

## Short Note

### Presence and Distribution of Hawaiian False Killer Whales (*Pseudorca crassidens*) in Maui County Waters: A Historical Perspective

Itana F. Silva,<sup>1,2</sup> Gregory D. Kaufman,<sup>1</sup> Robert W. Rankin,<sup>3</sup> and Daniela Maldini<sup>1,4</sup>

<sup>1</sup>*Pacific Whale Foundation, 300 Ma'alaia Road, Suite 211, Wailuku, Maui, HI 96793, USA*  
E-mail: itana\_freire@hotmail.com

<sup>2</sup>*State of Hawai'i Division of Aquatic Resources, 130 Mahalani Street, Wailuku, Maui, HI 96793, USA*

<sup>3</sup>*Cetacean Research Unit, School of Veterinary and Life Sciences, Murdoch University, South Street, Murdoch, WA 6150, Australia*  
<sup>4</sup>*Okeanis, PO Box 853, Moss Landing, CA 95039, USA*

False killer whales (*Pseudorca crassidens*) usually inhabit tropical and subtropical regions in relatively deep, offshore waters around the world (Stacey et al., 1994). However, they have also been sighted in shallow coastal and inland water habitats (Leatherwood et al., 1989; Acevedo-Gutiérrez et al., 1997; Mobley et al., 2000; Baird et al., 2005). In Hawai'i, two demographically isolated and genetically differentiated stocks have been identified: a large offshore stock and a small insular stock associated with shallow waters around the main Hawaiian Islands (Chivers et al., 2007, 2010; Baird et al., 2008a; Oleson et al., 2010; Carretta et al., 2011). Most recently, a third stock has been recognized; false killer whales inhabiting the insular waters of the Northwestern Hawaiian Islands (Bradford et al., 2012).

The Hawaiian false killer whale insular stock has become an increasing conservation concern given its small size, its limited reproductive output, and evidence of its decline in number. It is considered at risk of extinction (Stacey et al., 1994; Baird et al., 2005; Reeves et al., 2009; Carretta et al., 2011) and has recently been listed as endangered under the U.S. Endangered Species Act (75 FR 70169, 17 November 2010). The next step for this stock's protection will be to define its critical habitat—that is, areas of habitat that are vital for its conservation.

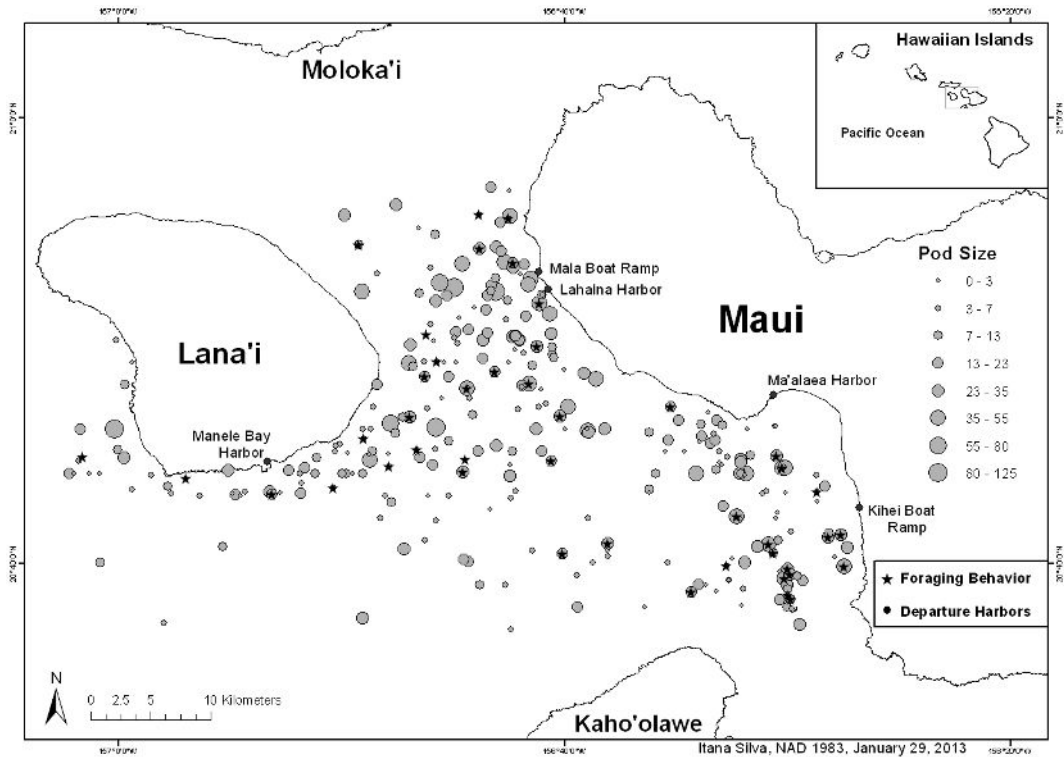
According to Purvis et al. (2000), some of the major risk factors for extinction are (1) small size, (2) slow life history, (3) narrow geographic range, and (4) higher trophic level—the Hawaiian false killer whale insular stock meets all of these criteria. In fact, its population has been estimated to be between 123 to 170 individuals, the lowest in abundance of all odontocete stocks in Hawai'i (Baird et al., 2005; Oleson et al., 2010). In addition,

