THE OCCURRENCE AND DISTRIBUTION OF MARINE MAMMALS ALONG OAHU'S EWA/HONOLULU COAST: A STUDY TO ASSESS POTENTIAL INTERACTIONS BETWEEN HIGH-SPEED FERRY TRAFFIC AND LOCAL POPULATIONS

Prepared for Pacific Marine & Supply Co., Ltd.

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ABSTRACT

The State Department of Transportation and Pacific Marine & Supply Co., Ltd. are testing the feasibility of establishing high-speed ferry service between leeward Oahu and downtown Honolulu. The presence of marine mammals, most notably humpback whales and spinner dolphins, in the area of operation has raised concerns regarding possible interactions with the ferry. A collision with a whale could be fatal for the animal and a risk for the ferry. Spinner dolphins that occupy the area year-round may also be negatively affected. Federal law mandates that steps be taken to mitigate potential hazards to marine mammals. To this end, a study was conducted to learn more about the occurrence of whales and dolphins along the Ewa/Honolulu coast. Ship-based surveys were used to map out distribution patterns over a 200-km^2 area. The results indicate that whales occur in significantly greater densities in waters less than 100 fathoms deep. A bank extending up to 6 km off Barber's Point had the highest concentration of whales. Spinner dolphins regularly occur in the shallow waters (< 50 fathoms deep) between Ewa beach and Waikiki where they spend most of the day resting. Although long-term impacts resulting from the ferry's operation are difficult to anticipate, certain steps can be taken to minimize the risk of an accident and avoid detrimental effects.

INTRODUCTION

The Wiki Wiki Ferry demonstration project is a joint venture between the State Department of Transportation and Pacific Marine & Supply Co. The project's aim is to assess the feasibility of establishing a permanent, high-speed ferry service between communities along leeward Oahu and downtown Honolulu. The "Foilcat", a 95-foot, 136-passenger hydrofoil vessel with a maximum speed in excess of 40 knots began service on October 18th, 1999 and is scheduled to operate for a one-year trial period. The ferry's route was initially set to provide service between Kalaeloa Barber's Point Harbor and Pier 9 at Aloha Tower Marketplace. Two alternate routes departing from Middle Loch and Iroquois Point have since been implemented to increase ridership.

Due to the high speed at which the Foilcat travels, concerns exist about the potential impact the ferry could have on marine mammals along the south shore. Of particular concern are humpback whales (*Megaptera novaeangliae*) known to occupy the area during the winter months, and a population of spinner dolphins (*Stenella longirostris*) resident along the south shore year-round. Although other marine mammals also occur in the area, these two species are believed to be of special concern for the following reasons:

- Humpback whales occur in Hawaiian waters between November and April where they socialize, mate and give birth. When engaged in singing, nursing and/or competition for mates, whales can become very vulnerable to human hazards, as their attention is sharply shifted towards reproductive activities. Their presence in the waters used by the ferry present a collision hazard. A direct strike is likely to be fatal for a whale (especially a calf) and a potential risk to the crew and passengers of the ferry.

- Spinner dolphins are a nocturnally active species with distinct residence patterns along a number of Hawaii's coastlines. Based on their known behavior elsewhere in the state, it is believed that these animals use selected areas along the south shore of Oahu during daytime hours for resting and breeding purposes. During these times, spinner dolphins become vulnerable to predation and human disturbances. While less of a safety threat to the ferry than whales, chronic encroachment into their habitat increases the potential for injury and/or disruption of their behavioral patterns.

Humpback whales are an endangered species protected under the Marine Mammal Protection Act (MMPA) and both State and Federal Endangered Species Acts. In addition, they are a valuable resource of tourist revenue to the State. By law, steps must be taken to minimize potential human threats. Spinner dolphins are also increasingly becoming a valuable tourist attraction for Hawaii and are Federally protected under the MMPA. Any act that has "the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" constitutes harassment (Sec. 3, 16 USC 1362) and is a violation of the MMPA.

To minimize the potential impact of the ferry on both humpback whales and spinner dolphins, a study was conducted to learn more about the occurrence and activities of these animals on and around the site of current and proposed future ferry operations. The study had two primary goals. The first was to map out the distribution patterns of marine mammals along the affected coastline in order to establish where densities are lowest. Humpback whales and spinner dolphins do not distribute themselves randomly, rather they tend to preferentially use and travel through specific areas (Frankel et al, 1995; Norris et al, 1994). By identifying such areas, steps can be taken to avoid direct interaction. The second goal was to identify so called “hot spots” of spinner dolphin activity. Such areas have been recognized along the Waianae coast as important habitats used almost daily by these animals to rest and recover after a night of foraging (Lammers, unpublished data). Identifying such areas along the south shore and defining periods of time during which spinner dolphins are at their most vulnerable is an important first step in mitigating any adverse effects by the ferry.

MATERIALS AND METHODS

The study’s objectives were addressed in two phases of data collection. The first phase was a survey effort directed at establishing a distribution pattern of marine mammals along the Ewa/Honolulu coast that took place between January and March of 2000. The second phase emulated an approach previously employed to study the behavioral ecology of spinner dolphins along the Waianae coast and was conducted between the months of May and July 2000.

Phase 1

Aerial surveys are generally considered to be the most effective means of studying marine mammal distribution patterns. In this study, however, that approach was not a viable option due to the proximity of the Honolulu International Airport and the restricted airspace associated with the study area. A line-transect method using a vessel was employed instead. The survey vessel used was the *Meleana*, a 32’ Grand Banks powered by a 120-hp diesel engine. It has an observation platform 16 feet above the waterline and operates at a cruising speed of approximately 8 knots.

The study area surveyed stretched from Honolulu harbor to Barber’s Point and was divided into two zones distinguished by divergent depth strata. Zone A is a 96-km^2 area characterized by a narrow coastal shelf with a 100-fathom depth contour only approximately 2 km from shore. Zone B is a 104-km^2 area consisting of a large bank less than 100 fathoms (600 feet) deep extending as far out as 6 km. Of the study site’s total area (200 km^2), 115 km^2 are characterized by waters deeper than 100 fathoms while 85 km^2 are shallower.

A saw-tooth transect pattern was created to maximally cover each zone within a period of approximately three hours (Fig. 1). The duration of surveys was limited in order to minimize any confounding effects introduced by diurnal variations in the distribution patterns of animals (Helweg and Herman, 1994) and changing sighting conditions. On a typical tradewind day (ENE winds at 10-20 mph) surface conditions usually deteriorate along the Ewa/Honolulu coast with increasing distance from shore and as the winds strengthen through the day. Therefore, transect legs were placed so as to intersect the ferry’s route at various points along the way while maintaining consistency in the ability to sight animals.

Transect A was composed of six legs ranging from 5.0 to 7.1 km in length (mean = 6.2 km; total transect length = 37 km), while transect B had five legs between 3.1 and 7.5 km long (mean = 6.0 km; total transect length = 30 km). The two transects provide a comparison between an area characterized by mostly deep water (Zone A, > 100 fathoms) and one with comparatively shallower waters (Zone B, generally <100 fathoms). Zone A can thus be considered indicative of what might be found in offshore waters beyond the limits of Zone B. However, to further investigate deep waters, four north/south 1.8-km extensions added to legs 3, 5, 7 and 9 were surveyed on days that conditions would allow it. Each zone was surveyed on separate days shortly after sunrise, always beginning with the easternmost leg and moving westward. This pattern was followed A) to coincide as much as possible with the ferry's first two runs of the day (at 5:30 AM and 7:30 AM) and B) to optimize sighting conditions by placing the sun's glare mostly behind the observers. Surveys were scheduled when forecasted winds for the day were no stronger than 10-25 mph and were continued as long as Beaufort Sea State conditions remained less than 4.

