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Effects of Human Traffic on the Movement Patterns of Hawaiian Spinner Dolphins (*Stenella longirostris*) in Kealakekua Bay, Hawaii

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Abstract

Kealakekua Bay is an important resting site for Hawaiian spinner dolphins (*Stenella longirostris*) and is popular with both local residents and tourists. Human activities occurring here include swimming, snorkeling, kayaking, and motor-boating. The objectives of this study were to document movement patterns of dolphin groups in Kealakekua Bay, to determine if different types and levels of human activity within the bay result in quantifiable changes in dolphin group movement patterns, and to provide baseline data for future studies. Theodolite tracking was used to assess responses of dolphin groups to human traffic. Variables examined included group mean leg speed (leg speed: the distance between two consecutive theodolite fixes of a dolphin group divided by time; mean leg speed: the average of all leg speeds comprising a track) and group reorientation rate. Swimmers and/or vessels were present within 100 m of all dolphin groups tracked during all surveys. Regression analyses were used to examine potential relationships between dolphin group related variables (e.g., reorientation rate, mean leg speed) and variables related to human activities (e.g., swimming, kayaking, motor-boating). Increasing levels of human activity had a limited but measurable effect on the movement patterns of Hawaiian spinner dolphin groups at this site.

Key Words: Hawaii, Kealakekua, theodolite tracking, human traffic, behavior, movement patterns, spinner dolphin, *Stenella longirostris*

Introduction

Interest in dolphin watching and swimming with wild dolphins has increased worldwide over the past several decades (Hoyt, 2001). There is every indication that this trend will continue into the near future. The effects of ecotourism activities on the behavior of wild cetaceans are becoming increasingly well-documented (Samuels et al., 2000; Bejder et al., 2006). The National Marine Fisheries Service (NMFS) (2007) has received an increasing number of complaints stating that Hawaiian spinner dolphins (*Stenella longirostris*) are commonly disturbed by swimmers and vessels. The 1994 reauthorization of the Marine Mammal Protection Act of 1972 (MMPA) made the harassment of marine mammals in United States waters illegal. *Level B harassment* was defined as "having the potential to disturb a marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering." Although the passage of this law effectively made it illegal to swim with dolphins, it has not resulted in a decrease in the number of dolphin-human interactions that occur. Many studies have focused on the behavioral effects of dolphin-human interactions. These studies have shown behavioral effects such as (1) changes in vocalizations (Scarpaci et al., 2000; Van Parijs & Corkeron, 2001; Buckstaff, 2004) and (2) avoidance of swimmers and/or vessels (Au & Perryman, 1982; Bejder et al., 1999; Constantine, 2001; Neumann & Orams, 2006). Additional reported responses to human activity include changes in (1) animal distribution (Lammers, 2004), (2) swimming speed (Williams et al., 2002; Ribeiro et al., 2005), (3) movement patterns (Acevedo, 1991; Constantine et al., 2004; Stensland & Berggren, 2007), and (4) surface behaviors (Janik & Thompson, 1996; Forest, 2001; Hastie et al., 2003). Long-term changes in dolphin responses to tourism activities have also been detected at a limited number of sites (Constantine, 2001; Lusseau, 2005; Bejder et al., 2006).

Kealakekua Bay, located along the west coast of the Big Island of Hawaii, has long been considered a prime resting area for Hawaiian spinner dolphins (Norris et al., 1994). Spinner dolphins were first studied here during the early 1970s (Norris & Dohl, 1980) and have been found to display a predictable daily pattern of behavior (Norris & Dohl, 1980; Würsig et al., 1994; Forest, 2001). Over the past few decades, several researchers have documented changing behavioral patterns of these dolphins and have suggested that these changes may be caused by an increase in human presence at this site over time (Baúza-Durán, 1999; Forest, 2001; Courbis, 2004). These include changes in areas of the bay frequented by dolphin groups and changes in aerial behaviors. This project was designed to assess movement patterns of dolphin groups in Kealakekua Bay in response to different types and levels of human activity. The NMFS is currently assessing if additional conservation measures and regulations are required to protect spinner dolphins in Hawaii (Department of Commerce, 2005, 2006). Results from this study could directly inform future decisions related to the protection of spinner dolphins in Hawaiian waters.

