A SURVEY FOR ODONTOCETE CETACEANS OFF KAUA'I AND NI'IHAU, HAWAI'I, DURING OCTOBER AND NOVEMBER 2005: EVIDENCE FOR POPULATION STRUCTURE AND SITE FIDELITY

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Summary

Considerable uncertainty exists regarding population structure and population sizes of most species of odontocetes in the Hawaiian Islands. A small-boat based survey for odontocetes was undertaken off the islands of Kaua‘i and Ni‘ihau in October and November 2005 to photo-identify individuals and collect genetic samples for examining stock structure. Field effort on 24 days covered 2,194 km of trackline. Survey coverage was from shallow coastal waters out to over 3,000 m depth, though almost half (47%) was in waters less than 500 m in depth. There were 56 sightings of five species of odontocetes: spinner dolphins (30 sightings); bottlenose dolphins (14 sightings); short-finned pilot whales (6 sightings); rough-toothed dolphins (5 sightings); and pantropical spotted dolphins (1 sighting). One hundred and five biopsy samples were collected and 14,960 photographs were taken to document morphology and for individual photo-identification. Photographs of distinctive individuals of three species (bottlenose dolphins, 76 identifications; rough-toothed dolphins, 157 identifications; short-finned pilot whales, 68 identifications) were compared to catalogs of these species from a survey off Kaua‘i and Ni‘ihau in 2003, as well as from efforts off O‘ahu, Maui/Lana‘i and the island of Hawai‘i. Within- and between-year matches were found for all three species with individuals previously identified off Kaua‘i and Ni‘ihau, though no matches were found with individuals off any of the other islands. This suggests site fidelity to specific island areas, and population structure among island areas for all three species. Movements of photographically identified bottlenose dolphins were documented between deep water areas off the islands of Kaua‘i and Ni‘ihau, as well as between shallow (<350 m) and deep (>350 m) waters. A lack of sightings or reports of false killer whales off Kaua‘i or Ni‘ihau during our study, combined with documented movements among the other main Hawaiian Islands, suggest that there is no “resident” population of false killer whales that inhabits waters only off Kaua‘i or Ni‘ihau

Introduction

Within waters off the United States, the region with the greatest uncertainty regarding the overall status of odontocete populations is most likely Hawai‘i. While densities of different odontocete species are low in Hawaiian waters (Barlow 2003), species diversity is high, with 18 species documented. Despite the high diversity, until recently relatively little research has been

undertaken on any species other than spinner dolphins (*Stenella longirostris*). There has been one long-term multi-species photo-identification effort off the island of Hawai‘i, initiated in the early 1980s (McSweeney unpublished, e.g., McSweeney et al. 2005), and since 2000 there have been more dedicated efforts to examine odontocete stock structure and assess population size of various species (Baird et al. 2001, 2002, 2003, 2005). However, efforts have been focused primarily off the eastern-most of the main Hawaiian Islands (off Maui/Lana‘i and the island of Hawai‘i) with relatively little sampling effort off O‘ahu and the islands of Kaua‘i and Ni‘ihau (Baird et al. 2003; Baird unpublished). One species of odontocete, the false killer whale (*Pseudorca crassidens),* is listed as “strategic” by NOAA Fisheries, as “takes” in the offshore long-line fishery are greater than levels the population is thought to be able to sustain. Several independent population estimates are available for false killer whales in Hawaiian waters, one each from aerial surveys (Mobley et al. 2000), large vessel line-transect surveys (Barlow 2003), and mark-recapture using photo-identified individuals (Baird et al. 2005), and all estimates are in the low hundreds of individuals. For the mark-recapture estimates, sample sizes are small and no photographs were available from Kaua‘i or Ni‘ihau (Baird et al. 2005). The purpose of this project was to increase sample sizes available for odontocete population assessment/stock structure off the islands of Kaua‘i and Ni‘ihau, with false killer whales as the highest priority species. Primary funding was received from the Pacific Islands Fisheries Science Center of NOAA Fisheries. Additional support to extend the field efforts were received from Dolphin Quest, and the Marine Mammal Commission provided funding for large vessel charters to extend the field effort farther offshore and allow for working in rougher conditions. This report documents survey efforts and preliminary results from field work in October and November 2005.

