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EFFECT OF SPINNER DOLPHIN PRESENCE ON LEVEL OF SWIMMER AND VESSEL ACTIVITY IN HAWAI‘IAN BAYS

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Questions have been raised about the effects human activity in Hawai‘ian bays has on dolphins. Concerns about the effects of this activity have led the National Marine Fisheries Service to begin the process of enacting regulations to reduce the impacts of swimmers and vessels on Hawaiian spinner dolphins (*Stenella longirostris*). One step in evaluating potential effects is to determine if dolphin presence attracts swimmers and vessels into bays. In this study, numbers of vessels and swimmers in Kealake‘akua, Honaunau, and Kauhako Bays were measured and related to spinner dolphin presence. In Kauhako Bay, mean number of swimmers per scan sample was significantly higher when dolphins were present, and in Honaunau Bay, mean number of kayaks per scan sample was significantly higher when dolphins were present. In addition to measuring the relationship between dolphin presence and vessel and swimmer presence, it is important to track vessel and swimmer numbers over time and to determine patterns of use in individual bays. This establishes trends in human use of bays and allows management on a more individual bay basis. During this study, Kealake‘akua Bay experienced significantly more vessel and swimmer activity than Kauhako Bay. Numbers of one- to three-person kayaks, motorboats <6 m, and zodiacs were highest in Kealake‘akua Bay. Numbers of swimmers from shore were higher in Honaunau Bay than in Kauhako Bay. Overall, numbers of vessels and swimmers in the bays were higher than in previous decades, and swimmers comprised the majority human activity in the bays.

Key words: Hawai‘i; Vessel; Swimmer; *Stenella longirostris*; Spinner dolphin

Introduction

Many studies have addressed the impacts of tourism on marine mammals in a variety of locations (Barr & Slooton, 1999; Blane, 1990; Blane & Jackson, 1994; Constantine, 2001; Duffus & Deardon, 1993; Lusseau, 2003; Orams, 1997). Marine mammal tourism can take many forms, including watching animals from shore or boats, swimming with animals, and feeding animals (Hoyt, 2001). In studies of dolphins and other odontocetes, impacts of interactions with swimmers and vessels have included changes in behavior (Acevedo, 1991; Bejder, 2005; Constantine, Brunton, & Dennis, 2004;

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Courbis, 2004; Lusseau, 2003; Ng & Leung, 2003; Ross, 2001), changes in swimming speed (Kruse, 1991; Nowacek & Wells, 2001; Ross, 2001), changes in surfacing patterns (Hastie, Wilson, Tufft, & Thompson, 2003; Janik & Thompson, 1996), changes in vocalizations (Lesage, Barrette, Kingsley, & Sjare, 1999; Scarpaci, Bigger, Corkeron, & Nugegoda, 2000), shifts in habitat preference (Allen & Read, 2000; Bejder, 2005), and reduction in distance between animals (Bejder, Dawson, & Haraway, 1999; Nowacek & Wells, 2001). Constantine (2001) found that bottlenose dolphins (*Tursiops truncatus*) in swim-with-the-dolphins programs in the Bay of Islands, New Zealand showed a significant increase in avoidance of swimmers across years. Dolphin avoidance of vessels has also been documented (Blane & Jackson, 1994).

Duffus and Deardon (1990) point out that effects of swimmers and vessels on dolphins can be cumulative rather than catastrophic, and Janik and Thompson (1996) emphasize that even interactions called "positive" in the literature (such as dolphins approaching a vessel), can have negative impacts on dolphin fitness. Studies have quantified some risks to fitness, such as increased risk of injury or death to calves and immature dolphins (Mann, Connor, Barre, & Heithaus, 2000; Samuels & Bejder, 2004) and reduced reproductive success of females (Bejder, 2005). Also, in interactions with humans, dolphins have been fed such dangerous objects as plastic bags chicken bones, beer, and bottle nipples (National Marine Fisheries Service, 1994; Rodriguez-Lopez & Mignucci-Giannoni, 1999). Dolphins can become aggressive toward swimmers who are attempting to feed or interact with them (Lockyear, 1990; Orams, 1997; Orams, Hill, & Bablioni, 1996; Perrine, 1990; Shane, Tepley, & Costello, 1993), and both humans (Santos, 1997) and dolphins (Orams, 1997; Stone & Yoshinaga, 2000) have been killed in human–dolphin interactions. Dolphins may abandon habitat in which humans increase their presence, or they may continue to use areas where there are high numbers of vessels and/or swimmers because of the value of the habitat rather than because of habituation to human activities (Gill, Norris, & Sutherland, 2001; International Fund for Animal Welfare, 1996).

In Hawai‘i, studies from the 1960s to late 1990s indicate an increase in the number of vessels and swimmers over time in Kealake‘akua Bay (Doty, 1968; Forest, 2001; Green & Calvez, 1999; Norris & Dohl, 1980; Norris et al., 1994). Studies such as Doty (1968) and Norris et al. (1994) also indicate that swimmer and vessel numbers in other bays, such as Honaunau Bay and Kauhako Bay, have also increased. This study quantifies levels of vessel and swimmer traffic in Kealake‘akua, Honaunau, and Kauhako Bays in 2002.

Spinner dolphins (*Stenella longirostris*) use bays such as Kealake‘akua, Honaunau, and Kauhako as havens in which to rest during the day year round (Norris & Dohl, 1980; Norris et al., 1994). As a result, dolphins have the potential to attract swimmers and vessels to bays. My study investigates the influence of spinner dolphin presence on the level of swimmer and vessel activity in Kealake‘akua, Honaunau, and Kauhako Bays. Understanding this relationship is an important step in beginning to assess the potential impact swimmers and vessels might have on spinner dolphins.