Materials and Methods

Study Area

Kealakekua Bay is on the leeward side of the Big Island of Hawaii (Figure 1). It is bounded by a sheer cliff at the back of the bay and flat peninsulas to the northwest and southeast. The bay is approximately 1.5 km across from Cook Point to Manini Point and spans slightly less than 1 km from shore to open ocean. In 1969, Kealakekua Bay was declared a Marine Life Conservation District (MLCD) and underwater state park by the State of Hawaii. The MLCD is divided into Subzone A, extending from shore seaward to a line drawn from Cook Point to the northwestern end of Napoopoo Beach, and Subzone B, extending from this first line seaward to a line connecting the tips of Cook and Manini Points. Fishing and taking or injuring any type of marine life or shells is prohibited in Subzone A. Hook and line and throw net fishing for finfish is permitted in Subzone B. The anchoring of boats is prohibited in Subzone A. Swimming, snorkeling, and kayaking are popular recreational activities within Kealakekua Bay and are currently allowed in both subzones. Several commercial companies

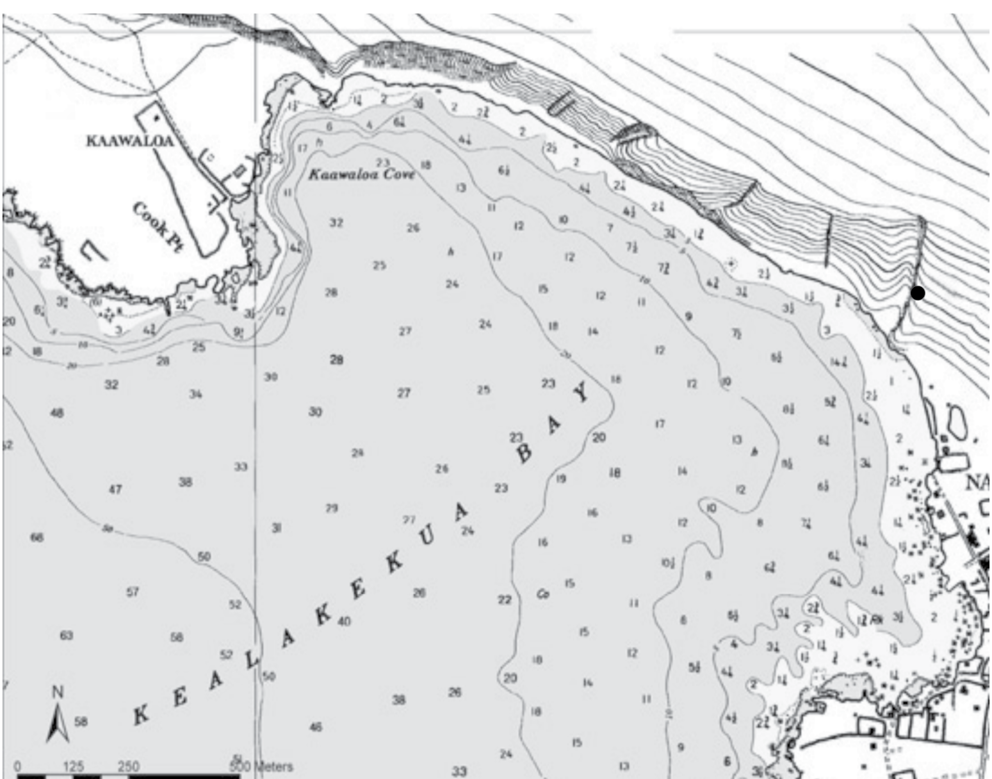

Figure 1. Kealakekua Bay, Hawaii (black dot indicates site of shore station)

offer boat tours to the bay on a daily basis, and kayak rentals are readily available.

