

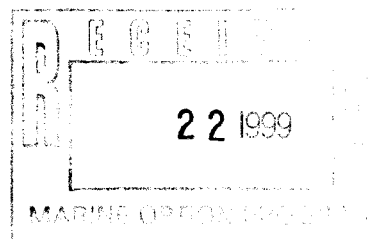
**Spinner Dolphins
(*Stenella longirostris*)
and Environmental Conditions**

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May 12, 1999

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Abstract

Spinner dolphins, *Stenella longirostris*, are known to come into rest areas along the shoreline after nighttime feeding. There is little known as to why they will rest in certain areas and not others. This study was undertaken to determine if *Stenella longirostris* occupy rest areas based on weather conditions. Observations were made between September 1998 - early February 1999 at Lelewi Beach Park and Kawaihae. Data collection included weather conditions, dolphins count and activity scans. The size of estimated feeding areas were also calculated. Dolphins were seen 19% of the time during the study. Weather conditions and number of dolphins did not correlate. Increases in aerial behaviors seem to be related to human activity. With exception of Kawaihae, the bigger feeding areas were found to have larger school sizes.

Introduction

The spinner dolphin, *Stenella longirostris*, is the most commonly found dolphin around the islands of Hawaii. They are best known for their ability to leap out of the water and spin on their longitudinal axis for up to four revolutions (Norris and Dohl 1980). They have a three tone color pattern, a long rostrum and are found in tropical and subtropical waters (Carwardine 1995).

The spinner dolphins feed upon the organisms of the deep scattering layer. This includes mesopelagic fish shrimp and squid (Norris and Dohl 1980) that migrate to the surface at night. This layer is located at daytime depths of about 400 to 700 meters below the surface (Reid *et al.* 1991).

Their general pattern of movement and daily activities are quite different from other dolphins, such as the bottlenose, *Tursiops truncatus* (Würsig and Würsig 1979 and Irvine *et al.* 1981). Norris and Dohl (1980) have shown that feeding starts around dusk and will last until morning. Once morning approaches, they make their way to shallow water along the coast of the island where they will gather in a sheltered location and spend some part of the day in a quiescent period. These locations are commonly referred to as rest areas. Rest areas described by Norris and Dohl (1980) need to consist of shallow sandy areas that are preferably white and less than 50 meters, and in close range of deep water that is usually greater than 500 meters.

Resting spinner dolphins will move slowly back and forth within a bay (Norris and Dohl 1980). During rest, their aerial behaviors become infrequent or stop completely. However, you are still able to see them. Their dorsal fins are clearly visible when they are at the surface. Norris and Dohl (1980) have shown that they tend to spend most of their time underwater when resting. This can last anywhere from one to three minutes before they will surface again.

Studies have shown that the Kona side seems to be a favored place for spinner dolphins due to calm conditions associated with the sea and weather (Norris *et al.* 1994). Yet, on the windward side, which is an area known for winds and rain, there is a location not too far from Hilo, that has been identified as a place where "spinner dolphins come and visit frequently" (Takei 1997).

Little is known on exactly why spinner dolphins choose to rest in certain areas and not others. Östman (1994) suggests that they select rest areas based primarily on water conditions and then, the distance to the feeding area. Takei (1997) has shown that they do visit Leleiwi Beach Park, on the windward side of the island, but was not always seen on observation days. In a study done off the Island of Mo'orea, Poole (1995), observed spinner dolphins and found that wind conditions did affect where they would rest. As the wind picks up, the dolphins would usually move to locations with less or calmer winds. Based on this information, I predict that the dolphins will use the resting areas when they are relatively calm.

Materials and Methods

Study Area

Spinner dolphins were observed at two sites on the Island of Hawai'i, Leleiwi Beach Park and Kawaihae (Figure 1). Leleiwi is on the windward side of the island. It has a shore that consists of green grass and three pavilions. Observations were made at sea level along a stone wall or at a pavilion. Kawaihae is located on the leeward side of the island. Observations were made along the coastline extending from Kawaihae Harbor and as far north as Kaiopae Point. However, the main study area where most of the observations were made was off the side of the road along the cliff shoreline. This site overlooks the bay area where Honokoa Gultch empties into the ocean.

Data Collection

Data collection began from September 1, 1998 and lasted until February 9, 1999. Observations were made between 6 a.m. and 12 p.m. and lasted anywhere between a half and hour to four and a half hours (Figure 2). This time period is when spinner dolphins are most likely to come into rest areas.