Hoyt (2001) estimated that more than five boats were involved in dolphin watching trips in the Hawai‘ian Islands in 1998–1999. In comparison, Courbis (2004) reported at least five daily motorized tour operations, three of which included at least four boats each, operating in Kealake‘akua Bay alone. As tourism has increased in Hawai‘ian bays, researchers have begun studying the impacts of this tourism on spinner dolphins (Courbis, 2004; Forest, 2001; Green & Calvez, 1999; Norris et al., 1994). These studies have led to growing concern about the effects of tourism on Hawai‘ian spinner dolphins (Department of Commerce, 2005). Hawai‘ian spinner dolphins are protected under the Marine Mammal Protection Act of 1972, which prohibits the killing or harassment of marine mammals. Harassment includes activities that can potentially injure or change the behavior of marine mammals (Department of Commerce, 2005). As a result of concern about the impact of such harassment, the National Marine Fisheries Service is preparing to make regulations regarding human interactions with spinner dolphins in Hawai‘i (Department of Commerce, 2005). Information regarding types of vessels and levels of swimmer and vessel activity in bays and their relationship to dolphin presence is necessary for determining what activities and locations may need regulation.

It is difficult to assess the effects of tourism on dolphins and their fitness because of lack of baseline data on both vessel traffic and swimmers and on "normal" dolphin behavior, lack of knowledge of delayed or cumulative effects of tourism, lack of ability to collect control data, and lack of knowledge of reproductive condition, age, sex, and other physiological parameters of dolphins (Bejder & Samuels, 2003). In addition, dolphins spend extended periods of time underwater and can be difficult to identify individually in the field (Bejder & Samuels, 2003). Bejder and Samuels break down key components in planning effective research to assess effects of human activities on dolphins. They describe three overall study designs: controlled experiments, opportunistic observations, and historical data. This study uses primarily opportunistic observations in each bay and incorporates the available historical data. Bejder and Samuels also describe three analytical designs: within effect comparison, control versus impact comparison, and before/during/after comparison. This study focuses on determining if dolphin presence affects swimmer and vessel numbers. It is a control versus impact comparison in which the control condition is dolphins not present in the bay. There were no instances in which dolphins were present without swimmers or vessels, so it was not possible to determine if dolphin presence would increase in the absence of vessels and swimmers.

Bejder and Samuels (2003) emphasize the importance of long-term studies for understanding the effects of tourism on dolphins. This study continues the observation of swimmers and traffic patterns in Kealake'akua Bay that began in the 1970s and creates baseline data for continued study of Honaunau and Kauhako Bays.

Study Sites

The study took place at three sites on the western (Kona) side of the Big Island of Hawai'i: Kealake'akua, Honaunau, and Kauhako Bays (Fig. 1). Vessels and swimmers in the bays were observed from land-based observation stations. At Kealake'akua Bay, the station was 69 m above the bay. This station was the same one used by Norris et al. (1994). Because of the size of Kealake'akua Bay (11.13 km^2), this bay was split into four sectors (Fig. 2). At Honaunau Bay, the observation station was at sea level. At Kauhako Bay, the station was 12 m above the bay (Fig. 1). These bays were not split into sectors.

Data Collection

The study began on February 11, 2002 and ended on May 29, 2002. Data were recorded from dawn to dusk on each day (approximately 0600 hours to 1900 hours) by three observers working in approximately 4-hour shifts. Vessel and swimmer numbers were recorded verbally on a hand-held tape recorder and later transcribed into Excel 2000 spreadsheets. Binoculars and a telescope were used to make vessels and swimmers identifiable at longer distances. Times of dolphin entry into and exit from bays were recorded. The numbers and types of vessels and swimmers were recorded every 5 minutes throughout the day as instantaneous scan samples (as defined by Altmann, 1974). Vessel and swimmer categories were defined as one- to three-person kayak/canoe, motorboat <6 m, zodiac, Fair Wind II (a 60-ft double-decked tour boat with a 100 passenger capacity found daily in Kealake'akua Bay), swimmer from shore, swimmer from kayak/canoe, swimmer from zodiac, and scuba diver. These were the vessel and swimmer types that occurred often enough in the bays for data analyses. However, there were occasionally other types of vessels, and their presence was recorded. In Kealake'akua Bay, the sector (Fig. 2) in which each vessel was seen was also recorded.

In Kealake'akua Bay, swimmers from zodiacs and Fair Wind II were too numerous and distant from the observers to count, so numbers of swimmers were not accurate after 0800 hours when these boats began entering the bay. Kayakers who beached their kayaks on the north side of Kealake'akua Bay were considered swimmers from shore unless their kayak was in the water with them. Many of these swimmers were also difficult to see. Scuba divers in Kealake'akua Bay could not be tracked in this study because they could not be seen entering and exiting this bay. All vessels and swimmers, including scuba divers, could be seen and counted in Honaunau and Kauhako Bays. A person in the water was considered a swimmer if he/she was in the water at knee level or deeper.

Observers gathered complete data from dawn to dusk on 39 days. On 7 additional days, observations were made for shorter periods of time: 0551–1651