there are only 46 breeding-age females (Stacey et al., 1994; Chivers et al., 2010). These false killer whales have a life history characterized by long calving intervals (i.e.,  $\geq 7$  y; Stacey et al., 1994); their stock is restricted in range to the Hawaiian Islands; and they feed high in the trophic chain, consuming primarily large pelagic fishes (Baird et al., 2008b, 2010).

Baird et al. (2005, 2010, 2011, 2012) showed evidence of frequent inter-island movements for this stock. In fact, false killer whales have been historically observed in waters between the islands of Maui, Moloka'i, Lana'i, and Kaho'olawe (Maui County waters; Figure 1), but no long-term studies on these animals have been conducted in this geographical area.

Despite increasing research effort dedicated to the Hawaiian false killer whale insular stock, there is still a considerable information gap and a lack of historical information. In this report, we summarize a long-term dataset, including historical sightings of false killer whales in the leeward waters of Maui County from February 1995 to October 2011 (Figure 1). This dataset may provide further insights into the designation of critical habitat for the insular stock.

We used data collected by opportunistic, directed, and systematic survey efforts (Table 1). *Opportunistic surveys* included all trips conducted by seven ecotour vessels as Platforms of Opportunity (PoPs). These vessels were operated by the Pacific Whale Foundation (PWF) in the leeward waters of Maui County between 1999 and 2011 but excluding 2007 and 2008 when no sighting data were recorded. All vessels were staffed with college-educated naturalists who were trained to recognize cetaceans and their behavior by the members of the research team;



**Figure 1.** Map of the study area, also showing all recorded false killer whale sightings from February 1995 to October 2011. Increasing area of circles indicates increasing pod size, and stars within circles indicate foraging behavior was observed at that location.