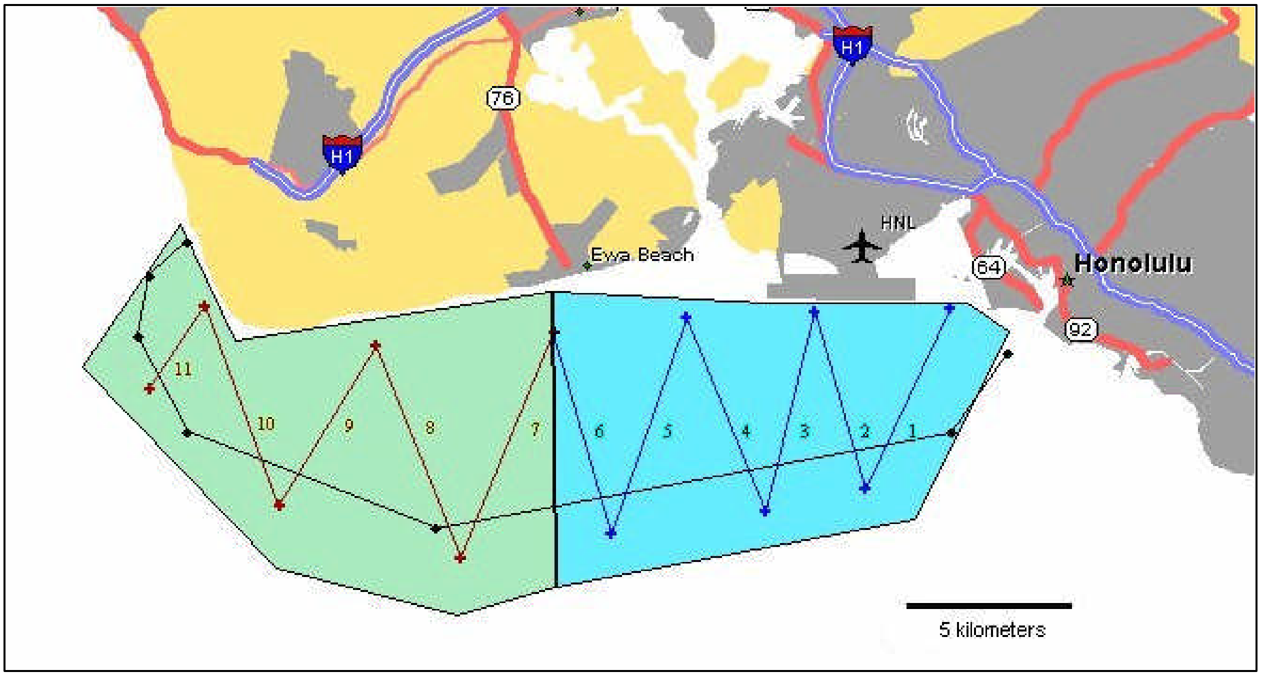

Figure 1 – Study area showing zone A in blue on the right and zone B on the left in green.

Sighting information was also collected while travelling to the beginning of transect B and while returning to Keehi harbor. These data, however were considered "off-effort" and were treated separately from "on-effort" data obtained during transects.

A total of 11 project personnel and volunteers took part in phase 1 of the project. Each survey's crew consisted of either 3 or 4 individuals. Two observers stationed on each side of the vessel's flying bridge scanned the waters 90° to either side of the vessel's bow. A boat driver navigated the vessel along the transect's path using a course pre-programmed into a Garmin 45 Global Positioning System (GPS). A data recorder collected reported positional and environmental information every 10 minutes, as well as sighting information when prompted by the observers (see Appendix 1). Communication between the observers on deck and the data recorder and boat driver in the cockpit below was achieved via two-way radios. Depth information was obtained from a Furuno FCV-582L depth finder. On days when only three individuals were available, the boat driver fulfilled the duties of the data recorder.

When a sighting was made the vessel was slowed from a survey speed of 7-8 knots to approximately 3 knots. The observer who made the sighting reported the species, the number of animals sighted, their bearing relative to magnetic north (using a ViewScope's digital bearing meter) and an estimated distance from the vessel. Each observer practiced distance estimation on the water using a ViewScope's rangefinder function prior to participating on a survey. To account for individual bias, each observer's estimating skill was calibrated by testing him or her with known distances to buoys at various ranges (measured using GPS positioning). A regression plot with a calibration function could thus be obtained for each observer and team of observers (for cases when a collective judgement on distance was made). Whales were never purposely approached closer than the 100-yard limit dictated by Federal law. When a whale's initial sighting was within 100 yards of the vessel, the engine was place in neutral gear until the whale had moved beyond 100 yards away.

Phase 2

The second phase of data collection was geared towards documenting the near-shore behavior of spinner dolphins along the Ewa/Honolulu coast. The method used had been previously developed to learn about the coastal use patterns of spinner dolphins along Waianae.

Mechanical problems prevented the use of *Meleana* during phase 2 of the study, so an 18' Boston Whaler powered by twin 70 hp engines was employed instead. Based on sighting information obtained from phase 1, a predetermined search pattern was adopted to seek out pods of spinner dolphins between the entrance buoy to Honolulu Harbor and Barber's Point (Fig. 2). On average, searches were begun at approximately 7:30 AM. Two observers scanned either side of the vessel for signs of dolphins while the boat driver navigated the search route using a GPS at a speed of approximately 9 knots (± 1 knot).

Upon encounter of a spinner dolphin group, one of the observers would note into a tape recorder: the group's position, an estimate of the number of animals present (within ± 5), environmental information (sea state, wind, nearby human activities) and a series of behavioral observations used to calculate a Behavioral Index. The Behavioral Index is a metric that was developed to describe the relative level of activity of a spinner dolphin group using three measures: the degree of coordination between individuals, the duration of dives and the amount of surface activity displayed. Each measure is defined as follows:

Coordination Index (C.I.): Group coordination is classified into three types. *Type I* – A group composed mostly of animals in pairs, triplets and alone swimming without much cohesion with one another (C.I. = 1). *Type II* – A core group of animals moving in a synchronized fashion with a number of individuals continuing to swim independently on the periphery (C.I. = 2). *Type III* – All animals within the group integrated into a tight cohesive unit (C.I. = 3).

Diving Index (D.I.): Dive patterns are timed and classified by observing marked individuals from the beginning of one surfacing event (often composed of consecutive breaths) to the beginning of the next. Dive intervals are classified as either *Short* – lasting less than one minute (D.I. = 1), *Medium* – lasting between 1 and 2 minutes (D.I. = 2), or *Long* – lasting longer than 2 minutes (D.I. = 3).

Aerial Index (A.I.): The surface and aerial acrobatic behaviors displayed by the group are catalogued during a five-minute sampling period using a customized ethogram. Behaviors are classified according to their relative level of intensity and/or by the function they are believed to play. An index ranging from 0 to 2 is calculated for each group based on the average number of behaviors observed per animal.

