Status Review of the AT1 Group of killer whales from the Prince William Sound and Kenai Fjords area.

1. Introduction

The AT1 group of killer whales was first recognized as a separate group of killer whales in 1984, when a group of 22 transient-type whales were documented in Prince William Sound (Leatherwood *et al*. 1984a, Heise *et al.* 1992), though individual whales from the group had been photographed as early as 1978. Once the North Gulf Oceanic Society began consistent annual research effort in Prince William Sound, AT1 killer whales were re-sighted(?) frequently, though not always as a single group. In fact, the AT1 group was found to be one of the most frequently sighted groups of killer whales in Prince William Sound (Matkin et al. 1993, 1994). Other transient killer whales were seen less frequently, with periods of several years between resightings not uncommon.

AT1 transients are similar to other transient populations in the North Pacific in their dietary specialization on marine mammals (Ford et al. 1998), their hunting strategy, that relies on passive listening and stealth (Barrett-Lennard et al. 1996) and their life history (Ford and Ellis 1999). The AT1 transients travel in groups of one to twelve, and at least seasonally appear to specialize on hunting harbor seals and Dall's porpoises in Prince William Sound and the Kenai Fjords region (Saulitis et al. 2000). They behave much like the transients described in British Columbia waters; however, unlike other transients, that are resighted sporadically, most of the AT1 transients are resighted in Prince William Sound and Kenai Fjords every year (Heise et al. 1992). The AT1 group has never been seen in association with sympatric resident killer whales or with other infrequently seen transient groups that occaisionally use Prince William Sound (Matkin et al. 1999b). In addition, acoustic behavior (Saulitis 1993) and genetics (Barrett-Lennard 2000) indicate the AT1 group is a genetically distinct, socially isolated group of killer whales.

The AT1 group has never been seen in association with sympatric resident killer whale pods or with other infrequently seen transient groups that occasionally use Prince William Sound (Matkin et al. 1999b). The AT1 group was identified as having an acoustic repertoire that was different from other transient killer whales (Saulitis 1993). Additionally, analysis of mitochondrial and nuclear DNA found that the AT1 group had significant genetic differences from both West Coast transients and the partially sympatric Gulf of Alaska transients (Barrett-Lennard 1999).

Eleven members of the AT1 group have not been seen since the 1989 Exxon Valdez oil spill; one of these individuals is known to have died and the rest are presumed dead (Matkin et al. 1999a). Sightings of the remaining individuals in the AT1 group have also declined in the years following the oil spill (Matkin et al. 1999a), and the population of one of their primary prey species, the harbor seal, has declined in recent years (Frost et al. 1999).

Under the US Marine Mammal Protection Act, AT1s are currently considered part of the eastern North Pacific (ENP) transient killer whale stock, which is the only currently defined “stock” of

transients in the North Pacific. The minimum population estimate for the ENP transient stock is 346 animals (Angliss et al. 2001).

NOAA Fisheries received a petition to designate the AT1 group as "depleted" under the MMPA. To do so, NOAA Fisheries would need to determine that the AT1 group was a separate stock under the MMPA, and then determine that that stock was depleted. This documents reviews biological information relevant to the stock definition and status of the AT1 group of killer whales.

2. Summary of petition to designate AT1 group as depleted under MMPA

The following represents a summary of the petition received from the National Wildlife Federation to designate the AT1 group of killer whales as depleted under the MMPA

Main points raised by the commenter:

- The petitioner states that the AT1 group is a stock and refers to the petitioner's comments on the 2002 draft SARs for support of this statement
- The petitioner listed the following supporting arguments for a depleted designation
  – In 1984 the AT1 group included at least 22 members; only 9 are alive today and the prospects for recovery are bleak
  – NOAA Fisheries intends to use 60% of the carrying capacity (K) as a way to determine whether southern resident killer whales are depleted, and this standard should also be used to determine whether AT1s are depleted
  – The carrying capacity for AT1s is unknown, but NOAA Fisheries generally uses the best estimate of maximum historical abundance as a proxy for K.
  – Thus the K for AT1s is at least 22 animals. The Optimum Sustainable Population level would be 60% of K, or 13 animals. Because 9 animals is below 13 the stock should be designated as depleted using NOAA Fisheries' own regulations.
- The petitioner listed the following as potential causes for depletion
  – The *Exxon Valdez* oil spill (some members seen swimming through oil and were never seen again; Matkin et al. 1999a)
  – Chemical contaminants (autopsy of a male in 2000 revealed high levels of DDT and PCBs)
  – Increased vessel traffic (may impact the AT1's ability to hunt; increased boat traffic may have cumulative impacts such as increased pollution, increased potential for collisions, and degraded habitat)
  – Reduction in available prey species (harbor seal population has decreased 80% from 1977-1997)
- The petitioner listed the following as benefits of designation as depleted
  – A designation as depleted will allow NOAA Fisheries to do a conservation plan for the stock
  – A designation as depleted will focus attention and funds on the whales
  – A designation as depleted is required by the spirit and the letter of the MMPA

3. Distribution, abundance, and population dynamics

The minimum population estimate for the ENP transient stock is 346 animals (Angliss et al. 2001). However, the AT1 group represents just a small fraction of that total.

The AT1 transients appear to have a more limited range than do other transients. Though seen mostly in Prince William Sound, some AT1s were photographed between Prince William Sound and Resurrection Bay in 1992 (K. Heise, pers. comm. in Matkin and Saulitis 1994). It is now known that they can be seen in Prince William Sound and Resurrection and Aialik Bays of the Kenai Fjords year-round (Saulitis et al. 2000). However, they are not known to travel east of Prince William Sound or west of Kenai Fjords, Alaska, an apparent range of at least two hundred miles (Matkin et al. 1999b). Consequently, most members of the AT1 group are resighted every year or two, while a decade or more may elapse between resightings of individual British Columbia transients, which have an apparent range of over 1500 miles (Ford and Ellis 1999).

Members of the AT1 group have been recognized as utilizing Prince William Sound since at least 1978 (Leatherwood et al. 1984a, Saulitis 1993), as three AT1s (AT7, AT15, AT16) were first photographed in 1978. In subsequent years, one was seen in 1980, one in 1982, and 7 in 1983 (Leatherwood et al. 1984a). The low numbers of individuals seen likely reflected the paucity of directed research effort in Prince William Sound. Once a major research effort was underway in Prince William Sound, 20 individuals were identified in 1984 (although 2 others were known to be present), 17 in 1985, and 21 in 1986 (Leatherwood *et al.* 1990). All individuals identified prior to 1984 (from 1978-1983) were seen alive in 1984 (Leatherwood *et al.* 1984a). AT1s were seen in Prince William Sound from April to August (Leatherwood et al. 1984a).