Data Collection

Data were collected from March 2000 to October 2001 and February to May 2002. Shore-based observations were performed from a cliffside observation platform 69 m above sea level, which provided an unobstructed view of the entire bay. Theodolite tracking methods described by Würsig et al. (1991) were employed. Positions of dolphin groups, swimmers, kayakers, and motor vessels were determined using a Lietz/Sokkisha Model DT5A theodolite with + 5 s precision and 30× magnification. The theodolite communicated with a Macintosh Powerbook 180 laptop computer in real time. Data were collected and recorded through the use of *Aardvark Editor*, Version 1.21 (Cornell University, Ithaca, NY, USA) data collection software. Observation periods were between 81 and 247 min in duration and were dependent upon appropriate weather conditions, adequate staffing, and instrument function. All surveys were made between 0733 and 1434 h. Most took place between 0900 and 1300 h.

Dolphins—At least two observers scanned the study site continuously with binoculars until a group or groups of dolphins were located. A focal group was then chosen to track. A group was defined as a clustering of more than one dolphin adjacent to another within 100 m. During most surveys, only one group was visible within the bay. If more than one group was present, the largest group was tracked. During the course of this study, several unsuccessful attempts were made to track two dolphin groups concurrently. Approximate group size was determined at the beginning of the observation period and reassessed regularly throughout the day. Dolphin groups were fixed at their center approximately every 90 s. A *theodolite fix* is defined here as the horizontal and vertical angle coordinates of the object being tracked and the time this information was obtained. The focal dolphin group and adjacent vessels were fixed alternately and as frequently as possible throughout the observation period.

Swimmers/Vessels—Theodolite tracking codes were as follows: swimmer or discrete group of swimmers, single person kayak, kayak with two or more individuals on board, small (less than 7 m in length) motor vessel, rigid-hulled inflatable motor vessel, motor or sail vessel greater than 7 m in length, and a commercial 20-m long motor catamaran. Individual kayaks were identified by vessel color and the number, gender, and clothing characteristics of those on board. An attempt was made to fix and describe all vessels within a 300-m radius of the center of the focal dolphin group. If this was not possible because of the presence of a large number of vessels adjacent to the group, then as many vessels as possible, without losing track of the dolphin group's position, were fixed, and counts of the number of swimmers and vessels within 50 m, 100 m, and 300 m of the dolphins were obtained and recorded. Swimmers were fixed after vessels as time allowed between dolphin group fixes. Otherwise, swimmers were counted and their positions relative to the dolphin group were described and recorded.

Data Analysis

Aardvark Viewer, Version 1.21, was used to examine all data. This application transformed theodolite data into geographical positions and allowed for the viewing of dolphin group and vessel tracklines. In an attempt to obtain a more accurate picture of dolphin group movement, tracks less than 30 min were excluded from further analysis. Mean track duration was 46.2 min (SD = 12.6 min). Parameters relevant to dolphin behavior were summarized over the course of an individual track and included the following:

- *Leg* – the distance between two consecutive fixes of a dolphin group or vessel
- *Leg Speed* – the distance between two consecutive fixes divided by time, expressed in kilometers/hour (km/h)
- *Mean Leg Speed* – average of all leg speeds comprising a track
- *Reorientation Rate* – the sum of all changes in a dolphin group's bearing divided by the total time tracked—It represents how often the group changes course during a track and is measured in degrees/min (Yin, 1999; Ross, 2001; Ribeiro et al., 2005).