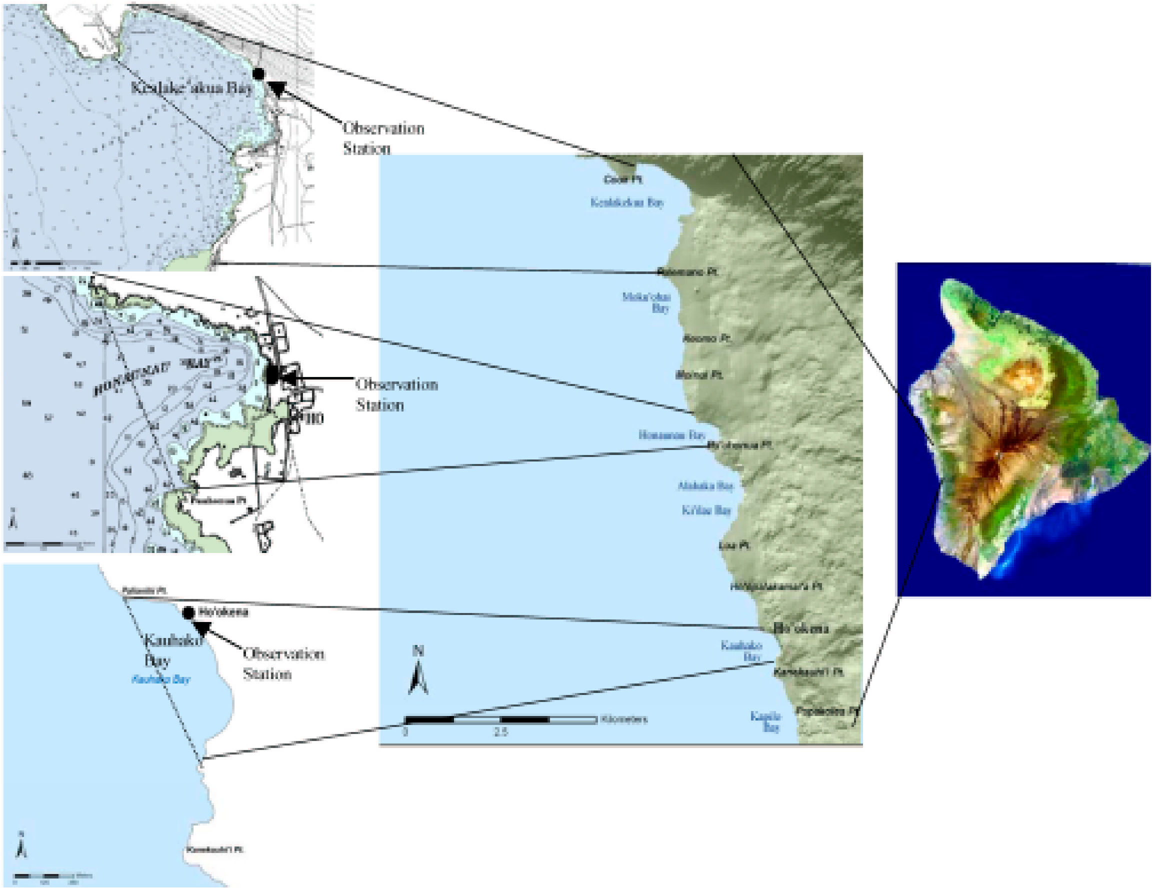

Figure 1. Dotted lines indicate edges of bays. Depths shown are given in feet. Maps were obtained in December 2004 from the NOAA National Ocean Service internet site using ArcView 8.2 software. Approximate lengths, widths, and areas, respectively, of study sites: Kealake‘akua 1575 m, 715 m, 11.13 km^2; Honaunau 577 m, 453 m, 1.66 km^2; Kauhako 709 m, 265 m, 1.17 km^2. These values were obtained using ArcView 8.2.

hours on May 1 and 0736–1052 hours on May 9 in Kealake‘akua Bay; 1030–1818 hours on February 18, 1030–1430 hours on March 17, and 0552–1107 hours on April 5 in Honaunau Bay; and 1031–1801 hours on February 17 and 0558–1905 hours (started after dawn) on May 17 in Kauhako Bay. Spinner dolphins were present in bays on 25 days: 9 out of 13 days in Kealake‘akua Bay, 5 out of 20 days in Honaunau Bay, and 11 out of 16 days in Kauhako Bay. Overall, 644 hours of observations were made, with 143, 274, and 227 hours taking place in Kealake‘akua, Honaunau, and Kauhako Bays, respectively. Within this time, dolphins were in each bay 66, 33, and 32 hours, respectively, for a total of 131 hours.

Data Analyses

Days were broken down into 1-hour increments for analyses (e.g., 0600–0700 hours, 0700–0800 hours). Vessels and swimmers per scan sample were calculated for each hour of each day by dividing the number of vessels and swimmers counted in that hour by the number of scan samples in that hour. The mean for each type of swimmer and vessel was calculated for each hour using all of the days. This mean for each hour of the day indicated how many vessels and swimmers of each type, on average, would be expected in an instantaneous scan sample at any time during that hour. Partial hours of data collection were only used in analy-