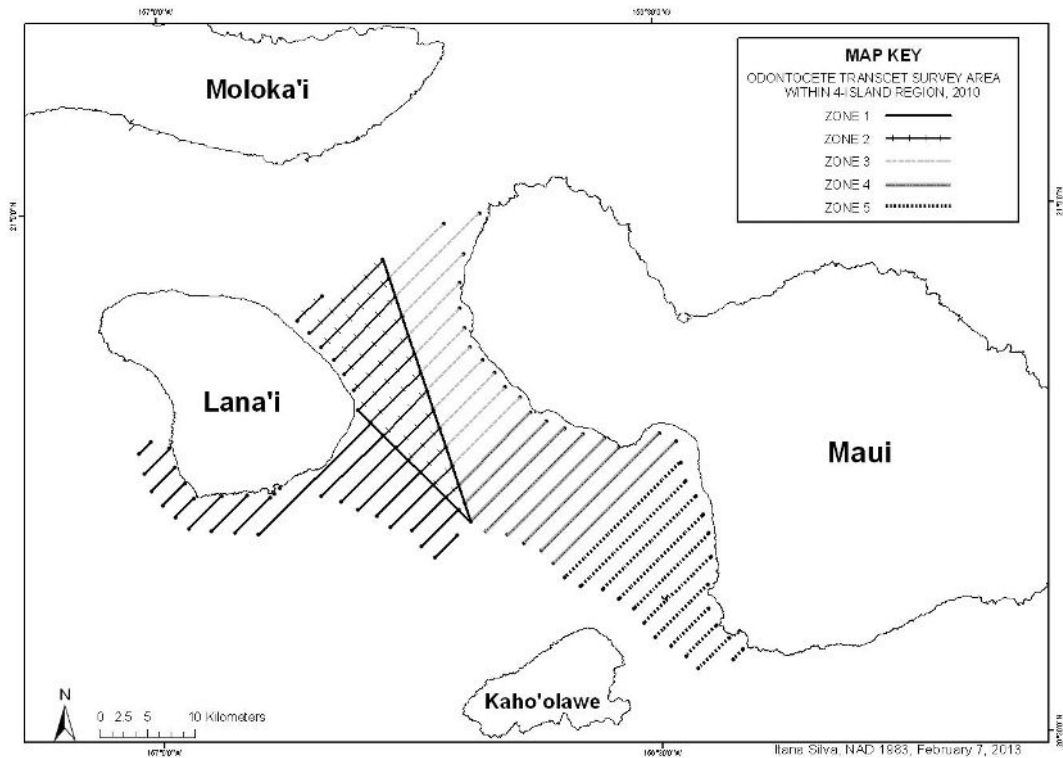
these trainings were conducted twice a year and included refresher trainings for veteran naturalists and standard trainings for new recruits. Ecotours occurred every day, year-round. On-board naturalists assigned to survey duties routinely logged cetacean sightings, including information about location (latitude and longitude), time, pod size, presence of calves, group activity, depth, and environmental conditions; all trips departed from either Lahaina or Ma'alaea harbors, located along the west and south shores of the island of Maui, respectively (Figure 1).

*Directed surveys* were conducted in 1999 and 2000. These surveys were similar in methodology to surveys conducted by Baird and colleagues during more current odontocete studies in Hawaii (Baird et al., 2005, 2008b). Directed surveys were nonrandom and nonsystematic and were conducted by a dedicated research vessel which covered as wide a survey area as possible in waters between the islands of Maui, Moloka'i, Lana'i, and Kaho'olawe. Occasionally, these surveys also covered waters on the leeward side of the island of Lana'i, which ecotour vessels do not normally visit.

*Systematic line transect surveys* were conducted in 2001, 2002, and 2010. During these surveys, research vessels ranging in size from 5.4 to 16.7 m followed predetermined transect lines in a study area encompassing waters between Maui, Moloka'i, Lana'i, and Kaho'olawe (Figure 2). The starting point on a transect line was selected at random, and as many consecutive lines as permitted by daylight and weather were completed during a survey day.

Between 1995 and 2011, 379 false killer whale sightings were recorded in leeward Maui County waters (Table 1). Although only genetic data would be able to confirm the stock to which the false killer whales sighted belonged, existing studies suggest that false killer whales of the offshore stock are not found in waters closer to shore than 42 km and that the Kaua'i stock is geographically isolated and unlikely to frequent Maui waters (Baird et al., 2008b; Baird, 2009). Therefore, we have plausible reasons to assume that the sightings we recorded are representative of the insular false killer whale stock.

False killer whale sightings occurred year-round (Table 1) and showed some seasonality (as