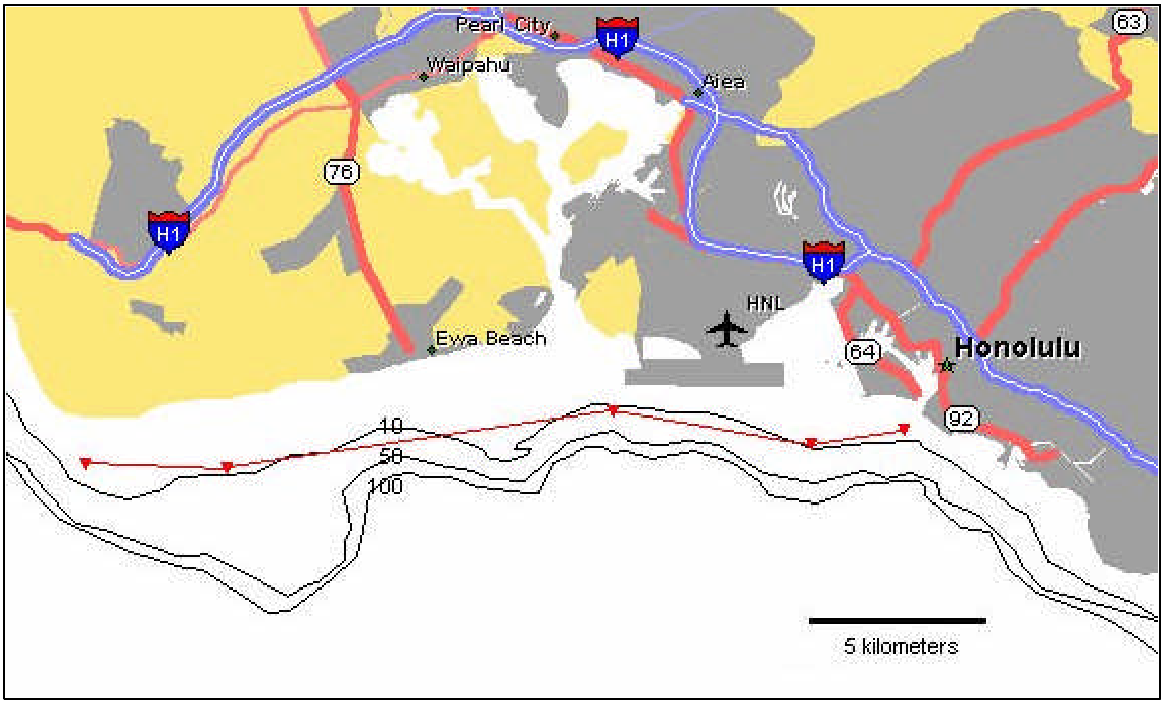

Figure 2 – Search pattern used to find spinner dolphins along the south shore during phase 2 of the study. Triangles represent GPS waypoints used to navigate the route. Contours mark the 10, 50 and 100-fathom isobaths.

Alert and socially interactive spinner dolphin groups are characterized by loose swimming formations, frequent surfacings and numerous aerial acrobatics. Conversely, resting groups form tight clusters, dive for long periods and suppress most surface behaviors. The Behavioral Index (B.I.) offers a means of quantitatively following the shifts in behavioral state of a group of spinner dolphins through the day. It is calculated using the following equation:

$$B.I. = C.I. + D.I. - A.I.$$

The result of this equation is a value ranging between zero and six. Low behavioral indexes, are representative of alert, socially active groups, while higher indexes indicate progressively more subdued groups. At a maximum behavioral index of six all the animals are tightly grouped and coordinated to the point of synchrony.

Spinner dolphin groups being tracked were flanked or followed at a distance of 100 to 500 meters. Following an initial period of habituation to the research vessel, most groups appeared to allow the vessel's presence nearby without displaying any overt avoidance reactions (i.e. significantly breaking from their pattern of movement and/or behavior). While tracking a group of dolphins, an observer would sample the animals' behavior every 30 minutes. If the group moved out of the study area it would continue to be tracked because of the possibility that it might re-enter the area again later. A group was tracked until it could no longer be sighted or followed due to poor surface conditions, cryptic behavior by the animals (i.e. during rest or while foraging in deep waters), or a combination of the two.

RESULTS

Phase 1

Twenty surveys were conducted of the study area between January 13th and March 29th. Ten surveys were made of zone A and ten of zone B. Two surveys of zone B were aborted prior to their completion due to unworkable surface conditions. The mean Sea State encountered in zone A was 1.62 (SD = 0.83), while in zone B it was 1.75 (SD = 0.80). A total of 53 on-effort whale sightings were made between the two zones. Of those, five were deemed re-sightings of a previously sighted animal by the observers and were not counted or plotted. Three sightings were of animals estimated to be more than 2000 m away from the vessel. Since observer calibration functions were unreliable beyond estimated distances of approximately 2000 m, these three sighting were counted but not plotted.

Figure 3 shows the distribution of all plotted on-effort sightings. Of a total of 48 counted sightings, 15 were in zone A and 33 were in zone B. This difference deviates significantly from an expected equal ratio (Chi-square test; $\chi^2 = 6.15$; DF = 1; p = 0.013). Whales were considerably more likely to occur in zone B than zone A.

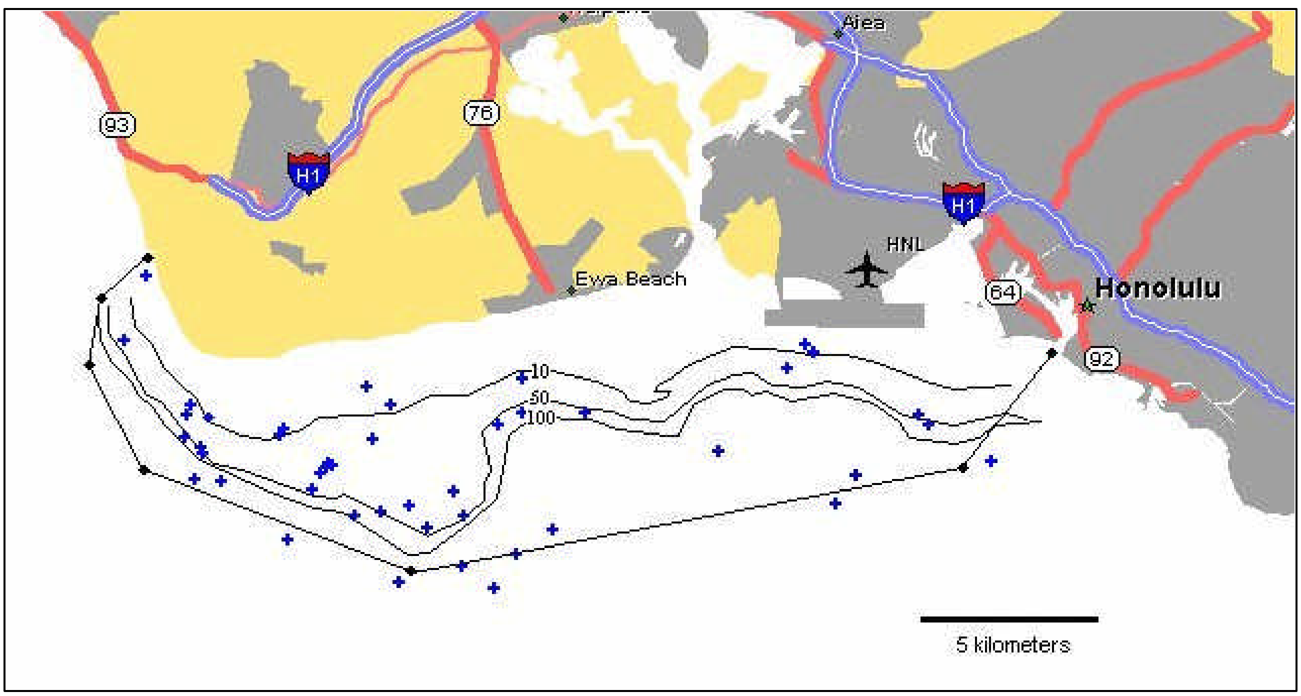

Figure 3 – Plot of on-effort whale sightings with respect to the ferry route and the 10, 50 and 100 fathom depth contours. A blue cross marks each sighting made.

The median depth measured while on surveys in zone A was 1105 feet (N = 179), while in zone B it was 495 feet (N = 136). This represents a statistically significant difference between the two zones (Mann-Whitney test; $p = 0.0051$). Between both zones, 73.3% of sightings were of whales in water less than 100 fathoms deep. The densities of whales sighted were 0.10 whales/ km^2 for the area of the study site with waters deeper than 100 fathoms and 0.39 whales/ km^2 in the waters less than 100 fathoms deep. This represents a significant deviation from an equal distribution (Chi-square test; $\chi^2 = 17.631$; DF = 1; $p < 0.001$). In all, 53.3% of whales were sighted within 1 km on either side of the 100-fathom contour, 31.1% were further inshore and 15.6% were further offshore.