Weather

Observations began by recording the time each observation started and what the weather conditions were like. The Beaufort Scale was used to describe what kind of state the sea was in. Swell size was determined by watching the waves as they came into shore and estimating their size. Wind direction was determined by the direction in which my hair would flow. If there was very little wind and my hair did not move in a direction, I recorded the direction as "variable". The leaves from the palm trees were also used as another reference for the direction of wind. Cloud cover was determined by dividing the sky into eight's and counting how many sections were filled with clouds. A tide chart was used to determine tide height. Sea surface temperature readings were obtained from the Natural Energy Lab of Hawaii Authority for the months of September 1982 through January 1999. This study focuses on the sea surface temperatures between January 1996 through December 1998.

Search Protocol

Binocular searches were performed every half-hour for 10 minutes. When dolphin schools were found, the time of

day and direction of movement was recorded. Dolphin school sizes were then estimated by counting dorsal fins when the group came up to the surface. Again, the time was recorded when dolphins left the area or the observation ended.

Activity Scans

An activity scan was performed when dolphins were in the observational areas following the protocol outlined in Norris *et al* (1994) and Östman (1994). Aerial behaviors were recorded every half-hour for 5 minutes. Data recorded included the start time and all aerial or out of water activity, including splashes, that was performed. An activity index was calculated by categorizing aerial behaviors and giving them a number based on the amount of energy expended. The activity index indicates the amount of energy that the school spends in aerial behaviors. It is expected that the amount of energy put into their behaviors will go down when they go into rest.

Feeding Areas

The size of feeding areas and their distances to the resting sites were estimated to see whether these parameters have any effect on the observed school sizes in the resting areas. A 15 nautical miles radius was

determined around each observational site. Then, the 220 and 380 fathom lines were estimated and the areas were traced on to paper, cut out and weighted with an analytical scale. Calculations were made and the feeding areas were determined. Leleiwi and Kawaihae were then compared to four other rest areas along the leeward side of the island, Makako Bay, Kailua Bay, Kealakekua Bay and Kauhako Bay (Östman 1994 and Östman per. comm.).

Statistical Analysis

The Spearman rank correlation was used to analyze the relationship between number of dolphins and all weather conditions (sea state, swell size, wind direction, tides and cloud cover), feeding areas and average school sizes, and monthly surface water temperatures and number of dolphins. The sample size consists of data when dolphins were seen and when they were not seen. Each day was treated as one observation. For days when no dolphins were seen and there are changes in a weather condition, one sample was chosen based on a similar time when dolphins were seen on another day.

Results

Sightings Recorded

Dolphins were seen 15 days out of 78 observational days (19%) (Figure 2). There was a lower percentage of sightings at Leleiwi (14%) than at Kawaihae (37%) (Table 1). At Leleiwi, dolphins were usually sighted in the rest area after 10:30 a.m. There were a couple of times when dolphins were sighted around 8:00 a.m. (Table 4). The average school size was 37 ± 18 (Table 2). Five out of the eight days (November 11 & 19, December 2, January 18 & 19) that dolphins were seen they were already in the bay when observations began (Table 4). There were three days when dolphins were sighted but just passed by. One of those days the dolphins came less than half way into the bay before turning around and leaving. There was a total of 81 hours spent at Leleiwi (Table 1).

At Kawaihae, dolphins were sighted anywhere between 7:00 a.m. and 10:00 a.m. (Table 5). The average school size was 42 ± 20 dolphins (Table 2). Most of the time, four out of seven days (September 5 & 8, December 12 & 26), dolphins were seen traveling from the north direction and heading south to the harbor. They would go travel all the way to the buoys, which were close to the harbor. They would stay for a while and eventually head north. Five out

of seven days, dolphins were seen traveling north when leaving the study area. Only one time the dolphins travel from the north direction all the way down to the harbor, turned around and traveled to the second bay. This as is the next bay area north of the main study area. They were seen milling in the bay when observations ended. There were two days when dolphins were seen to come from the direction of the harbor and head north. A total of 41 hours were spent at Kawaihae (Table 1).

Weather Conditions

Table 2 represents the results from the statistical analysis between weather variables and number of dolphins. Each weather variable (sea state, tides, swell size, wind direction, and cloud cover) and number of dolphins did not show any significant correlation's ($P > 0.05$). However, the number of dolphins per unit effort decreases as the sea state gets higher (Figure 3). There were more dolphins were seen at sea state two for both Leleiwi and Kawaihae. There were also a higher number of dolphins seen at sea state two and sea state three for Leleiwi (Figure 3).