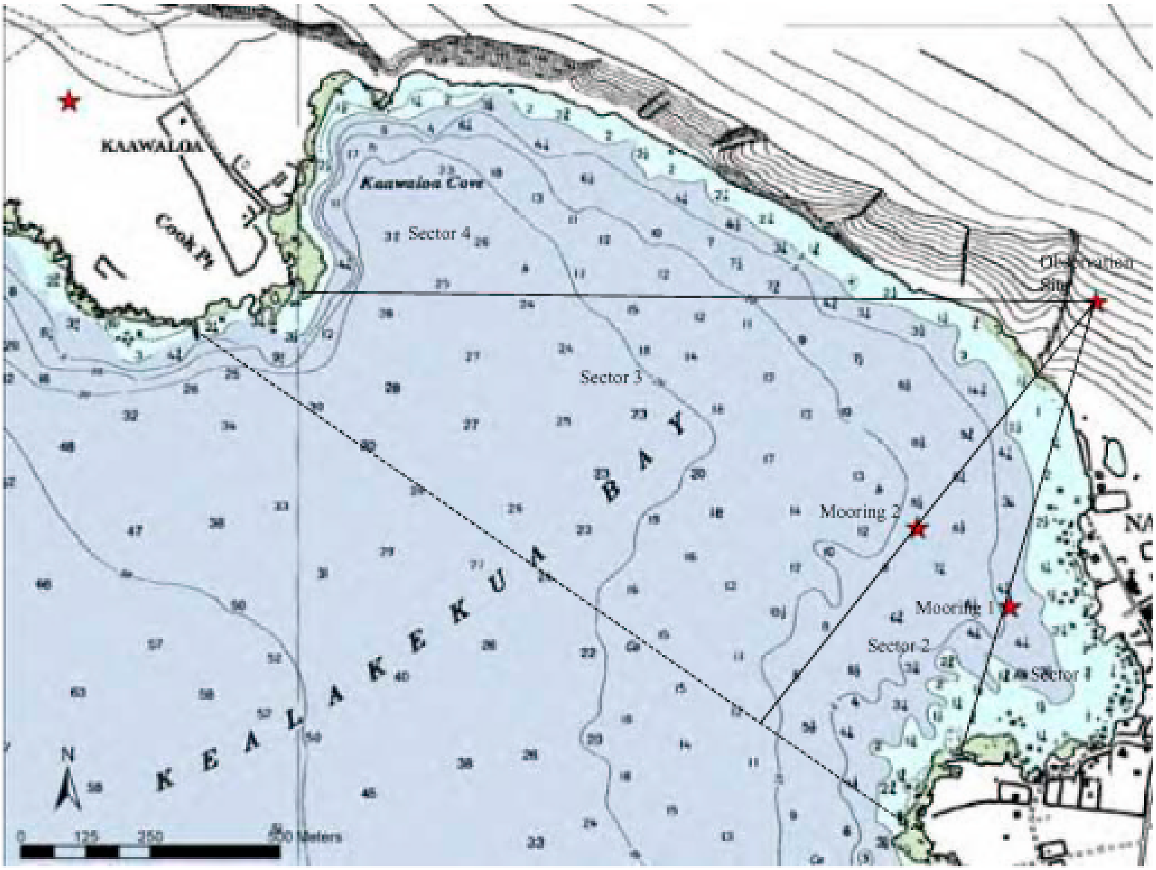

Figure 2. Borders of the sectors of Kealake'akua Bay are shown with straight lines. The two moorings and Cook Point were used to visually identify the edges of the sectors from the observation point. The edge of the bay is represented by the dotted line. Depths shown are in feet. This map was obtained in December 2004 from the NOAA National Ocean Service internet site using ArcView 8.2 software. Moorings and observation site were inserted using latitude and longitude coordinates obtained with a theodolite.

ses if more than 30 minutes of data collection had taken place during the hour. For example, if data were collected from 1802 to 1847 hours at 5-minute intervals, there would be 10 scan samples. If the total number of vessels counted over the 45-minute time span was 50, the number of vessels per scan would be 50 divided by 10, equaling 5. There was no distinction between a situation in which three different vessels were counted in three different samples or the same vessel was counted in three different samples. Therefore, the results do not reflect the number of different vessels and swimmers in the bay, but rather reflect a snapshot of how many are typically present during particular hours of the day.

Data were statistically analyzed using Minitab 13.31 software. ANOVAs and *t*-tests were used to compare data. Multiple range analyses (Student-Newman-Keuls and Tukey Test for Unequal Sample Sizes) were used to find which means significantly differed when an ANOVA indicated that significant differences existed. Multiple range analyses were done by hand using Zar (1999) for formulas and *q*-tables.

Vessel and Swimmer Patterns and Relationship to Dolphin Presence

Comparisons

Total vessel and swimmer numbers in Kealake'akua and Honaunau Bays tended to peak

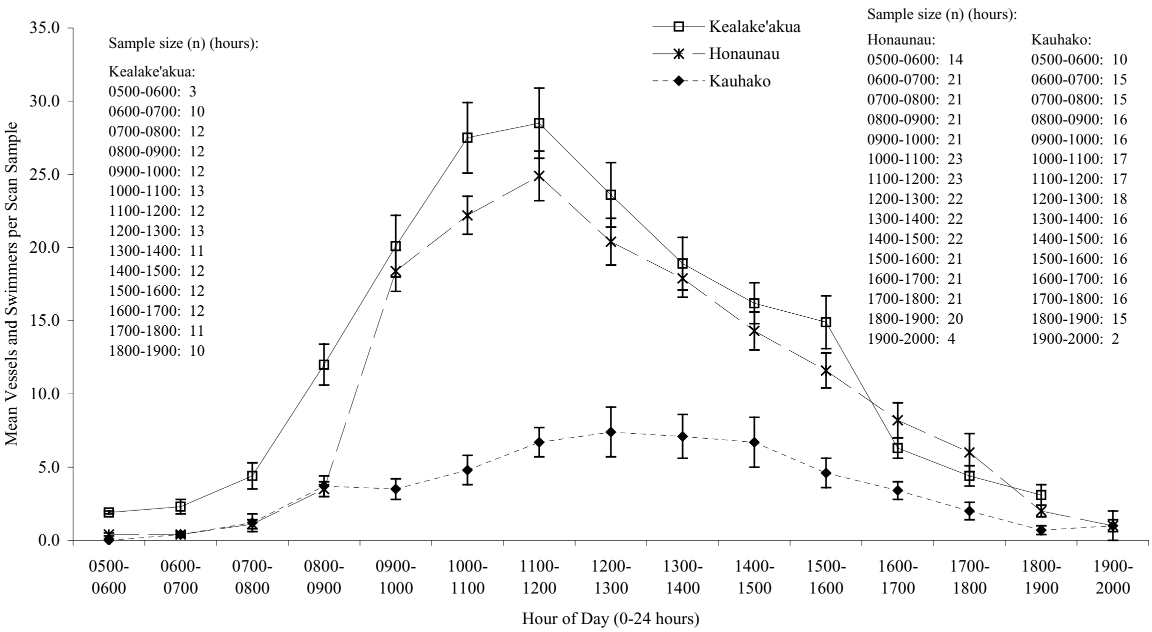

Figure 3. Comparison of mean number of vessels and swimmers per scan sample in relation to time of day for Kealake‘akua, Honaunau, and Kauhako Bays. Numbers are lower than true values for Kealake‘akua Bay because swimmers were too difficult to count on the north side of bay after 0800 hours. Sample size (*n*) represents the number of days of data that contributed to each mean. Standard error bars are shown.

from 1000 to 1200 hours (Fig. 3). In Kauhako Bay, there were no distinct peaks and overall fewer swimmers and vessels (Fig. 3). If the numbers of vessels and swimmers per scan for each hour of each day are pooled, the means are 13.2 ± 9.7 (SE), 10.1 ± 8.9), and 4.1 ± 2.4 for Kealake‘akua, Honaunau, and Kauhako Bays, respectively. These means indicate how many vessels and swimmers would be present, on average, in each bay at any given time. However, variation from hour to hour is high, as indicated by the large standard errors. Also, the mean is an underrepresentation for Kealake‘akua Bay because most swimmers could not be counted after 0800 hours. An ANOVA shows that the means among the bays differ significantly [$F(2) = 4.75$, $p = 0.014$]. Multiple range tests show that the mean for Kealake‘akua Bay is significantly higher than for Kauhako Bay.

