

Results of 2004 Aerial Surveys of Humpback Whales

North of Kauai



Quicklook Report Submitted to:

North Pacific Acoustic Laboratory (NPAL) Program

Scripps Institution of Oceanography

Submitted by:

**Joseph R. Mobley, Jr., Ph.D.
Marine Mammal Research Consultants, Ltd.**

Date:

April 30, 2004

Abstract

Eight aerial surveys of marine mammals were performed during the 2004 winter season (Feb 4 – Apr 4) around the islands of Kauai and Niihau on days corresponding with transmissions of the North Pacific Acoustic Laboratory (NPAL) sound source. The survey protocol and rules for transect placement were identical to those used during the previous three years when the NPAL source was operating (2002-03) and when it was not (2001). A total of 209 sightings of marine mammals representing seven identified species were noted throughout the Kauai/Niihau regions, including 187 pods of humpback whales and four sightings of sperm whales. Comparisons between the 2001 (sound off) and 2004 (sound on) seasons were limited to the area north of Kauai within 40 km of the NPAL source. More humpback whales were sighted in this region during the 2004 surveys (N=90) relative to 2001 (N=75), though this difference was not statistically significant ($p>.05$). Additionally, more odontocete species (i.e., dolphins and toothed whales) were sighted in 2004 (N=14) relative to 2001 (N=12) but this change was also not statistically significant. Subsequent analyses focused on two variables as indicators of possible changes in distribution: distance from NPAL source, and distance offshore. Analyses were performed for humpbacks only, for odontocetes only, and for all species combined. No significant changes in distance from NPAL source or in distance offshore were noted for humpbacks, odontocetes or all sightings combined. Thus, there is no evidence to suggest that exposure to the NPAL source has resulted in changes in distribution for the cetacean species studied.

Background

Aerial surveys of all marine mammal species in the waters surrounding Kauai were performed during the 2001-04 winter seasons (Feb-Mar) as part of the North Pacific Acoustic Laboratory (NPAL) Marine Mammal Monitoring Program using methods consistent with previous all-island surveys in Hawaiian waters (1993-2000, Mobley et al., 2001). The mission of these surveys was to document the distribution of all marine mammals with focus on endangered humpback whales both prior to NPAL transmissions (2001) as well as during (2002-04). This report will first summarize the results of the 2004 season, then compare to those of the baseline year (2001) when the NPAL source was not operating.

Statistical analyses summarized here focused on possible changes in marine mammal distributions in waters north of Kauai within 40 km of the NPAL source across the 2001 and 2004 seasons. Results for humpback whales are presented first, followed by results for odontocete species as well as all sightings combined.

Method

A total of eight weekly surveys of the waters adjoining the islands of Kauai and Niihau were performed during the period Feb. 4 through April 4, 2004. This period coincides with the time of peak residency of humpback whales based on the results of past surveys (Baker and Herman, 1981; Mobley, Bauer and Herman, 1999; Mobley et al. 1999). Methods were consistent with those used during the previous three years when the NPAL source was not operating (2001) and when it was (2002, 2003) (Mobley, 2001, 2002, 2003). Survey protocol was based on distance

sampling theory, which is the standard accepted approach for estimating abundance of free ranging animal populations (Buckland et al. 2001).

During the 2004 season, all surveys were scheduled to coincide with NPAL transmission days. Specifically, we commenced surveying the north shore of Kauai immediately following a 24-hr transmission cycle (ca 1000 hrs). This was done to maximize the potential for detecting any possible distribution changes in response to the transmissions. Scheduling was further constrained by the status of military warning areas north of Kauai as well as by prevailing weather conditions.

Surveys followed pre-determined north-south tracklines spaced 13 km apart within a 40-km radius of the NPAL source and 26 km apart throughout the remainder of the area surveyed (Figure 1). For the area north of Kauai, one or two additional lines spaced 6.5 km apart were added in the immediate vicinity of the NPAL source to permit greater sampling effort in that area. Starting longitudes were randomly chosen per distance sampling methodology (Buckland et al. 2001) so that the exact trackline configuration varied for each survey.

The survey aircraft was a twin-engine Partenavia Observer (P68) flying at a speed of 100 knots and an altitude of 244m (800 ft). Two experienced observers made sightings of all marine mammal species, one on each side of the aircraft. Sightings were called to a data recorder who noted the species sighted, number of individuals, presence or absence of a calf, angle to the sighting (using hand-held Suunto clinometers), and any apparent reaction to the aircraft. Additionally, GPS locations and altitude were automatically recorded onto a laptop computer at 30-sec intervals, as well as manually whenever a sighting was made. Environmental data (seastate, glare and visibility) were manually recorded at the start of each transect leg and whenever conditions changed. The two data sources (manual and computer) were later merged into a single data file.

For the purposes of this quicklook report, sighting positions were based on the position of the plane at time of sighting, as derived from GPS data. For the subsequent annual report, these positions will be corrected to approximate the true position of the sighting based on altitude, sighting angle and observer position.