The average sea surface temperatures for 1998 are lower than 1996 and 1997. October 1998 shows a substantially lower temperature then the other two years

(Figure 4). For the month of October, no dolphins were found at Kawaihae (Figure 3).

Aerial Activity Scans

Aerial behavior was looked at between 8 a.m. and 12:50 p.m. Spinner dolphins at Leleiwi show a gradual increase in aerial behavior throughout the morning hours. Boats were observed to pass by Leleiwi 10 out of 59 days. Only one out of the ten days, dolphins were sighted in the bay. There was no change in activity observed during that day. The activity index was not found to be higher than 100 (Figure 6).

Throughout the morning hours, the dolphins resting off Kawaihae show distinct increases and decreases in aerial behaviors. The peaks in aerial activity coincided with human activity near dolphin school: At 9.13, kayakers were moving through the school. At 9.67, a boat was about 200m to the right of the bay. At 9.70, a boat was coming out of the harbor, about 100m away from the dolphins. At 10.45, kayakers were in the area and about 30m from a group of dolphins. The activity index fell between 0 and 200 (Figure 7).

Feeding Areas

Leleiwi is on the windward side and has a feeding area of 100 km² but the average school size is 37. Kawaihae is the northern most rest area on the leeward side. It has the largest feeding area consisting of 377 km² with an average school size of 41 dolphins (Table 6). Makako, Kailua, Kealakekua and Kauhako are also on the leeward side of the island. These four bay areas are in order from north to south, with a decrease in feeding areas as you move south (Table 6).

A Spearman rank correlation was performed between the feeding areas of Leleiwi, Makako Bay, Kailua Bay, Kealakekua Bay and Kauhako Bay. A significant correlation was found between all feeding areas and their average school size (Spearman rank test statistic = 0.900, p=0.037). Kawaihae was not considered in this statistical test because it has a very large feeding area associated with it, with a relatively small resting school. Figure 8 shows that there is an increase in the average number of dolphins as the feeding area gets bigger with the exception of Kawaihae.

Discussion

Sightings

Spinner dolphins were not seen as often as expected at Leleiwi (14%) and Kawaihae (37%) during this study. In another study by Takei (1997) spinner dolphins were observed at Leleiwi during September 1996 through February 1997 except for the month of December. She reported dolphins to be seen at Leleiwi 50% of the time. Why there is a decrease in dolphin numbers is not clearly known.

At Leleiwi, most of the time, dolphins were already milling in the bay when observations began. It was hard to determine when the dolphins would appear because they were not seen in the area very often and when they were seen, they would come in at different times. On two occasions dolphins were seen to enter into the bay from the east side where Richardson's Ocean Park is located. Observations were also made at sea level making it more difficult to observe. An elevated observation site would have made the searches easier.

At Kawaihae, dolphins were sighted in the morning hours of 7:00 a.m. to 10:00 a.m. Most of the time they were traveling down from the north and heading south to the

Kawaihae Harbor. They would stay close to the buoys near the harbor and in the main study area before eventually heading back north along the coastline. Due to the difficulties of seeing the coastline from the road, it is not clear as to how far north the dolphins traveled or what their activity was like. Once they headed north, they were not seen coming back into the main study area.

Weather Conditions

Certain weather conditions from previous studies have been found to be important in determine resting areas. Around the Big Island, Hawaii, Norris *et al* (1994) was able to find a correlation between sea state, number of schools and animals per school. They did state however, that this correlation might be biased due to the ability of observers to see rather than a correlation. Wind direction was found to affect spinner dolphins off the Island of Mo'orea (Poole, 1995).

This study was not able to show any significant correlation between spinner dolphin choice of rest area and weather conditions. Still, there seems to be a trend when looking at the number of dolphins per hour by sea state (Figure 4). As sea state increases the number of dolphins decreases for both locations. Calmer conditions may be

more favorable to rest in (Norris *et al* 1994). The average number of dolphins was found to be higher at Kawaihae, which tends to have calmer, drier weather condition than Leleiwi. Searches at sea level and during rough seas were difficult to do. A bigger sample size may be needed at both locations in order to show any type of significant correlation with weather conditions.

In 1998, the average sea surface temperature was lower than in 1996 and 1997. Particularly, during the month of October 1998 the sea surface temperature was the lowest when comparing it to 1996 and 1997. In this month, there were no dolphins observed at Kawaihae. Could a decrease in sea surface temperatures have an effect on the dolphins? But, if dolphins avoid the lower sea surface temperatures, then where did they go?