Small boat-based field efforts that focused on assessing odontocete populations around Kaua‘i/Ni‘ihau have been previously undertaken only in May and June of 2003 (Baird et al. 2003). In comparisons with survey efforts around the other main Hawaiian Islands, effort around the islands of Kaua‘i and Ni‘ihau indicated a relatively high density of bottlenose dolphins (*Tursiops truncatus)* and rough-toothed dolphins (*Steno bredanensis),* and relatively low density of pantropical spotted dolphins (*Stenella attenuata)* and short-finned pilot whales (*Globicephala macrorhynchus)* (Baird et al. 2003). Additionally, sighting and individual photo-identification efforts with bottlenose dolphins around Kaua‘i and Ni‘ihau indicated the presence of two

putative populations, with one found in shallow (<350 m) water and one found in deep (>350 m) water (Baird et al. 2003). Analysis of genetic samples collected during that earlier effort supports the existence of two populations generally inhabiting different water depths, and both genetic analyses and photo-identification data suggest some degree of reproductive isolation of bottlenose dolphins off Kaua‘i/Ni‘ihau from other island areas to the east (Martien et al. 2005; Baird et al. 2003). During the May/June 2003 project, photo-identification efforts around Kaua‘i and Ni‘ihau resulted in catalogs of individually distinctive bottlenose dolphins (41 individuals), rough-toothed dolphins (79 individuals), and short-finned pilot whales (28 individuals) (Baird unpublished). One of the goals of the 2005 effort was to obtain additional photo-identification data from these species to address population structure (i.e., whether movements to/from islands to the east occur) and determine whether populations around Kaua‘i and Ni‘ihau exhibit long-term fidelity to these islands.

Methods

The primary survey vessel was a 6.4 m Boston Whaler with twin outboard engines. This vessel had an elevated observation tower (eye height 3.96 m) for two observers, and other observers were stationed on the bow (eye height = 2.28 m) and/or back deck. Two other larger vessels were used for some surveys, a 10.4 m inboard-powered catamaran with observers divided between upper (eye height = 3.96 m) and lower (eye height = 2.54 m) observation areas, and a 12.8 m inboard-powered monohull with observers divided between the bridge (eye height = 3.58 m) and bow (eye height = 2.36 m). Efforts were made to cover as broad a survey area as possible, and as wide a range of depths, given sea conditions and logistical constraints (e.g., distance to port). Location of survey effort was recorded on board the survey vessel automatically at five-minute intervals using a GPS, and efforts were made to avoid overlap with previous survey lines each day. Information was recorded on sea state (using the Beaufort sea state scale) and swell height, as either changed. Surveys were not undertaken on days when wind speeds were known or expected to be greater than about 30 km/hour early in the day. Surveys typically began at sunrise, since the daily pattern of increasing winds usually prohibited surveying by about 1000 to 1100 hrs each day.

Surveys were undertaken with four to six observers scanning 360 degrees around the survey vessel. Survey speed was approximately 15 to 25 km/hour, depending on sea conditions and the vessel used. Because our goal was to maximize encounters for the purposes of photo-identification and biopsy sampling, we were also in regular contact with other vessels on the water (primarily dolphin watching/sightseeing vessels) regarding dolphin or whale sightings, and altered our search effort accordingly.

When cetaceans were observed, groups were approached to confirm species identity, determine location, and to estimate group size. In most cases two or three photographers would simultaneously attempt to obtain identification photographs (e.g., dorsal fin photos) of all individuals present using digital SLR cameras (*Canon* 10D and 20D), as well as photographs of the body in front of and behind the dorsal fin, to examine pigmentation patterns and external morphology. In addition, skin biopsy samples were collected when possible using either a pole spear (for bow-riding animals) or a crossbow (*Barnett* RX-150, 67 kg pull). Biopsy tips used were 25 mm in length and 8 mm in diameter, though a stopper on the pole spear/biopsy arrows limited penetration to approximately 18 mm. Factors that limited ability to obtain identification photos or biopsy samples included sea conditions and/or the behavior of the individuals (e.g., some groups were lost). In the latter two thirds of our efforts when sea conditions were particularly good, we did not attempt to sample/photograph groups of spinner dolphins that were encountered early in the day, as spinner dolphins were frequently encountered and were easily available for sampling.

