A survey to assess overlap of insular and offshore false killer whales (*Pseudorca crassidens*) off the island of Hawai‘i

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Summary

There are two populations of false killer whales within the Hawaiian Exclusive Economic Zone, an insular population around the main Hawaiian Islands and an offshore population. In order to assess the degree of overlap of individuals from these populations, surveys offshore of the island of Hawai‘i were undertaken in 2008, using a medium-sized charter vessel to survey further from shore than has been undertaken in previous small-boat surveys. In 10 days of survey effort 1,850 km of trackline were covered, with more than 60% of the effort in depths >4,000 m, and survey coverage out to 129 km from shore. Forty sightings of nine species of odontocetes were documented, with high sighting rates of species typically seen in very deep waters in Hawai‘i, including rough-toothed dolphins (n = 11 sightings), striped dolphins (n = 5 sightings), and Risso’s dolphins (n = 3 sightings). Three sightings of false killer whales were documented from 106-124 km offshore, all on Jaggar Seamount. A comparison of photographs of 13 distinctive/very distinctive individuals to a catalog of 152 distinctive/very distinctive individuals photo-identified around the main Hawaiian Islands revealed no matches, suggesting the individuals documented were part of the offshore population. Genetic analyses of three biopsy samples collected from two of the groups encountered confirmed these individuals were part of the offshore population.

Introduction

False killer whales in the central tropical Pacific interact with long-line fisheries, and are occasionally killed or seriously injured in those fisheries (Forney and Kobayashi 2007). Within the Hawaiian Exclusive Economic Zone (EEZ) the estimated number killed or seriously injured exceeds the Potential Biological Removal (PBR) level, based on available population estimates (Forney and Kobayashi 2007; Carretta et al. 2007). Fishing effort, and thus mortality or serious injury of false killer whales, does not occur evenly throughout the Hawaiian EEZ. Most of the long-line fishing effort occurs in the eastern half of the Hawaiian EEZ, with little effort in waters offshore of the northwestern Hawaiian Islands. Furthermore, to reduce competition with near-shore fisheries, the Hawai‘i-based long-line fishery is managed with geographic closures around the main Hawaiian Islands. This boundary varies in part seasonally; from February through

September the closest that long-line fishing may occur to the main Hawaiian Islands is 79 km (42.4 nm), while from October through January more than half the boundary contracts towards the islands, with some long-line fishing occurring as close as 45 km (24.3 nm) from the main Hawaiian Islands.

Within the Hawaiian EEZ, two genetically differentiated populations of false killer whales have been identified, an insular population, known to be associated with the main Hawaiian Islands, and an offshore population (Chivers et al. 2007; Baird et al. 2008a). Estimates available for both populations indicate small population sizes. Based on mark-recapture analyses of photo-identified individuals, the insular population was estimated at 123 (CV = 0.72) individuals (Baird et al. 2005). Based on large vessel line transect surveys, the abundance of false killer whales in offshore waters of the EEZ was estimated at 484 (CV = 0.93) individuals (Barlow and Rankin 2007). Understanding the ranges and potential overlap of these populations is important in terms of assessing whether strict geographic boundaries exist between them, determining whether both populations overlap with the long-line fishery, and potentially apportioning bycatch from the fishery to each population.

There is some previous information available from both satellite tagging and photo-identification to suggest a potential overlap. Based on satellite tagging of one individual from the insular population, it is known that individuals from this population may range as far as 96 km from shore (Baird et al. 2008b). Based on photo-identification, it is thought that the offshore population may approach as close as 42 km from shore, although no genetic samples (to confirm population identity) were collected from the putative offshore group 42 km from the islands (Baird et al. 2008a). The majority of photo-identification effort in Hawaiian waters has been concentrated within approximately 40 km of shore, due to sea conditions and the size of available survey vessels. The purpose of this study was to survey in waters greater than 40 km from shore (using a larger vessel), to better assess the area of potential overlap between the insular and offshore populations. We use a combination of photo-identification and genetic analyses of biopsy samples to assess whether false killer whales encountered are part of the insular or offshore populations. In addition, we discuss sightings of other species in relation to

what is known of their distribution and encounter rates based on long-term surveys off the island of Hawai‘i.