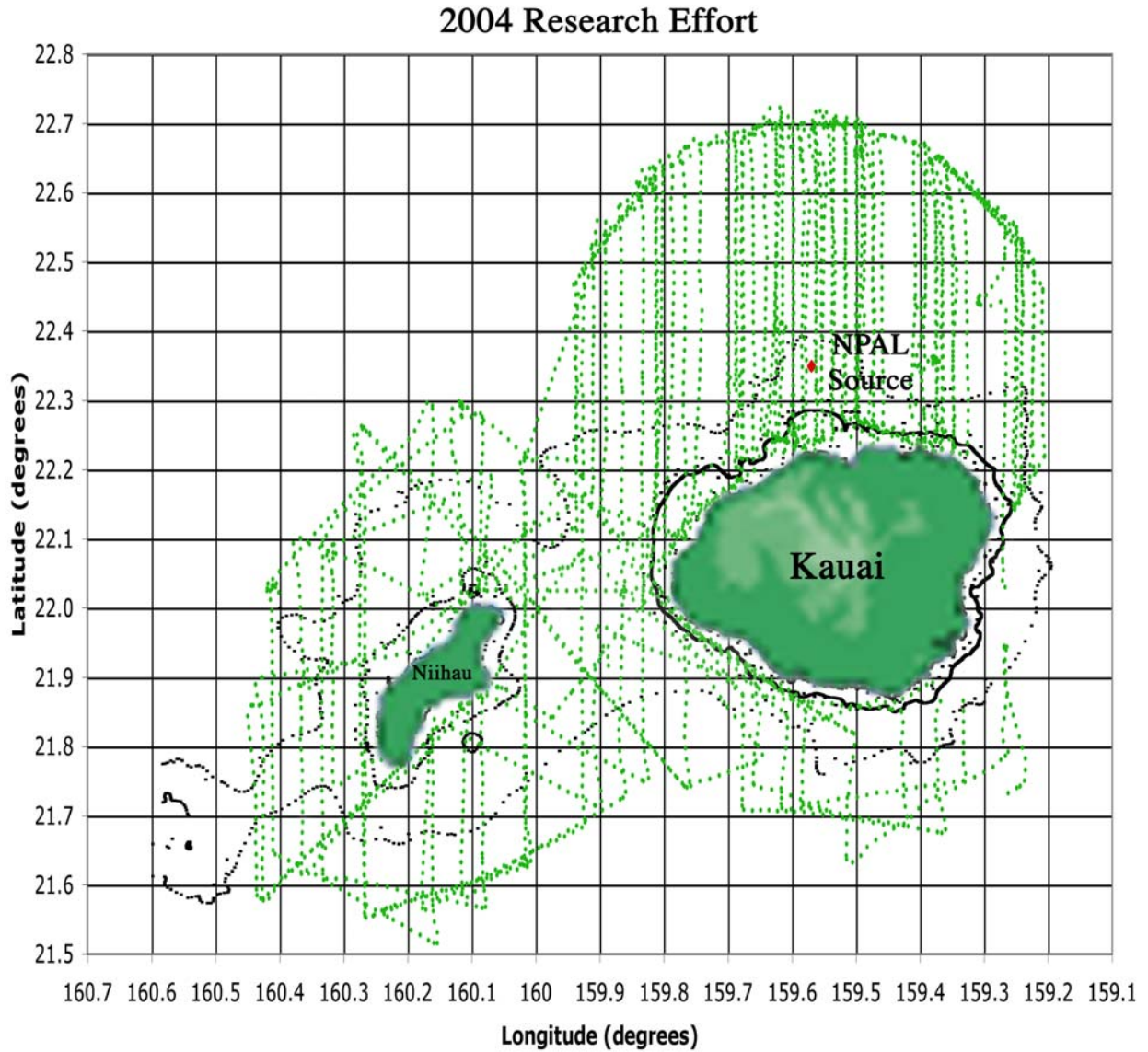


Figure 1. 2004 Survey Effort--green dots show survey effort of all eight surveys based on GPS data. Effort north of Kauai within 40-km radius of NPAL source was more intensive, with north-south lines spaced 13 km apart; all other north-south lines were spaced 26 km apart. Inner and outer bathymetry lines correspond to the 100 and 1000 fathom contours, respectively.

Results

Part A. 2004 Survey Results

A total of 209 marine mammal sightings were recorded during the 2004 surveys, including seven identified species (Table 1). Similar to the 1993-2000 all-island survey results (Mobley et al., 2001), the most frequently recorded species were humpback whales, which accounted for 89% of all sightings. The next most frequently sighted species were sperm whales (2% of total sightings).

Species	No. Sightings	No. Individuals
Humpback whales (<i>Megaptera novaeangliae</i>)	187	268
Spotted dolphins (<i>Stenella attenuata</i>)	1	50
Short-finned pilot whales (<i>Globicepha macrorhynchus</i>)	2	27
Spinner dolphins (<i>Stenella longirostris</i>)	2	54
Bottlenosed dolphins (<i>Tursiops truncatus</i>)	2	8
Cuvier's beaked whale (<i>Ziphius cavirostris</i>)	2	6
Sperm Whales (<i>Physeter macrocephalus</i>)	4	9
Unidentified Dolphins	7	73
Unidentified Whales	2	2
TOTALS:	209	497

Numbers of humpback sightings were higher during the first four surveys (Feb 4-16) than during the last four (Feb 28-Apr 4). Sighting frequencies tended to correlate with seastate conditions, with the two lowest counts corresponding to survey dates with the poorest seastate conditions (Mar 7 and Apr 4) (Table 1). Seastate is the primary environmental factor affecting sighting probability of cetaceans (Buckland et al. 2001).

Humpback whales were more concentrated in the shallow water areas (<100 fathoms) around Kauai and Niihau (Figure 4), similar to their range preferences throughout the Hawaiian Islands (Mobley et al., 1999, 2001).

Table 2. Summary of 2004 Humpback Whale Sightings by Date

Survey No.	Date	No. Whale Sightings	Mean Seastate	Survey No.	Date	No. Whales Sighted	Mean Seastate
1	Feb. 4	35	3.17	5	Feb. 28	16	3.29
2	Feb. 8	49	2.04	6	Mar. 7	7	4.52
3	Feb. 12	28	3.54	7	Mar. 27	12	2.64
4	Feb. 16	33	3.83	8	Apr. 4	5	4.74

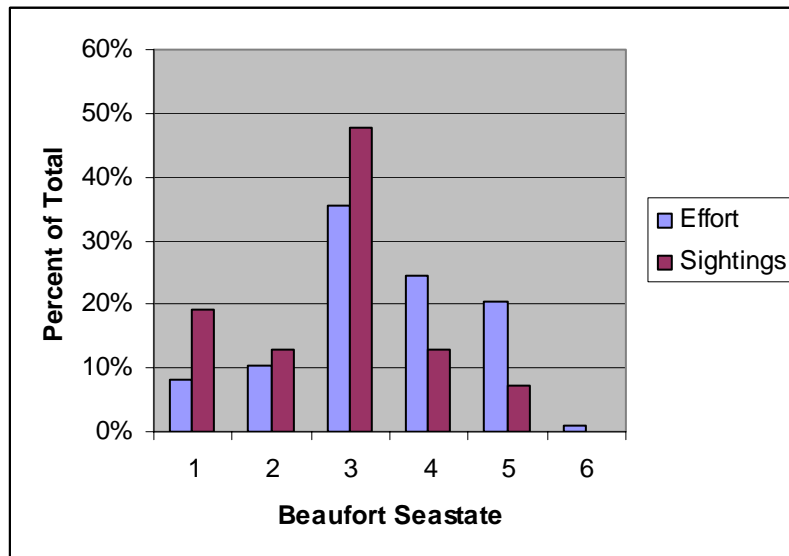


Figure 2. 2004 Sightings by Beaufort Seastate—all sightings combined. The majority of sightings occurred in Beaufort 3 and sighting probabilities dropped substantially beyond that value.