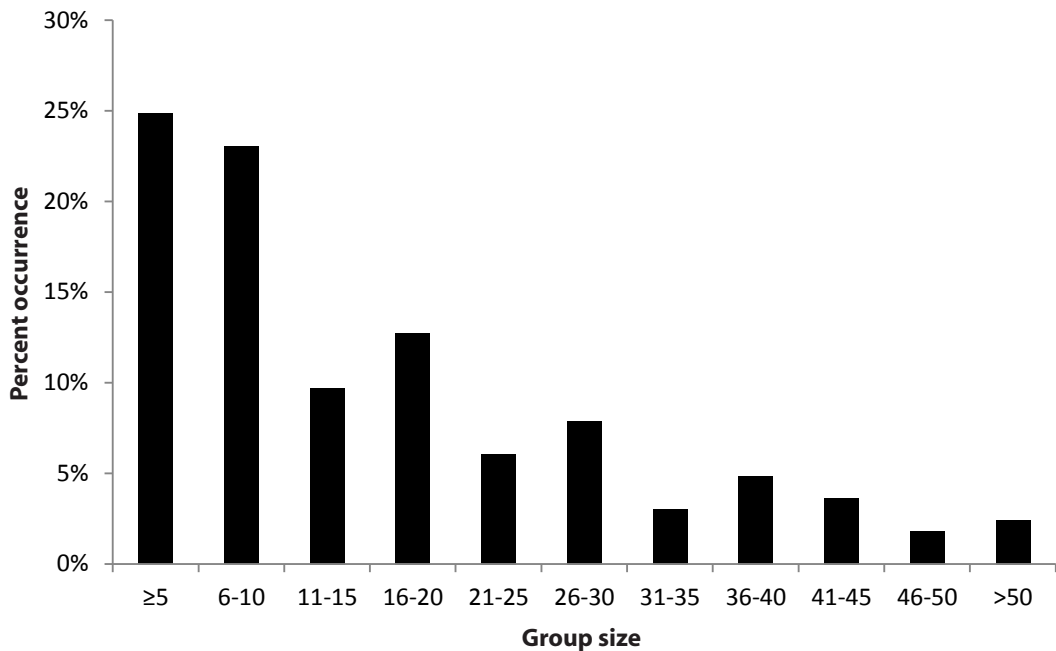
**Figure 2.** Layout for systematic line transect survey conducted in 2001, 2002, and 2010

**Table 1.** Summary of survey efforts completed in south Maui County waters between 1995 and 2011, including opportunistic, directed, and systematic surveys and respective number of false killer whale sightings for each; seasonal categories were based on Flament et al. (1996).

	Total	Summer Aug-Oct	Fall Nov-Jan	Winter Feb-April	Spring May-July
No. opportunistic surveys (1999-2011)	11,429	1,489	4,155	4,181	1,604
No. sightings	362	90	115	111	46
Opportunistic survey effort (h)	29,161	6,354	6,465	9,337	7,005
No. directed surveys (1999, 2000)	23	8	3	6	6
No. sightings	12	3	5	4	0
Directed survey effort (h)	1,422	450	99	276	597
No. systematic surveys (2001, 2002, 2010)	17	6	2	1	8
No. sightings	5	3	1	0	1
Systematic survey effort (h)	653	234	34	5	380
Total sightings/h		0.014	0.018	0.012	0.006

defined in Flament et al., 1996), being the most frequent in the fall (37%) and the least frequent in the spring (6%), when taking seasonal differences in survey effort into consideration. Factors affecting this seasonality are unknown at this time, and a more in-depth investigation of food resource seasonality is critical.

Estimated group size ranged from two to 125 individuals, with groups of  $\leq 30$  animals being the most common (98%; Figure 3). Depth was recorded for 70 of the sightings, and depth information indicates that false killer whales traveled over both shallow and deep waters (5 to 649 m) within the geographic area surveyed. The majority



**Figure 3.** Percent occurrence of false killer whale group size categories for pods sighted in the leeward waters of Maui County

(34%) of the sightings occurred over waters 50 to 75 m in depth. A one-way Kolmogorov-Smirnov test ( $D = 0.2031$ ;  $p = 0.052$ ) suggested a statistically marginal preference by false killer whales for foraging in waters deeper than 100 m while in the study area. In fact, pelagic fish, which constitute the bulk of the false killer whales' diet (Baird et al., 2008b), are more likely to be found in deeper waters (Brill et al., 1999; Itano & Holland, 2000; Seki et al., 2002). However, the strength of the correlation between depth and foraging should be further investigated as much needed information about foraging behavior is currently unavailable.