Methods

Ten days of surveys were undertaken in April, May, and July 2008. The primary research vessel used was a 16-m power vessel (nine days of surveys), with one day of survey undertaken from an 8.4 m power vessel. The surveys were based out of Honokohau Harbor on the west side of the island of Hawai‘i to take advantage of the large lee extending offshore, with the bulk of the island deflecting the predominant easterly trade winds. Most surveys departed prior to sunrise in order to maximize survey effort in the primary study area (>40 km from shore). Survey routes typically involved a direct transit offshore until the vessel reached 40 km from shore. Once >40 km, the survey routes diverged, attempting to cover as broad an area as possible west of the island of Hawai‘i, while trying to remain in areas of Beaufort 3 or less, and simultaneously minimizing overlap with previous survey tracklines. During each survey five to six observers scanned 360 degrees around the survey vessel, either unaided or with binoculars. During the first three days of surveys a towed 90-m four element hydrophone array was monitored intermittently to assist with detection. Vessel locations were automatically recorded using a GPS every five minutes to document survey tracklines, and sea state was noted as it changed.

When cetaceans were observed, the group was approached for species confirmation, group size was estimated, and the location of the group was recorded. For false killer whales and other species for which photo-identification catalogs exist (e.g., rough-toothed dolphins), attempts were made to photograph all individuals present for the purposes of individual identification. Biopsy samples were collected from some groups for genetic studies, using either a pole-spear (for bowriding individuals) or a crossbow, with 25 mm biopsy tips. After collection biopsy samples were stored on ice while on the research vessel and then stored at -20°C until transport to the Southwest Fisheries Science Center.

Depth, slope, and distance to shore were extracted for all effort and sighting locations by overlaying point location data on a bathymetric raster surface in ArcGIS Version 9.2 (ESRI,

Redlands, California). Depths (in meters) were transferred to point locations using the ‘intersect point tool’ in Hawth’s analysis tools (Beyer 2004). A 50 m x 50 m multibeam synthesis bathymetry model from the Hawai‘i Mapping Research Group[1] was used. The model had areas of no data, so the grid was overlaid on a 3-arc second (90 m x 90 m) U.S. Coastal Relief Model bathymetry from the National Geophysical Data Center[2] to provide 90 m resolution data where 50 m resolution data were absent.

False killer whale photographs were sorted by individual and matched among encounters and to an existing photo-identification catalog following the protocol described by Baird et al. (2008a). The existing catalog contained 152 distinctive/very distinctive individuals (individuals with multiple dorsal fin notches that could be identified among encounters even with fair or poor quality photos; see Baird et al. (2008a)) documented from around the main Hawaiian Islands from 1986 through 2007. Genetic analyses of false killer whale biopsy samples were undertaken at the Southwest Fisheries Science Center using previously described methods (Chivers et al. 2007).

Results and Discussion

Surveys were undertaken on three days in April, four days in May, and three days in July, 2008, spanning two of Hawai‘i’s oceanographic seasons, winter (February-April) and spring (May-July; Flament 1996). A total of 1,850 km of survey trackline were covered during daylight hours, with 109.7 hours of survey effort. Almost three quarters (74.5%) of survey effort was in depths greater than 3,000 m, and surveys covered areas out to 129 km from shore (Figure 1, Figure 2). Sea states were generally favorable for sighting cetaceans, with 87.0% of the survey effort in Beaufort sea state of 3 or less, and 64.7% in Beaufort 2 or less. Sea states were similar in waters less than 40 km from shore (average Beaufort 2.2) and greater than 40 km from shore (average Beaufort 2.5), although swells in offshore waters limited photography, biopsy sampling and tagging of individuals encountered.