Part B. Comparison of 2001 and 2004 Results

The remaining analyses are limited to the region north of Kauai within 40-km of the NPAL source. The focus is on assessing possible distribution changes between 2001 (NPAL source off) and 2004 (NPAL source on). Analyses involved two distribution-related variables: distance from NPAL source and distance from shore. Effort within this study area was essentially identical across the two years.

Seastate differences. The distribution of seastates varied significantly across years, $\chi^2(5) = 540.05$, $p < .05$. Specifically, there was a greater relative incidence of higher seastates (i.e.,

Beaufort 3 and greater) during 2004. Despite the better sighting conditions during 2001, more sightings occurred during 2004 (Table 4).

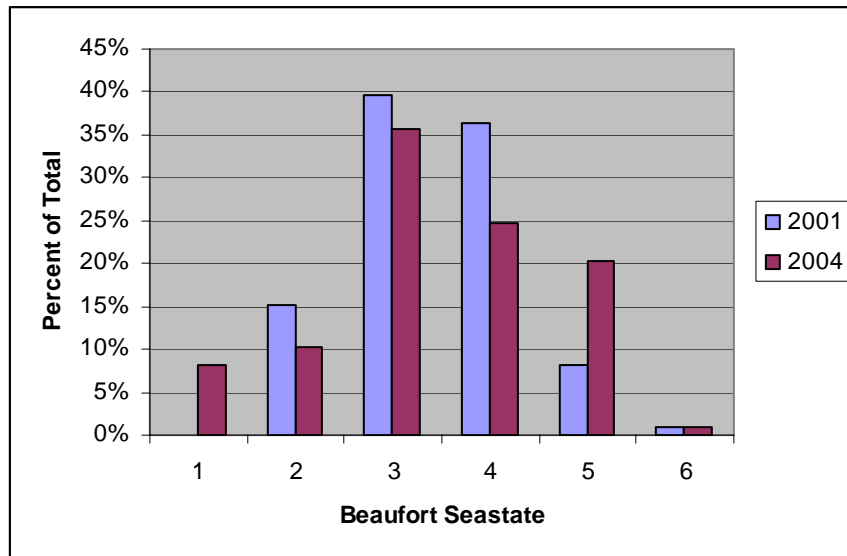


Figure 3. Comparison of Beaufort Seastate Across Years—2001 and 2004. For the region north of Kauai, seastate was significantly better during the 2001 season relative to 2004 as reflected by the higher incidence of seastate three and greater during the latter year.

Number of sightings. A total of 106 marine mammal sightings were recorded within the 40-km radius surrounding the NPAL source during the 2004 season as compared with 88 sightings during 2001 (Table 4). This difference was not significant, chi-square(1) = 1.67, $p > .05$. Similarly, the difference between numbers of humpback sightings (N=75 for 2001; N=90 for 2004) was not significant, chi-square(1) = 1.36, $p > .05$.

Survey No.	2001 Date	2004 Date	Survey No.	2001 Date	2004 Date
1	Feb. 11	Feb. 4	5	Mar. 11	Feb. 28
2	Feb. 17	Feb. 8	6	Mar. 17	Mar. 7
3	Feb. 24	Feb. 12	7	Mar. 24	Mar. 27
4	Mar. 3	Feb. 16	8	Mar. 31	Apr. 4

Table 4. Summary of 2001 and 2004 Species Sightings Within 40-km Radius of NPAL Source

Species	2001 Sightings	2004 Sightings
Humpback Whales (<i>Megaptera novaeangliae</i>)	75	90
Sperm Whales (<i>Physeter macrocephalus</i>)	0	2
Bottlenosed dolphins (<i>Tursiops truncatus</i>)	3	2
Spinner dolphins (<i>Stenella longirostris</i>)	1	0
Spotted dolphins (<i>Stenella attenuata</i>)	0	1
Short-finned pilot whales (<i>Globicephala macrorhynchus</i>)	1	1
Cuvier's beaked whale (<i>Ziphius cavirostris</i>)	0	2
Fin whale (<i>Balaenoptera physalus</i>)	1	0
Unidentified dolphins	7	6
Unidentified whales	0	2
TOTAL:	88	106

Distance Analysis—Humpback Whales

Distance from NPAL source. The distances between humpback whale sightings and the NPAL source were calculated based on GPS positions for the 2001 data (NPAL source off) and for the 2004 data (NPAL source on) (Figure 6). As shown in Figure 6, the distribution of distances clearly departs from normality. For this reason, a non-parametric rank sum test was used to analyze the results (Welkowitz, Ewen and Cohen, 1991) (Note: the rank sum test was used for all distance analyses described here). Though more whales appeared to occupy the furthest distance category (35-40 km) during 2004 (Figure 6), the difference in mean distance was not statistically significant, $Z_{75, 90} = 0.04$, $p > .05$.

Distance from shore. Similarly, distances offshore were calculated based on GPS positions of sightings and map coordinates of closest points along the Kauai shoreline. Humpback whales tended to be found relatively closer to shore during both 2001 and 2004 (Figure 7). Comparisons of the mean distances offshore for humpbacks (Table 5) showed no statistically significant difference across the 2001 and 2004 seasons, $Z_{75, 90} = 1.22$, $p > .05$.