Numbers of swimmers from shore can be compared between Honaunau and Kauhako Bays. (Swimmer numbers could not be accurately recorded after 0800 hours in Kealake‘akua Bay.) A *t*-test shows that the mean number of swimmers from shore per scan in Honaunau Bay (7.2 ± 1.7) was significantly higher than in Kauhako Bay (3.2 ± 0.7) ($t = -3.50$, $p = 0.004$, $n = 15$). Vessel types that frequent both Kealake‘akua Bay and Honaunau Bay can be compared as well. (Vessels rarely use Kauhako Bay.) The *t*-tests show that mean numbers of one- to three-person kayaks, motorboats <6 m, and zodiacs per scan are significantly higher for Kealake‘akua Bay (4.1 ± 0.9, 1.6 ± 0.1, and 1.0 ± 0.3, respectively) than for Honaunau Bay (0.4 ± 0.1, 0.2 ± 0.0, and 0.2 ± 0.1, respectively) (kayaks: $t = 4.06$, $p = 0.000$, $n = 14$ for Kealake‘akua, $n = 15$ for Honaunau; motorboats: $t = 18.24$, $p = 0.000$, *n*s are the same; zodiacs: $t = 2.51$, $p = 0.018$, *n*s are the same).

Kealake‘akua Bay

In Kealake‘akua Bay, mean vessels and swimmers per scan were highest in sector four, peaking from 1000 to 1200 hours (Fig. 4). An ANOVA indicated that the daily means of vessels and swimmers per scan were significantly different among sectors [$F(3) = 35.87$, $p = 0.000$]. Multiple range tests sug-

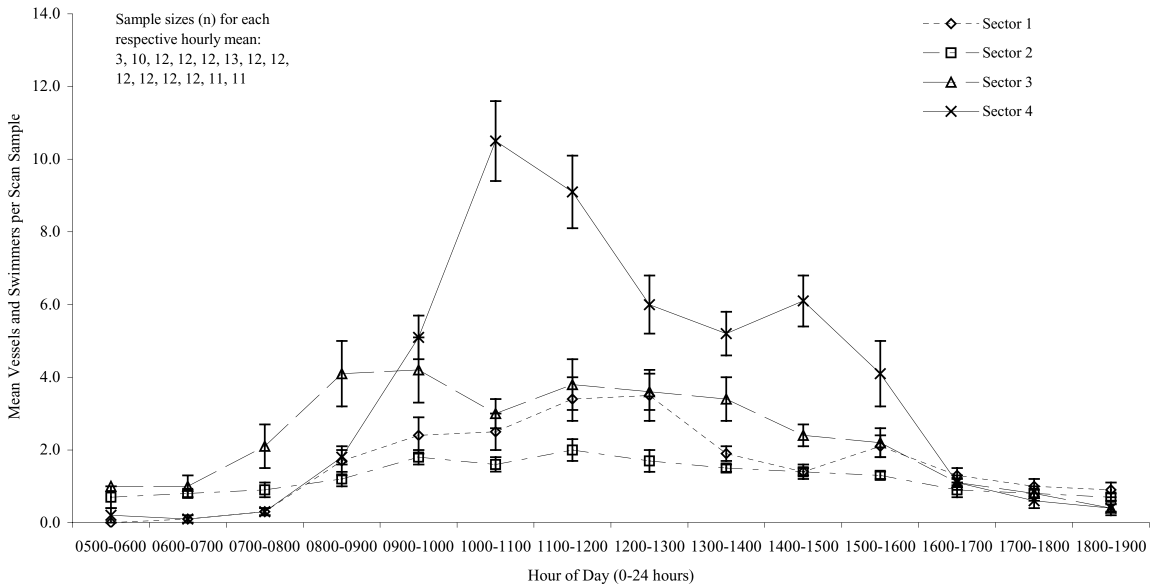

Figure 4. Comparison of mean number of vessels and swimmers per scan sample in relation to time of day in each of the four sectors of Kealake'akua Bay. Numbers are lower than true values for Kealake'akua Bay because swimmers were too difficult to count on the north side of bay after 0800 hours. Sample size (*n*) represents the number of days that contributed to the mean. Standard error bars are shown.

gested that the mean for sector four (3.9 ± 0.3) was significantly higher than the means for sectors one (1.7 ± 0.1), two (1.3 ± 0.1), and three (2.5 ± 0.2), and the mean for sector three was significantly higher than the means for sectors one and two. In other words, vessels and swimmers were more frequently in the northern part of the bay. No significant differences were found between the mean vessels and swimmers per scan for sectors one and two (multiple range test $p > 0.05$).

Because swimmers from shore could be counted accurately only until 0800 hours, it was difficult to make comparisons. Mean number of swimmers from shore per scan from 0700 to 0800 hours was not significantly different when dolphins were or were not present (Table 1). However, standard errors of the means did not overlap (Table 1). The lack of significance may be due to small sample size and high variability. For example, there were zero swimmers from shore from 0700 to 0800 hours on May 2, but the next lowest value was 2.1 swimmers from shore per scan on March 28. A larger sample size would be necessary to resolve the issue of differences in mean swimmers per scan based on dolphin presence.

Between 0600 and 0800 hours, kayaks started crossing the bay from the boat launch at the south end to the Captain Cook Monument at the north end. A bell-shaped curve describes mean kayaks per scan through the day (Fig. 5). Mean swimmers from kayaks per scan followed a pattern similar to that of kayaks but with lower values (Fig. 5). In addition to kayaks, zodiacs started arriving in the bay between 0800 and 0900 hours. Mean number of zodiacs per scan peaked from 1000 to 1100 hours and again from 1400 to 1500 hours (Fig. 5). There were four zodiac tour companies that were seen daily in the bay: Captain Zodiac, Sea Quest, Nautica, and Orca. Nautica only brought one boat into the bay at a time. Sea Quest and Captian Zodiac often brought in three or four boats at a time. Orca appeared more sporadically than the other zodiacs but would sometimes bring in four boats at a time as well. Each zodiac usually carried 7–11 people. Zodiacs were usually gone from the bay by 1600 hours.