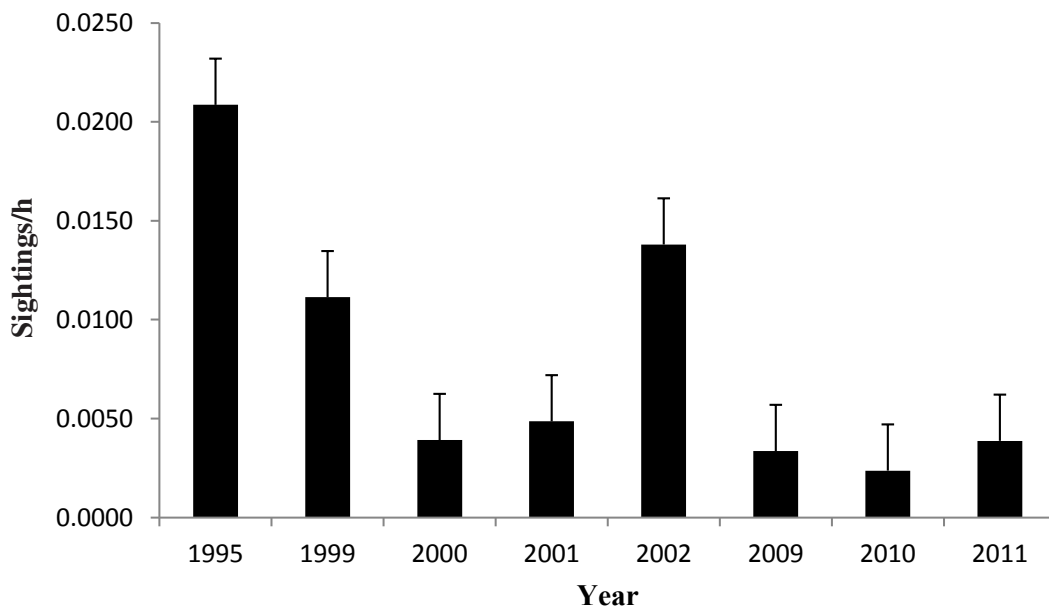
Existing studies show evidence of sharp population decline for the insular false killer whale over the years (Stacey et al., 1994; Baird et al., 2005; Reeves et al., 2009; Carretta et al., 2011). Aerial survey sightings in June and July 1989 suggest that false killer whales in the Main Hawaiian Islands have declined over the last 20 y (Baird et al., 2005, 2008b; Chivers et al., 2007; Reeves et al., 2009). During 1989 surveys in leeward areas, the false killer whale was the third most frequently seen species of odontocete, comprising groups up to 470 animals (Reeves et al., 2009). Aerial surveys were also conducted between 1993 and 2003 in both leeward and windward areas of all of the main Hawaiian Islands (Mobley et al., 2000; Mobley, 2004), reporting a decrease in sighting rates and no false killer whale sightings in 2000 and 2003.

Because of the wide time-span of our dataset, we looked at trends that might support previous findings. In fact, the number of sightings per hour of effort across all three methods of data collection suggest that the rate of encounter of false killer whales in leeward Maui County waters in 1995 was over five times greater than in 2011. Despite some variation through the years, our data strongly supports the hypothesis of a population decline (Figure 4).

In summary, our historical data suggests that the sheltered leeward waters of Maui County are a habitat to be considered in conservation plans. Furthermore, the fact that false killer whales seasonally use the shallower waters of Maui's leeward shores where most of the pleasure craft and tour-boat traffic is concentrated should be deemed important from a management perspective as disturbance by vessels and potentially adverse interactions may further jeopardize the endangered status of the insular false killer whale stock. In addition, evidence of foraging behavior in leeward Maui County waters suggests their potential importance should be further investigated when considering critical habitat designation.

#### Acknowledgments

We would like to thank Pacific Whale Foundation boat-based staff for regularly logging cetacean sightings over the course of 16 years. Thanks to



**Figure 4.** False killer whale sightings per hour of effort recorded by both PoPs and research vessels in leeward Maui County waters between 1995 and 2011

all the field-based researchers, interns, and volunteers involved in the collection of data on odontocete sightings in Maui County waters over the years. Research in 2010 was undertaken under NMFS Scientific Research Permit No. 13427-01.

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