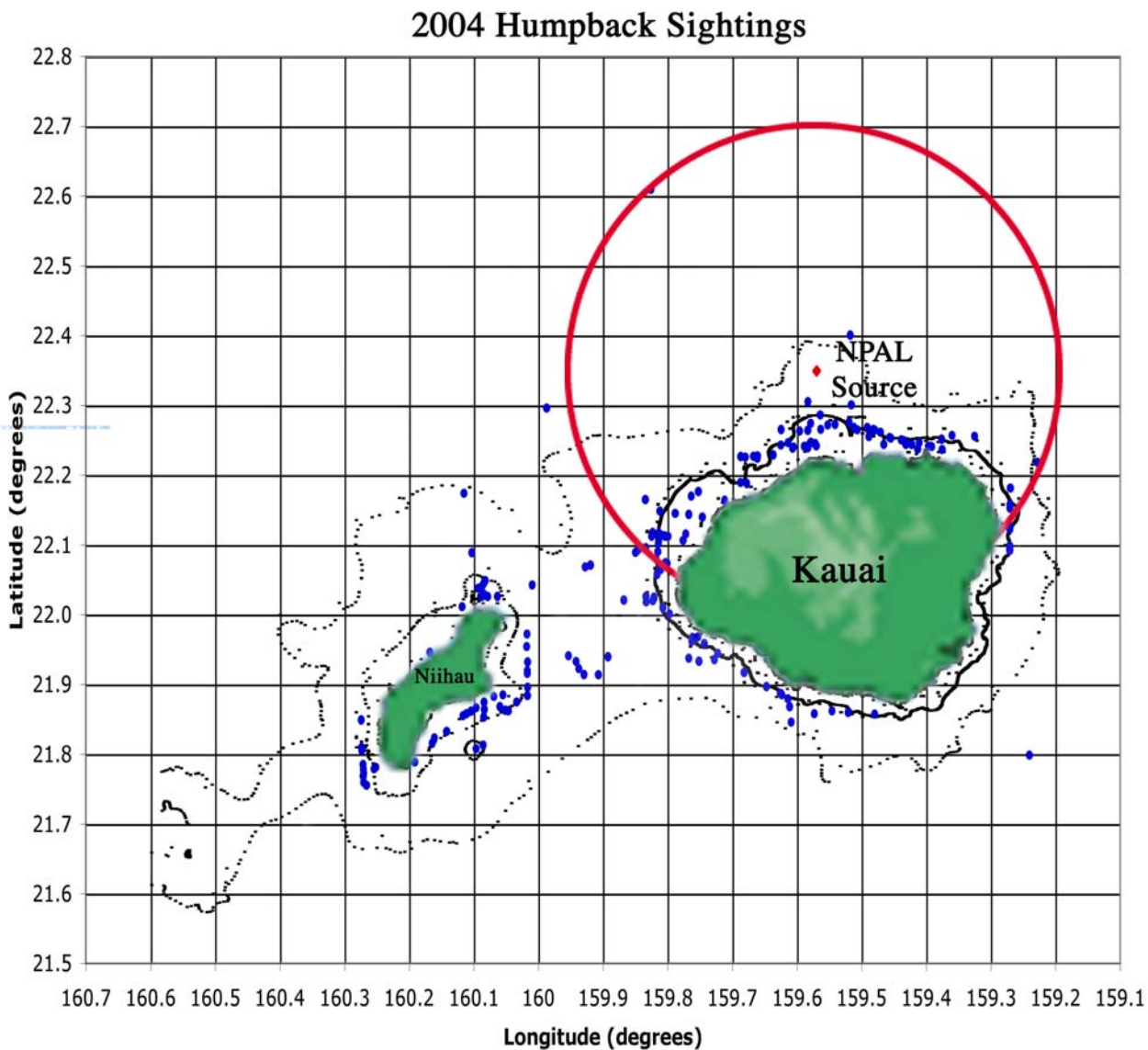


Figure 4. Sightings of Humpback Whales—2004 Survey Results. Blue dots indicate sightings of humpback whales. Similar to previous all-island surveys (1993-2000), humpbacks prefer the shallow water shelves less than 100 fathoms. A total of 187 humpbacks pods were sighted, including 90 humpback pods seen inside and 97 seen outside the 40-km radius around the NPAL source. Bathymetry lines correspond to 100 (inner) and 1000 fathom (outer) contours.