The 1997-98 El Niño may have impacted my data. It is considered one of the strongest El Niño ever recorded (Henson 1998). This phenomenon may have affected the dolphins in some way. A follow-up study during a non El Niño or La Niña year should be conducted to get more insight into the question of why dolphins choose certain rest area over others.

Aerial Activity

Resting spinner dolphins are associated with low activity levels (Norris *et al* 1994). The activity index for Leleiwi was fairly low which indicates that resting might be occurring. There was not a lot of energy being put into their aerial behaviors. Human activity was very little at Leleiwi. There was only one day when a boat passed by and dolphins were in the bay, but they did not show any change in aerial activity.

Kawaihae had a very high activity index compared to Leleiwi. There were many peaks of activity, which indicates that more energy is being used. When humans come in contact with spinner dolphins, aerial behaviors tended to increase (Norris *et al*, 1994). Each peak of the activity index for Kawaihae was due to the presence of humans around the dolphins when they are in their resting sites (Figure 4). The first and third peaks were due to the presence of kayakers and the second peak was due to a boat leaving Kawaihae harbor. The influence of human activity in the water greatly affected the activity level of Kawaihae dolphins when they were in rest areas. This may be due to the fact the resting areas observed at Kawaihae are located right next to the Kawaihae Harbor. Many boats

and kayakers were observed to pass through resting areas during most of the observations. Dusky dolphins also show an increase in social activity after feeding. They will also associate with boats and human swimmers (Würsig and Würsig 1980).

Feeding Areas

Östman (1994) indicated that the abundance of food might be related to school sizes. With the exception of Kawaihae, a bigger feeding is likely to have larger school sizes because there is an abundance of food available for more dolphins (Östman 1994). Starting north at Makako Bay and moving south along the Kona coast, the feeding areas and average number of dolphins decrease. Both Leleiwi and Kawaihae showed low numbers of average schools sizes relative to their feeding areas. Kawaihae may have a large feeding area but there may not be enough food available in this area which would result in a small school size (Östman per. comm.) Kahena is another known rest area for spinner dolphins but not much is known about this area. It has a feeding area of about 74 km². Based on the information from the other feeding areas, I predict that Kahena will have an average school size of about 45 dolphins.

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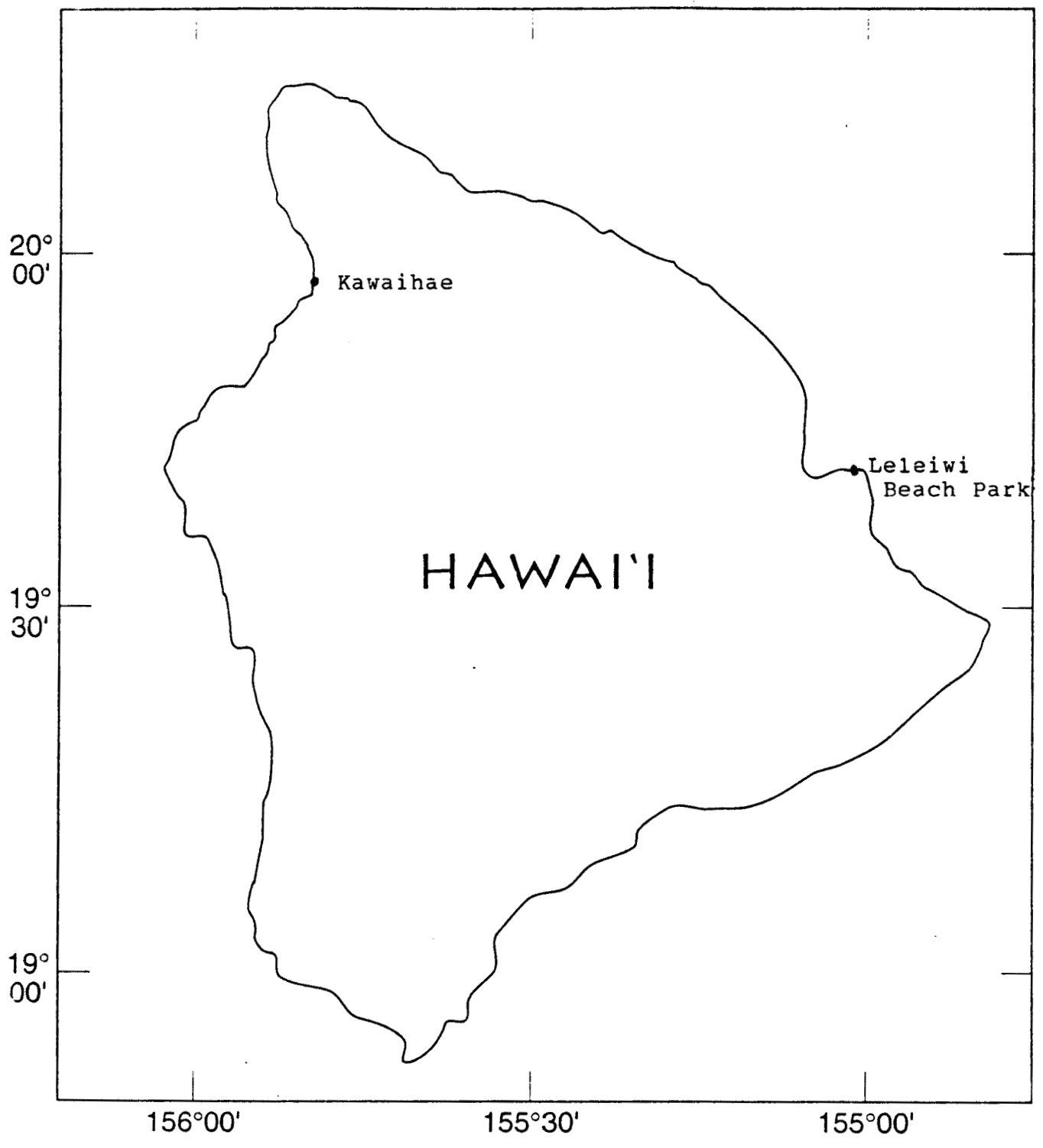