If biopsy samples were large enough they were sub-divided into three samples: one-third of the skin was frozen for genetic analyses to be undertaken through the Southwest Fisheries Science Center of NOAA Fisheries, one-third of the skin was preserved in a salt solution saturated with DMSO for long-term storage (or in the case of spinner dolphins for genetic analyses by K. Andrews, University of Hawaii), and one-third of the skin with available blubber attached was frozen for storage at the Pacific Islands Fishery Science Center of NOAA Fisheries or at Cascadia Research.

For three of the species encountered (rough-toothed dolphins, bottlenose dolphins, short-finned pilot whales), photographs were sorted within encounters into individual folders, using

distinguishing characteristics such as notches on the trailing and leading edge of the dorsal fin, pigmentation patterns, scarring, and dorsal fin shape. The best quality photograph of each individual was assigned a photo quality (excellent, good, fair, poor) based on the focus, the angle of the dorsal fin relative to the frame, the size of the fin relative to frame size, and whether the fin was obscured in any way by water or other dolphins. Each individual was also assigned a distinctiveness rating (very, average, slightly, not) based on the number, size and configuration of dorsal fin notches. Individuals with no dorsal fin notches were considered not to be distinctive, though they could often still be sorted within encounters based on pigmentation patterns and scarring. Photographs of these three species were compared to long-term photo-identification catalogs of these species from within the main Hawaiian Islands, which include photographs of all three species from the Kaua‘i/Ni‘ihau area as well as from O‘ahu, Maui/Lana‘i, and the island of Hawai‘i (Baird unpublished).

Bottom depths at effort and sighting locations were derived by overlaying the point location data on a bathymetric raster surface in ArcGIS 9.1. Underlying depth values (in meters) were transferred to point locations using the ‘intersect point tool’ in Hawth’s analysis tools (Beyer 2004). We used gridded 3-arc second US Coastal Relief Model bathymetry (~90 m^2) from the National Geophysical Data Center (http://www.ngdc.noaa.gov/mgg/coastal/coastal.html).

Results and Discussion

Surveys were undertaken between October 11, 2005 and November 14, 2005. This period was characterized by moderate to strong easterly trade-winds, with only a few days where trade winds were weak or absent. Thus survey effort was generally concentrated in the lee area off the south and west shores of the island of Kaua‘i (Figure 1). On days with relatively light winds or when a larger vessel was available we attempted to work further from shore and/or cover areas that had not been previously covered during this survey. In total 145 hours were spent on-effort on 24 days, and 2,194 km of trackline were covered in a study area approximately 2,150 km^2. In general sea conditions were less favorable (Table 1) than surveys in May/June 2003. Search effort covered depths out to over 3,000 m, though almost half (47%) of the search effort was in

water less than 500 m in depth, in comparison to ~34% of search effort in water less than 500 m in depth in 2003 (Figure 3).

Five species of odontocetes were documented in 2005, with a total of 56 sightings (Figure 2, Table 2), in comparison to 65 sightings of 12 species in 2003 with approximately 30% more research effort (Baird et al. 2003). Despite the reduced diversity, overall sighting rates were higher in 2005 than in 2003 (Table 3). Higher sighting rates were due primarily to the large number of sightings of spinner dolphins in 2005, reflecting several factors: 1) two of the 30 spinner dolphin sightings (and the one pantropical spotted dolphin sighting) were cued by other vessels; 2) a high proportion of the effort was in shallow water areas where spinner dolphins are typically found (Figure 4); and 3) the area immediately adjacent to our launching site was a traditional daytime “resting” area for spinner dolphins, and seven (of 30) groups were observed in the vicinity immediately after departure in the morning or while returning to harbor.