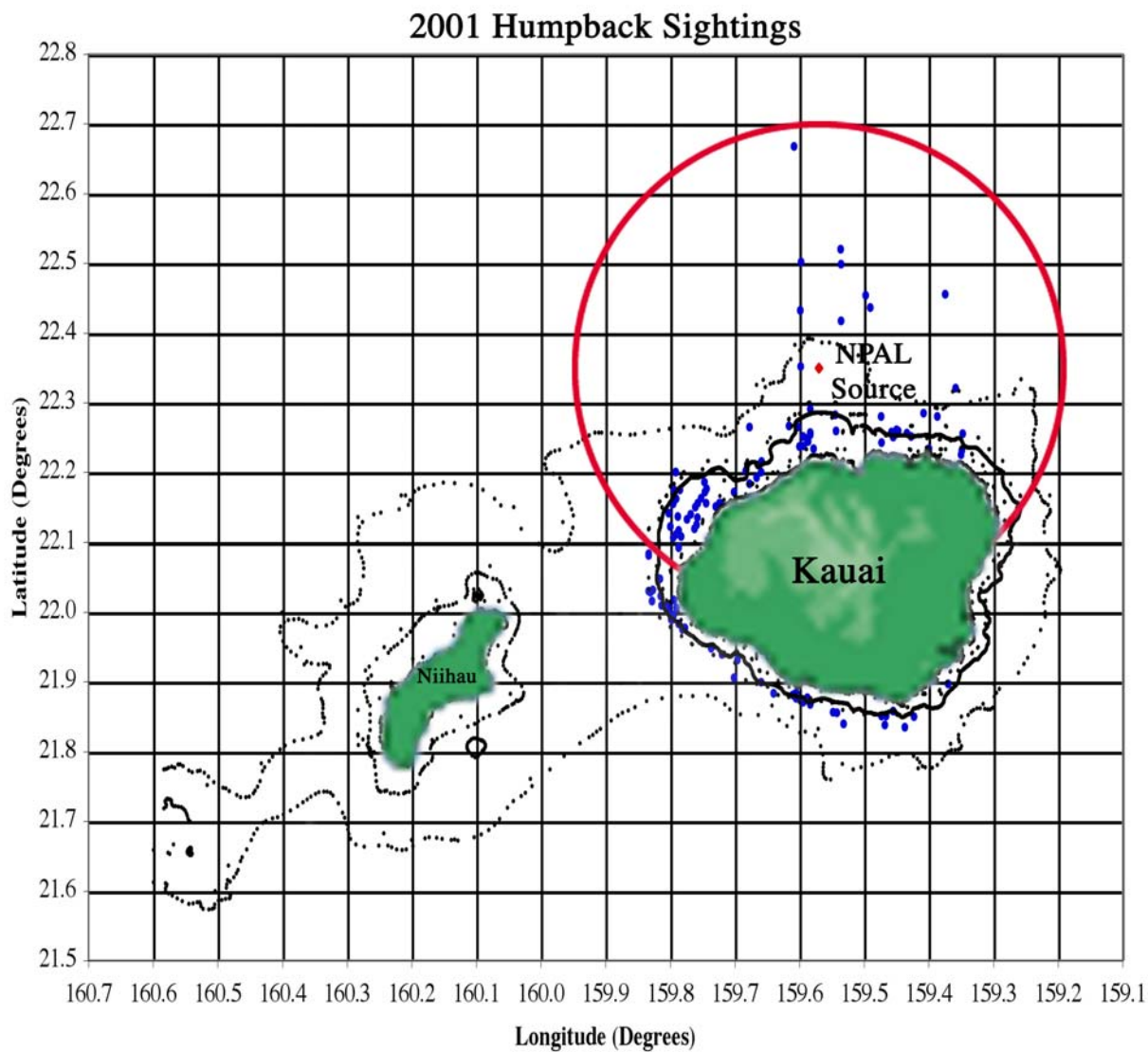


Figure 5. Sightings of Humpback Whales—2001 Results showing 40-km radius around NPAL source. See Figure 4 for comparison with 2004 results.

Table 5. Analysis of Distances—Humpback Whales Only									
<u>Distance from Source (km):</u>					<u>Distance from Shore (km):</u>				
Year	N	Mean	SD	Z	Year	N	Mean	SD	Z
2001	75	22.13	9.16	0.04	2001	75	7.58	9.28	1.22
2004	90	22.49	11.03		2004	90	6.61	7.28	

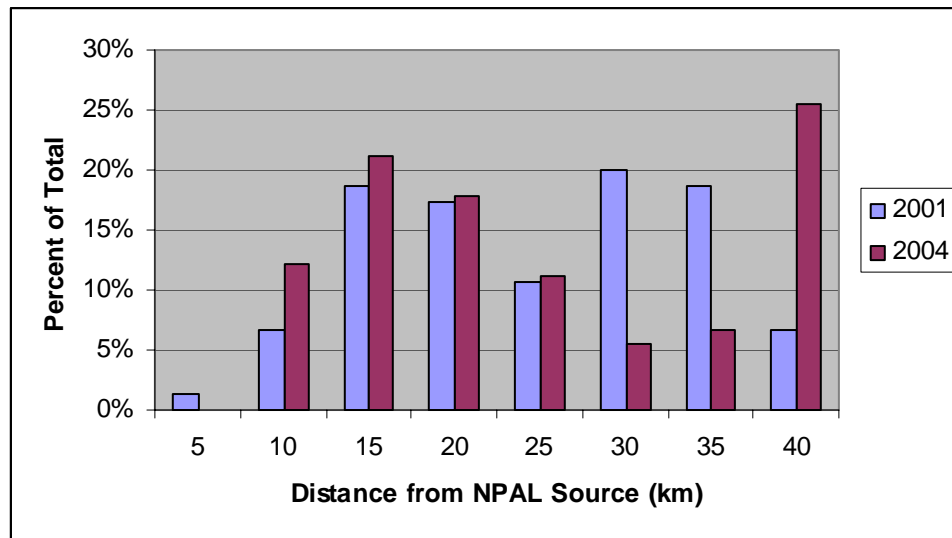


Figure 6. Distance from Source—Humpbacks Only—more humpbacks occupied the furthest distance category (35-40km) during 2004 when the NPAL source was transmitting. However, the difference in mean distance was not significant (Table 5).

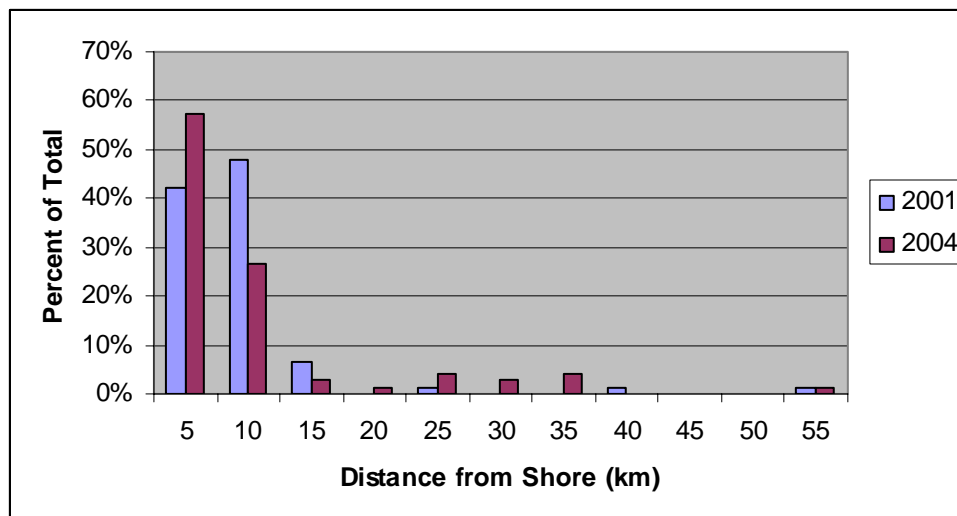


Figure 7. Distances from Shore—Humpbacks Only. More humpback whales were found in the closest offshore distances (0-5 km) during 2004 relative to 2001. However, the difference in mean offshore distance was not statistically significant (Table 5).