In 1984, 3 AT1s were classified as juveniles or calves (Leatherwood et al. 1984a or b?), indicating reproduction had occurred within the previous 8 years or so. However, Matkin et al. (1999a) reports that no new calves have been observed since 1984. As of 1987, 9 of 22 AT1s were considered adult males (Leatherwood et al. 1990), which is an unusually high percentage. Such a high percentage could arise from a loss of adult females, but it also could arise from a long period where little or no recruitment takes place, and the population becomes composed of mostly adult animals.

All 22 AT1s were seen annually or biannually from 1984 to 1988 (Matkin et al. 1999a). The *Exxon Valdez* oil spill occurred in spring of 1989. Nine individuals from the AT1 group have been missing since 1990 (last seen in 1989), and 2 have been missing since 1992 (last seen in 1990 and 1991). All 11 are presumed dead (Matkin et al. 2000). Three of the AT1s that presumably died (AT5, AT7, and AT8) were seen near the Exxon Valdez (with AT6) shortly after the spill (Matkin et al. 1993, 1994). One of the 11 was confirmed dead – AT19 was found dead on a beach in the spring of 1990 (Matkin et al. 1994). Two other carcasses of killer whales were found in Prince William Sound in 1990, and one was found in 1992. Two of those three were confirmed as transients based on marine mammal parts found in their stomach (Matkin et al. 1994). A fifth killer whale carcass was found on Kayak Island 60 miles southeast of the sound, also with marine mammal parts in its stomach (date not reported) (Matkin et al. 1993). No other killer whale carcasses were found in the Prince William Sound region from 1983 through 1992 (Matkin et al. 1994). In addition, no strandings of killer whales were reported from Prince

William Sound from 1975 to 1987 (Zimmerman 1991). In sum, these facts lead to the conclusion that the 11 whales missing since 1991 should be presumed dead, though only one was documented to have died.

There is an interesting parallel with the AB pod of residents in Prince William Sound, which were seen swimming through oil from the Exxon Valdez oil spill. The pod had 36 animals before the spill, but in the first year after the spill the pod lost 7 animals, and in the next year the pod lost 6 animals (Matkin et al. 1994).

In the AT1 group, all 11 individuals confirmed as alive after 1989 were seen nearly every year from 1990-92 (Matkin et al. 1994). The number of individuals seen in subsequent years was 8 in 1993, 5 in 1994, 11 in 1995, 9 in 1996, 6 in 1997, 8 in 1998, and 7 in 1999 (Matkin et al. 2000). Since 1993, only in 1995 was every individual whale seen in every year. However, when considering pairs of years, all 11 individuals were seen again in 1996-97, and all 11 individuals were seen again in 1998-99. Therefore, it can be concluded that no mortalities occurred between 1992 and 1998.

Using more current unpublished information, no births have occurred since 1999, and the population size as of the summer of 2002 is thought to be nine whales (C. Matkin, pers. comm.). Of the current 9 animals in the group, 4 are female.

4. Prey preferences

Transient killer whales have been documented to kill a wide variety of marine mammals (Jefferson et al. 1991, Ford et al. 1998, Ford and Ellis 1999). Saulitis et al. (2000) note that potential marine mammal prey in Prince William Sound includes Dall's and harbor porpoise, humpback, minke, and gray whales, harbor seals, Steller sea lions, and river and sea otters. However, Matkin et al. (1999b) describe AT1s as specializing in harbor seals and also Dall's porpoise, at least in summer when photo-identification effort is highest. In the study of Prince William Sound killer whales undertaken by Saulitis, Matkin, and colleagues, only 3 species of marine mammal were seen killed, including harbor seals (10), Dall's porpoise (12), and harbor porpoise (2) (Saulitis et al. 2000). The majority of these observed kills were by AT1 whales, but their data also include a few observations of Gulf of Alaska transients that came into Prince William Sound. All of the harbor seal kills were by AT1s. AT1s were never seen to kill a Steller sea lion, and were never seen foraging around Steller sea lion haul-outs (Saulitis et al. 2000). AT1s were seen harassing Steller sea lions (4 occurrences), humpback whales (6 occurrences), and sea otters (2 occurrences) (Saulitis et al. 2000).

In contrast, at least some Gulf of Alaska transients appear to take Steller sea lions, and were seen in the same study to harass Steller sea lions on ten occasions, even though there were only 22 encounters with Gulf of Alaska transients and there were 174 encounters with AT1s in the study (Saulitis et al. 2000). Two Gulf of Alaska transient individuals were observed on 11 occasions near a Steller sea lion haul-out. Though no kills were observed during the Saulitis et al. (2000) study, other observations have documented Gulf of Alaska transients killing Steller sea lions in northern Prince William Sound (Barrett-Lennard et al. 1995). Stomach content data are also consistent with the idea that Gulf of Alaska transients may take Steller sea lions, while AT1s do

not. Additionally, one Gulf of Alaska transients was found with 14 Steller sea lion tags in its stomach, whereas neither of the two carcasses identified as AT1s contained sea lion remains (Saulitis et al. 2000).

Transient killer whales in British Columbia prey on a higher percentage of harbor seals than did AT1s (as much as 67% of all observed kills) (Ford et al. 1998). Saulitis et al. (2000) suggest that low harbor seal numbers account for the nearly equal proportions of harbor seal and porpoise in the observed AT1 diet. They note that attacks on porpoise take much longer than attacks on harbor seals, and have a much lower success rate (Ford et al. 1998).

Not surprisingly, AT1s took harbor seals while engaging in nearshore foraging, and took Dall's porpoise when engaged in open water foraging. Gulf of Alaska transients also engaged in nearshore foraging in Prince William Sound, but it was usually adjacent to a Steller sea lion haul-out.

5. Threats to the population

Oil Spills/Environmental contaminants

The threat to this population from oil spills has been demonstrated, as the above discussion regarding the Exxon Valdez oil spill relates. As it is covered above, no further discussion of this event is provided here. Because oil is still transported through Prince William Sound, the threat of oil spill impacts on this group remains.

Seven individuals from the AT1 group have been analyzed for contaminant concentrations (Ylitalo et al. 2001). They were found to have significantly higher organochlorine (OC) concentrations than residents. Transient killer whales throughout the North Pacific have been documented to have higher levels of contaminants than those reported for resident whales. Given the dietary preferences of transient whales (i.e., marine mammal eaters), high levels of OCs and PCBs are expected to accumulate in the tissues of North Pacific transient killer whales due to their life history and feeding ecology. The causal factor for low reproduction in AT1 group is not known, but exposure to toxic OCs may be the factor or a contributing factor (Ylitalo et al. 2001).