Species observed in 2003 that were not documented in this effort (Table 3) were those typically found in deep waters (e.g., striped dolphins, *S. coeruleoalba,* Blainville’s beaked whales, *Mesoplodon densirostris*, sperm whales, *Physeter macrocephalus* and *Kogia spp.*, melon-headed whales, *Peponocephala electra*), several of which (i.e., dwarf sperm whales, *K. sima,* pygmy sperm whales, *K. breviceps,* Blainville’s beaked whales) are only typically observed in relatively calm sea conditions (e.g., Beaufort 2 or less; Baird 2005). As in 2003, sighting rates of pantropical spotted dolphins were extremely low (Table 3). This is surprising, given the relative high sighting rates of this species off O‘ahu, in the Maui/Lana‘i area, and off the island of Hawai‘i (average of 0.49 groups/100 km; Baird unpublished).

Though false killer whales have been documented off of Kaua‘i (e.g., Mobley et al. 2000), none were observed during this effort, and no groups were reported by local dolphin-watching or sightseeing operators during the period of the study. There was one sighting off the island of Hawai‘i during the period of our survey (McSweeney, pers. obs.). Throughout the main Hawaiian Islands false killer whales are only infrequently encountered, with an average of one sighting every 2,100 km of small boat-based search effort (Baird, unpublished). The lack of sightings or reports off Kaua‘i or Ni‘ihau during this study (or in May/June 2003), combined with the known inter-island movements among the main Hawaiian Islands to the east (Baird et

al. 2005), suggest that there is no “resident” population that lives only off Kaua‘i and Ni‘ihau. Individual false killer whales have been documented moving approximately 283 km between O‘ahu and the island of Hawai‘i (Baird unpublished), thus it is likely that individuals documented off O‘ahu or islands to the east may also move to Kaua‘i and Ni‘ihau.

Patterns of depth distribution documented (Figure 4; Table 2) were similar to previous efforts off Kaua‘i/Ni‘ihau. Spinner dolphins were primarily restricted to very shallow waters (only 3 of 30 sightings in greater than 100 m depth), though one group (of 7 individuals, the smallest group of spinners observed) was documented in 1,783 m depth in mid-afternoon. Bottlenose dolphins were found both in shallow (<100 m) near-shore waters and in depths of up to 623 m. Both short-finned pilot whales and rough-toothed dolphins were found in deeper portions of the survey area (Figure 4).

A total of 14,960 photographs were taken during the project. Analysis of photographs to identify distinctive individuals has been undertaken for three species: bottlenose dolphins; rough-toothed dolphins; and short-finned pilot whales. Using only those individuals with distinctiveness codings of “average” or “very”, with at least one photograph of quality “fair”, “good” or “excellent”, resulted in 76 identifications of bottlenose dolphins, 157 identifications of rough-toothed dolphins, and 68 identifications of short-finned pilot whales (Table 4). Re-sightings of all three species occurred both within the period of the field project, and with individuals photo-identified in 2003. There were no matches with individuals of any of these species photo-identified off other islands, despite larger sample sizes available for all three species off the eastern-most main Hawaiian Islands. This combination of within- and between-year re-sightings with animals identified off Kaua‘i and Ni‘ihau, and no matches with individuals photographed off the other main Hawaiian Islands, supports the supposition that individuals show fidelity to particular island areas, that is, that there is considerable population structure within the main Hawaiian Islands for all three species. Some evidence for such population structure was previously available for bottlenose dolphins and rough-toothed dolphins in Hawaiian waters (Baird et al. 2002, 2003; Webster et al. 2005), though it has not been previously reported for short-finned pilot whales.

Re-sighting rates were highest for short-finned pilot whales (Table 4): all 25 distinctive individuals documented in 2003 were identified in 2005. Such a high re-sighting rate reflects not only high apparent site fidelity, but also the strong associations for this species (see Shane and McSweeney 1990). The 25 individuals photo-identified in 2003 were from two encounters (12 identified in one, 13 in the other); individuals within those groupings were identified together in encounters in 2005. There were also high re-sighting rates for bottlenose dolphins (11 between-year matches with a catalog of 41 individuals from 2003), indicating both high site fidelity and a small population size off Kaua‘i/Ni‘ihau, as has been documented off Maui//Lana‘i (Baird et al. 2002; Baird et al. 2003). Changes in the “marks” used to identify individuals over the 2.3 year period were documented for all three species (Table 5), though the mark changes were relatively small (and in the case of pilot whales were likely not great enough to result in any missed matches, given that all 25 distinctive animals from Kaua‘i/Ni‘ihau in 2003 were documented in 2005). For bottlenose dolphins and rough-toothed dolphins it is more likely that some matches between the two periods were missed because mark changes obscured the existing features used to identify the individuals, thus the re-sighting rates found may under-represent site fidelity.