Distance Analysis—Odontocete Species

Distance from NPAL Source. Since the number of sightings for a given odontocete species was relatively small, distance analyses were performed with all sightings combined to increase statistical power (Figure 10). Comparison of mean distances showed no significant effect, $Z_{12, 14} = 0.46$, $p > .05$.

Distance from Shore. Odontocetes were generally found further offshore than humpbacks (Figure 11). Comparison across years showed no significant difference, $Z_{12, 14} = 0.03$, $p > .05$.

Distance Analysis—All Sightings Combined

Distance from NPAL Source. When all sightings were combined, comparison of mean distances from the NPAL source revealed no statistically significant difference across years, $Z_{88, 106} = -0.71$, $p > .05$ (Table 7).

Distance from Shore. Similarly, there were no significant changes in distance offshore between 2001 and 2004 when all sightings were combined, $Z_{88, 106} = -0.83$, $p > .05$ (Table 7).

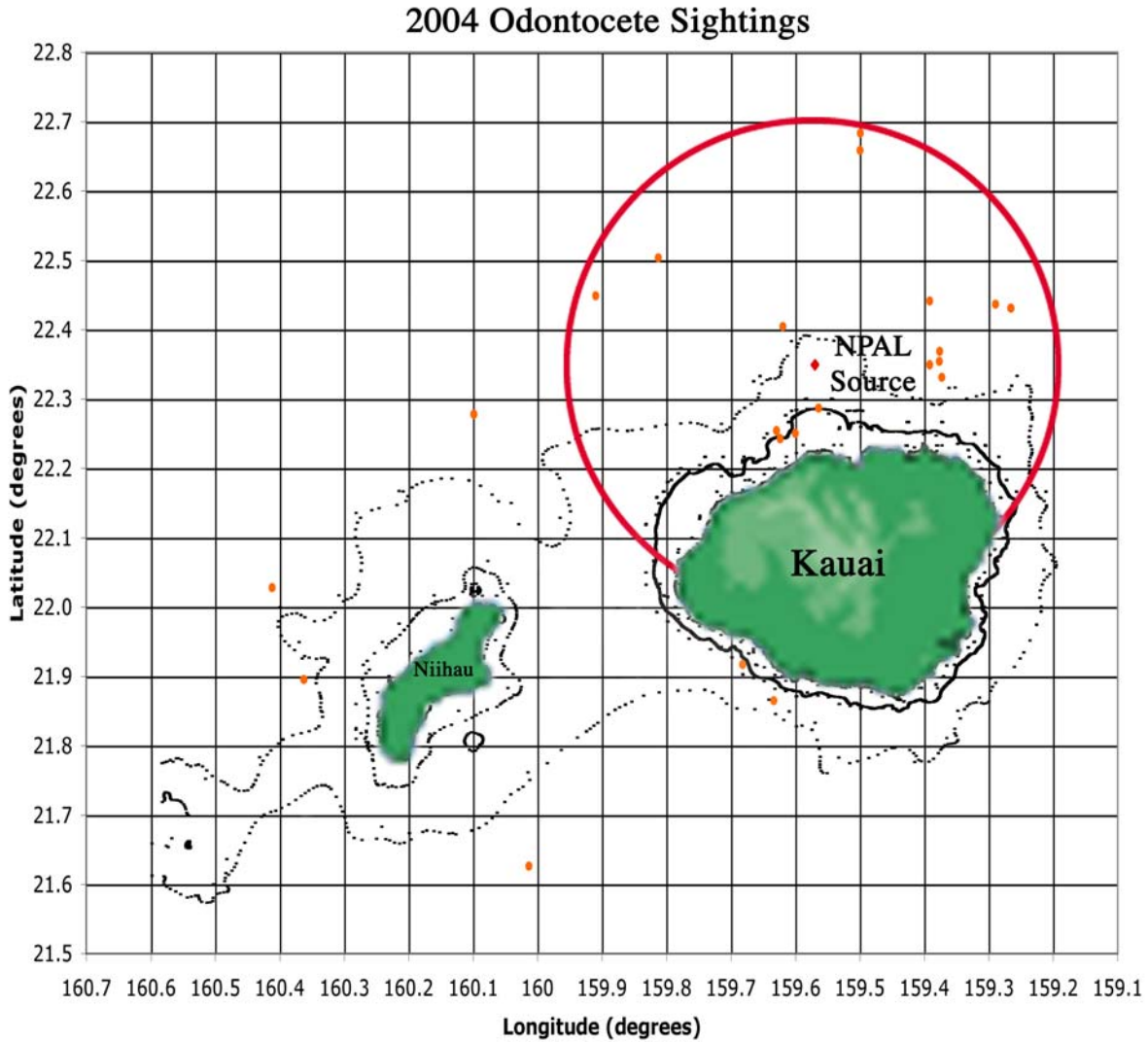


Figure 8. 2004 Odontocete Sightings observed north of Kauai. A total of 20 odontocete sightings were made in all, including 14 sightings inside and 6 sightings outside the 40km radius around the NPAL source. For details of species observed see Table 4. Red diamond indicates location of NPAL source.