[1]Available from http://www.soest.hawaii.edu/HMRG/Multibeam/index.php

[2]Available from http://www.ngdc.noaa.gov/mgg/coastal/coastal.htm

A total of 40 sightings of nine species of odontocetes were documented. Relative species encounter rates during these surveys differed from surveys undertaken off the island from 2002 through 2007 (Table 1). Several species (rough-toothed dolphins, striped dolphins, Risso's dolphins) were encountered at much higher rates during the current study than during previous research (Table 1). For example, despite 24,466 km of search effort spread over 11 months of the year (1,574 hours; Baird et al. unpublished), Risso's dolphins and striped dolphins had only previously been encountered two and 13 times off the island, respectively, while with less than 8% of that effort we encountered Risso's dolphins three times and striped dolphins five times during the 2008 surveys. The differences in relative species encounter rates reflect the typically deep-water habits of those species (Table 1; Baird et al. 2008c) and the offshore distribution of survey coverage (Figure 1), rather than any seasonal differences in survey effort.

Three species (rough-toothed dolphins, striped dolphins and false killer whales) were seen on the slopes of Jaggar Seamount, and sperm whales were seen on Indianapolis Seamount (Figure 2). In total, three groups of false killer whales were documented, all over a 2-day period in April 2008 (April 21, 22). Although false killer whales were sighted further from shore than any other species (distances of 106.5, 111.8 and 123.8 km), depths of false killer whale sightings were among the shallowest documented (1,463 m, 2,000 m 2,727 m) of all species due to the clustering of sightings on Jaggar Seamount (Table 2). Identification photographs were obtained from all three encounters (864 photos total), and biopsy samples were obtained from two of the three encounters (three samples total, from the two encounters on April 21). One individual, from the second encounter on April 21, was satellite tagged to examine movements; results of this work are reported elsewhere (Baird et al. 2008b). Bowriding was documented during all three encounters, and three instances of predation on unidentified large fish were observed in two of the three encounters. From the photographs, 15 individual false killer whales were documented with good or excellent quality photographs. Of these, 13 were considered distinctive or very distinctive, and two were considered slightly distinctive. There were no matches among the three encounters, and a comparison to the photo-identification catalog of Baird et al. (2008a) indicated no matches. The lack of matches to the catalog of Baird et al. (2008a) suggest these individuals are not part of the insular population. Baird et al. (2008a) note that on average, the proportion of distinctive and very distinctive individuals within groups documented on multiple

occasions was 76.8%, and other than one putative offshore group seen 42-70 km from shore, the largest group with no matches to the catalog was two individuals.

The suggestion that these individuals are not part of the insular population was supported by genetic analyses. Mitochondrial DNA haplotypes for the three false killer whales biopsy sampled were all of the "pelagic" type (see Fig. 3 in Chivers et al. 2007). One sequence was identical to haplotype 9, the most common eastern North Pacific haplotype documented from false killer whales sampled off Mexico, Palmyra Atoll and in offshore waters of the Hawaiian EEZ. The other two samples had the same, previously undocumented, haplotype, two base pairs different from haplotype 21, which was identified from a false killer whale sampled in the Indian Ocean (Chivers et al. 2007). While this apparent spatial incongruence is likely due to the limitations of the available genetic samples from across the North Pacific, the relationship suggests these animals are not part of the insular population.

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Table 1. Sightings by species, with information on group size and habitat use and a comparison to relative encounter rates from sightings from surveys off the island of Hawai‘i from 2002-2007*.

Species	Group size Median (range)	# sightings this study	% sightings this study	% sightings 2002-2007*	Depth (m) median, range	Distance from shore (km) Median, range
Rough-toothed dolphin	6 (2-40)	11	27.5	10.5	4,316 (1,658 – 4,739)	29.9 (8.7 – 99.1)
Pantropical spotted dolphin	45 (20-120)	9	22.5	25.4	4,692 (3,766 - 4,800)	44.5 (31.7 – 57.3)
Striped dolphin	35 (20-38)	5	12.5	2.1	4,617 (2,495 – 4,790)	48.4 (30.6 – 97.1)
Short-finned pilot whale	12 (2-20)	5	12.5	24.7	1,749 (1,213 – 3,085)	7.3 (3.2 – 37.1)
Risso’s dolphin	4 (4-4)	3	7.5	0.3	4,419 (3,750 – 4,739)	56.5 (44.7 – 57.4)
False killer whale	14 (5-18)	3	7.5	1.8	2,000 (1,463 – 2,728)	111.8 (106.4 – 123.8)
Sperm whale	9, 13	2	5.0	3.1	4,220, 4,645	41.5, 71.2
Bottlenose dolphin	2	1	2.5	3.7	397	9.2
Dwarf sperm whale	1	1	2.5	3.6	4,724	40.2
Total		40				

*Baird et al. unpublished data (618 sightings of 17 species based on 24,466 km (1,574 hours) of search effort).

