MELON-HEADED WHALES IN THE HAWAIIAN ARCHIPELAGO: AN ASSESSMENT OF POPULATION STRUCTURE AND LONG-TERM SITE FIDELITY BASED ON PHOTO-IDENTIFICATION

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Summary

We assess the potential for population structure of melon-headed whales (*Peponocephala electra*) around the main Hawaiian Islands based on photo-identification data from 2002 through 2010, to help inform genetic analyses of population structure and interpretation of data obtained from satellite tags. In addition, we compare photographs obtained from 1986-1996 to more recent photos to assess long-term site fidelity, and photos obtained from Palmyra Atoll from 2006-2009 to assess the potential for movements between Hawai‘i and Palmyra. Associations among individuals indicates the existence of at least two populations of melon-headed whales around the main Hawaiian Islands, a small population resident to the island of Hawai‘i (the Hawai‘i Island resident population) and a larger population of individuals that move throughout the main Hawaiian Islands (the main Hawaiian Islands population). Genetic samples are available from both populations and satellite tags have also been deployed on individuals from both populations. Re-sightings of individuals from the Hawai‘i Island resident population span up to 22.6 years and of individuals from the main Hawaiian Islands population span up to 13.1 years, indicating long-term site fidelity for both populations. There were no matches of individuals from Palmyra Atoll to Hawai‘i, however only a small number of identifications were available from Palmyra (66 distinctive or very distinctive individuals), thus comparisons of additional photos from Palmyra are warranted.

Introduction

Around the main Hawaiian Islands there is evidence of multiple populations or stocks of a number of species of odontocetes. Based on both genetics and association patterns, there is evidence of four different populations of common bottlenose dolphin (*Tursiops truncatus*), with individuals around each island (or island group in the case of Kaua‘i/Ni‘ihau, and Maui/Lana‘i/ Kaho‘olawe/Moloka‘i) apparently socially and genetically isolated from those around other islands (Baird et al. 2009; Martien and Baird 2006). Based on genetic evidence both spinner dolphins (*Stenella longirostris*) and pantropical spotted dolphins (*S. attenuata*) appear to have multiple populations, with individuals around each island group genetically isolated from those around other islands (Andrews et al. 2010; Courbis et al. 2009). Based on association patterns,

movements of individuals, behavior, and habitat use, there is evidence of at least two populations of rough-toothed dolphins (*Steno bredanensis*) in the main Hawaiian Islands (Baird et al. 2008a). For false killer whales (*Pseudorca crassidens*), genetics, association, and movement data all indicate there is a single population around the main Hawaiian Islands with frequent movements among islands (Baird et al. 2008b, 2010), and a separate offshore population, with some overlap between the two (Baird et al. 2008b, 2010; Chivers et al. 2007, 2010).

Although there are at least half a dozen other species of odontocetes that may have discrete island-associated populations in Hawai‘i (see e.g., McSweeney et al. 2007, 2009; Mahaffy et al. 2009; Schorr et al. 2009a), sufficient genetic samples and/or identification photographs to assess the potential for isolation are limited to only a couple of species. One of these species, the melon-headed whale (*Peponocephala electra*), is only infrequently encountered around the main Hawaiian Islands, with sightings in small-boat surveys on average every two weeks (Aschettino 2010). There is some evidence that melon-headed whales may be vulnerable to impacts from mid-frequency sonar use (Southall et al. 2006; Brownell et al. 2009), and thus information on population structure is needed to assess vulnerability of populations, particularly in areas like Hawai‘i with frequent naval activities.

As part of a long-term multi-species odontocete research effort in Hawai‘i (e.g., Baird et al. 2008a, 2008b, 2009), 120 genetic samples from melon-headed whales were obtained throughout the main Hawaiian Islands between 2002 and 2008. Preliminary examination of movements of photo-identified individuals from that research effort indicated that at least some melon-headed whales move extensively among the main Hawaiian Islands (Huggins et al. 2005), and results from satellite tagging indicate substantial offshore movements of some individuals as well (Schorr et al. 2009b). Although the aforementioned genetic samples were obtained from 18 different groups of melon-headed whales, it is not known whether all of these groups are from a single population or potentially from multiple populations, as has been documented for spinner dolphins, common bottlenose dolphins and pantropical spotted dolphins.

The primary purpose of this report is to compare individual photographic identifications of melon-headed whales from all groups documented around the main Hawaiian Islands from

which genetic samples were obtained or when satellite tags were deployed, to determine whether these samples and data from satellite tags were from a single population or potentially from multiple populations. In addition, we compare photographs from recent survey efforts (2002-2008) to photographs obtained prior to the initiation of this study (1986-2001) to assess long-term site fidelity, and also compare photos from the main Hawaiian Islands to those obtained from Palmyra Atoll to assess the potential for movements between these two areas.