Figure 1.--Map of Big Island, Hawai'i, showing study sites.

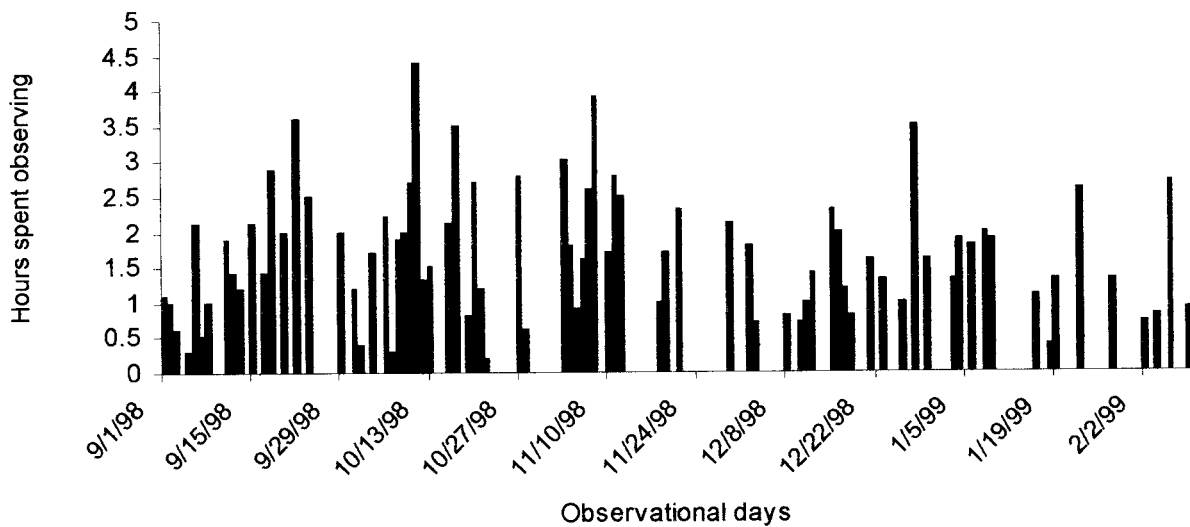


Figure 2.—Total number of hours spent for each observational day at both locations.