Prey availability

In the Prince William Sound area, there has been a reduction in available prey for the AT1 group. Harbor seals in eastern and central have decreased 63% from 1984-1997 (Frost et al. 1999). Researchers have reported a decrease in the rate of encounters with AT1s since 1989 (Matkin et al. 2000). Whether this indicates AT1s have changed their foraging behavior in response to the decline of harbor seals in Prince William Sound is unknown, but remains a possibility. However, the entire geographical range of the AT1 group is currently unknown. In addition, the AT1's diet may vary seasonally or geographically (e.g., areas outside Prince William Sound).

Fisheries interactions

Several different commercial fisheries in Alaska that could incur serious injuries or mortalities of killer whales were monitored for incidental take by fisheries observers. Of six observed fisheries, killer whale mortalities occurred only in the Bering Sea groundfish trawl and longline fisheries. In 1999, a dead killer whale was brought aboard a trawl vessel. The whale had apparently been caught in a trawl net and then hoisted aboard the fishing vessel. Skin samples and photographs were taken. Through genetic analysis, it was determined that this whale was a transient killer whale (AT1 haplotype). All other dead killer whales brought aboard trawling vessels and subsequently sampled (n=4) were determined through genetic analysis to be resident killer whales.

There are, of course, interactions between killer whales and fishing boats that do not lead to injuries, such as killer whale depradation of fish from longlines in Alaska and reports of killer whales consuming the processing waste of Bering Sea groundfish trawl fishing vessels. However, it is most likely that "resident" killer whales are involved with these interactions since these whales are known fish eaters whereas "transients" whales typically prefer feeding on marine mammals.

Shooting of killer whales in Alaska has also been documented. Most incidents of shooting may involve resident killer whales since commercial fishermen are most likely to observe resident whales interacting with their fishing operations. However, during analysis of photographs collected in 2001 and 2002 of Alaskan transient killer whales by NMML staff, bullet wounds have been observed on the fins of transient killer whales (M. Dahlheim, pers. commn.). In addition, NOAA Fisheries has received few reports of shooting incidences, and none have been successfully prosecuted in recent years.

Disease and predation

There is very little known about the existence of disease in killer whale populations, and no information on the extent to which disease could threaten the existence of killer whale groups or populations. Therefore, it is not possible to estimate the probability that disease poses a major risk to the AT1 transient group. The level of contaminants seen in killer whales has been calculated to exceed thresholds that are believed to cause immune suppression in harbor seals (Ross et al. 2001), so it is a possibility that this is affecting the AT1 group Killer whales have no known predators except humans.

Parasitism

Although several endoparasites have been described for killer whales, it is unlikely that parasites pose a major risk to the AT1 transient killer whale group.

Whale watching/vessel traffic

Although whale watching activities in Alaska have dramatically increased over the past ten years, there is no evidence that the AT1 group has been impacted by this activity. The majority of interactions with whale watching activities and killer whales involve resident groups of Prince William Sound/Kenai Fjords. The level of overall maritime traffic has also increased and this could be a potential threat. Cetaceans, in particular the odontocetes which include killer whales, have a highly developed acoustic sensory system. Killer whales most likely rely on their

acoustic sensory system while navigating and foraging. There is a hypothesis that noise generated by increased vessel activities could mask the signals that the whales need, and thus, adversely affect their foraging and reproductive success.

6. Historical population size and carrying capacity

The pristine (pre-human impact) size of the AT1 group of killer whales is unknown. Information only goes back as far as 1984, when it was known that 22 individuals were alive. It can be presumed that carrying capacity for the AT1 group of killer whales is at least 22 individuals.

At least 11 animals were alive in 1998, but it appears that as of 2002, only 9 individuals may be alive. Therefore, the AT1 group has been reduced to at least 50% (11/22) of its 1984 level, and has likely been reduced to 41% (9/22) of its 1984 level.

Populations are considered depleted under the MMPA if they fall below their Maximum Net Productivity Level (MNPL). Several methods are used to determine if a population is below its MNPL (Gerrodette and DeMaster 1990). It is generally agreed that for marine mammals, the MNPL is likely to be within the range of 50-70%K (Taylor and DeMaster 1993). For this reason, 60%K has often been used as a benchmark for depletion determinations, though in some cases a range of values for MNPL such as 50-70%K have been considered (e.g., Wade 1993, 1994).

A population that declines by at least 50% from a previously known level, even if carrying capacity is not known, can therefore be considered to be below its MNPL, and would be considered depleted under the MMPA. This line of reasoning was used to designate the northern fur seal population as depleted, as well as the coastal stock of bottlenose dolphins (though this particular designation was done through indirect evidence from strandings, not from a direct measured decline in the population) (Taylor et al. 2000).

If the AT1 group were to be considered a population stock, they would be considered to be below their MNPL level, and not at their Optimum Sustainable Population level under the MMPA.

7. Definition of population stocks under the MMPA

The following represents the current guidelines for defining a population stock under the MMPA. It is reproduced here in its entirety from Wade and Angliss (1997).

> "Population stock" is the fundamental unit of legally-mandated conservation. The MMPA defines population stock as "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature." To fully interpret this definition, it is necessary to consider the objectives of the MMPA. In Sec. 2 (Findings and Declaration of Policy) of the MMPA it is stated that "...species and population stocks of marine mammals...should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem in which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population." Further on in Sec. 2,

it states "...the primary objective of their management should be to maintain the health and stability of the marine ecosystem. Whenever consistent with this primary objective, it should be the goal to obtain an optimum sustainable population keeping in mind the carrying capacity of the environment." Therefore, stocks must be identified in a manner that is consistent with these goals. For the purposes of management under the MMPA, a stock is recognized as being a management unit that identifies a demographically isolated biological population. It is recognized that in practice, defined stocks may fall short of this ideal because of a lack of information, or for other reasons.

Many types of information can be used to identify stocks of a species: distribution and movements, population trends, morphological differences, genetic differences, contaminants and natural isotope loads, parasite differences, and oceanographic habitat differences. Evidence of morphological or genetic differences in animals from different geographic regions indicates that these populations are reproductively isolated. Reproductive isolation is proof of demographic isolation, and thus separate management is appropriate when such differences are found. Failure to detect differences experimentally, however, does not mean the opposite. Dispersal rates, though sufficiently high to homogenize morphological or genetic differences detectable experimentally between putative populations, may still be insufficient to deliver enough recruits from an unexploited population (source) to an adjacent exploited population (sink) so that the latter remains a functioning element of its ecosystem. Insufficient dispersal between populations where one bears the brunt of exploitation coupled with their inappropriate pooling for management could easily result in failure to meet MMPA objectives. For example, it is common to have human-caused mortality restricted to a portion of a species' range. Such concentrated mortality (if of a large magnitude) could lead to population fragmentation, a reduction in range, or even the loss of undetected populations, and would only be mitigated by high immigration rates from adjacent areas.