The 1.8-km extensions to legs 3, 5, 7 and 9 could each only be surveyed on three occasions. On most days, conditions became too poor offshore to yield data useful for comparison to the near-shore transects. In all, only one whale sighting and one spotted dolphin sighting were made between all the extensions combined.

The mean group size sighted was 1.58 whales per group (SD = 0.75). A comparison of the median water depth for mother/calf pair sightings (144 feet, N = 7) to the median depth of single animal sightings (300 feet, N = 14) yielded a difference closely approaching statistical significance (two-tailed, 1-sample Wilcoxon test; $p = 0.052$).

Figure 4 shows the distribution of off-effort sightings made while traveling close to shore on the way to and from the harbor. The path taken varied somewhat depending on conditions but was generally between the 10 (60 feet) and 50-fathom (300 feet) depth contours. Although the plot suggests that whales occurred more in the shallow waters of zone A than zone B, the reverse is actually true. When the total time spent crossing each zone is factored in, an average of 1.44 whales per hour were sighted passing through zone B compared with only 0.65 whales per hour in zone A.

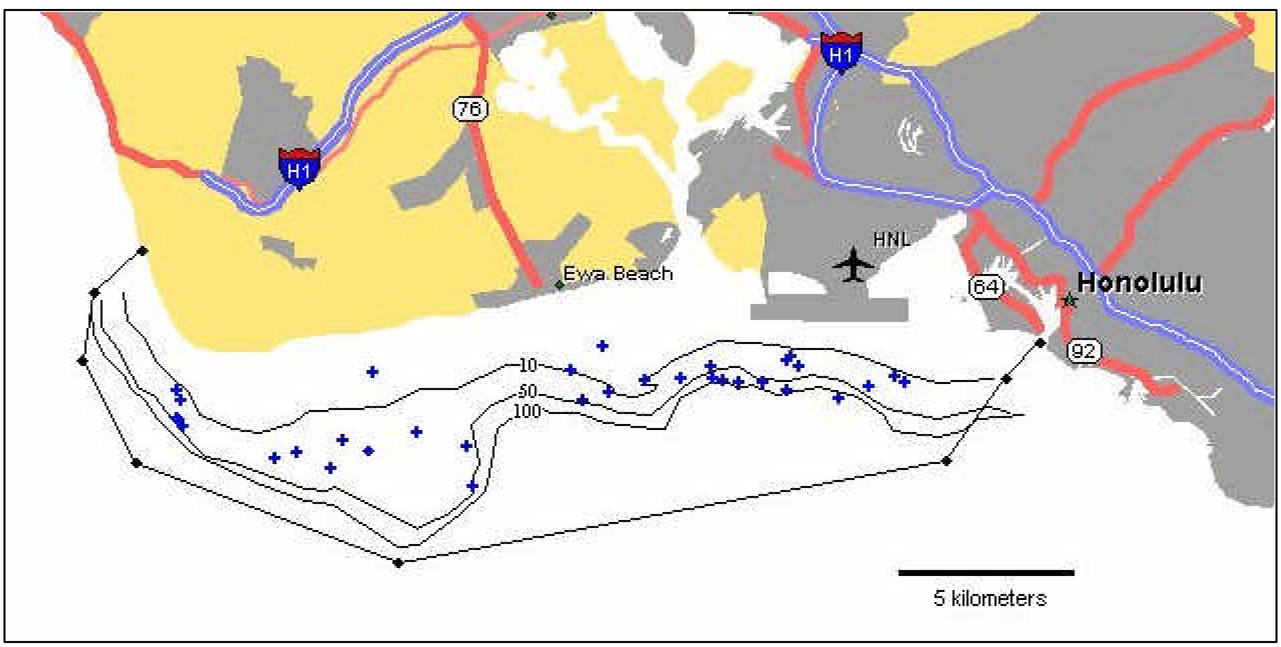

Figure 4 – Distribution of off-effort whale sightings made relative to the ferry route and the 10, 50 and 100 fathom depth contours. A blue cross marks each sighting made while traveling to or from Keehi harbor prior to or following a transect.

On-effort dolphin sightings were considerably less frequent than whale sightings. Figure 5 shows the distribution of dolphins encountered by species. Sample sizes are too small to make formal inferences, but some basic trends can be observed. Bottlenose dolphins (*Tursiops truncatus*) had the most varied distribution. Sightings were made in both deep and shallow waters at various hours of the morning. Group sizes averaged 7.6 animals (N = 5). Their behavior ranged from traveling to feeding on at least one occasion while in deeper waters off the Barber's point bank. Pantropical spotted dolphins (*Stenella attenuata*), were sighted exclusively in deeper waters. Their group sizes were considerably larger, averaging 43 animals (N = 3). Feeding behavior was also suspected on at least one occasion along the western edge of the bank. Finally, spinner dolphins were encountered four times, always close to the 10-fathom contour. Group size averaged 34.5 animals. Spinners were always found either traveling along the coast or showing clear signs of resting behavior (long dives, clustered groups).

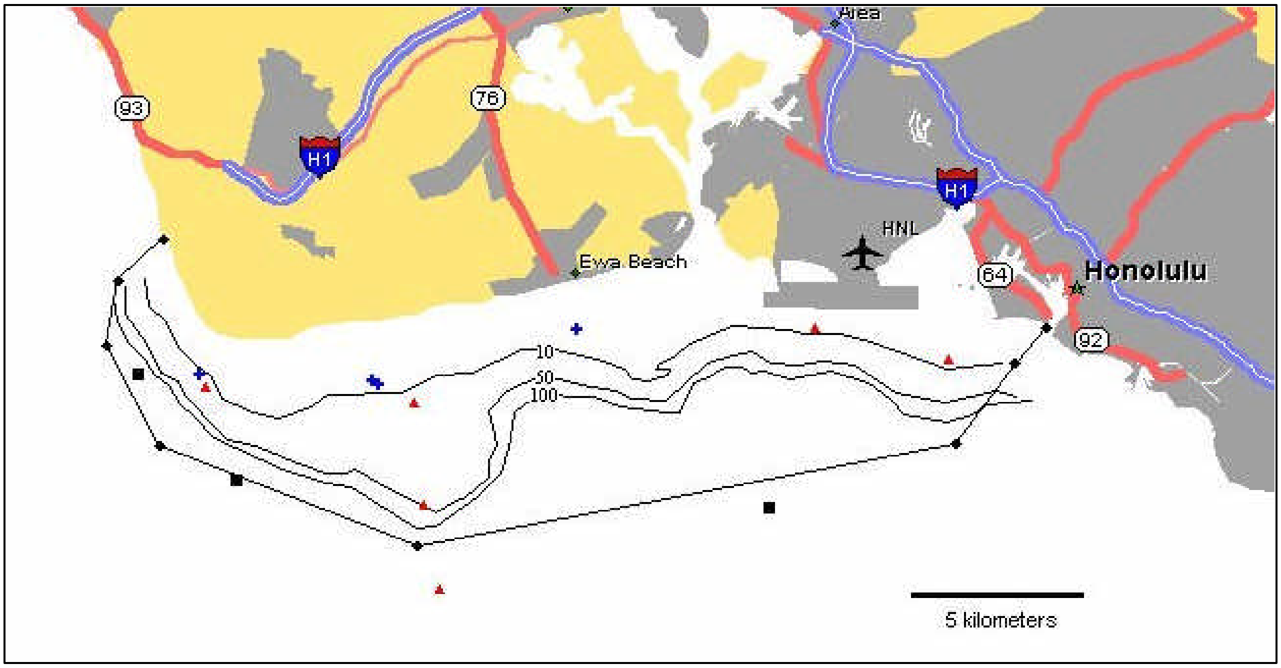

Figure 5 – Distribution of on-effort dolphin sightings made during phase 1 transects. Triangles represent bottlenose dolphins, squares are spotted dolphins and crosses indicate spinner dolphins.

