versus killer whales need to be compared prior to using the dart on killer whales.

In the Goodyear system only the dart head penetrates the skin and blubber. The instrument is attached outside the skin by a jointed swivel that allows the instrument to stream at right angles. Depth is regulated by a stop.

Both the Watkins and Goodyear systems have their advantages. The Watkins system is all internal and does not disturb the animal by allowing instruments to move on the skin. A modified Watkins system for killer whale could be available within the next two to three years (Watkins, pers. commn.). The Goodyear attachment system can be coupled with many kinds of instruments. It is highly likely that this system, after detailed testing, could be ready for use in the proposed killer whale studies by the fall of 1993.

An important concern is that of tag longevity. The longest the Watkins or Goodyear systems are known to have remained attached are 6 weeks and 4 years, respectively. The maximum longevity of either

tag is unknown because either the instruments they contained stopped transmitting, the animal migrated, or both. In the current killer whale study, we had proposed to tag whales in September. It would be important to have transmitters working for at least eight months (until May) to gather needed information of whale movements during the late fall, winter and early spring seasons. To date, no satellite tag has continued to operate for eight months.

In addition to our investigations on examining current methods of instrumenting cetaceans, we have also taken the opportunity on several occasions to discuss our proposed satellite tagging program on killer whales with various members of the environmental community and research community. In all cases, the responses have been favorable and supportive of our research. All groups that we approached believed that it was important to collect this habitat information on Prince William Sound killer whales. They agreed that the information collected would be put to good use in protecting whale habitat. Of utmost concern to all individuals interviewed was the question of how the tag would be attached.

Discussions also took place with the National Marine Fisheries Service, Office of Protected Species, in Washington, D. C., regarding the issuance of permits for killer whale tagging research. Representatives from this office provided helpful suggestions regarding preparation of the permit application and indicated that it would take 6 to 12 months to obtain a permit.

In summary, the technology exists to place satellite transmitters on killer whales. However, for cetaceans, tag delivery and attachment methods are still being evaluated. Currently the best method of instrumenting a killer whale would be through a dorsal mount bolted to the leading edge of the dorsal fin. The whale would have to be captured which is probably not a viable option. We are currently investigating ways in which we could attach a tag to a killer whale's dorsal fin from a moving, vessel platform. We are also considering the "Watkins" or "Goodyear" systems. Considering certain limitations with both systems (i.e., size of the Watkins tag and longevity issues with both systems), successful deployment of tags may not be possible until September 1994 season.

CONCLUSIONS

1) The most reliable/current population estimates of Alaskan killer whales have resulted from NOAA's three-year investigations (1989-1991) in Prince William Sound/Southeast Alaska. Other killer whale population levels are not known for most Alaskan waters. Nothing is known regarding separation of stocks of Alaskan killer whales.

2) Distributional patterns of Alaskan killer whales have been provided by NOAA's Platform of Opportunity Program. This 35-year database provides an extensive overview of killer whale distribution throughout Alaskan waters. However, these sighting

data only represent information in areas or seasons where effort was concentrated. For example, considerable effort is available for nearshore waters during the summer season versus offshore waters in the winter season. These sighting data reflect that effort and thus do not truly represent complete distributional patterns of killer whales.

3) Reliable information is not available on the seasonal movements of killer whales in Alaskan waters. We assume that movements by whales are tied to movements in the prey resources. Some Prince William Sound killer whales have been observed in Southeast Alaska while others have been observed in Kodiak waters. Studies currently being conducted by NMML in Southeast Alaska and Kodiak will add to our knowledge of Prince William Sound killer whales.

4) Although little is known about the diet of killer whales, a rich diversity of prey species occurs in Prince William Sound to support killer whale populations. Information on food habits and food preferences of Prince William Sound killer whales results primarily from observational data. Although of value, this information should be carefully evaluated. Fisheries data do not accurately reflect where fish were caught and limits the possibility of correlating whale locations with salmon abundance. Few stranded killer whales have been found and in most cases the stomachs of these whales were empty. Every effort will be made to investigate stranded Alaskan killer whales.

5) Meaningful correlations cannot be made between killer whale distribution and water depth (sightings occur in waters of all depths); or water temperatures (lack of consistent sighting data throughout the year).