To examine potential relationships between dolphin group movement patterns and associated human activities, human-related parameters were also summarized over the course of the track. Swimmers and vessels were divided into three categories based on their distance from the center of the focal dolphin group. The first category included all swimmers and vessels within a 300-m radius of the dolphin group's center. The second category comprised all swimmers and vessels within a 100-m radius of the center, and the third category included all swimmers and vessels within 50 m of the center of the dolphin group. Mean counts of swimmers, kayaks, motor vessels, total vessels (kayaks plus motor vessels), and swimmers plus total vessels were calculated for the three different measures of distance from the center of the dolphin group. This was calculated for all tracks. Values were collected for each fix, and then the mean was taken across the whole track. Fixes less than 30 s apart or greater than 210 s apart were not used for calculations. Additional variables included for further analyses were (1) mean distance between the dolphin group center and the closest vessel during a track and (2) mean speed of the vessel closest to the center of the group. A data table was constructed that combined dolphin group variables with those pertaining to swimmers and/or vessels.

Multiple regression analysis was used to examine the relationships between swimmer/vessel-related variables and dolphin-related variables. Dolphin group behaviors that were analyzed include mean leg speed and reorientation rate. Variables associated with human behaviors include the number of swimmers, number of kayaks, number of motor vessels, total number of vessels, and total number of vessels plus swimmers. The effect(s) of the mean speed of the closest vessel to the dolphin group center and mean distance from the group center to the closest vessel were also examined. Simple linear regression was used to examine the relationship between two individual variables. Data were analyzed using *SPSS*, Version 11.5, software and the R Project for Statistical Computing (see www.r-project.org).

Results

Descriptive Summary

A total of 265 h was spent at the shore station observing dolphin behaviors and human activities. Dolphin groups were observed and tracked in the bay for 178 h, which was 67% of the total observation time. Swimmers and/or vessels were present within 100 m of the focal dolphin group during all tracks and were present during 77% of all dolphin group fixes. Dolphin groups were observed exiting the bay and not returning during only two observation periods. The maximum number of swimmers and/or vessels within 300 m of the center of the dolphin group was 34. The mean group size for all tracks was 30 dolphins.

Figure 2 is an illustration of dolphin group theodolite fixes made during multiple observation periods during the course of this study. Fixes were plotted using GIS data and *ArcGIS*, Version 9.0, software (Environmental Systems Research Institute, Inc., 1999-2004). This figure illustrates typical locations of spinner dolphin groups fixed within Kealakekua Bay during this study. Nearly all sightings occurred in a band between about