The plot of off-effort encounters of dolphins (Fig. 6) provides a better perspective of spinner dolphin occurrence along this coast. A total of 20 spinner dolphin sightings were made, of which 19 were in zone A. This corresponds to 0.66 sightings per hour in zone A and only 0.11 sightings made per hour in zone B. Only one group of 15-20 bottlenose dolphins was encountered while off-effort. It appeared to be associated with a pod of six whales traveling west. On March 3rd a rare sighting of false killer whales (*Pseudorca crassidens*) was made while returning to the harbor from transect B. The group of approximately 30-35 animals was followed for about an hour as they traveled west and fed on tuna (fish were actually seen being shared by individuals).

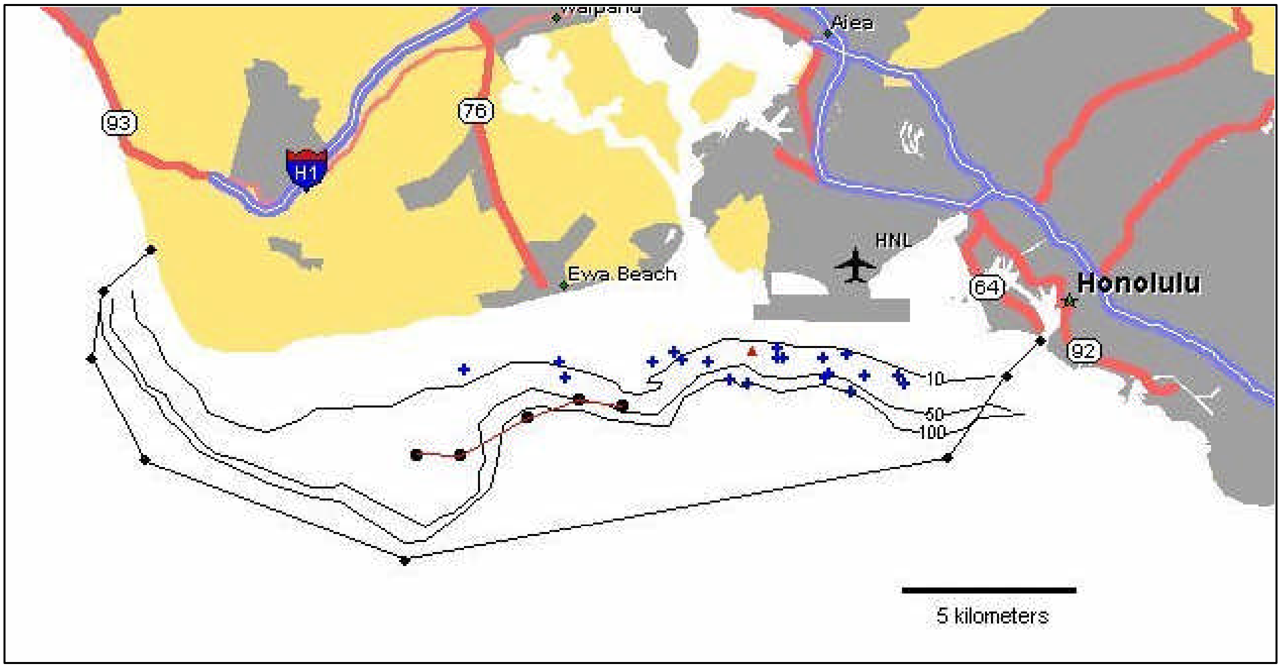

Figure 6 – Distribution of off-effort sightings of dolphins made while traveling to or from Keehi harbor. The triangle denotes a group of bottlenose dolphins, crosses are for spinner dolphins and the circles connected by a red line represent a one-hour follow of a group of false killer whales.

Phase 2

Limitations tied to the use of the alternate research vessel (availability, weather) restricted the number of surveys made between May 29th and July 12th to nine. Spinner dolphin groups were found and tracked on six occasions, representing a 67% encounter rate. The search route from Honolulu harbor to Barber's point was covered in its entirety both ways without encountering any dolphins four times. On one of these occasions the dolphins were found near Kewalo basin following a complete search of the study area. The average group size upon initial encounter was approximately 65 animals (SD = 23.5), but fluctuated through the day as groups fused and fragmented. The average duration of a track was 5 hrs and 05 min (SD = 2.16).

The behavioral index patterns of spinner dolphin groups measured during daytime hours over a four-year period indicate a significant shift towards a resting state between approximately 11 AM and 3 PM (Lammers, unpublished data). The hours before this (8 - 10 AM) are characterized by a period termed "descent into rest" (Norris et al, 1994), during which individuals in a group gradually transition from being in an interactive social state to becoming highly coordinated members of a vigilant, but subdued dolphin cluster. The data collected during the six tracks made in this study conformed to this pattern. Four examples are presented below to illustrate the way spinner dolphins occupy and move along the south shore.

Track B – June 2nd, 2000 (Fig. 7)

A group of approximately 80 animals traveling east was encountered off the airport runway at about 8:30 AM. The group was composed of several subgroups, each displaying varying levels of activity. Subgroup affiliations of individuals appeared to be relatively fluid, so the entire group was sampled as a unit. The behavioral index was calculated to be 3.4, suggesting a moderately active group. As the dolphins progressed eastward, the subgroups began to separate and the behavioral index gradually increased. Off Waikiki, at approximately 11:30 AM most of the original group appeared to have rejoined. About 30 animals continued their eastward journey, presumably leaving the rest behind them. This group rounded Diamond Head and entered a pattern of very subdued activity, suggesting "deep" rest (Norris et al, 1994). The behavioral index remained at 6 as the animals progressed east towards Koko Head. The dolphins were lost from sight at about 3 PM.

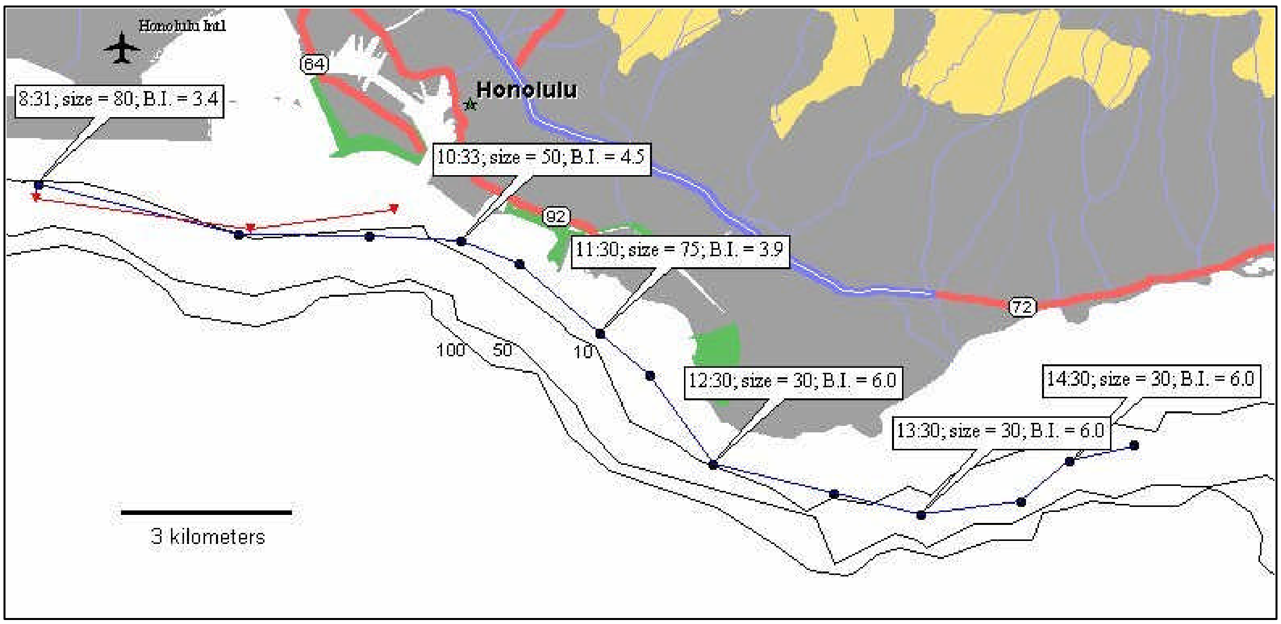

Figure 7 – Spinner dolphin track made on June 2nd, 2000. Red triangles connected by a line represent the search route followed prior to encountering the animals. Each cross denotes a GPS waypoint obtained approximately every half-hour.