6) To afford adequate protection for PWS killer whales, habitat requirements of killer whales must be determined. Useful information on seasonal movements across all seasons can only be obtained by placing satellite transmitters on whales. The placement of transmitters on selected individual whales from various pods could add significantly to our understanding of seasonal movements and habitat requirements of killer whales. Although the technology currently exists (electronics, sensors, etc.), methods of tag delivery and attachment still need to be refined. If funding continues, it is reasonable that existing systems could be modified and that killer whale tagging studies could occur in the fall of 1994. We recommend that investigations on killer whale satellite tagging be continued.

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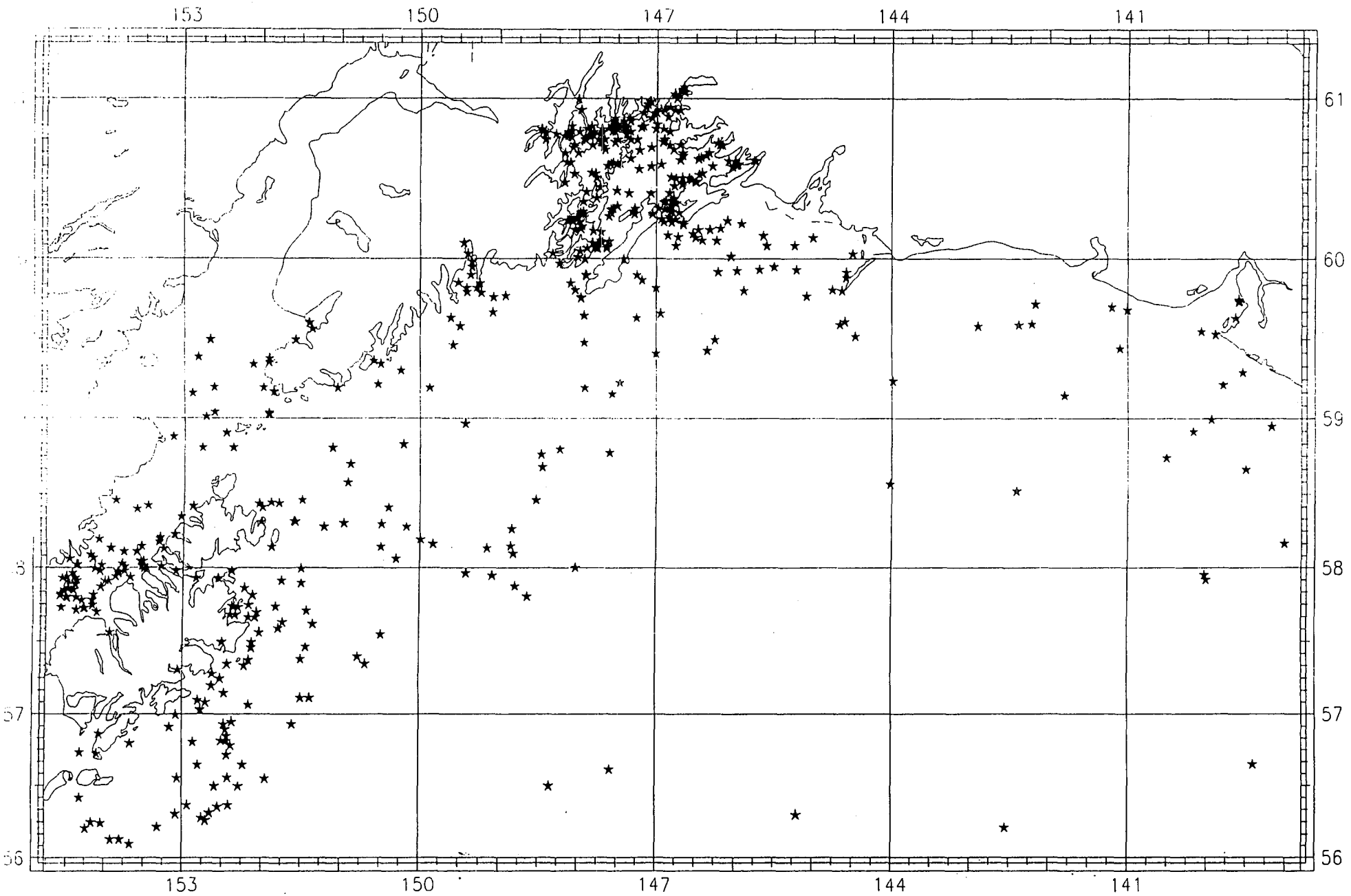