The 60-ft double-decked tour boat, *Fair Wind II*, made one or two trips into Kealake'akua Bay each day (Fig. 5). It had a capacity of 100 passengers. It moored near the Captain Cook Monument (sector

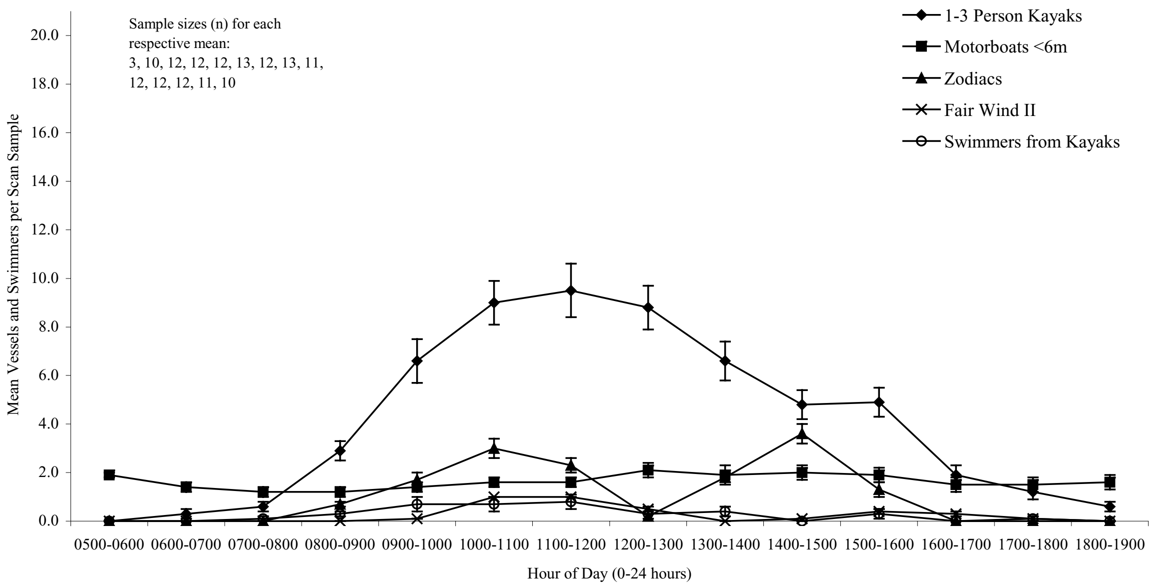

Figure 5. Mean number of vessels and swimmers per scan sample in relation to time of day for different vessel and swimmer categories in Kealake‘akua Bay. Vessel types rarely seen in the bay and swimmers from shore, which were too difficult to count after 0800 hours, are not included. Sample size (*n*) represents the number of days of data that contributed to each mean. Standard error bars are shown.

four) for a mean of 2.64 ± 0.03 hours ($n = 12$ days) each morning, arriving at a mean time of 0955 ± 0.03 h) and leaving at a mean time of 1233 ± 0.03 hours). On 5 of 12 days, the *Fair Wind II* came back into the bay a second time in the late afternoon. It moored near the monument for an average of 2.22 ± 0.21 hours ($n = 5$ days), arriving at a mean time of 1453 ± 0.03 hours and leaving at a mean time of 1706 ± 0.23 hours. Motorboats less than 6 m in length also traveled into Kealake‘akua Bay throughout the day, and two motorboats were moored in the bay on most days (Fig. 5). There were no significant differences found for the mean number per scan for any of the vessel categories when dolphins were and were not present in Kealake‘akua Bay (Table 1).

Honaunau Bay

Overall, mean numbers of vessels and swimmers per scan were not significantly higher when dolphins were present in Honaunau Bay (Table 1). Swimmers were a large portion of the human activity in this bay (Fig. 6). Starting between 0700 and 0800 hours, swimmers would begin to enter the bay. Mean number of swimmers from shore per scan followed a fairly bell-shaped curve through the day (Fig. 6). Swimmers from zodiacs were present only from 0900 to 1200 hours (Fig. 6). There were no significant differences between number of swimmers from shore per scan or swimmers from zodiac per scan when dolphins were and were not present in the bay.

Mean number of kayaks per scan peaked from 1100 to 1200 hours and again from 1700 to 1800 hours (Fig. 6). Mean number of kayaks per scan was significantly higher when dolphins were present (Table 1). Mean number of motorboats per scan was highest from 0500 to 0700 hours and then stayed at low levels throughout the day (Fig. 6). Mean number of motorboats per scan was significantly lower when dolphins were present (Table 1). Scuba divers were present in the bay through most of the day (Fig. 6). At 0930 hours, Sea Quest tour zodiacs would begin entering the bay. Up to four Sea Quests zodiacs, each with 7–11 people aboard, would drift in the bay until approximately 1030 hours, allowing passengers to snorkel (Fig. 6). The boats were always in the southwestern part of the bay. Occasionally, a Nautica tour zodiac would also come into the bay to deploy snorkelers. There was no significant

Table 1

Paired *t*-Tests Comparing Mean Number of Vessels and Swimmers per Scan Each Hour When Dolphins Were Present and Not Present in the Bays

	Kealakeʻakua Bay		Honaunau Bay		Kauhako Bay	
	With Dolphins	Without Dolphins	With Dolphins	Without Dolphins	With Dolphins	Without Dolphins
All vessels/swimmers	2.2 ± 0.2	2.0 ± 0.3	3.2 ± 0.2	2.4 ± 0.1	**2.6 ± 0.4**	**0.7 ± 0.1**
t	0.56		2.29		5.58	
p	0.615		0.149		0.031	
n	4		3		3	
Swimmers from shore	2.8 ± 1.1	0.9 ± 0.0	2.4 ± 0.2	1.7 ± 0.2	**2.5 ± 0.4**	**0.6 ± 0.1**
t	1.74		2.14		5.07	
p	0.180		0.165		0.037	
n	4		3		4	
Swimmers from zodiacs	N/A	N/A	0.1 ± 0.1	0.1 ± 0.0	N/A	N/A
t			–0.48			
p			0.681			
n			3			
Scuba divers	N/A	N/A	0.3 ± 0.1	0.3 ± 0.1	N/A	N/A
t			–0.60			
p			0.612			
n			3			
Kayaks	0.7 ± 0.1	0.6 ± 0.1	**0.1 ± 0.0**	**0.0 ± 0.0**	N/A	N/A
t	0.32		8.75			
p	0.767		0.013			
n	4		3			
Swimmers from kayaks	0.1 ± 0.0	0.0 ± 0.0			N/A	N/A
t	1.97					
p	0.143					
n	4					
Motorboats <6 m	0.3 ± 0.0	0.2 ± 0.1	**0.0 ± 0.0**	**0.0 ± 0.0**	N/A	N/A
t	2.53		–4.72			
p	0.086		0.042			
n	4		3			
Fair Wind II	0.0 ± 0.0	0.0 ± 0.0	N/A	N/A	N/A	N/A
t	0.69					
p	0.541					
n	4					
Zodiacs	0.2 ± 0.0	0.2 ± 0.0	0.0 ± 0.0	0.1 ± 0.0	N/A	N/A
t	–0.25		–1.65			
p	0.822		0.242			
n	4		3			