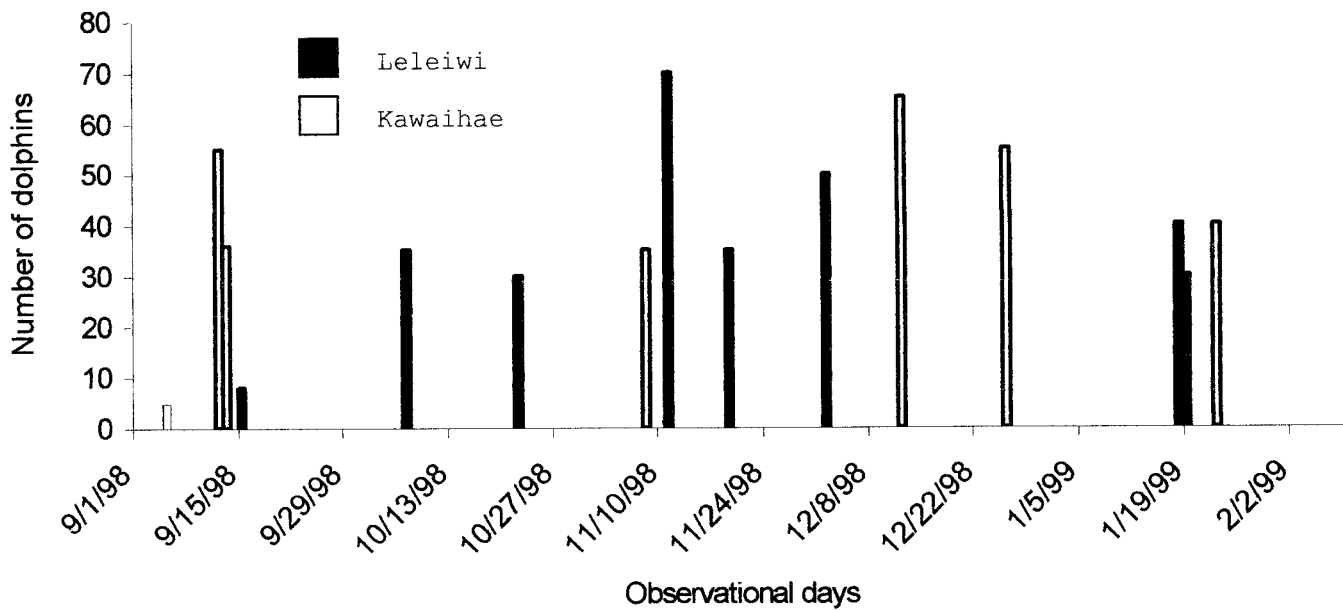


Figure 3.—Number of dolphins at Kawaihae and Leleiwi.

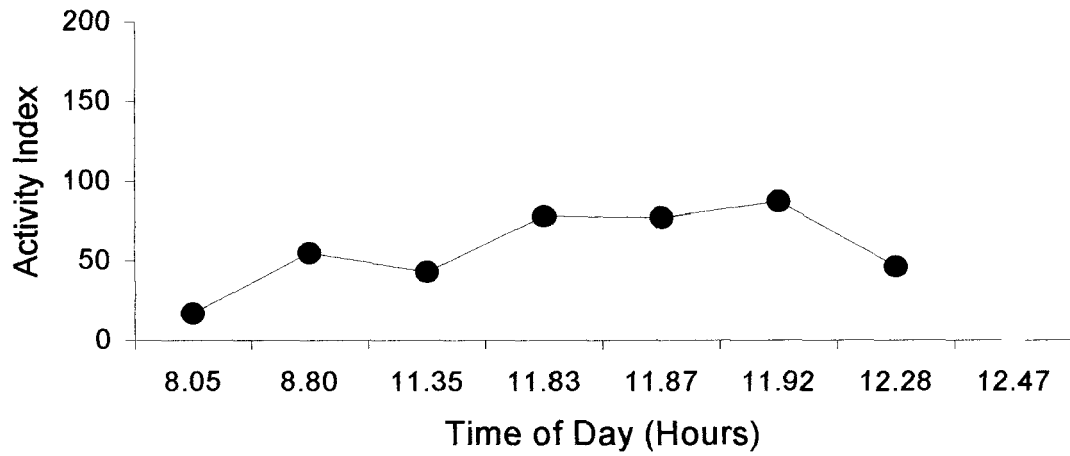


Figure 6.—Behavior of dolphin schools at Leleiwi Beach Park. The Activity Index (AI) indicates amount of energy the school of dolphins put into aerial activity. See text.