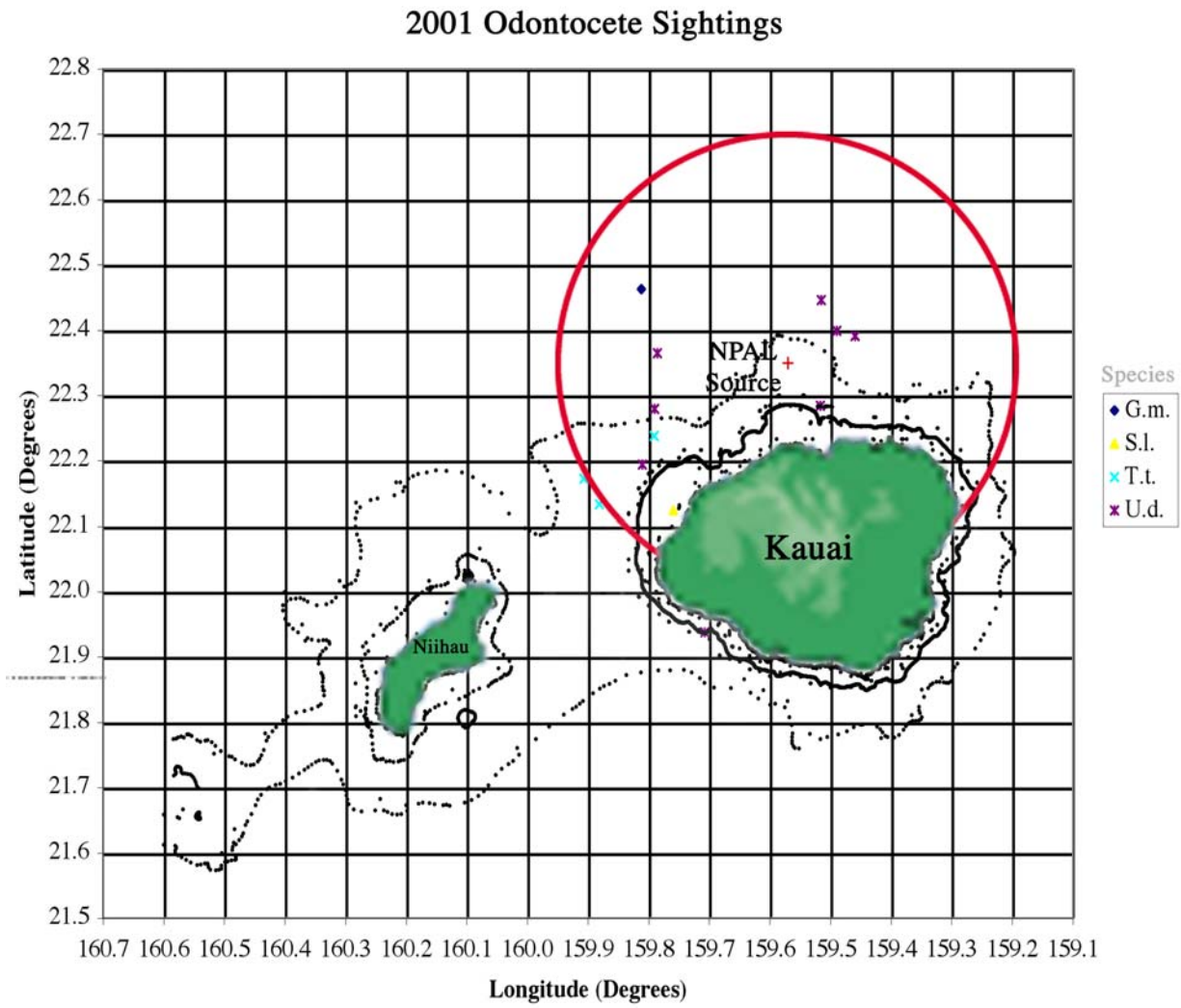


Figure 9. 2001 Odontocete Sightings. Positions of Odontocete species sightings during 2001 field season (Note: Gm = short-finned pilot whales, *Globicephala macrorhynchus*; Sl = spinner dolphins, *Stenella longirostris*; Tt = bottlenosed dolphins, *Tursiops truncatus*; Ud = Unidentified dolphin species).

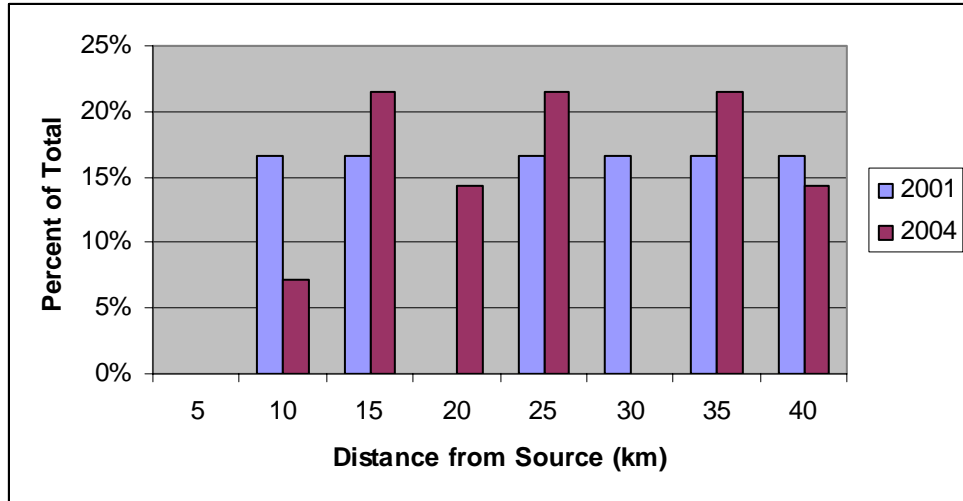


Figure 10. Distance from NPAL Source—Odontocetes Only. No statistically significant difference was found in distance from NPAL source across the two years (2001 and 2004; N = 12 for 2001; N = 14 for 2004) ($p > .05$).

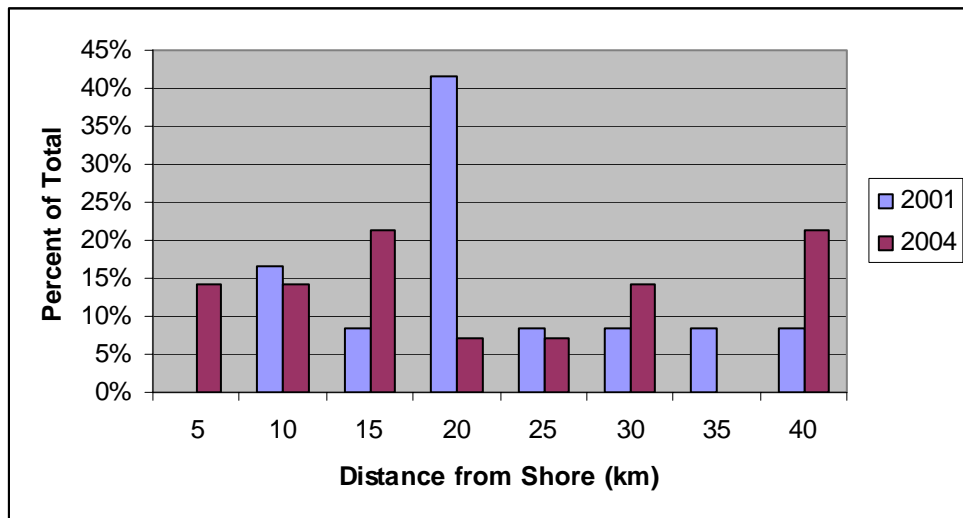


Figure 11. Distance from Shore—Odontocetes Only. There were no statistically significant differences in distance from shore across the two years studied (2001 and 2004, N = 12 for 2001; N = 14 for 2004) ($p > .05$).