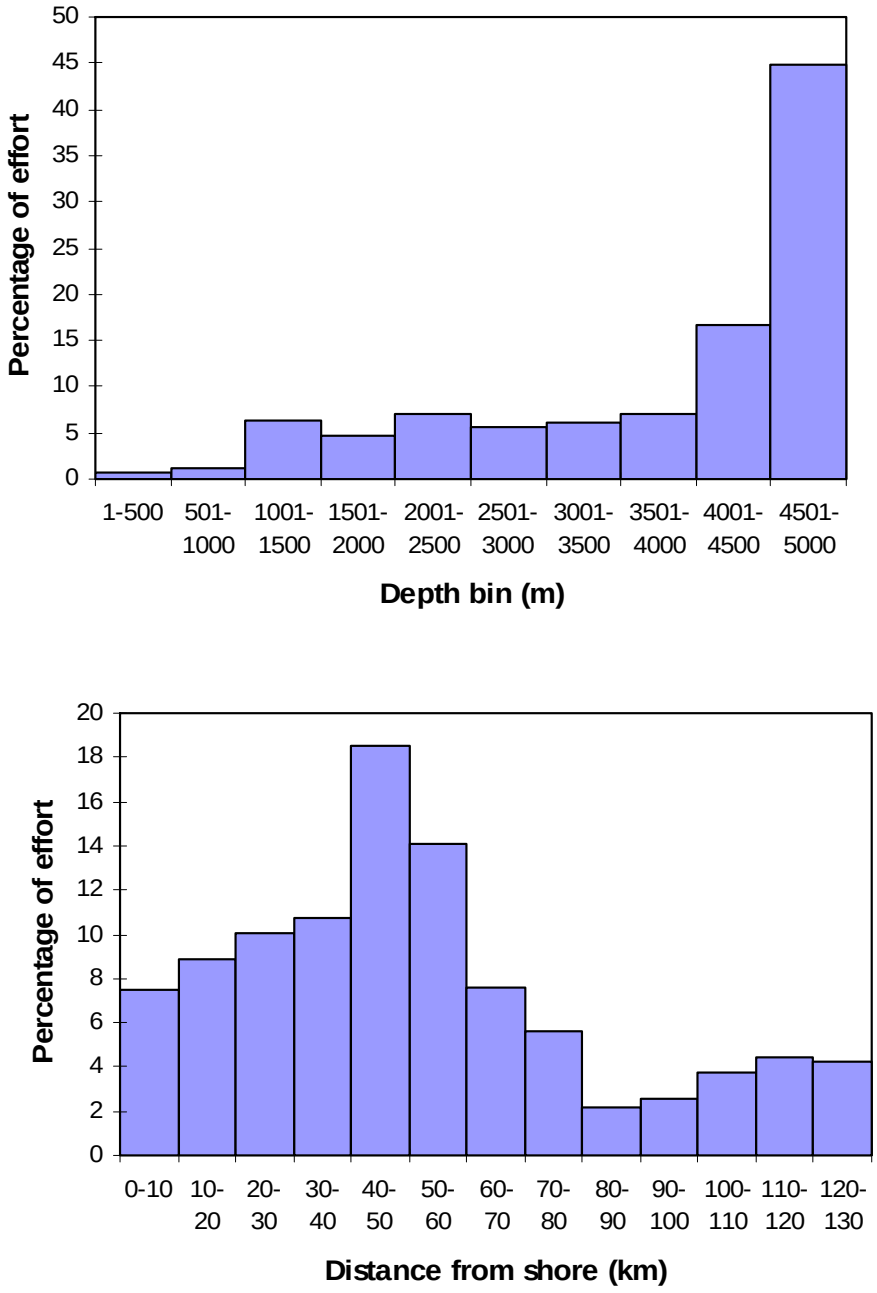

Figure 1. Distribution of survey effort by depth (top) and by distance from shore (bottom). The relative lack of survey effort in depths of less than 1000 m due to the steep bathymetry immediately offshore of Honokohau Harbor and typical departures prior to sunrise.