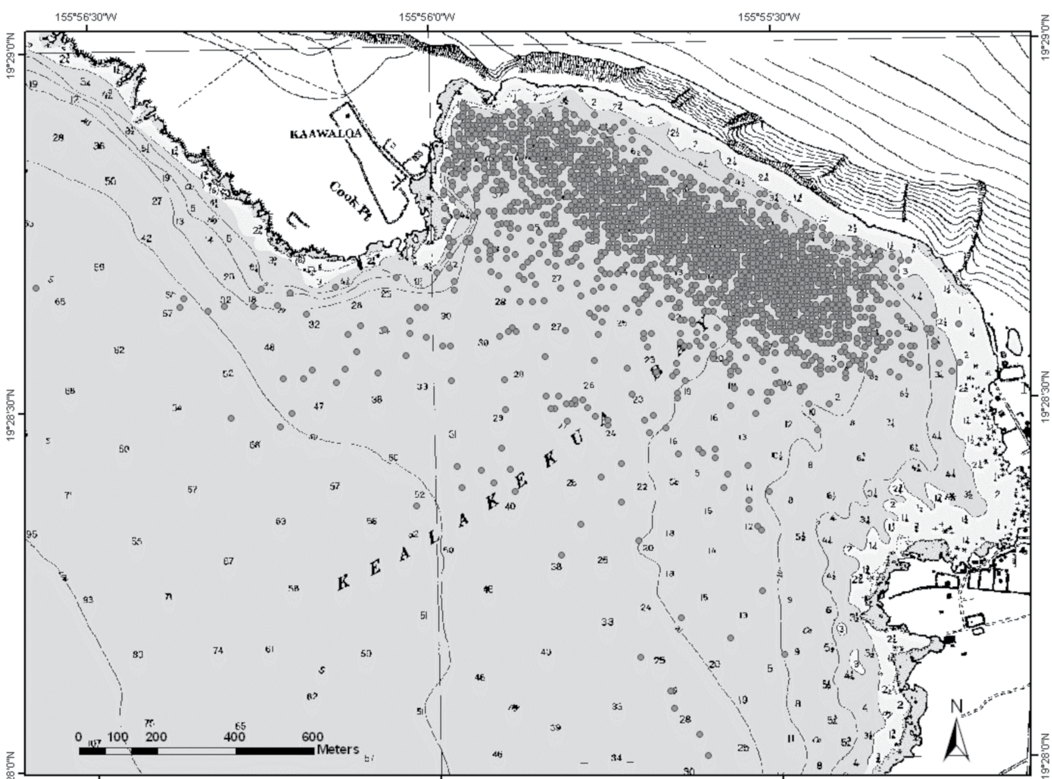

Figure 2. Spinner dolphin group fixes, Kealakekua Bay, 2000 and 2001

50 m and 500 m from shore in all but the southeastern quarter of the bay. The mean number of vessels of all types (total vessel count) on the water in Kealakekua Bay during all observational periods was 10.3 (SD = 3.4). Significantly more vessels were present during observational periods when dolphins were present (mean = 11.5 total vessels, SD = 3.5, $n = 355$) than when dolphins were absent (mean = 8.6, SD = 2.0, $n = 174$) (Student's t test, $p < 0.0005$). Swimmers were present within at least 50 m of an observed dolphin group during 85% of all tracks, and kayaks were present during virtually all tracks (Table 1). Motor vessels were less commonly near the dolphin group, being present within 50 m during less than half of all tracks, increasing to 65% at 300 m (Table 1). There were no tracks during which dolphins were not closely accompanied by swimmers and/or vessels. The mean speed of the closest vessel to the center of the dolphin group for all observation periods was 2.3 km/h (SD = 1.1). The mean group reorientation rate for all observation periods was 37.9°/min (SD = 8.8). The mean group mean leg speed for all observation periods was 3.0 km/h (SD = 0.83).

Regression Analyses

Potential seasonal (winter, spring, summer, fall) and yearly effects on group reorientation rate and group mean leg speed were evaluated using data from 2000 and 2001. Analysis of variance (ANOVA) yielded no significant differences in these measures for the data collected during this project. There was also no significant change in dolphin group size between 2000 and 2001. As no seasonal or yearly differences in behavior were observed, data were pooled for further analyses. Since dolphin groups were closely accompanied by swimmers and/or vessels during all tracks, no control data were available. Simple linear regression and multiple linear regression were used to examine trends between different combinations of variables. Simple linear regression was used to look for correlations between two individual variables at a time. Multiple linear regression was used to determine the effect of a set of four variables on a single response variable (reorientation rate or mean leg speed) in an attempt to better explain that effect.

Reorientation Rate—When the number of swimmers and vessels was related to group reorientation rate, simple linear regression resulted in an r-value (correlation coefficient) of 0.40 (Table 2). As the number of swimmers and vessels increased, the dolphin group tended to change direction (reorient) more frequently. Results were similar when swimmer numbers were plotted against reorientation rate and when kayak numbers were plotted against reorientation rate at all three distance radii—50 m, 100 m, and 300 m (Table 2). In addition, dolphin groups tended to reorient less as vessel speed increased (r = -0.28; Table 2). Table 3 summarizes the results of multiple linear regression of dolphin group reorientation rates relative to the following variables: (1) number of swimmers and vessels within a specific distance criterion, (2) separation between dolphin group center and closest vessel, (3) vessel speed, and (4) group size. Reorientation rates were significantly affected by the above variables when examined at all three radii (50 m, 100 m, 300 m; $p < 0.05$; Table 3). Number of swimmers and vessels had the greatest effect on reorientation rate for this multiple regression.