Methods

Photographs were obtained from three sources: 1) 39 encounters (40,303 photos) from small-boat field studies around the main Hawaiian Islands from 2002-2010 (see Baird et al. 2009; Aschettino 2010); 2) 16 encounters (2,062 photos) off the island of Hawai‘i as part of a long-term study of odontocetes from 1986-2001 (see McSweeney et al. 2007, 2009); and 3) 9 encounters (136 photos) from Palmyra Atoll, most taken as part of research efforts there studying odontocete acoustic ecology from 2006, 2007 and 2009 (Baumann-Pickering 2009).

Photographs were incorporated into an existing photo-identification catalog following the same protocols as used for catalogs of eight other species of Hawaiian odontocetes (see Baird et al. 2008a, 2008b, 2009; McSweeney et al. 2007, 2009). All individuals were graded for distinctiveness and photos were graded for quality as described by Aschettino (2010), and quantitative analyses were restricted to distinctive and very distinctive individuals documented with good or excellent quality photos, to reduce the likelihood of bias associated with poorly marked individuals or poor quality photographs. Social network diagrams were produced with Netdraw (Borgatti 2002) to illustrate associations among individuals between groups. Analyses of the majority of photos available were included in Aschettino (2010), although additional photos from prior to 2002, from Palmyra, and from 2010 have been incorporated into these analyses. Encounters from Hawai‘i in late 2009 and in 2010 have only been partially matched to confirm population identity of each group. Quantitative analyses are based on photos from 2002-2008 as reported by Aschettino (2010).

Results and Discussion

From around the main Hawaiian Islands and restricting analyses to good and excellent quality photos of distinctive or very distinctive individuals, from 1986 to 2001 there were 124 individual melon-headed whales documented, and from 2002 to 2008 there were 1,046 individuals documented. Examining the subset of individuals documented between 2002 and 2008, 78.4% of these were linked by association in a single cluster, and 17.3% of the individuals were linked in a second cluster (Figure 1, see Aschettino 2010). Based on these association patterns, Aschettino (2010) concluded there are two distinct social groupings or populations of melon-headed whales around the main Hawaiian Islands; we refer to these hereafter as the main Hawaiian Islands population and the Hawai‘i Island resident population. Individuals from the main Hawaiian Islands population move extensively among the islands and are typically found in deep waters (median depth = 1,844 m), while individuals from the Hawai‘i Island resident population appear to have a restricted range off the island of Hawai‘i and generally inhabit shallower (median = 381 m) water (Aschettino 2010; Schorr et al. 2009). Based on mark-recapture analyses, Aschettino (2010) estimated abundance of the main Hawaiian Island population of 5,794 individuals (CV = 0.20), and of the Hawai‘i Island resident population of 447 individuals (CV = 0.12). Re-sighting rates varied between these two populations, reflecting the differences in population size. Restricting analyses to groups where all individuals were matched resulting in 20 or more identifications of distinctive or very distinctive individuals, the percentage of individuals within groups seen on more than one occasion ranged from 4.5% to 92.8% for the main Hawaiian Islands population (median = 31.8%, n = 13 groups), and from 48.0% to 75.0% for the Hawai‘i Island resident population (median = 62.2%, n = 5 groups).

To assess long-term site fidelity identifications from 1986 through 1996 were examined. From this period there were 118 individuals that were distinctive or very distinctive with good or excellent quality photographs; based on association patterns 30 were from the Main Hawaiian Islands population, 64 were from the Hawai‘i Island resident population, and 24 were of unknown population identity (i.e., there were no re-sightings of any individuals in those groups, thus the groups could not be linked by association to either of the two known populations). Two of the 30 main Hawaiian Island population individuals (6.7%) were seen more than once, with

the longest span of re-sightings from October 1995 to December 2008. By comparison, 14 of the 64 Hawai‘i Island resident individuals (21.8%) were seen more than once, with two individuals having re-sightings spanning from April 1986 to December 2008. Given the small sample size of individuals available from 1986 through 1996 in comparison to current population estimates, and the potential for mark changes in the intervening period, these long re-sighting spans are evidence of long-term site fidelity for both populations.

Genetic samples have been obtained from individuals from both populations and satellite tags have also been deployed on individuals from both populations (Table 1). In addition, genetic samples were obtained from one group (seen September 22, 2004) that does not link by association with either the main Hawaiian Islands population or the Hawai‘i Island resident population (Table 1). It is interesting to note that this group was found in the deepest water (4,772 m) of all encounters documented, and among the furthest from shore (24.4 km; Table 1). Identification photographs of 52 individuals (26 that were distinctive or very distinctive individuals with good or excellent quality photos) were obtained from this group, and there were no matches to any other group (Figure 1). Given the range in proportion of individuals within groups from the main Hawaiian Islands population being seen on more than one occasion (4.5% to 92.8%), anywhere from 1 to 24 of the 26 distinctive or very distinctive individuals would have been expected to be re-sighted if this group was part of the main Hawaiian Islands population, suggesting the possibility that this group may represent a third, perhaps open-ocean, population of melon-headed whales. Satellite tagged melon-headed whales from the main Hawaiian Islands population have moved extensive distances offshore (Schorr et al. 2009b), so distance from shore alone does not appear to be enough to assess population identity.