Track D – June 9th, 2000 (Fig. 8)

A group of approximately 75 animals was found just off the Pearl Harbor channel entrance at approximately 8:40 AM. As in track B, the group was slowly moving eastward. At about 9:40 AM the animals became fairly active (B.I. = 2.8) and began milling in front of the airport runway. Then, shortly before 11:00 AM, two subgroups totaling roughly 45-50 animals began moving eastward again, leaving the remaining animals behind. This group was followed as it progressed first towards Honolulu Harbor, then to Waikiki. Behaviorally, the animals gradually became more restful with time. The group was lost at 2:10 PM when they traveled around Diamond Head and entered rough waters.

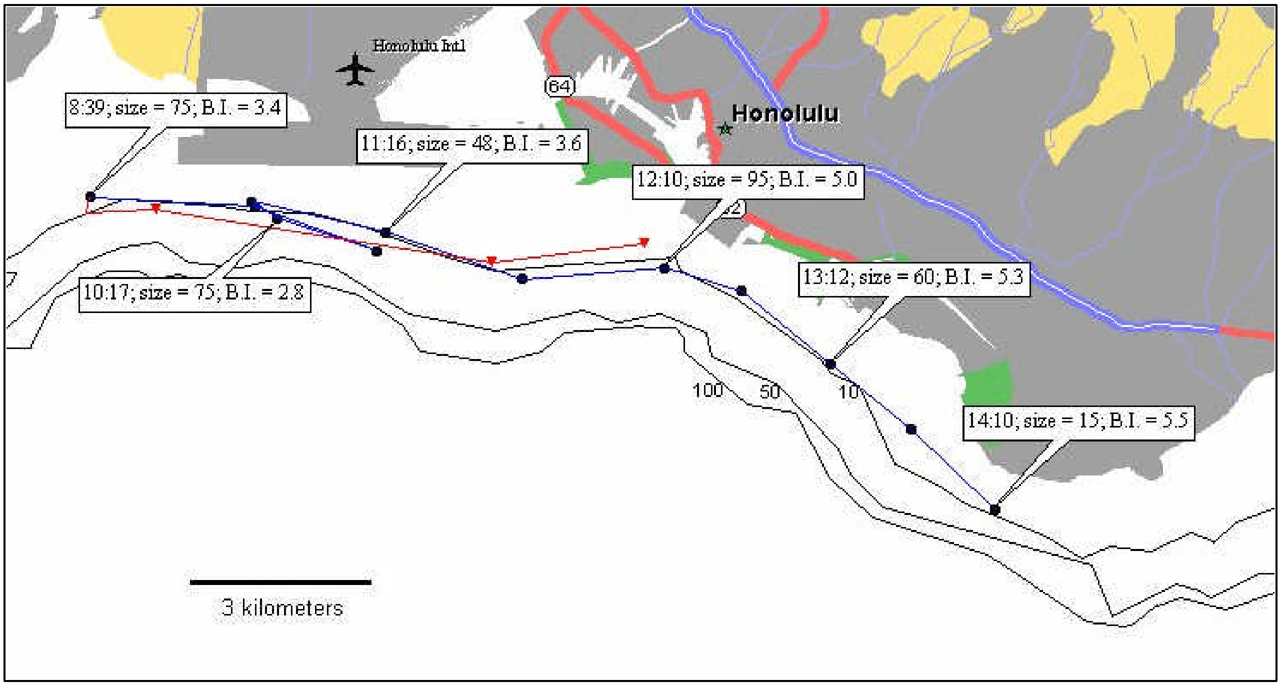

Figure 8 – Spinner dolphin track made on June 9th, 2000. Red triangles connected by a line represent the search route followed prior to encountering the animals. Each cross denotes a GPS waypoint obtained approximately every half-hour.

Track E/F – June 20th, 2000 (Fig. 9)

A very large group of close to 100 animals was encountered off Ewa beach shortly before 9:00 AM. Several subgroups showed signs of resting behavior as they milled about a fairly restricted area. This pattern continued until, at approximately 10:45 AM, a sudden separation occurred resulting in about half the animals leaping rapidly to the west and the other half rapidly swimming east. The abruptness of this event gave one the impression that something unexpected had occurred, such as a shark attack. This, however, could not be confirmed. The group that moved to the west was quickly lost, while the eastbound group was found again two kilometers from the point of separation in a relatively alert state (B.I. = 2.8). Surface conditions were quite rough on this day (Sea State 3 – 4) and the dolphins were lost shortly before 1:00 PM.

Track H – June 21st, 2000 (Fig. 10)

The entire westbound search route was completed before finding a group of 30 dolphins off Ewa beach at 11:15 AM during the eastbound return. As was the case on each previous day, this group also traveled east. These animals, however, did not show strong signs of resting behavior (B.I. = 2.5 – 2.8) until they were met by another group of about 25 animals at around 2:00 PM. The two groups followed one another closely and proceeded to go into rest as they traveled from Honolulu Harbor to the Waikiki area. Resting ceased rather abruptly at approximately 4:30 PM when the animals began rapidly moving westward and spreading out over a large area (2-3 km^2). Shortly after 5 PM the animals were lost after they started doing long dives in deep water, presumably as they began to forage.

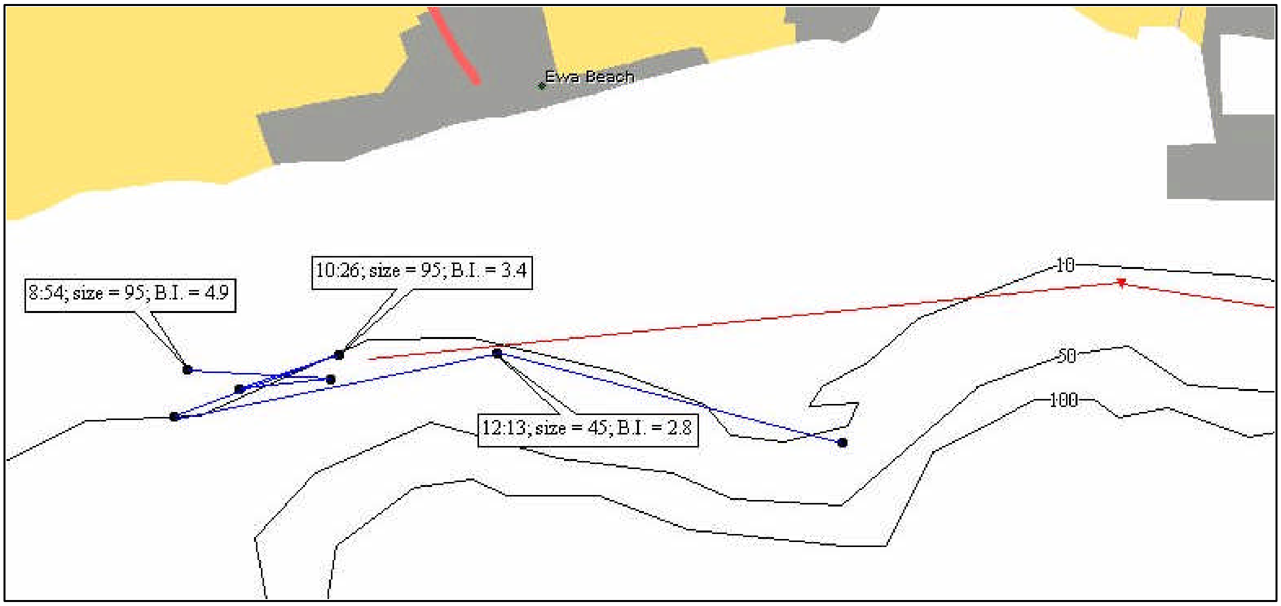

Figure 9 – Spinner dolphin track made on June 20th, 2000. The red triangle connected by a line represents the search route followed prior to encountering the animals. Each cross denotes a GPS waypoint obtained approximately every half-hour.