Therefore, careful consideration needs to be given to how stocks are defined. In particular, where mortality is greater than a PBR calculated from the abundance just within the oceanographic region where the human-caused mortality occurs, serious consideration should be given to defining an appropriate management unit in this region. In the absence of adequate information on stock structure and fisheries mortality, a species' range within an ocean should be divided into stocks that represent defensible management units. Examples of such management units include distinct oceanographic regions, semi-isolated habitat areas, and areas of higher density of the species that are separated by relatively lower density areas. Such areas have often been found to represent true biological stocks where sufficient information is available. There is no intent to define stocks that are clearly too small to represent demographically isolated biological populations, but it is noted that for some species genetic and other biological information has confirmed the likely existence of stocks of relatively small spatial scale, such as within Puget Sound, WA, the Gulf of Maine, or Cook Inlet, AK.

In trans-boundary situations where a stock's range spans international boundaries or the boundary of the U.S. Exclusive Economic Zone (EEZ), the best approach is to establish an international management agreement for the species. In the interim, if a stock is

migratory and it is reasonable to do so, the fraction of time in U.S. waters should be noted, and the PBR for U.S. fisheries should be apportioned from the total PBR based on this fraction. In a non-migratory situation, the PBR for U.S. fisheries should be calculated based on the abundance estimate of the stock residing in U.S. waters. For situations where a species with a broad pelagic distribution which extends into international waters experiences mortalities within the U.S. EEZ, PBR calculations should be based on the abundance in the EEZ area unless there is evidence for movement of individuals between the EEZ and offshore pelagic areas.

8. Relationship between the AT1 group and other transient killer whales

Association information

The AT1 group has never been seen in association with sympatric resident killer whale pods or with other infrequently seen transient groups that occasionally use Prince William Sound (Matkin et al. 1999b). Matkin and Saulitis (1994) reported that seven different groups of Gulf of Alaska transients have been documented using Prince William Sound. Most were photographed only once and were usually seen only once in a season. They were never seen mixing with AT1s.

Acoustic calls

Barrett-Lennard et al. (1995) found that the echolocation clicks of British Columbia and Prince William Sound transients differ significantly from those of residents in both of those areas. Transients used irregularly spaced and low amplitude clicks, whereas residents used higher amplitude clicks nearly continuously when foraging. These differences presumably reflect the differences between foraging for prey that hears (marine mammals) versus prey that does not (fish).

In addition to differences in echolocation clicks, different call types have been found between different killer whale populations (Ford 1989, 1991). Transients have very different call types from residents (Ford and Hubbard-Morton 1990, Ford and Ellis 1999). Saulitis (1993) found that the AT1 group had a distinct dialect that was different from both West Coast transients and Gulf of Alaska transients. In this study, only one of the calls produced by the AT1 group ("Call 3") was similar to a call used by all other transients recorded in other areas (Saulitis 1993). In addition, the AT1 group has a larger dialect, using up to 14 different discrete pulsed calls, while transients of Vancouver Island have small dialects of 4-7 discrete pulsed calls (J. Ford pers. comm. cited in Saulitis 1993).

Further studies of killer whale acoustics have been undertaken since the Saulitis (1993) study. The call types of GOA transients are not yet as well known as those of AT1 and WC transients. To date there only exist a handful of recordings (7) . Based on those recordings, GOA transients may have as many as 8 or more distinct calls in their repertoire. Six of those calls are not shared by the AT1 group. Two calls, which have only been recorded on one occasion, have a similar acoustic structure to two AT1 calls (Saulitis 1993), but it has yet to be determined whether those are common calls used by all GOA transients. The two calls always occur together in AT1

recordings. A similar semantic rule exists for at least two calls used by WC transients. Those two calls also show some structural similarity to both the AT1 and GOA calls. These results (a low amount of call sharing between the groups) indicates that GOA transients are acoustically distinct from the AT1 group as well as from the WC transients (H. Yurk, pers. comm., U.B.C., Vancouver, B.C.).

Genetic relationships

The genetic structure of transients in the North Pacific has been investigated by Barrett-Lennard (2000), who showed genetic differences between 3 groups of mammal-eating killer whales: west coast transients, Gulf of Alaska transients, and the AT1 group. Both mitochondrial (mtDNA) and microsatellite DNA analyses have been conducted.

mtDNA

In general, killer whales have low diversity in mtDNA haplotypes in the North Pacific, and diversity does not appear to be very high worldwide (Hoelzel et al. 1998, 2002). AT1s have what was until recently thought to be a unique mtDNA haplotype, different from the one sequence described for west coast Transients (WCT) and the 2 (or more) sequences described for Gulf of Alaska transients (GAT, using Barrett-Lennard's naming conventions). However, the "AT1 haplotype" has now been found in 4 whales from the Bering Sea area. SWFSC (unpublished data) identified one from an animal that stranded in August 1999 near the mouth of the Yukon river. Rus Hoelzel (unpublished data) identified another AT1 haplotype from a sample collected August 20, 1999 by a NMFS fisheries observer from a killer whale that was a bycatch mortality in a pollock trawler in the central Bering Sea. Finally, National Marine Mammal Laboratory (NMML) personnel biopsy sampled 2 whales seen in the eastern Aleutians (south of Umnak Island) that were encountered as part of a group of 5 killer whales in July 2002 on the DART killer whale survey. Both of these samples were found by the SWFSC genetics lab (unpublished data) to have the same haplotype as do the AT1s.

Photographs of the 5 individuals encountered in the eastern Aleutians, as well as the one individual found in the trawl net, have been examined and compared to photographs of the 22 known individuals in the AT1 group (alive or presumed dead). No matches were found on preliminary determination, indicating none of these individuals are a part of what is currently considered the AT1 group.

The discovery of animals in a wide variety of locales with the AT1 mtDNA haplotype might suggest that there are individuals closely related to the AT1 group that frequent other part of the North Pacific. However, some caution needs to be used in interpretation of the significance of the distribution of where different mtDNA haplotypes of killer whales are found. In some instances mtDNA haplotypes appear to be diagnostic to a population, such as the fixed differences seen between southern and northern resident killer whales (fixed difference in this sense means that all individuals in one group have a different haplotype than all individuals in another group). In other words, it is not just a case of there being frequency differences in haplotypes, as seen between beluga whale populations in Alaska (O'Corry-Crowe et al. 1999). However, the same two haplotypes seen in, , southern residents and northern residents, respectively are the only two haplotypes also seen in Alaska residents (i.e., only two haplotypes

have been seen in all resident killer whales in the North Pacific). The mtDNA haplotype is only diagnostic for the southern resident population because there is concurrent evidence of geographic separation from Alaska residents. However, an mtDNA haplotype does not usually unambiguously assign an individual to a population worldwide. For example, it should be noted that the "southern resident" haplotype has also been found in the north Atlantic (Hoelzel et al. 1998). The southern/northern resident difference is a parallel situation to the comparison of AT1s to other North Pacific transients, as the AT1group is fixed at a single haplotype which was previously unknown in other killer whales groups (though it has now been found in the Bering Sea area)..