Figure 1. Killer whale sightings. NOAA's Platform of Opportunity Program (1956-1990)

Orca Spring

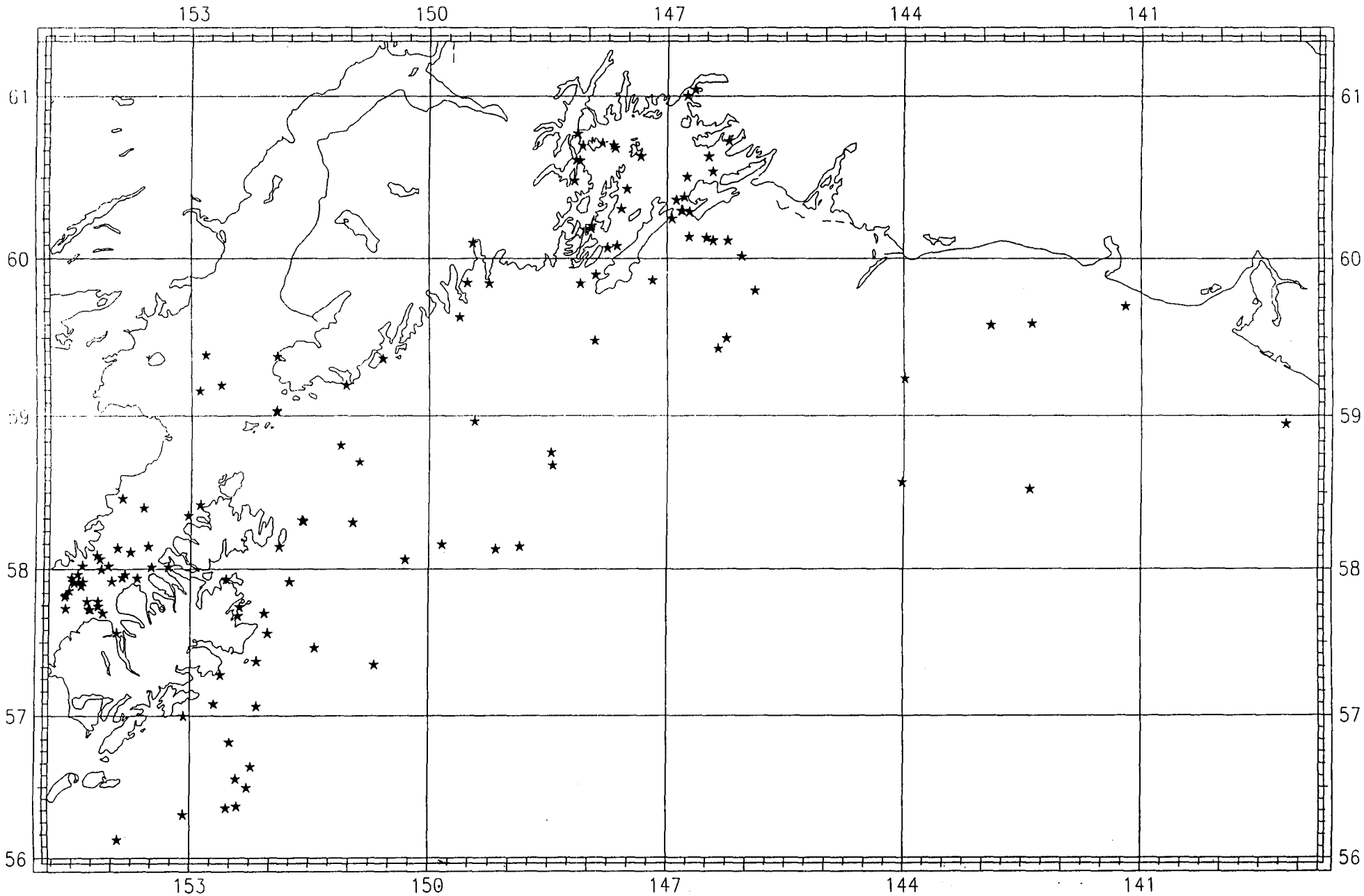

Figure 2. Killer whale sightings (April, May, June). (1956-1990).