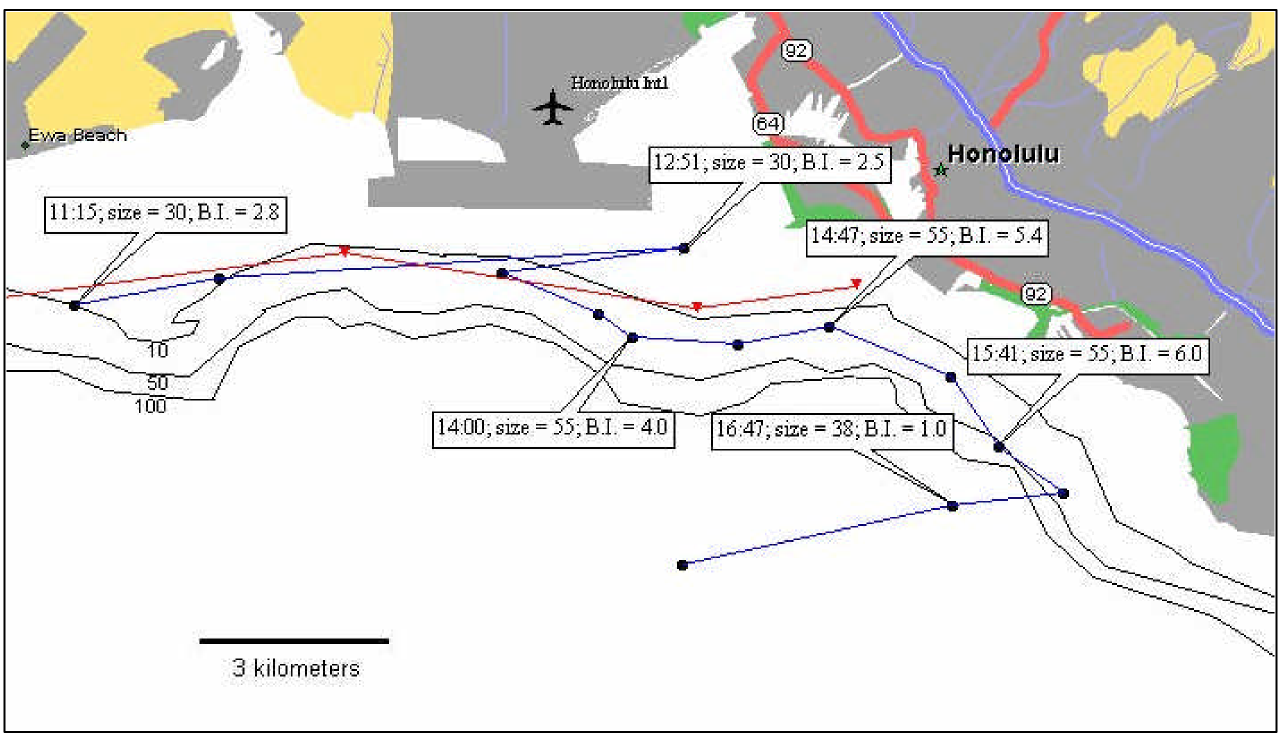

Figure 10 – Spinner dolphin track made on June 21st, 2000. Red triangles connected by a line represent the search route followed prior to encountering the animals. Each cross denotes a GPS waypoint obtained approximately every half-hour.

Two main patterns of behavior stand out from the data collected. The first is that spinner dolphins, whether milling or traveling, appear to strongly associate with waters on or close to the 10-fathom depth contour during the morning and afternoon hours. Some of their tracks appear to follow this mark almost precisely. This may represent a predator avoidance strategy that limits the ability of sharks to attack from below while the group is most vulnerable (i.e. during rest). Another pattern is the tendency to travel from west to east along the south shore. Figure 11 shows a regression plot of all the recorded longitude positions obtained during spinner dolphin tracks relative to the time of day they occurred. An r^2 value of 0.41 suggests that a pattern is there, but that quite a bit of variability is also present.

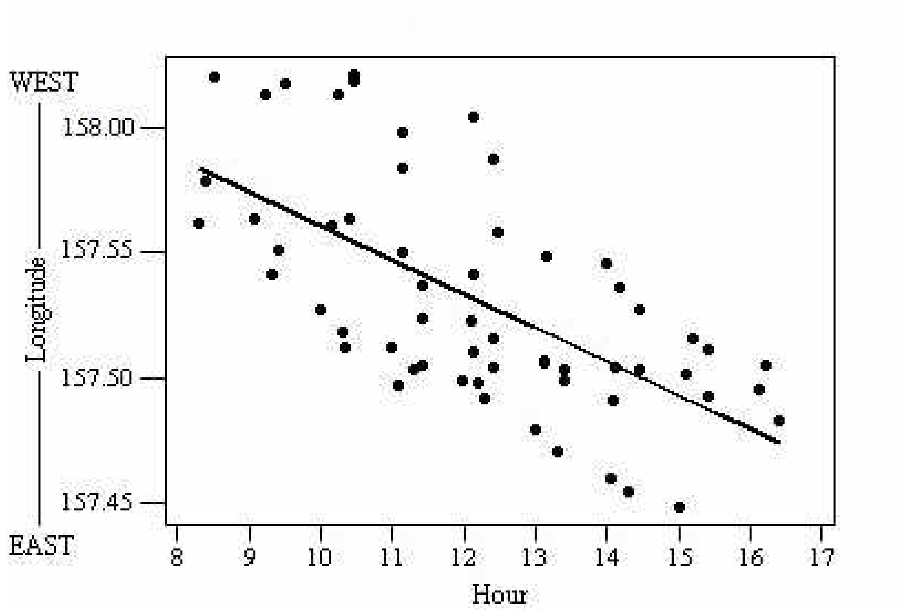

Figure 11 – Longitude (in degrees and minutes) of all the spinner dolphin groups tracked vs. time of day. Between 8 AM and 4:30 PM spinner dolphins tend to move from west to east along the Ewa/Honolulu coast.

DISCUSSION

Natural History

The data collected in both phases of the study reveal that marine mammals along the coastline affected by the ferry do not distribute themselves randomly. The higher occurrence of whales in water shallower than 100 fathoms is in agreement with the findings of previous studies on whale distribution patterns in Hawaii (Herman and Antinoja, 1977; Mobley et al, 1994). It's been suggested that mothers and calves seek out shallow waters to obtain greater protection from predators such as sharks, killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*) and pygmy killer whales (*Feresa attenuata*) (Smultea, 1994). It's also been proposed that male singers may benefit from acoustic properties created by bathymetric features conducive to the propagation of their song (Frankel et al, 1995; Mercado and Frazer, 1999). These hypotheses may help explain why whales occurred with greater frequency in the shallower waters of zone B than in zone A. The bank extending out from Barber's Point is the primary feature creating this effect. The finding that a majority of sightings occurred close (within 1 km of the 100-fathom contour) to the slope of the bank suggests a preference, by at least some whales, for certain bathymetric features.

Local acoustic characteristics may be one explanation for such a bias. Female choice of habitat might offer another explanation. If females preferentially use a particular area, males are likely to follow. Alternatively, the whales may simply have been avoiding the industrial ship traffic occurring close to the center of the bank on most days (tankers unloading their oil cargo at the mooring buoys off Campbell industrial park).