Significant differences are shown in bold. Hours and number of days used for analyses were based on hours of the day and number of days dolphins were present in the bays. In Kealakeʻakua Bay, 0700–1600 hours were compared; in Honaunau Bay, 0900–1600 hours; and in Kauhako Bay, 0800–1100 hours. Because swimmers from shore could not be counted after 0800 hours in Kealakeʻakua Bay, the comparison of swimmers from shore for that bay only includes 0700–0800 hours and the total numbers do not include swimmers from shore after 0800 hours. Values are rounded to the nearest tenth.

difference in number of zodiacs per scan when dolphins were and were not present.

Beginning in April, a canoe club began training for races 2–3 days per week. This club would launch 1–5 six-person canoes and 1–5 one-person kayaks into the bay around 1600 hours. They would typically leave the bay immediately. The canoes and attending kayaks were taken out of the water around 1815 hours. There were not enough data to compare six-person kayaks per scan when dolphins were and were not present.

Kauhako Bay

Overall mean numbers of vessels and swimmers per scan were significantly higher when dolphins were present in Kauhako Bay (Table 1). Swimmers comprised almost all human activity in Kauhako Bay

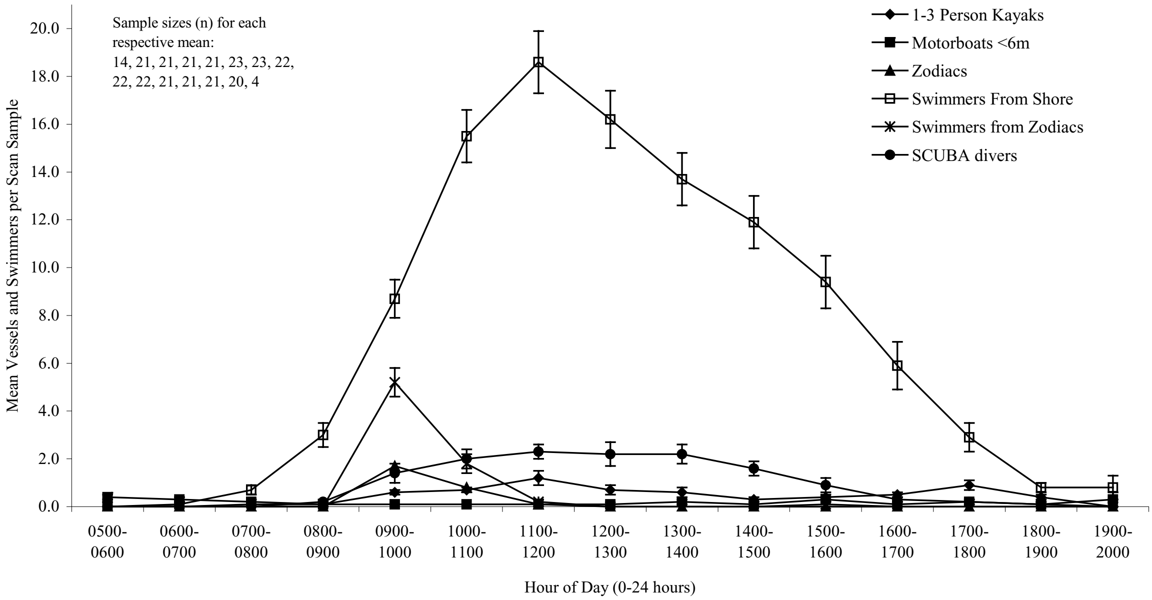

Figure 6. Mean number of vessels and swimmer per scan sample in relation to time of day for different vessel and swimmer categories in Honaunau Bay. Vessel types rarely seen in the bay are not included. Sample size (*n*) represents the number of days of data that contributed to each mean. Standard error bars are shown.

(Fig. 7). On the 6 days when dolphins were not present before 0700 hours, swimmers from shore were never recorded before 0700 hours. However, a paired *t*-test indicated the difference between means from 0600 to 0700 hours with and without dolphins present to be insignificant (mean = 0.7 ± 0.3 present, mean = 0 not present, $t = 2.16$, $p = 0.083$, $n = 6$ days present, $n = 6$ days not present). The lack of significance is probably the result of variability in the data on days when dolphins were present. On 2 of the 6 days, no swimmers entered the bay before 0700 hours; on 2 days, numbers were 1.7 and 1.8 swimmers per scan; and on 2 days, there were 0.6 and 0.2 swimmers per scan. Mean number of swimmers from shore per scan was significantly higher from 0800 to 1100 hours when dolphins were present (Table 1). Other vessel types were too rare to use in analyses, and dolphins were not present often enough to include hours after 1100 hours in the analyses.