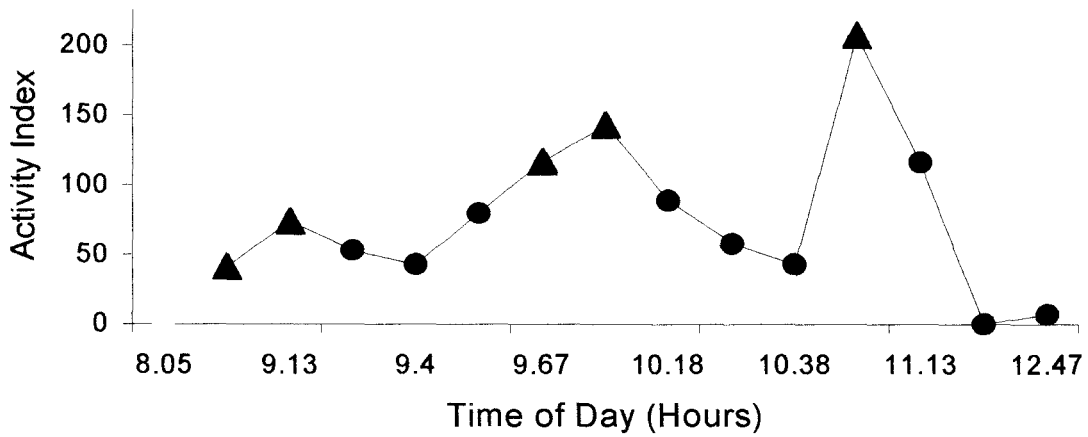


Figure 7.—Behavior of dolphins schools at Kawaihae. The black triangles represent human activity observed near or among dolphins when in rest areas. The Activity Index (AI) indicates amount of energy the school of dolphins put into aerial activity. See text.

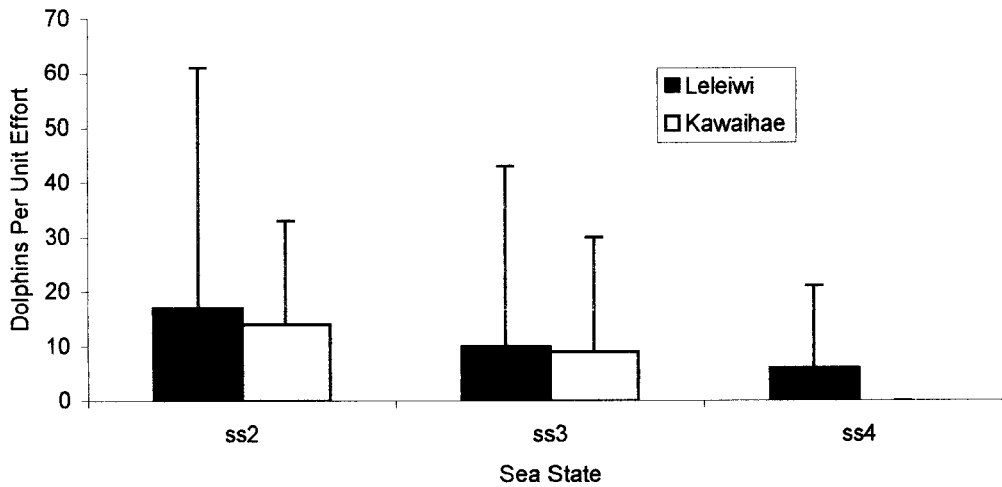


Figure 4.—Number of dolphins/hour by sea state. Lelewi is black and Kawaihae is white.

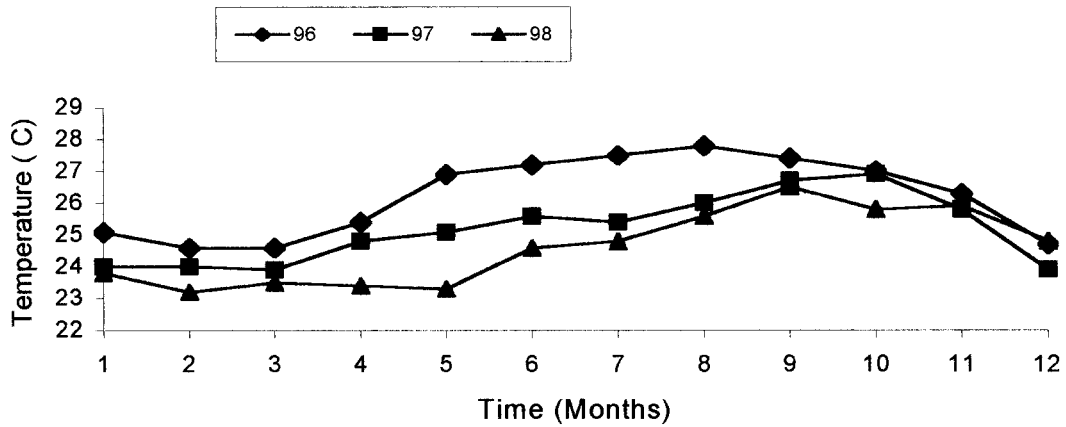


Figure 5.—Average sea surface temperatures taken at The Natural Energy Lab of Hawaii Authority. Each line and symbol represents a different year.