As noted above, the presence of two putative populations of bottlenose dolphins off Kaua‘i and Ni‘ihau, with one in shallow water and one in deeper water, was suggested based on a bimodal distribution of depths of sightings and on within-year re-sightings of 10 individuals from 2003 (Baird et al. 2003), and was supported by differences in haplotype frequencies based on genetic analyses of samples collected (Martien et al. 2005). Combining bottlenose dolphin identifications obtained during 2003 and 2005, there are a total of 31 individuals seen on two or more occasions (for a total of 81 identifications). Of these, 15 individuals were seen only in deep (>350 m) water (with 34 identifications) and 10 individuals were seen only in shallow (<350 m) water (with 29 identifications). However, six individuals were seen in both shallow and deep water (with 18 identifications), demonstrating that movements between these habitats occur. These latter six individuals were linked by association with other individuals in both shallow and deep water, implying that despite apparent preferences for shallow or deep water habitats, individuals within these putative populations are unlikely to be completely reproductively isolated. Matches of five individual bottlenose dolphins have been documented between deep water areas off Kaua‘i and deep water areas off Ni‘ihau, with straight-line distances between the

furthest pair of re-sightings of 44.4 km. There have been no matches between Kaua‘i and Ni‘ihau of dolphins documented in shallow water.

One-hundred-and-five biopsy samples (from four species) were collected (Table 2), substantially increasing the sample sizes available for genetic analyses of stock structure from these islands. Previous analyses of stock structure in bottlenose dolphins from Kaua‘i and Ni‘ihau had 21 samples from the deep water (>350 m) strata and 23 samples from the shallow water (<350 m) strata (Martien et al. 2005), while efforts from this survey resulted in 10 additional samples from the shallow water strata and 11 samples from the deep water strata. Combining further genetic analyses with these photo-identification results should help clarify the relationship between bottlenose dolphins in shallow and deep water habitats in this area.

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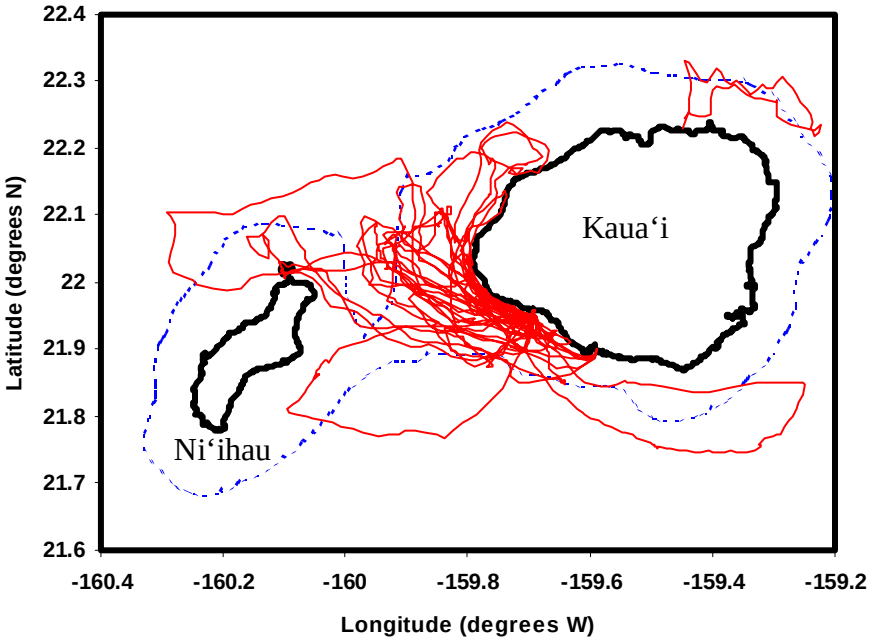

Figure 1. Study area showing survey effort (solid red line) with approximate 1,000 m depth contour (dashed blue line).