Conclusion

Mean number of swimmers per scan in the bays was significantly higher when dolphins were present in Kauhako Bay. This suggests that there were either more swimmers in the bay on days with dolphins, or swimmers spent more time in the bay on those days. The relationship between dolphin presence and numbers of swimmers from shore in Kealake‘akua Bay was unclear because swimmers were difficult to count after 0800 hours and the data before 0800 hours were highly variable. However, Forest (2001) found that more people entered Kealeke‘akua Bay on days when dolphins were present, and Barber, Barber, and Jackson (1995) reported that presence of dolphins in Kealake‘akua Bay significantly influenced the presence of swimmers, kayaks, and motor vessels. Green and Calvez (1999) also reported that human use of Kealake‘akua Bay was markedly lower on days without dolphins present. Although in the current study there was a tendency for motorboats, swimmers, and kayaks to have higher means per scan in Kealake‘akua Bay when dolphins were present, the differences were not significant. However, differences were significant for motorboats and kayaks in Honaunau Bay. Mean number of motorboats per scan was significantly higher in Honaunau Bay when dolphins were not present. A future study may be able to determine if location of dolphins in this bay tends to block

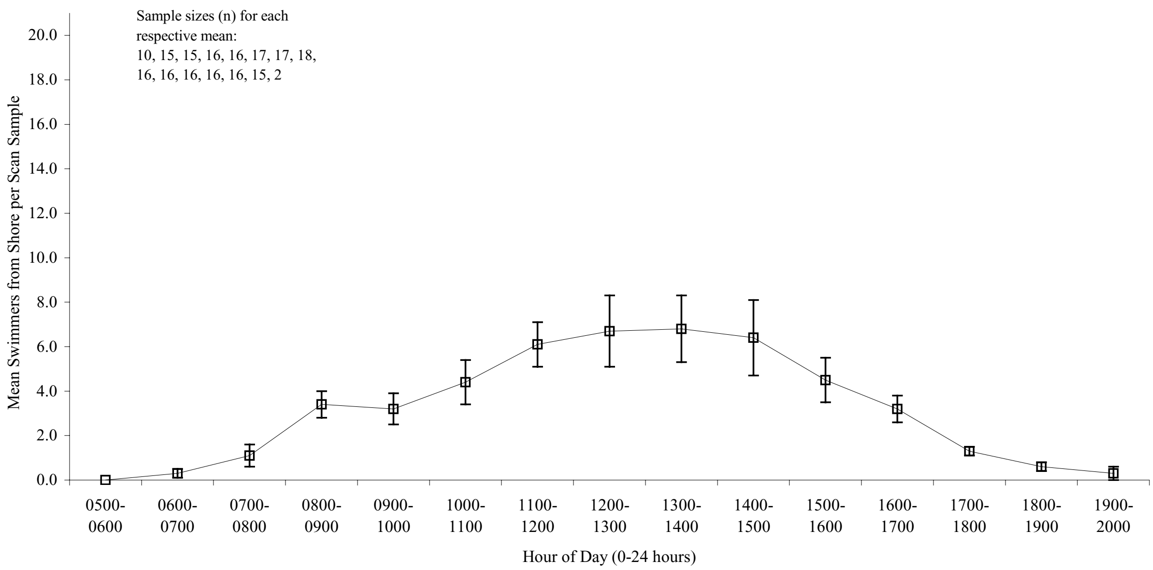

Figure 7. Mean number of swimmers from shore per scan sample in relation to time of day in Kauhako Bay. All other vessel and swimmer categories were rare in this bay. Sample size (*n*) represents the number of days that contributed swimmers per hour to the mean. Standard error bars are shown.

the boat channel or if swimmer location tends to be in the boat channel when dolphins are present. Swimmers or dolphins obstructing the small channel available for motorboat entry into and exit from the bay may reduce motorboat activity when dolphins are present.

As to the general vessel and swimmer patterns in Kealake'akua Bay, Forest (2001) reported similar patterns in her 1993–1994 study, with morning activity dominated by swimmers following dolphins and afternoon activity consisting mainly of kayaks and motorized vessels (including tour boats). Green and Calvez (1999) also found this pattern in 1998–1999. In comparison, Doty (1968) indicated that there was little tourism in Kealake'akua Bay in the 1960s. At that time, two tourist vessels made daily trips to the bay from the Kailua-Kona resort area. Norris and Dohl (1980) stated that local people seldom disturbed dolphins in Kealake'akua Bay, and only cruise boats seeking pods and running through them were a predictable disturbance. This suggests that the level of traffic has increased considerably in the bay since the 1960s and 1970s. Forest (2001) recorded data when dolphins were present but vessels were not present in Kealake'akua Bay in 1996. Vessels were never absent when dolphins were present in the current study, suggesting that traffic in Kealake'akua Bay continued to increase from 1996 to 2002.

Previous studies do not specify the location of vessels and swimmers within Kealake'akua Bay. The current study found vessel and swimmer numbers to be significantly higher on the northern side of the bay. Courbis (2004) found that dolphins spent significantly more time on the northern side of the bay, although this was not the case in the past (Doty, 1968; Norris et al., 1994). It is hard to say whether this correlation implies that vessels are staying near dolphins or vice versa. Further research may help clarify this relationship.

There are no major studies of Honaunau or Kauhako Bays with which to compare the current study. However, Doty (1968) and Norris et al. (1994) give some indications that vessel and swimmer numbers in these bays were very low in the 1960s and 1970s. Residents living on the shores of these bays indicated that swimmer and vessel numbers have increased in both bays over the last decade. In Honaunau Bay, zodiac tours, such as Sea Quest and Nautica, began coming into the bay, and the number of swimmers from shore increased as well. Additionally, several local dive shops now teach scuba classes in Honaunau Bay.

Overall, data indicate that marine tourism in the three Hawai‘ian bays studied has increased dramatically in the last several decades. Swimmers were the dominant category recorded in this study and should continue to be a focus of future research. In addition, each bay had differing swimmer and vessel types, patterns, and numbers. In Kealake‘akua Bay, swimmers and kayakers focused on reefs and the Captain Cook Monument in addition to dolphins. In Honaunau Bay, swimmers also focused on reefs. However, in Kauhako Bay, there was virtually no activity in the bay outside of swimming with dolphins. An exception is attempts to swim with humpback whales (*Megaptera novaeangliae*) and calves (Courbis, 2004). This activity also occurs in Kealake‘akua Bay (Courbis, 2004). Even though there are fewer vessels and swimmers in Kauhako Bay than the other two studied, the number of swimmers and/or duration of swimming in this bay is tied to dolphin presence. This indicates that alone, numbers of swimmers may not be a good criterion for detecting human–dolphin interaction and disturbance. Future research should continue to document vessel and swimmer patterns in Hawai‘i and their relationship to wildlife. More baseline data and more long-term studies are needed to improve managers' ability to conserve wildlife and promote responsible, economically beneficial marine tourism in this state. Ideally, management should be implemented individually for each bay based on its particular patterns of human and wildlife use.

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