Palmyra Atoll is located approximately 1,700 km south of Hawai‘i, and melon-headed whales are regularly documented around Palmyra (Baumann-Pickering 2009), with groups of up to about 1,000 individuals recorded there (Brownell et al. 2009). However, regular on-the-water effort around Palmyra Atoll has documented extended periods (e.g. months) when no melon-headed whales are seen (A. Kierzek, pers. comm.), suggesting that individuals from Palmyra move elsewhere. One satellite tagged melon-headed whale from the main Hawaiian Islands population moved 559 km from the tagging location in just nine days (Schorr et al. 2009b), so it

is certainly possible that movements between the two areas may occur. From Palmyra, there were 138 identifications of 131 individuals, 66 of which were considered distinctive or very distinctive with photo qualities that were considered good or excellent, from seven different encounters. The number of distinctive/very distinctive individuals documented per encounter was small (range of 2-42, median = 4), thus the likelihood of re-sightings between encounters was low. Five of the 66 individuals (7.6%) were seen on two occasions, but there were no matches of individuals from Palmyra to Hawai‘i. However, the sample from Palmyra is very small relative to the population size, and comparisons of a larger sample size of photographs from Palmyra to the main Hawaiian Island population, as well as to the unknown September 22, 2004 group encountered in Hawai‘i, would be of value.

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Table 1. Melon-headed whale encounters around the main Hawaiian Islands from which genetic samples were obtained or satellite tags were deployed. Population identity is based on association patterns from photo-identification (MHI = main Hawaiian Islands population, Resident = Hawai‘i Island resident population).

Date	Enc. #	Closest Island	Distance from shore (km)	Start depth (m)	Group size (best)	# photos	Population identity	# sat tags	# genetic samples
04/10/02	1	Hawai'i	4.2	1,625	300	177	MHI	0	1
29/05/03	2	O'ahu	43	968	190	131	MHI	0	7
05/06/03	3	Kaua'i	5.1	1,165	200	527	MHI	0	17
13/10/03	2	Hawai'i	10.4	2,175	275	501	MHI	0	13
14/10/03	2	Hawai'i	7.8	1,644	275	126	MHI	0	3
17/09/04	4	Hawai'i	6.3	1,271	300	1,206	MHI	0	9
22/09/04	2	Hawai'i	24.4	4,772	240	359	unknown	0	6
03/10/04	3	Hawai'i	3.5	1,293	120	447	MHI	0	5
03/10/04	4	Hawai'i	20.2	3,517	220	642	MHI	0	4
22/11/04	1	Hawai'i	9.9	1,860	450	827	MHI	0	3
25/11/04	1	Hawai'i	7.5	2,409	250	938	MHI	0	3
22/01/05	5	Hawai'i	23.6	3,457	420	1,003	MHI	0	3
24/01/05	1	Hawai'i	26.8	4,014	800	868	MHI	0	4
25/01/05	1	Hawai'i	10.9	1,375	525	450	MHI	0	2
02/02/05	4	Hawai'i	7.3	321	550	929	Resident	0	4
26/03/06	3	Hawai'i	9.6	374	350	956	Resident	0	11
30/03/06	1	Hawai'i	8	285	210	650	Resident	0	5
19/04/08	1	Hawai'i	10.1	2,450	325	2,265	MHI	2	6
25/04/08	4	Hawai'i	10.7	1,525	182	840	MHI	1	0
25/06/08	2	Ni'ihau	8.6	1,050	220	2,045	MHI	2	0
29/06/08	5	Ni'ihau	21.2	2,000	340	2,136	MHI	1	0
30/06/08	3	Kaua'i	7.6	1,871	340	2,108	MHI	0	1
02/07/08	2	Hawai'i	3.4	1,400	300	651	MHI	2	0
10/12/08	1	Hawai'i	26.7	1,100	335	2,767	MHI	3	9
10/12/08	2	Hawai'i	18.6	895	525	847	Resident	0	5
15/12/08	1	Hawai'i	15.7	420	425	1,974	Resident	1	0
09/12/09	2	Hawai'i	6.7	400	160	609	Resident	1	0
23/07/10	6	Hawai'i	8.6	920	175	2,684	Resident	0	7
18/08/10	2	Hawai'i	20.1	421	190	4,511	Resident	0	8

Figure 1. Reproduced from Aschettino (2010). Social network diagram showing associations of melon-headed whales including good and excellent quality photographs of distinctive and very distinctive individuals only. Nodes correspond to individual melon-headed whales, and lines between nodes represent presence within the same group. The majority (78.4%) are linked to the main cluster (the main Hawaiian Islands population), 17.2% are part of a second large cluster (the Hawai‘i Island resident population, left side), and the remaining 4.4% are part of three small clusters not linked to either of the main clusters. Biopsy samples collected on 22 September 2004 from an unknown group (see Table 1) were from the upper right cluster. When relaxing distinctiveness restrictions the small cluster on the left side links to the main Hawaiian Islands population.