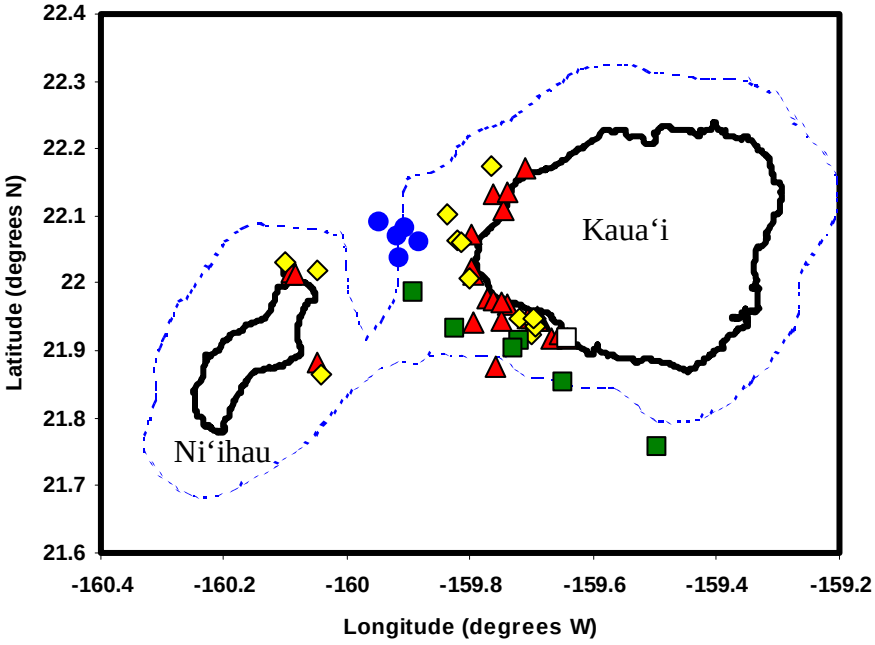

Figure 2. Sighting locations of rough-toothed dolphins (●, blue), bottlenose dolphins (♦, yellow), short-finned pilot whales (■, green), spinner dolphins (▲, red), and pantropical spotted dolphins (□, black), with approximate 1,000 m depth contour (dashed line).

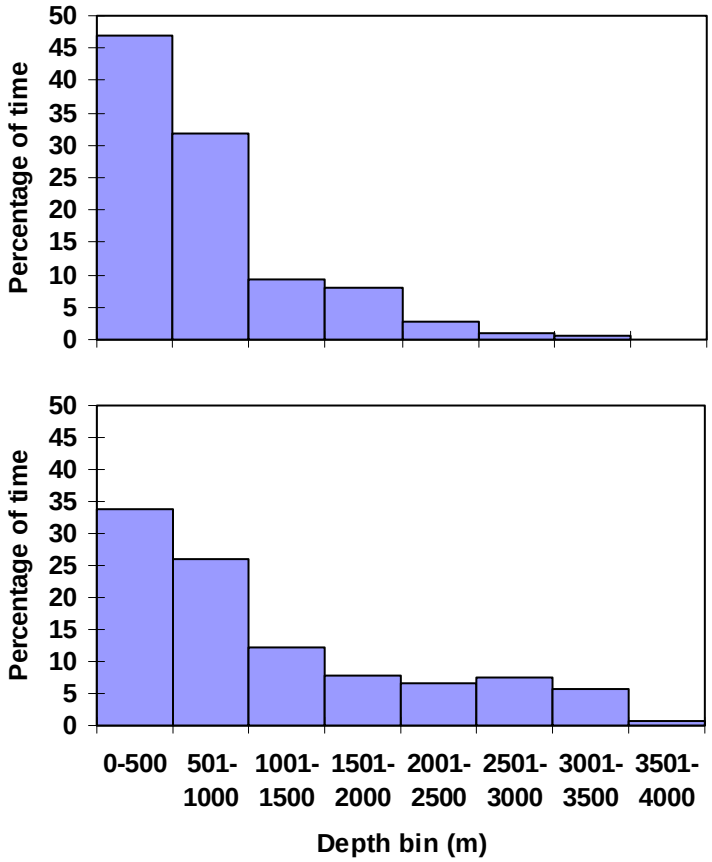

Figure 3. Depth distribution of search effort in Oct/Nov 2005 (top) and May/June 2003 (bottom).