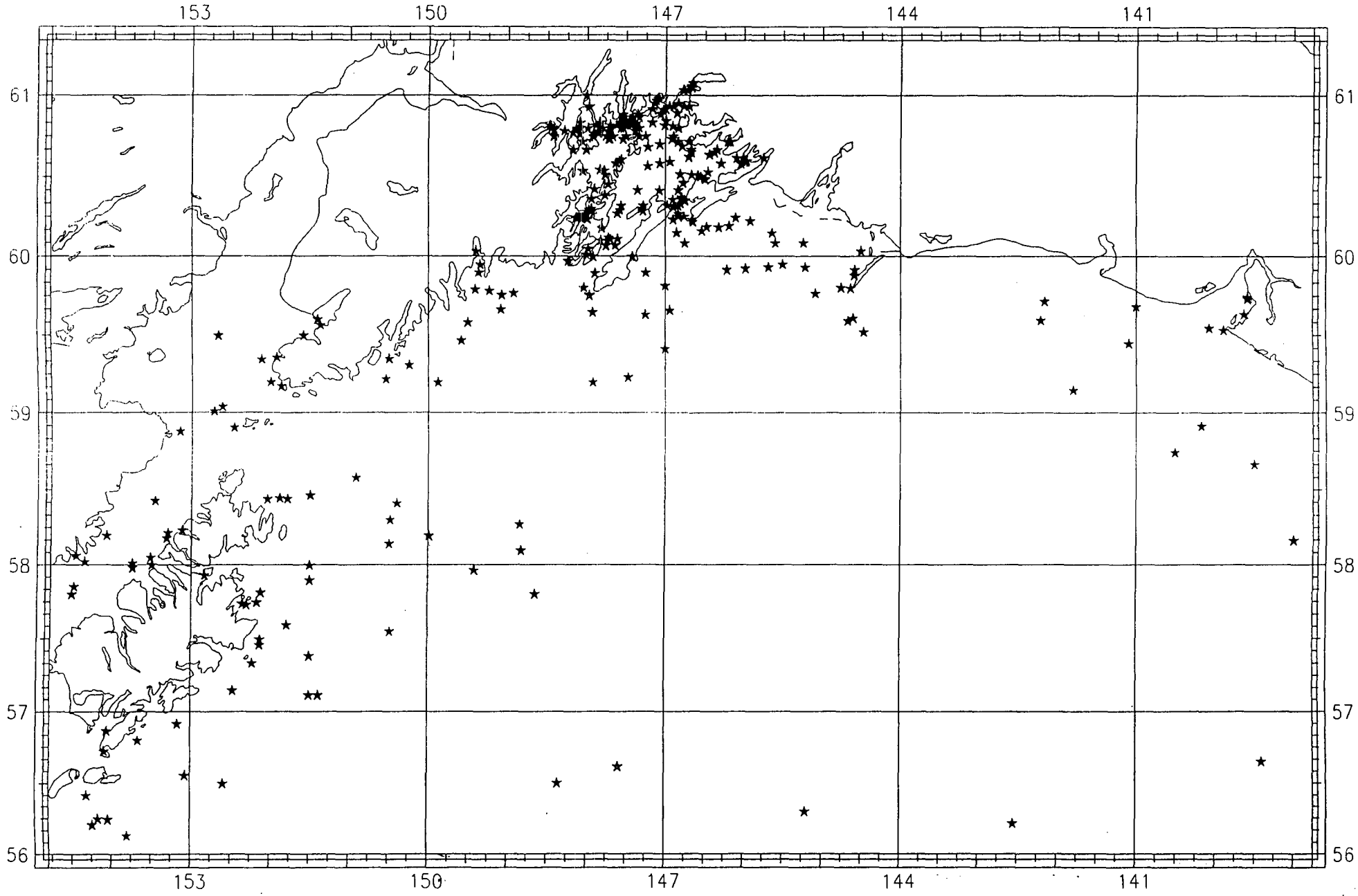

Figure 3. Killer whale sightings (July, August, September) (1956-1990).