Although the possession of a particular haplotype may not unambiguously assign an individual to a population, differences in frequencies of mtDNA haplotypes are routinely used to identify population structure (e.g., O'Corry-Crowe et al. 1999). Southern resident killer whales clearly have large frequency differences in mtDNA from the northern residents or Alaska residents. Similarly, all 3 putative transient populations in the North Pacific were previously thought to not share any haplotypes (Barrett-Lennard 2000), which represents an extreme frequency difference. Although association and acoustic data are not available for the whales seen in the Aleutians and Bering Sea with the "AT1" haplotype, there would still be very large frequency differences between the AT1 group and the Gulf of Alaska transients if these whales were added to the "Gulf of Alaska" transients samples.

microsatellite DNA

Barrett-Lennard (2000) also found significant genetic differences in nuclear (microsatellite) DNA between AT1s, GAT, and West Coast transients (as well as very strong differences between each transient group and all resident groups examined). In particular, the AT1 group sample was found to be the most divergent in its microsatellite allele frequencies because they were more divergent from the nearby GOA Transients and WC Transients than those groups were from each other. The estimates of F_{st} between the AT1 group and the other groups were values that would be considered "large" by most population geneticists. If this level of divergence was observed between two large (e.g., N > >100) outbreeding populations, this would be consistent with populations that had been demographically isolated for many generations.

In the case of the AT1 group, however, the high level of divergence might alternatively be related to the group's very small size. The average level of heterozygosity in the AT1 group is ~60% that of the other transient groups. Interestingly, this was not consistent across loci, as a few loci had no heterozygosity and other loci had greater heterozygosity than in other transient populations (Barrett-Lennard 2000). Lower heterozygosity is consistent with the AT1 group being part of a smaller population, though still considered greater heterozygosity than expected from a population that has been at a very small size (circa 22 individuals) for any length of time. The rate of genetic differentiation through genetic drift will occur more rapidly in a small population. Under a pure drift model, the rate of differentiation is directly proportional to population size, so a faster rate of differentiation would be consistent with a small effective size compared to the other groups studied. In other words, for a small population the level of genetic difference seen between AT1 killer whales and other transient groups could occur relatively quickly (perhaps within a few generations).

Irrespective of how many generations it took to generate, the degree of difference in microsatellite DNA is consistent with demographic isolation between the AT1 group and Gulf of Alaska and West Coast transients.

Preliminary results from analysis of new genetic samples from the northern Gulf of Alaska
Since the analyses documented in Barrett-Lennard (2000), the number of biopsy samples of transient killer whales from the Gulf of Alaska to the Bering Sea has increased substantially. A preliminary analysis of those new data (in combination with existing data) was undertaken with the intent of potentially clarifying the relationship between the AT1 group and other transient killer whales in Alaska (Barrett-Lennard and Miscampbell, pers. comm.).

Samples from 48 transient killer whales from the northern Gulf of Alaska were genotyped. Of these, 32 were sampled by L. Barrett-Lennard and C.O. Matkin, and 16 by the National Marine Mammal Laboratory/NOAA Fisheries. Of the 48, 11 of the samples were from members of the AT1 population from the Prince William Sound/Kenai Fjords area(are there 9 or 11 members of AT1?), 19 were so-called Gulf of Alaska transients sampled in the Kodiak Island/Resurrection Bay/Prince William Sound area, 17 were sampled in the eastern Aleutians and southern Bering sea, and one in the Shumagin Islands area (mid-way between the last two areas mentioned above). Prior to this analysis, the mitochondrial D-loop region of the all of the samples had been sequenced. All members of the AT1 population were shown to have a distinct haplotype, as described in Barrett-Lennard 2000. All but one of the other transients had one of two similar haplotypes (GAT1 and GAT2, by the terminology of Barrett-Lennard 1990). Of special interest was a killer whale biopsied near Umnak Island that had the same haplotype as the AT1 population (2 other available samples with the AT1 haplotype from western Alaska did not fully amplify and were therefore unavailable for this microsatellite analysis).

The data were analysed using assignment tests (Waser and Strobeck 1998) as implemented in the program WHICHRUN 4.1 (Banks and Eichert 2000). The test assigns individuals to previously-characterized putative populations based on the expected frequencies of their genotypes in those populations. It can be used to calculate the likelihood that an individual sampled within a population's range in fact belongs to the population, or to ask which of two or more candidate populations a disperser individual belongs to. Here, the test was used both to assign the transient killer whale from Umnak Island to a population, and to ask whether the known AT1 members assign strongly to the AT1 group. The samples were grouped into three different scenarios of population grouping for analysis. In the first scenario, three putative populations were considered, a) the NMML-sampled whales (except the Umnak whale) binned with the whales biopsied by Barrett-Lennard and Matkin in the eastern Aleutians, b) Gulf of Alaska transients collected by Barrett-Lennard and Matkin in the Kodiak/Prince William Sound/Kenai Fjords area, and c) the AT1's. In the second scenario, three putative population groupings were considered: a) the AT1's, b) eastern Aleutian transients, and c) Gulf of Alaska transients (collected by both NMML and Barrett-Lennard/Matkin near Prince William Sound, Kenai Fjords and Kodiak Island). In the third scenario, two putative population grouping were considered: a) the AT1's, and b) all other transients, excluding the Umnak whale.

Consistent with the *Fst*-based analysis of Barrett-Lennard 2000, the AT1's were very distinct from all other transient killer whales under all three scenarios. All but one AT1 was correctly assigned in scenarios one and two, and all were correct in scenario three. In all three scenarios, the likelihood of the Umnak whale belonging to the AT1 population was substantially less than the likelihood it belonged to either of the other transient groups considered in the analyis.

The analysis provided no reason to believe that the Umnak killer whale with the AT1 haplotype is either a member of the AT1's, or a member of a closely-related population. The fact that it has the same haplotype is probably the result of lineage sorting. Furthermore, there was no clear evidence that any of the other transients sampled in the Gulf of Alaska are closely related to the AT1's.

9. Population structure of transients in Alaska

Under the US MMPA, the AT1 group is currently considered part of the eastern North Pacific (ENP) transient killer whale stock, which is the only currently defined "stock" of transients in the North Pacific. The total picture of population structure of transient killer whales in Alaska is incomplete as yet, particularly because of a lack of adequate samples from some regions such as the Bering Sea. However, sufficient data exist to examine the relationship of AT1 killer whales to other transients in Alaska that have been studied.