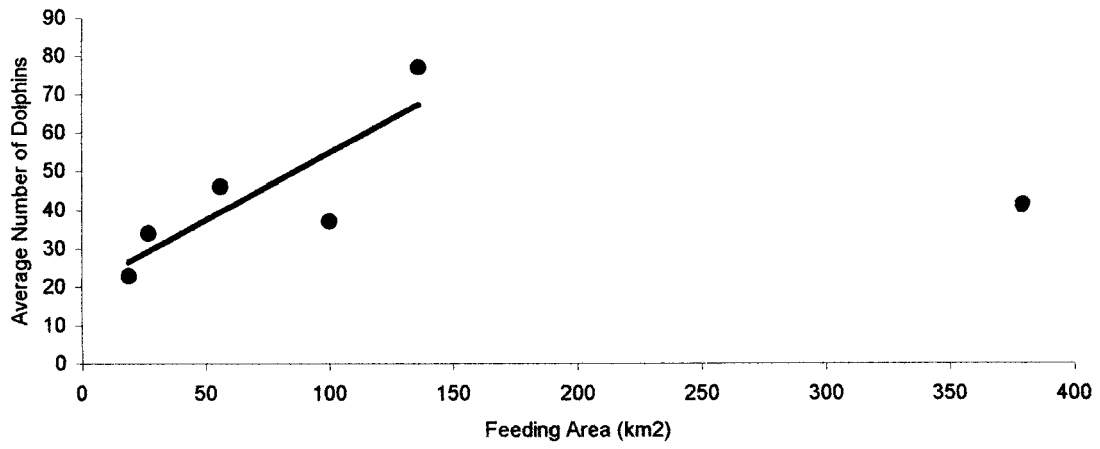


Figure 8.—Feeding area size vs. average school size for rest areas at Leleiwī and along the Kona coast

Tables 1.--Percentage of day's dolphins were sighted.

Location	Hours	Total observed days	Days dolphins present	% days dolphins seen
Leleiwi	81	59	8	14
Kawaihae	40	19	7	37
Total	121	78	15	19

Table 2.--Average number of dolphins seen.

Location	Number of dolphins	Days dolphins present	Average number of dolphins
Leleiwi	298	8	37
Kawaihae	291	7	42
Total	589	15	39

Table 3.--Leleiwi time recordings of observations and dolphin sightings.

Date	Observation began	Dolphins sighted	Dolphins last sighted	End of observation
9/15/98	7:11	8:05	8:12	8:20
10/7/98	6:33	7:27	7:47	8:14
10/22/98	10:58	11:34	11:44	11:55
11/11/98	11:45	11:45	12:27	12:27
11/19/98	10:35	10:55	12:25	12:34
12/2/98	7:45	7:45	9:30	9:30
1/18/98	13:20	13:20	13:45	13:50
1/19/98	10:59	11:10	12:15	12:15

Table 4.--Kawaihae time recordings of observations and dolphin sightings.

Date	Observation Began	Dolphins sighted	Dolphins last sighted	End of observation
9/5/98	7:33	9:55	10:10	12:15
9/12/98	7:53	7:53	9:18	12:15
9/13/98	8:23	8:23	9:41	9:41
11/8/98	8:36	9:09	13:07	13:07
12/12/98	7:34	9:07	10:30	10:40
12/26/98	8:26	8:40	9:37	9:50
1/23/98	8:07	8:27	10:40	11:00

Table 5--Statistical test results of the Spearman Rank Correlation between number of dolphins and weather variables.

Weather Variables	Sample Size	Spearman Rank Statistic	P-Value
Sea State	78	-0.153	0.184
Tides	78	-0.079	0.496
Swell Size	70	-0.137	0.257
Wind	70	0.016	0.893
Direction			
Cloud Cover	78	-0.102	0.375

Table 6.--Feeding area and average school sizes for Leleiwi and four other locations on the Kona coast.

Locations	Feeding Area (km²)	Average school size
Leleiwi	100	37
Kawaihae	377	41
Makako Bay	136	77
Kailua Bay	56	46
Kealakekua Bay	27	34
Kauhako Bay	19	23