Dolphin Group Mean Leg Speed—Mean leg speed was most strongly correlated with the distance between the dolphin group center and the closest vessel ($r = 0.29$) (Table 4). Dolphins tended to swim faster when farther away from vessels. Larger groups tended to swim faster than smaller groups ($r = 0.23$) (Table 4). There were no significant correlations between increasing swimmer and vessel numbers and group mean leg speed. There was a weak correlation between speed of the closest vessel and mean leg speed ($r = 0.17$) that suggests that dolphins may tend to swim faster in the presence of faster vessels (Table 4). The same four

Table 1. Mean number of swimmers and vessels present within different radii from focal dolphin groups during tracks, along with the percentage of tracks during which swimmers and vessels were present

	50 m	100 m	300 m
Mean # swimmers	1.6	1.9	2.3
present during tracks	85.33%	86.67%	89.33%
Mean # kayaks	1.3	1.9	3.1
present during tracks	97.33%	97.33%	97.33%
Mean # motor vessels	0.1	0.1	0.3
present during tracks	44.00%	52.00%	65.33%
Mean # total vessels	1.4	2.0	3.4
Mean # swimmers and vessels	3.0	3.9	5.7

Table 2. *r*-values, reorientation rate; bottom four rows are independent of the radius from the center of the dolphin group

	Reorientation rate		
	50 m	100 m	300 m
Swimmers	0.36	0.33	0.31
Kayaks	0.34	0.36	0.35
Motor vessels	0.04	0.12	0.03
Total vessels	0.34	0.37	0.35
Swimmers and vessels	0.40	0.40	0.40
Separation		-0.14	
Vessel speed		-0.28	
Time of day		-0.07	
Dolphin group size		-0.01	

Table 3. Summary of the results of multiple regressions of dolphin group reorientation rate against four independent variables for each of three radii from the center of the group

	50 m	100 m	300 m
Residual SE	8.37	8.36	8.41
	df = 62	df = 62	df = 62
Multiple R^2	0.180	0.182	0.173
Adjusted R^2	0.128	0.129	0.119
F-statistic	3.412	3.449	3.235
	df = 4, 62	df = 4, 62	df = 4, 62
p-value	0.01381	0.01311	0.01783

explanatory variables listed above for reorientation rate were used to assess changes in group mean leg speed (Table 5). Mean leg speed was significantly affected by the above variables when examined at all three radii. Separation between the group center and closest vessel had the greatest effect on group mean leg speed. Also, using mean leg speed as the response variable resulted in a significant relationship in the multiple regression analysis ($p < 0.05$; Table 5).

Discussion

This is the first time that reorientation rate has been reported for Hawaiian spinner dolphin groups within this bay. Group swimming speed was previously reported by Würsig et al. (1994). Dolphin presence at this site was similar to that reported in previous studies (Norris & Dohl, 1980; Würsig & Würsig, 1983; Forest, 2001; Courbis, 2004; Courbis & Timmel, 2008). Dolphin group sizes within Kealakekua Bay were also comparable to those recorded in previous studies (Norris

Table 4. *r*-values, mean leg speed; bottom four rows are independent of the radius from the center of the dolphin group

	Mean leg speed		
	50 m	100 m	300 m
Swimmers	-0.02	-0.06	-0.05
Kayaks	-0.10	-0.03	-0.01
Motor vessels	0.07	0.00	0.08
Total vessels	-0.09	-0.02	0.01
Swimmers and vessels	-0.05	-0.05	-0.03
Separation		0.29	
Vessel speed		0.17	
Time of day		0.13	
Dolphin group size		0.23	

Table 5. Summary of the results of multiple regressions of dolphin group mean leg speed against four independent variables for each of three radii from the center of the group

	50 m	100 m	300 m
Residual SE	0.7861	0.7862	0.7876
	df = 62	df = 62	df = 62
Multiple R^2	0.171	0.171	0.168
Adjusted R^2	0.118	0.117	0.114
F-statistic	3.198	3.190	3.127
	df = 4, 62	df = 4, 62	df = 4, 62
p-value	0.01879	0.01901	0.02082

& Dohl, 1980; Östman, 1994; Würsig et al., 1994; Forest, 2001; Courbis, 2007).