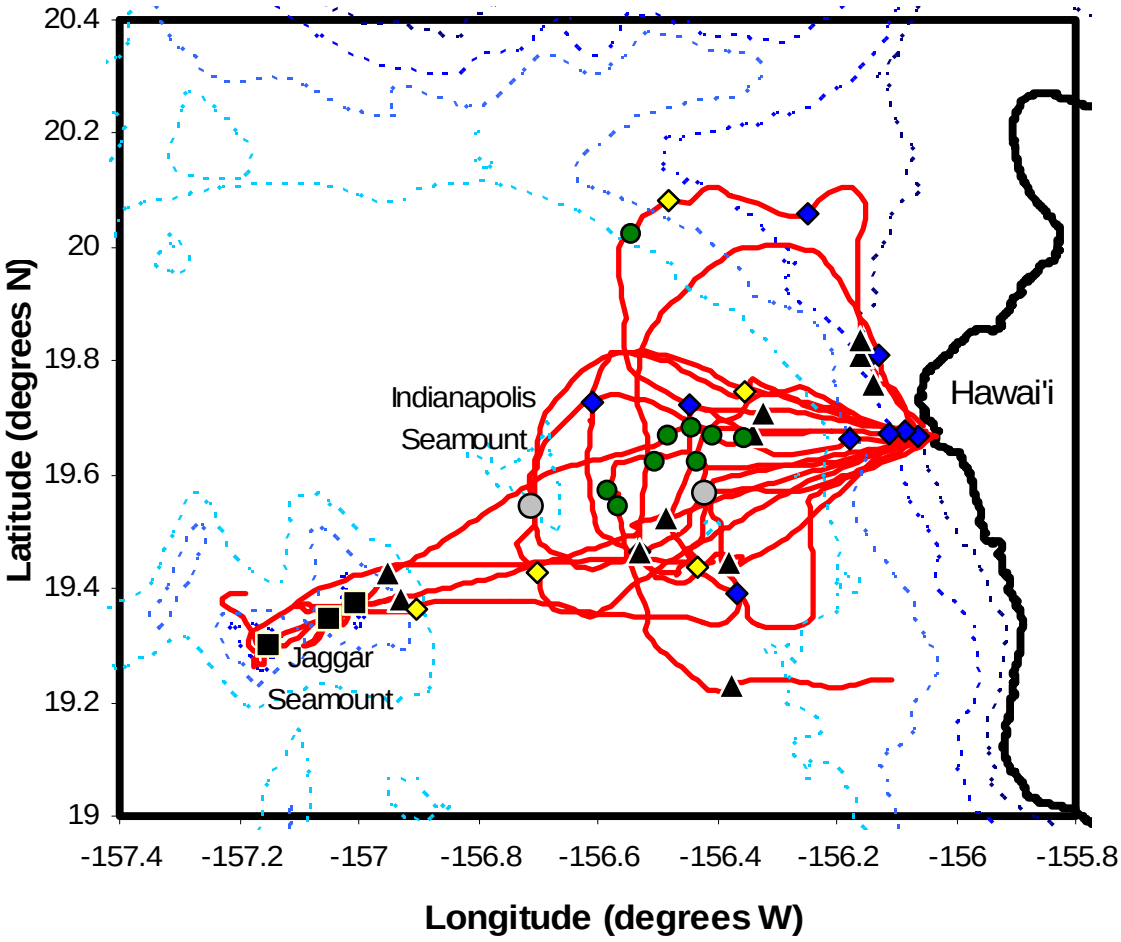

Figure 2. Map showing distribution of survey effort (red lines), including sightings of false killer whales (black squares), rough-toothed dolphins (black triangles), pantropical spotted dolphins (small green circles), sperm whales (large gray circles), striped dolphins (yellow diamonds), and other species (blue diamonds). The 1,000 m, 2,000 m, 3,000 m and 4,000 m depth contours are shown.