Table 6. Analysis of Distances—Odontocetes									
<u>Distance from Source:</u>					<u>Distance from Shore:</u>				
Year	N	Mean	SD	Z	Year	N	Mean	SD	Z
2001	12	23.77	10.53	0.46	2001	12	18.45	7.66	0.03
2004	14	22.09	8.64		2004	14	21.23	15.99	

Table 7. Analysis of Distances—All Sightings									
<u>Distance from Source (km):</u>					<u>Distance from Shore (km):</u>				
Year	N	Mean	SD	Z	Year	N	Mean	SD	Z
2001	88	22.35	9.38	-0.71	2001	88	9.08	9.73	-0.83
2004	106	22.60	10.73		2004	106	9.05	10.81	

Discussion

More humpback whale pods were sighted in the waters within 40-km of the NPAL source during the 2004 season relative to those seen in 2001, though the difference was not statistically significant. The greater numbers seen during 2004 are particularly noteworthy given the less favorable seastate conditions relative to 2001 (Figure 3). Numbers of odontocetes seen within 40-km of the source also increased slightly from 2001 to 2004, though this difference was also not statistically significant.

Distributional analyses indicated no statistically significant difference in distances from the NPAL source or distances offshore from 2001 (NPAL source off) to 2004 (NPAL source on).. Further, aerial survey results for the previous two years (2002, 2003) when the source was operating showed no significant changes in distance from source and distance offshore (Mobley, 2002, 2003). Past studies showing significant distributional changes relative to the ATOC/NPAL source showed an increased distance from the source (Calambokidis, 1998; Frankel and Clark,

2002). This finding has not been replicated in the current series (2001-04). Similar to the case for humpbacks, distance analyses for the odontocete sightings and all marine mammal sightings combined showed no statistically significant distributional changes across years.

In summary, aerial survey comparisons of the numbers and positions of marine mammals within 40 km of the NPAL source both when the source was on (2004) and when it was not (2001) suggest no clear effects of the sound. Subsequent analyses (i.e., for the annual report) will be based on corrected positions for all sightings, taking into account sighting angle, altitude and observer position. The results of those analyses will better determine the robustness of the findings reported here.

Acknowledgements

Data reported here were collected under Scientific Collecting Permit No. 642-1536-00 issued by NOAA Office of Protected Resources to the author. Funds for these surveys were provided by the North Pacific Acoustic Laboratory as sponsored by the Office of Naval Research (ONR). I would like to thank our competent crew of observers including Kim Andrews, Brian Branstetter, Marlee Breese, Marc Lammers, Amy Miller, and Velvet Voelz. Thanks also to Scott Spitz who prepared the graphics in this report. Finally, I am grateful to John Weiser for his superb piloting.

References

Baker, C.S. and L.M. Herman (1981). Migration and local movement of humpback whales (*Megaptera novaeangliae*) through Hawaiian waters. *Canadian Journal of Zoology*, 59, 460-469.

Buckland, S.T., Anderson, D.R., Burnham, K.P, Laake, J.L., Borchers, D.L. and Thomas, L. (2001). *Introduction to distance sampling: Estimating abundance of biological populations*. New York: Chapman and Hall.

Calambokidis, J. (1998). Effects of the ATOC sound source on the distribution of marine mammals observed from aerial surveys off central California. World Marine Mammal Conference, Monte Carlo, Monaco, January 20-24, 1998, Abstracts, p. 22.

Frankel, A.S. and Clark, C.W. (2000). Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. *Journal of the Acoustical Society of America*, 108:1-8.

Frankel, A.S. and Clark, C.W. (2002). ATOC and other factors affecting distribution and abundance of humpback whales (*Megaptera novaeangliae*) off the north shore of Kauai. *Marine Mammal Science*, 18:644-662.

Mobley, Jr., J. R. (2001). Results of 2001 aerial surveys of humpback whales

north of Kauai. Annual report submitted to the North Pacific Acoustic Laboratory (NPAL), Scripps Oceanographic Institution, 7 pp.

Mobley, Jr., J. R. (2002). Results of 2002 aerial surveys of humpback whales north of Kauai. Annual report submitted to the North Pacific Acoustic Laboratory (NPAL), Scripps Oceanographic Institution, 17 pp.

Mobley, Jr., J. R. (2003). Results of 2003 aerial surveys of humpback whales north of Kauai. Annual report submitted to the North Pacific Acoustic Laboratory (NPAL), Scripps Oceanographic Institution, 23 pp.

Mobley, Jr., J. R., Bauer, G. A. and Herman, L. M. (1999). Changes over a ten-year period in the distribution and relative abundance of humpback whales (*Megaptera novaengliae*) wintering in Hawaiian waters. *Aquatic Mammals*, 25(2):63-72.

Mobley, Jr., J.R., Spitz, S.S., Grotefendt, R, Forestell, P.H., Frankel, A.S. and Bauer, G.A. (2001). Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. Report prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary, Nov. 26, 2001.

Mobley, Jr., J.R., Grotefendt, R.A., Forestell, P.H. and Frankel, A.S. (1999). Results of aerial surveys of marine mammals in the major Hawaiian Islands (1993-98): Final Report to the Acoustic Thermometry of Ocean Climate Program (ATOC MMRP), 34 pp.

Welkowitz, J., Ewen, R.B. and Cohen, J. (1991). *Statistics for the behavioral sciences* (4th Ed.). New York: Harcourt, Brace, Jovanovich.