Spinner dolphin locations within Kealakekua Bay were consistent with those reported by Würsig et al. (1994). Dolphins appear to be in the most protected part of the bay and were never observed near Napoopoo Beach. The Napoopoo Beach area is characterized by having a high level of human presence. This differs from what was reported by Doty (1968), who observed spinner dolphins spending a significant amount of time near Manini Beach Point, but it is similar to what was reported by Courbis (2004, 2007). The mean total vessel count for the bay was significantly higher during observational periods in which dolphins were present within the bay. This corresponds with Forest's (2001) findings but differs from Courbis's (2007). However, Courbis's (2007) study included all daylight hours. Possibly, swimmers and vessels may reduce activity in the late afternoon and evening hours regardless of dolphin presence. Based on the current observations, when dolphins are not present, kayakers tend to travel a direct path from the boat launching area across the bay to the Cook Monument. Small commercial motor vessels tend to enter the bay to the northwest and travel directly to this same area. In contrast, when dolphins are present, kayakers spend a significant amount of time following and attempting to observe and interact with them. The general pattern of dolphin and human behavior observed during this study was as follows: swimmers and/or vessels would approach a spinner group. The dolphins would remain in the same location for several minutes and then move away in a directed manner without visibly altering their swimming speed. As the dolphin group moved away, adjacent swimmers and kayakers would increase their speed in order to maintain close contact with the dolphins. Thus, as the dolphins followed a more direct course away from swimmers and vessels, the swimmers and vessels would increase their speed in order to catch up. This was a personal observation, also reported by Courbis (2004), that is suggested statistically by a weak negative correlation between reorientation rate and the separation between the dolphin group and the closest vessel (r = -0.14). This pattern suggests that dolphins may tolerate the close presence of swimmers and vessels for a time, but they are intolerant of prolonged interactions with swimmers and/or vessels.

A primary goal of this study was to determine if a relationship exists between dolphin group movement patterns and swimmer and/or vessel traffic. Regression analyses revealed significant relationships between human activity-related variables and both dolphin group reorientation rate and dolphin group mean leg speed. However, in all cases, the regressions were a poor fit. This study was complicated by the complete lack of control data available. There were no observation periods when dolphin groups could be tracked and observed without the presence of swimmers and/or vessels in close proximity.

The number of people (swimmers and vessels) adjacent to the dolphins appears to be of more importance than their specific activity, but responses to different human activities could not be studied in a controlled manner. Mean reorientation rate was less than that reported by Ross (2001) for Hawaiian spinner dolphins at Midway Atoll. This may be related to differences in levels of anthropogenic activity between the two study sites. Ross reported that in the presence of boats, Midway spinner dolphin groups changed course less frequently and increased their swimming speed. There is a tendency for dolphin groups in Kealakekua Bay to change course more frequently but to maintain their swimming speed as the number of swimmers and/or vessels proximate to them increases. The intensity of human activity is greater at Kealakekua Bay than that described for Midway. The type of activity is also very different. Vessel activity at Midway Atoll is characterized by the presence of small numbers of motor vessels (Ross, 2001), whereas human activity at Kealakekua Bay is predominantly swimming and kayaking. The difference in reorientation rates between these two sites may reflect different tactics used by these two dolphin populations to avoid vessels. Reduced reorientation rate may allow dolphins to move more quickly and efficiently away from approaching swimmers or kayaks, whereas an increased reorientation rate may allow dolphins to dodge more numerous vessels faster. Yin (1999) reported that in the presence of boats, dusky dolphins (*Lagenorhynchus obscurus*) off the coast of New Zealand made slightly more course changes than when boats were absent. Ribeiro et al. (2005) reported this same finding for foraging Chilean dolphins (*Cephalorhynchus eutropia*) in Yaldad Bay, Southern Chile. This is similar to the trend observed during this study—that is, increased group reorientation rate in the presence of increased numbers of swimmers and/or vessels.