The AT1 group was recognized as a separate group or subpopulation from association and acoustic data prior to the initiation of genetic studies. Subsequent genetic analyses confirmed that the AT1 group was significantly different from other transient killer whales in the northeast Pacific in both mtDNA and microsatellite DNA.

There are at least three possible scenarios that might lead to the genetic differences that are seen between AT1 and other transient groups, though the three scenarios are not necessarily equally plausible given the available information. An assumption that is made when speculating about these scenarios is that a very small population (circa 22 animals) could not persist as an independent population for a very long time. Similar issues were raised when considering the possible history of the southern resident killer whale population in a recent biological review (Krahn et al. 2002).

The first scenario is that the AT1 group represents a remnant of a previously larger population. In this situation, there were two separate populations of transient killer whales in Alaska that were clearly distinct, and genetically and demographically isolated. One of these populations declined in population size, and what remains is what is now known as the AT1 group. These two populations currently have some degree of sympatry in their ranges, but the historical habitat use of the two populations is unknown.

The second scenario is that the AT1 group split off from another transient population relatively recently, and has never been a particularly large population. As previously stated, genetic drift can occur rapidly in a small population, so the observed genetic differences could have arisen fairly recently. A small unit like the AT1 group may never have had a high probability of

persisting as a separate population over a long time period. In other words, if the AT1 group arose via fission from another transient population but was never large in size, it may have been doomed to relatively rapid extinction from the beginning of its existence. One problem with evaluating the importance of this possible scenario is that the terms "relatively recent" and "long time" are hard to define quantitatively.

A third scenario is that the AT1 group is part of a larger population of transient killer whales that have, as yet, gone unsampled. This putative population might well represent a population stock under the MMPA, but what that population would be is currently unknown.
Although the population structure of transient killer whales in the Aleutians, Bering Sea, and in the western North Pacific is not yet fully determined, some conclusions can begin to be made. Analysis of further samples from this region will provide additional insights into transient killer whale population structure in Alaska.

At this time, there is no evidence to support the third scenario (that the AT1 group are part of a second more widespread Alaska transient population that is largely sympatric with the "Gulf of Alaska" transients from Prince William Sound to the Bering Sea), so it remains only hypothetical. Various researchers had hypothesized that more AT1s might be found in western Alaska, where little sampling had previously been done. Fairly substantial sampling from 2001-02 along the Alaska Peninsula, along the Aleutians, and in the Bering Sea, has failed to find killer whales that are closely related genetically to the AT1 group. Although four individuals have been found with the same mtDNA haplotype as found in AT1s, the one individual for which a complete microsatellite analysis was available was strongly assigned to Gulf of Alaska transients, rather than the AT1 group. Another explanation for the presence of the "AT1" haplotypes in western Alaska is that the "AT1" haplotype is a relatively rare haplotype that is also found in the Gulf of Alaska transient population. A third possibility is that transient killer whales in the Aleutians and Bering Sea represent a separate population from Gulf of Alaska transients found from Kodiak to Prince William Sound, and this population contains some low frequency of the "AT1" haplotype. This would be entirely consistent with what is known about other cetacean populations, where mtDNA haplotypes are often shared between what are known to be separate populations, but occur at different frequencies.

Regarding the first two scenarios, the data are relatively consistent with either scenario, and it is worthwhile to have a thorough discussion of the available data and their interpretation, including discussion of how long the AT1 group has been separated from other transient killer whales.

The association data support the conclusion that the AT1 group is a separate unit. Social barriers to interaction might arise fairly rapidly, although it is difficult to know for certain if this is likely. One might assume that such barriers would arise in nearly complete isolation, so the current sympatry with Gulf of Alaska transients suggests these barriers arose some time in the past when the two groups did not overlap in distribution.

Under the assumption that the acoustic repertoire is learned at a young age and is thought to be relatively fixed for life, then the AT1 group has been separate for at least a period longer than the oldest individual in the group. There is perhaps no easy way to judge how quickly the evolution of differences in call types might have occurred. Acoustic calls in other populations have

apparently been relatively stable for 20 or so years – researchers do not see rapid changes in call types from year to year. It is therefore conceivable that the large difference in call types indicates the AT1 group has been separate for at least hundreds of years. On the other hand, it is also conceivable that there could have been a period of relatively rapid evolution of call types, for unknown reasons.

The AT1 group is genetically distinct from other killer whales in the north Pacific, including other transient killer whales. This was true for both mtDNA and microsatellite DNA, which indicates there is little if any mating or dispersal between the AT1 group and other killer whale groups. The greatest uncertainty in the interpretation of the genetic data is how long the AT1 group has been separated. Genetic drift can happen quickly in small populations, so the AT1 group could have become genetically distinct relatively recently. Genetic data alone are likely insufficient to distinguish between the first and second scenarios. It is difficult to distinguish (1) a larger population separated for a longer period of time that has dwindled to a small size from (2) a smaller group separated for a shorter period of time. The AT1 group has less genetic diversity than other North Pacific transients, but more genetic diversity than would be expected if they had been at a very small population size for a long time.

If killer whale social structure leads to small groups of whales being demographically isolated from other such groups (meaning there is no dispersal between such groups), this could lead to rapid genetic differentiation (*i.e.*, genetic drift happens more rapidly in small populations). However, this circumstance would still be indicative of demographic isolation.

A group of 22 individuals appears to be too small a group to persist as a population for much time. However, the southern resident killer whale population has been recognized as a stock under the MMPA though it has never been seen to be larger than 98 individuals. Although the expectation is that population stocks will usually be larger numerically, it has not been considered that, as top predators, killer whale populations would be expected to be smaller than populations of species that feed at a lower trophic level.

Another aspect to consider is the partial sympatry between the AT1 group and Gulf of Alaska transients. Gulf of Alaska transients are consistently encountered in the same area as the AT1 group, albeit at lower frequencies than the AT1s. However, though the details of the movements of transient killer whales are not well known, they often can range hundreds of miles, such as known movements between California and Southeast Alaska (Goley and Straley 1994). If individuals are covering large ranges, it stands to reason that they might not be in any one location for any great length of time, but that location would still be considered a part of its range.

It is not clear if the Gulf of Alaska transients that are occasionally seen in Prince William Sound occur there less frequently than they do in other parts of Alaska. In other words, it may not be that Gulf of Alaska transients are unusually rare in Prince William Sound; it appears that individuals from the AT1 group are seen more commonly than transients are typically seen throughout their range, perhaps because the AT1s use a smaller range than other transient killer whales.

How two different populations of transient killer whales that are partially sympatric in range came into existence is uncertain, and will likely remain so. A variety of historical scenarios could have led to this. For example, it has been suggested that the Cook Inlet beluga population was "left behind" and became isolated during a post-glacial return to more northerly waters that had been ice-covered (O'Corry Crowe et al. 1999). Though perhaps not as straightforward in this case, one could speculate that some similar type of historical scenario created a situation in which the AT1 group was isolated from Gulf of Alaska transients, and accounts for the founding of the AT1s as a separate group.