Orca fall

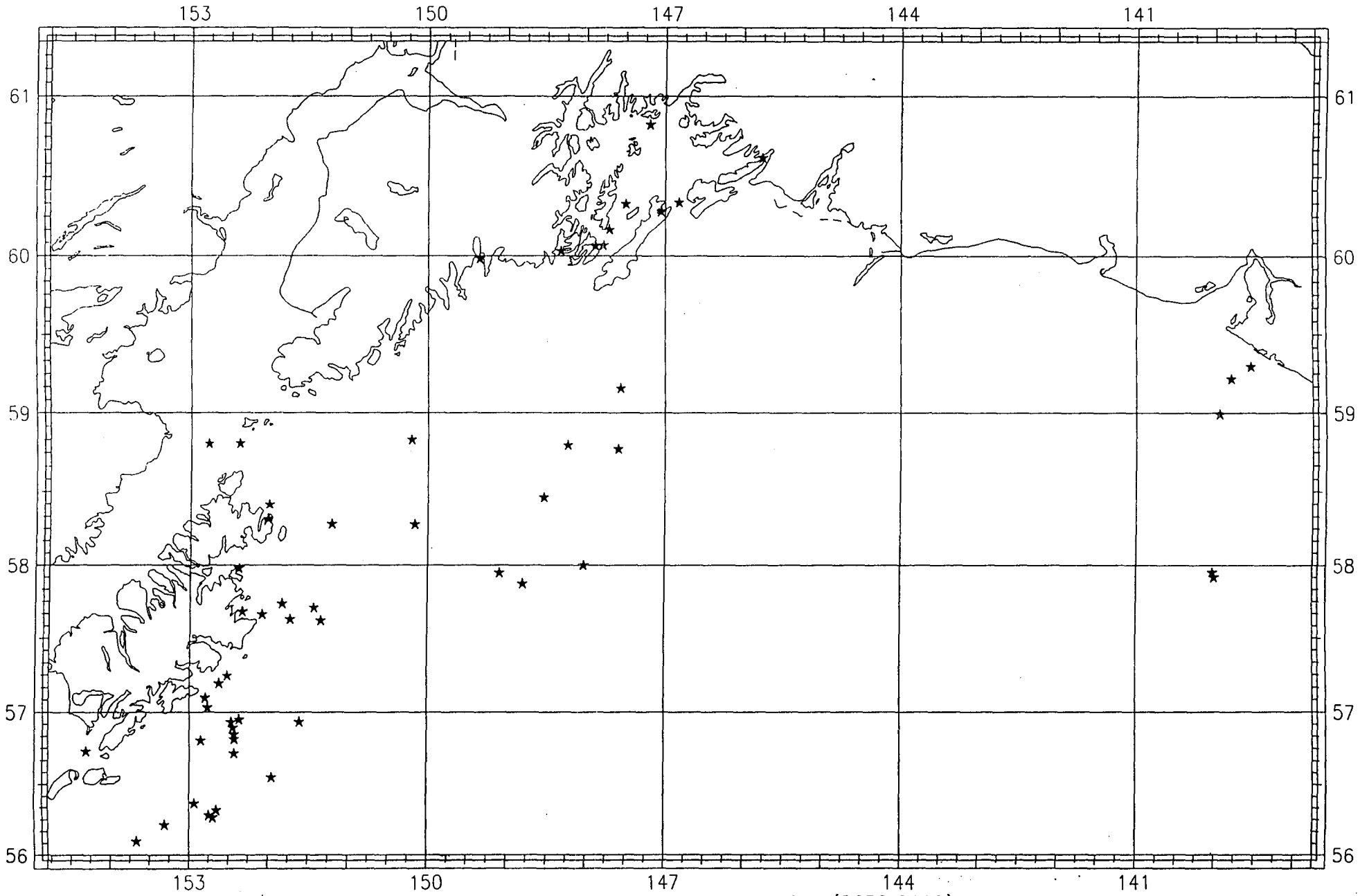

Figure 4. Killer whale sightings (October, November and December). (1956-1990).