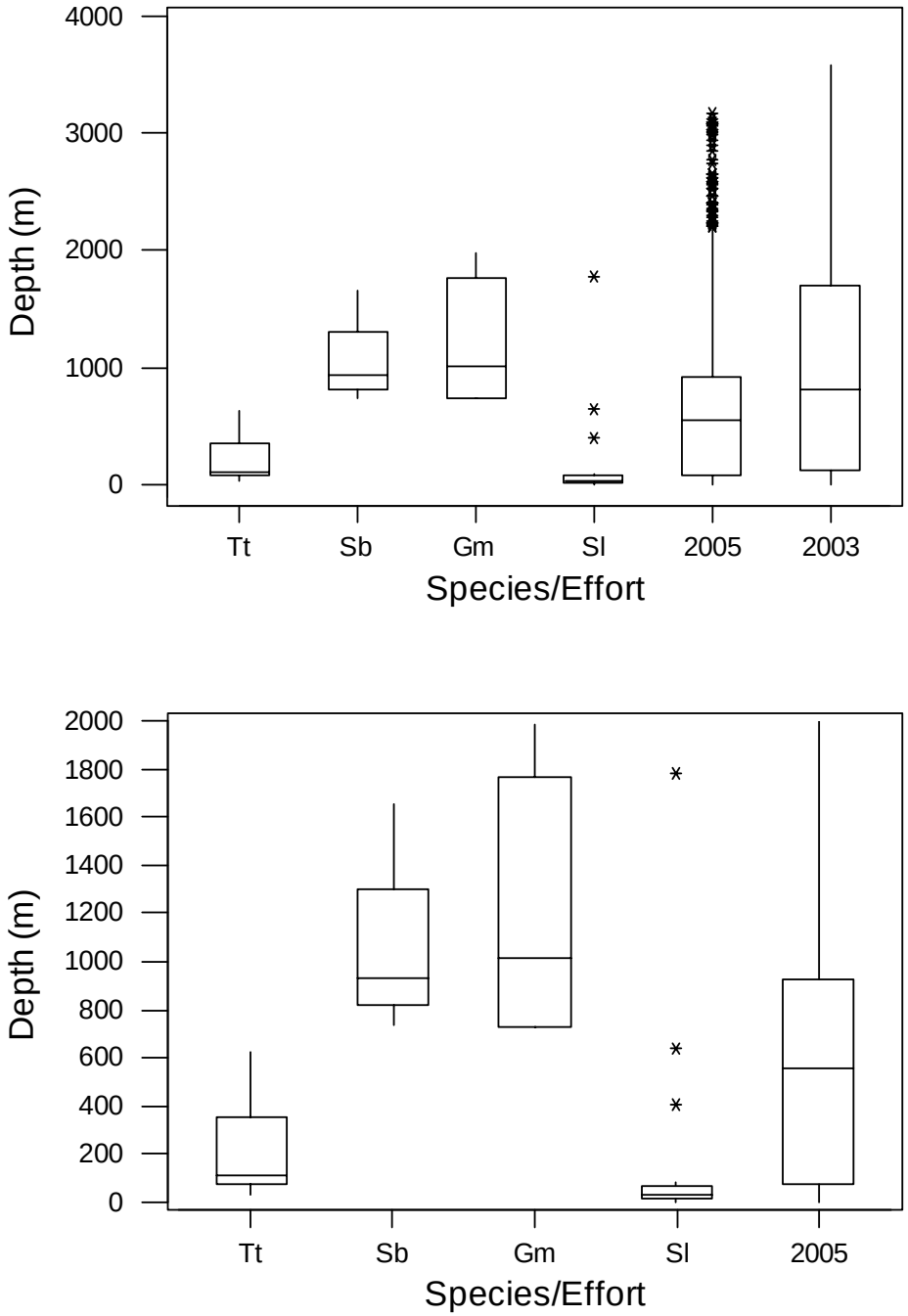

Figure 4. *Top.* Boxplot showing depth distribution of sightings from October/November 2005, including effort from both 2005 and 2003 (for comparison). X-axis codes: Tt = *Tursiops truncatus;* Sb = *Steno bredanensis;* Gm = *Globicephala macrorhynchus;* Sl = *Stenella longirostris;* 2005 = 2005 effort; 2003 = 2003 effort. *Bottom.* Same as top with y-axis to only 2,000 m to illustrate differences among species and sighting depths in relation to effort (bottom graph excludes 2003 effort).

Table 1. Information on Beaufort (Bft) sea states during the 2005 survey and a survey from Kaua‘i and Ni‘ihau in May/June 2003 (data from Baird et al. 2003).

Year	# hrs	# km	% km Bft 0	% km Bft 1	% km Bft 2	% km Bft 3	% km Bft 4	% km Bft 5	% km Bft 6
2005	145.9	2,194	0.9	6.9	44.8	21.1	20.8	4.9	0.6
2003	195	3,222	20.3	34.6	19.2	20.8	4.2	0	0

Table 2. Information on encounters and sampling.

Species	N	Group size Mean (SD) range	Depth (m) Mean (SD) range	# biopsy samples	# photos
Bottlenose dolphin	14	11.2 (11.6) 1-40	202 (181) 29-623	21	3,190
Pantropical spotted dolphin	1*	1	10	0	149
Spinner dolphin	30	43.3 (39.6) 7-170	127 (338) 3-1,783	35	3,874
Short-finned pilot whale	6	23.0 (5.7) 16-29	1,196 (528) 731-1,984	12	2,421
Rough-toothed dolphin	5	32.0 (35.8) 3-90	1,033 (356) 734-1,651	37	4,602
Total	56			105	14,960

*Single pantropical spotted dolphin seen with a group of spinner dolphins.

Table 3. Comparison of odontocete sighting rates from this survey to May/June 2003 survey (from Baird et al. 2003).

Species	Sightings per unit effort (#/100 km)	
	Oct/Nov 2005	May/June 2003
Bottlenose dolphin	0.64	0.71