Barrett-Lennard (2000) suggested another potential mechanism for the creation of adjacent killer whale populations. He suggested that in a large and wide-ranging population, groups of whales at the extremes of the range could diverge in social behavior to the point where they no longer recognized each other as belonging to the same population. This would set up a social barrier to reproduction between the extremes. Groups in the middle of the range might initially still interact with both extremes, but as the separate communities continued to diverge, intermediate groups would eventually be pulled into one or the other of the two communities, which would at that point be separate populations. In the case of the AT1s, under this scenario, the two populations would have initially been allopatric, but could have become secondarily sympatric through expansion of one or both ranges.

The complexity of killer whale social structure makes the interpretation of killer whale population structure itself, complex. For example, one might raise the possibility that the AT1 group is a group of closely related animals, and represent essentially an extended family group. A family group could, to some degree, be more closely related to each other genetically than to the population of which they are a part. This could lead to the possibility of apparent genetic differences between a family group and the overall population to which they belong. This genetic distinction would likely only occur if there was some degree of inbreeding within the family group; if substantial outbreeding was occurring between the family group and the rest of the population there would be no genetic differences.

The small number of individuals in the AT1 group, and the possibility that they may all be relatively closely related, could influence interpretation of the genetic results. Whereas we often think of population stocks as being purely panmictic, this is likely not the case very often. In fact, populations may have considerable structure within them. Killer whale behavior could lead to structure within populations, if individuals associated and mated predominantly with other closely related animals.

Resident killer whales have been seen to persist in matrilines, meaning that offspring do not disperse from their mother's group. This tendency may lead to more rapid differentiation in mtDNA through lineage sorting, for example. However, resident whales appear to mate outside their matriline, and there is even evidence that they preferentially mate with whales they are least closely related to within a population (Barrett-Lennard 2000). Such behaviorally mediated outbreeding would work against the idea that family groups (matrilines) would become genetically distinct in nuclear (microsatellite) DNA from other family groups in the same population. In other words, if transients similarly tend to mate outside of their matriline, and the AT1 group is simply a family group within the larger Gulf of Alaska transient population, then

the microsatellite DNA from the AT1 group should not differ from that of the Gulf of Alaska transients.

Transient social behavior does not appear to be identical to resident social behavior. Some transients do not appear to have the same fidelity to matrilines, as some individuals disperse from their mothers by the time they reach sexual maturity, and associations do not always seem as persistent through time (Ford and Ellis 1999). Dispersal from the matriline in this way (as long as subsequent mating was outside the matriline) would have the same effect as in residents, where one would not expect microsattelite differences between matrilines.

The tendency for killer whales to be found in relatively small communities should lead to accelerated genetic differentiation in nuclear DNA. In the event that a small community of related whales started using a more limited geographic area, their opportunities for outbreeding could be reduced and lead to rather rapid genetic differentiation. However, although the known range of AT1s does seem smaller than the known range of other transients, both the AT1s and the Gulf of Alaska transients use Prince William Sound, although the Gulf of Alaska transients do not inhabit the area as long as the AT1s. In other words, there would presumably be some opportunity for encounters between the AT1 group and Gulf of Alaska transients.

By definition, individuals in one population are more closely related to each other than they are to individuals in another population. If mating only occurs within a community, then the community is *de facto* the inter-breeding population unit. If killer whale communities are simply social or family groups, the specific question to ask is whether a family or social group that does interbreed with other such groups would appear genetically distinct from those groups just because the unit being sampled is a group of closely related animals. This would likely only be the case if there was some degree of inbreeding going on within the family group, because if they are freely outbreeding with the rest of their population, they would not be genetically different. However, Barrett-Lennard (2000) found no evidence of inbreeding in north Pacific transient killer whales.

Comparisons with other mammalian populations

Another way of addressing whether social or family groups may become genetically distinct is to see if social groups of other mammals have been found to be genetically distinct from one another. Storz (1999) reviewed genetic data from nine species of Primates in 14 studies. In only one case (one of four studies of the red howler monkey, *Aloutatta seniculus*) was there genetic differentiation between troups or herds within a locality, where levels of gene flow were too low to counteract genetic differentiation of social groups via drift. In the 13 other studies, the social groups were not found to be genetically distinct from one another.

In West African chimpanzees (*Pan troglodytes vents*), a community of 55 individuals was found to have substantial gene flow with other communities, as non-community males accounted for half the paternities in a 5-year study (Gagneux et al. 1999). Although the authors were not able to sample from other communities in order to perform formal statistical comparisons between communities, this high degree of mating between communities would presumably lead to little genetic differentiation in microsattelite DNA between communities.

Spong et al. (2002) used microsattlite DNA to study the genetic structure of lions (*Panthera leo* L.). Over a total of 16 lion prides, there were no significant pair-wise comparisons among two prides after a multiple test correction was used. Neighboring prides often had close relatives, but few relatives were found between prides not sharing a border. Significant genetic structuring was found between all prides, but this genetic structuring was found to be at the level of geographic collections of prides ("superprides"). They attributed the overall genetic structuring to female philopatry and a high degree of relatedness between females in a pride, whereas males within a pride were not closely related.

A study of African wild dog (*Lycaon pictus*) packs found there was a high degree of relatedness of individuals within a pack, with adult males tending to be related and adult females tending to be related, but the dominant male and female were generally unrelated (Girman et al. 1997). Females were not randomly distributed amongst packs, but males were, suggesting there would not be genetic differences between packs in nuclear DNA, though no specific tests of that type were performed in the study.

The available literature suggests that strong genetic differentiation between social groups of terrestrial mammals appears relatively rare, as it was only found in one of the 17 studies summarized above. Therefore, it appears unlikely that a community of killer whales would be found to be genetically distinct from other communities (at the level of the difference seen between AT1s and other transients) simply because they represented a social or family group. For most of the species reviewed, gene flow from neighboring social groups prevented genetic differentiation of the social group. An example of this is known from resident killer whales, as Barrett-Lennard (2000) found that most matings occurred between matrilines (the social group), even though no individuals dispersed from their matriline. In resident killer whales this maintains gene flow between social groups, at least at the level of matrilines or "family" groups. It is important to note both that the analogies between transient killer whales and these social terrestrial mammals are not perfect and that resident and transient killer whales do not exhibit identical social behavior. Therefore, caution should be used in drawing strong conclusions from these other studies.

Population stock summary

Under the first scenario (AT1s are a remnant of a killer whale population that has been separate for a long time), the AT1 group would meet the definition of a stock under the Marine Mammal Protection Act. Their current small population size would be interpreted as indicating they exist now only as a remnant of their former population level.