Increasing numbers of swimmers and/or vessels were not correlated with measurable differences in mean leg speed. However, dolphins appear to swim slightly faster when further away from vessels, and larger pods appear to travel slightly faster than smaller pods. Dolphin groups may increase their swimming speed in order to maintain or increase their distance from pursuing swimmers and/or vessels. Würsig et al. (1994) reported an average swimming speed of 2.6 km/h (SD = 2.68) for spinner dolphin groups within Kealakekua Bay. This is slightly less than the average mean leg speed of 3.0 km/h (SD = 0.83) in this study. The earlier data was collected at a time when it is generally accepted that the intensity of dolphin-focused human activity was much less than at the time of this study. Ross (2001) found that the mean leg speed increased for all dolphin groups at Midway Atoll when vessels were present. Once again, the difference between these two populations of dolphins may be attributed to different environments, differences in human activity levels observed during the respective studies, or alternative tactics used by dolphins to avoid vessels. A future comprehensive study involving both locations and using consistent methodologies, including controlled approaches if possible, may serve to answer some of these questions. Kruse (1991) reported that killer whales (*Orcinus orca*) in Johnstone Strait, British Columbia, swam more rapidly when approached by boats than whales unaccompanied by boats. Williams et al. (2002) reported that female killer whales, also in Johnstone Strait, responded to the presence of vessels by swimming faster, but that male killer whales maintained their previous speed. Yin (1999), however, reported that the presence of boats did not result in a significant change in group mean leg speed by dusky dolphins observed off the coast of Kaikoura, New Zealand. Ribeiro et al. (2005) reported that foraging Chilean dolphins showed no change in swimming speed when approached by boats, but, when traveling, they reacted to boats by increasing their swimming speed. The data from the current study suggest that dolphins in Kealakekua Bay tend to alter their direction more frequently in the presence of increased numbers of vessels, but they do not tend to alter their swimming speed. It is possible that different populations of dolphins at different locations have evolved different strategies for avoiding vessels.

This study demonstrated weak but significant correlations between human activity-related variables and two different measures of dolphin group movement. The original study design called for a comparison between tracks when human traffic was absent and tracks when different types (e.g., swimmers, kayaks, motor vessels) and different levels of anthropogenic activity were present. This proved impossible because there were no tracks during which swimmers and/or vessels were not adjacent to the dolphin group being observed. Once spinner dolphin groups have descended into rest, their behavior becomes relatively consistent and resistant to change (Norris et al., 1994). This appeared to be the case in this study and may partially explain the decreased statistical significance of some of the correlations reported here. It may also be that since there is a greater intensity of anthropogenic activity in Kealakekua Bay, these dolphins have become more tolerant than those at Midway.

Although it is possible that spinner dolphins have partially habituated to increasing levels of human activity within Kealakekua Bay, care should be taken not to interpret the results of this study to mean that these activities have only a limited effect on these dolphins. It has been suggested that the effect of disturbance is cumulative rather than catastrophic (Duffus & Dearden, 1990). Over time, small changes in behavior may have a negative effect on the fitness of the spinner dolphins (Bejder et al., 2006). More detailed, comprehensive studies are recommended to better determine the impact that various recreational activities may have on the fitness of these animals. Continued opportunistic observations will prove useful, but controlled experiments would ideally also be a part of any overall study design. These types of experiments would require appropriate permitting and assistance from authorities, tour operators, and kayak rental companies. Controlled experiments would allow for each group of dolphins to serve as its own control. Dolphin groups would ideally be observed under different *control* and *impact* conditions (Williams et al., 2002). This would be the most direct approach to sorting out differing responses to different types and levels of human activity. Different measures of potential *impact* should also be considered. In the case of spinner dolphins at this location, the use of an Activity Index (AI), as described by Lammers (2004), could be an effective method for quantifying responses to anthropogenic activity. In the meantime, caution is warranted, and the efforts being undertaken by the NMFS to protect dolphins in Kealakekua Bay are justified.

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