Pantropical spotted dolphin	0.05	0.12
Spinner dolphin	1.37	0.28
Short-finned pilot whale	0.27	0.06
Rough-toothed dolphin	0.23	0.34
Dwarf sperm whale	0	0.22
Dense-beaked whale	0	0.12
Melon-headed whale	0	0.03
Sperm whale	0	0.03
Pygmy killer whale	0	0.03
Striped dolphin	0	0.03
Pygmy killer whale	0	0.03
Overall	2.55	2.02
Number of species	5	12

Table 4. Photo-identification results from October/November 2005 with matches from previously catalogued individuals. Sample sizes available for comparisons from previous work off Kaua‘i/Ni‘ihau and for matching with other islands are indicated. No matches with individuals from other islands were found, despite the large sample sizes of individuals available for comparison.

Species	# identifications 2005	# individuals 2005*	# individuals Kaua‘i/Ni‘ihau May/June 2003	# matches with Kaua‘i/Ni‘ihau May/June 2003	# individuals for comparison from other islands (2000-2005)
Bottlenose dolphin	76	51	41	11	154
Rough-toothed dolphin	157	152	79	6	103
Short-finned pilot whale	68	50	25	25	106

*# individuals excludes within-year within-area re-sightings.

Table 5. Mark change for individuals re-sighted between May/June 2003 and October/November 2005, including number of notches/individual for context of degree of mark change.

Species	# matches from May/June 2003	# (%) individuals with mark change	# notches* Mean (SD)	Type of mark change
Bottlenose dolphin	11	4 (36%)	4.1 (2.3)	Change in notch shape (1), small new notch (3)
Rough-toothed dolphin	6	2 (33%)	5.7 (1.7)	Change in notch shape (2), new notch (1)
Short-finned pilot whale	25	8 (32%)	7.7 (2.8)	Change in notch shape (4), small new notch (4)

*# notches in individuals when re-sighted.