If the second scenario was true (AT1s are a relatively recent separation and have never been numerically large), it is less definitive if the AT1 group would be considered a stock under the MMPA. They would still meet the literal definition of a population stock in the MMPA ("…a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature"). Note that there is no specific requirement that a group of animals need to be "significant" to qualify as a stock under the MMPA. This is different than the policy for defining Distinct Population Segments (DPS) under the Endangered Species Act, where a population needs to be discrete and significant to be declared a DPS.

However, in the guidelines for defining stocks (Wade and Angliss 1997), it is stated "there is no intent to define stocks that are clearly too small to represent demographically isolated biological populations, but it is noted that for some species genetic and other biological information has confirmed the likely existence of stocks of relatively small spatial scale, such as within Puget Sound, WA, the Gulf of Maine, or Cook Inlet, AK." This leads to the question: was the AT1 group ever large enough to be considered a demographically isolated biological population? The southern resident killer whale stock (that was already defined at the time the guidelines were written) serves as a precedent to which to compare the AT1 group. The AT1 group has a spatial range that is similar in size to the summer range of the southern resident population. The southern resident population has numbered as many as 98 individuals, and was thought to be at a higher level than that in the 1960s (Krahn et al 2002). The AT1 group has never been known to number more than 22 individuals. Therefore, the key questions to consider are (1) what population size would be large enough to represent a biological population, and (2) were the AT1s ever larger than that population size? Unfortunately, neither of these questions can be answered definitively.

There is no specific evidence supporting the third scenario (AT1s are part of a larger transient population that has not yet been sampled), although the lack of sampling in far offshore waters does not allow this possibility to be entirely excluded.

The types of evidence (genetic, acoustic, and behavioral data) and level of differences seen between the AT1 group and other transient killer whales are consistent with the type of information used to designate other populations of marine mammals as stocks under the US MMPA, and are consistent with the guidelines for defining MMPA stocks. For example, southern resident killer whales have been designated a stock under the MMPA. They show genetic differences from other resident killer whales in much the same way that AT1s are genetically different from other transient killer whales. In fact, the AT1 group is, on one measure, more divergent from other transient groups than southern residents are divergent from northern and Alaska residents, as the F_{st} values for comparisons between the AT1 group and the two other transients groups are larger than the F_{st} values between southern residents and the other resident groups. Population size affects this measure, so the large difference could be a consequence of the small size of the AT1 group. However, southern residents are not that much greater in population size (circa 80 individuals). This apparently large difference in microsatellite (nuclear) DNA indicates the AT1 group is demographically isolated from the two other known transient groups. In general, significant genetic differences are viewed as evidence for stock structure under the MMPA.

Though many uncertainties remain, all available information suggests that the AT1 group has been separate from other transient killer whales in the North Pacific for at least 50-100 years or longer. The only difference in the situation for the AT1 group compared to the southern resident killer whale population is the smaller population size of the AT1 group. The one key uncertainty is how large a population they may have been in the past. The AT1 group appears to have greater genetic diversity than one would expect from a population that was never much larger than 22 individuals over a long period of time, suggesting they were either at a level greater than that or split off relatively recently.

10. Conclusions

Stock structure

Under the US MMPA, the AT1 group is currently considered part of the eastern North Pacific transient killer whale stock, which is the only currently defined "stock" of transients in the North Pacific. However, various lines of evidence suggest this stock structure should be reexamined.

The definition of a "stock" in the GAMMS guidelines is demographic isolation, as reviewed above. Association data, genetics data, and acoustic data are all consistent with the hypothesis that the AT1 group is demographically isolated from other killer whales groups (i.e., there is no current or recent dispersal of individuals between the AT1 group and other groups).

Consistent with the above, the Alaska Scientific Review Group recently recommended that NMFS consider splitting the one current eastern North Pacific stock of transient killer whales into three stocks for the MMPA stock assessment reports: West Coast, Gulf of Alaska, and AT1.

With the exception of their smaller recent population size, the AT1 group meets the same type of criteria as does the southern resident killer whale population, which has been recognized as a population stock under the MMPA since 1995. The AT1 group is more divergent in microsattelite DNA from other transients than the southern resident population is from other resident populations.

Several historical scenarios were identified that could be viewed as consistent with available data. No current information supports one scenario, which is the hypothesis that the AT1 group is part of a larger, as yet un-sampled, population, though it still remains a possibility until the entire northern Pacific has been adequately sampled. Two of the other scenarios differ mainly in the length of time that the AT1 group has been separate from other transient killer whales in the North Pacific, and how large the AT1 group might have been in the past. Under the "remnant population" scenario, the AT1 group is hypothesized to have once been a substantial population that was clearly separate from other killer whale populations, but has recently declined to a small population size. Under this scenario the group would clearly meet the criteria for being a stock under the MMPA. Alternatively, under the "splinter group" scenario, the AT1 group is hypothesized to have split relatively recently from other killer whale populations, and were never very numerous. If the AT1 group has separated quite recently and has never been much more numerous than 22 individuals, their status as a population stock under the MMPA would be more ambiguous. They would meet the definition of being a population that interbreeds when mature, they would be demographically isolated from other killer whale groups, but the guidelines state there is no intent to define stocks so small they would not represent a biological population. Under this scenario, determining whether the AT1 group was ever large enough in the past to represent a biological population is uncertain.

The level of genetic diversity in the AT1 group is thought to be more than would be expected from a population at a level of only 22 individuals for any length of time (Barrett-Lennard 2000). This indicates that if the AT1 group has been a separate population for some time, it was

numerically larger in the past, but how much larger is uncertain. Alternatively, if the AT1 group had recently split off from a larger population, this might also explain why they carry more genetic diversity than expected for their population size. The degree of genetic divergence in microsattelite DNA indicates the AT1 group has been separate for some length of time, though what constitutes some length of time is not completely known. Estimating time since divergence is complicated, but under some assumptions at a very small population size the degree of observed divergence could have happened in just a few generations. Alternatively, it could have taken much longer. Social barriers to interaction with other transients and the use of different acoustic call types from other transients also suggests that the AT1 group have been separated for some length of time, but this is more of a qualitative statement than a quantitative one.

Population Status

Under the current transient stock structure, there is no information on population trends or historical abundance that would provide information about whether transients throughout the eastern North Pacific were depleted or not. Similarly there is insufficient historical data on Alaska transients to provide information on trends in abundance in Alaska. The AT1 group is the only group of transients whose recent history is known This group is better known because of its small size and the fact that most of the individuals in the group are seen every year, which is not the case for most other transient killer whales. If the AT1 group is considered a population stock under the MMPA, there is little doubt that it would be considered to be below its MNPL level, as it has declined by more than 50% from historic levels (since 1984). Therefore, under that scenario, the AT1 group would be considered to be below OSP.

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