Orca Winter

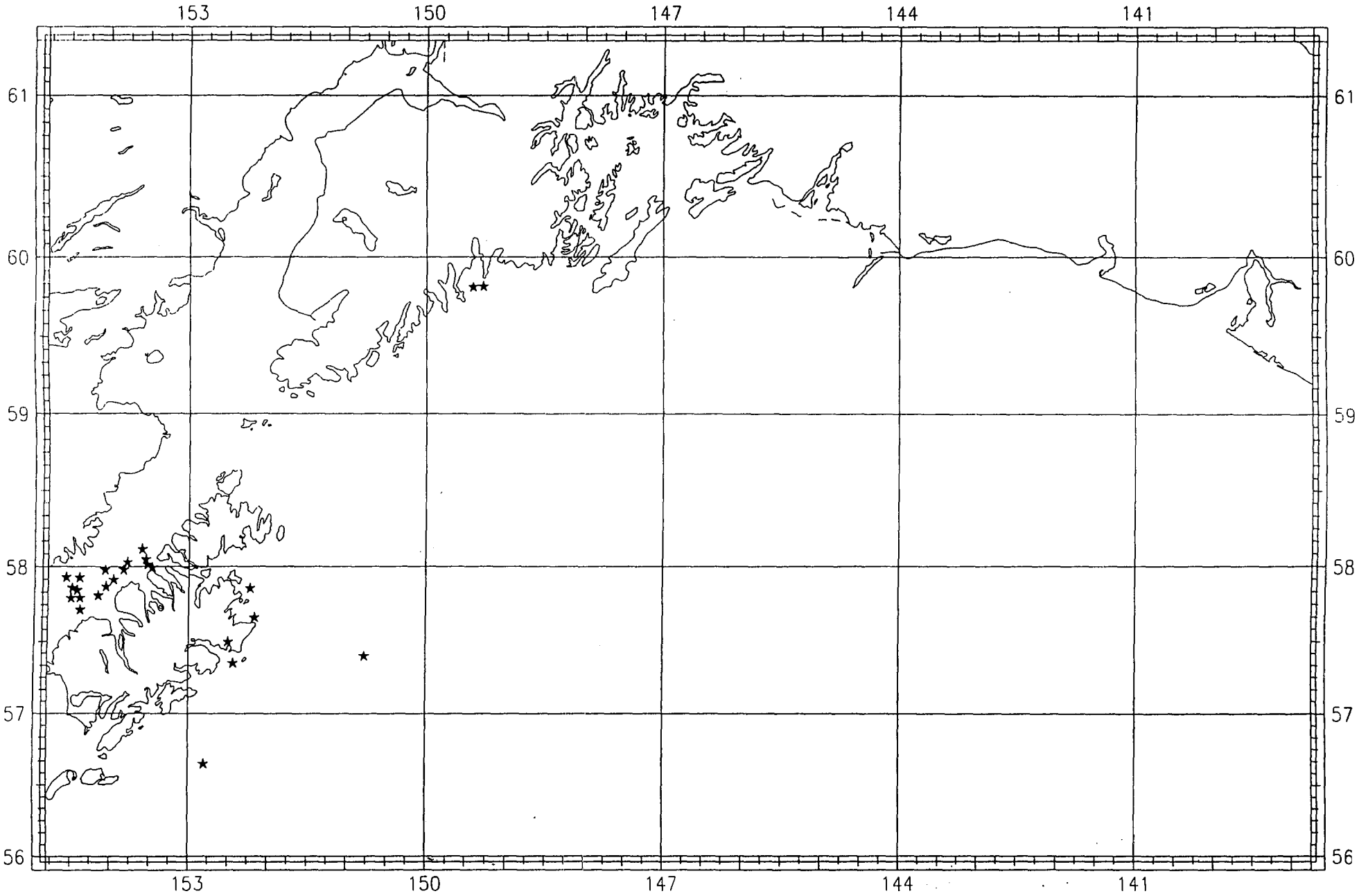

Figure 5. Killer whale sightings (January, February, March). (1956-1990).

APPENDIX ONE

Discussions on the feasibility of placing satellite tags on killer whales have taken place with the following groups and individuals.

Enviornmental Organizations

American Cetacean Society
Center for Marine Conservaton
Greenpeace
Sierra Club

Killer Whale Researchers

Ken Balcomb
Kelly Balcomb-Bartok
Prentice Bloedel
Robin Baird
Dave Ellifrit
Dave Bain
Janice Waite
Craig Matkin
Dan McSweeney
Rich Osborne
Jeff Jacobsen
Pam Stacey