The distribution of dolphins observed was consistent with what is know about their natural history. Spotted dolphins, generally considered to be daytime feeders, occupied the deeper waters off the bank where their prey is likely to be in greatest abundance. Bottlenose dolphins tend to be one of the more generalist dolphin species, often feeding opportunistically on a variety of prey. This was consistent with their diverse distribution within the study area. Spinner dolphins, which feed almost exclusively at night, were only found in shallow waters, consistent with their tendency to rest during the day.

The behavior of spinner dolphin groups tracked along the south shore suggests that these animals use the area between Ewa beach and Honolulu Harbor for resting and socializing purposes most of the time. The fact that no dolphins were found in the area on three surveys indicates that they probably use other areas as well. The variability in their occurrence may be tied to fluctuations in the distribution of their prey, predominant weather conditions, or some other variable not readily observed.

Ferry Interactions

Short of a direct strike, the effect of current and proposed future ferry operations on the biology of whales in the area is difficult to predict. Au and Green (2000) demonstrated that the noise levels of several whale watching vessels operating in the Maui area were negligible compared to the levels produced by chorusing whales. No data is currently available on the noise levels produced by the ferry to establish whether a sufficient masking effect on songs is present to alter the behavior of whales. Nearby vessel traffic can influence the short-term behavioral patterns of whales (Bauer, 1986), but it is difficult to say what level of ferry traffic would induce long-term changes in the use of this particular habitat.

The most imminent danger posed by the ferry's operation results from the speed at which the vessel travels. The current ferry route (from Kalaeloa Barber's Point Harbor to Honolulu Harbor) has three zones where the possibility of a direct strike or close encounter with a whale is highest (Fig. 12). Two of these are at the entrances to both harbors when the ferry crosses shallow waters. The third is along the western and southern edge of the Barber's Point bank, where the ferry parallels the 100-fathom depth contour less than a kilometer away. The data suggest that the likelihood of a close encounter or strike diminish with increasing distance from the bank. Even so, the risk is never entirely absent. Ultimately, the ability to sight animals in advance and maneuver around them when necessary is the key factor in preventing a collision. Avoiding high-density areas of whales can only reduce the danger, not eliminate it. It should be noted that data from another study indicate that the population of wintering humpback whales in Hawaii is on the rise (Mobley et al, 1999). If this trend continues, waters on and around the Barber's Point bank will likely become more crowded with whales, presenting a greater hazard to the ferry.

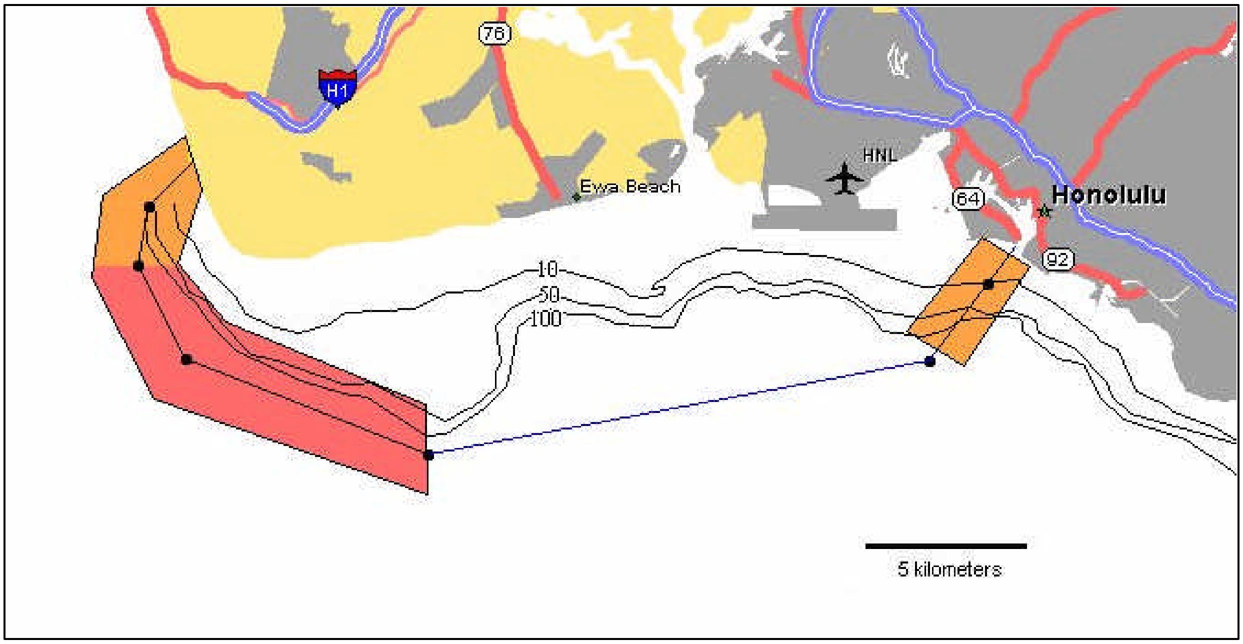

Figure 12 – Plot of the ferry route relative to the 10, 50 and 100-fathom depth contours. Zones of greatest concern with respect to marine mammals are the entrances to the two harbors (shaded in orange) and the southwest edge of the Barber's Point bank (shaded in red).

Unlike whales, which are likely to only transit through the study site or occupy it temporarily (Mate et al, 1998), spinner dolphins are yearlong residents. While generally more agile and capable of rapid movements in response to the ferry, it cannot be assumed that they will be unaffected by its operation in their habitat. Their occurrence in waters heavily navigated by commercial, industrial and private vessels suggests a certain amount of tolerance towards nearby boats and ships. However, none of these other vessels travel at 40 knots. The ferry has the unique ability to happen upon a group of resting spinner dolphins without providing them with much of an opportunity to move out of the way. Such an occurrence has the potential to injure, separate or scatter the members of a group, thereby exposing them to greater predation risks. Repeated or chronic occurrences can raise stress levels, which could impact reproductive cycles. Federal law prohibits a vessel from knowingly cutting through a pod of dolphins of any species. Operators of the ferry should be made aware of this fact and be instructed to take appropriate measures to avoid such an act.

The data show that spinner dolphins are a regular occurrence both near Pearl Harbor and just off the Honolulu Harbor channel entrance. Resting behavior appears to be tied more to the time of day than specific locations along the study site. Present ferry operations restricted to early morning and late afternoon runs probably do not interfere with the ability of spinner dolphins to effectively use the near-shore coastline. However, additional ferries or scheduled runs departing from the Middle Loch and/or Iroquois Point locations, especially towards the middle of the day, could have a more significant effect on this population. Disturbances that are chronic could well cause changes in the dynamics of the population.

RECOMMENDATIONS

Given the evidence presented, four recommendations can be made regarding the ferry's operation along the Ewa/Honolulu coast. They are as follows:

1. During whale season, the route taken around Barber's Point should maintain the maximum distance possible from the edge of the shallow bank. This will serve to create a buffer zone between the ferry and the area containing the highest density of whales.

2. The ferry should transit through the shallow waters off both harbors with extreme caution, preferably not reaching full speed until in deeper waters.

3. When encountering a pod of dolphins the ferry should be maneuvered around it or, if in a restricted channel entrance, be slowed to a speed more customary with other vessels using the area.

4. Technology should be explored that employs forwardly directed high-frequency active sonar to detect whales ahead of the vessel. Efforts are presently underway to develop such a system (Miller et al, 1999).

Following these guidelines should mitigate many of the foreseeable problems associated with marine mammals occurring in the area. These guidelines, however, only serve to lower the probabilities of a detrimental effect or accident. Since probabilities are a function of the frequency of occurrence, as ferry traffic increases in the area, so will the potential impact on the marine mammals inhabiting it.

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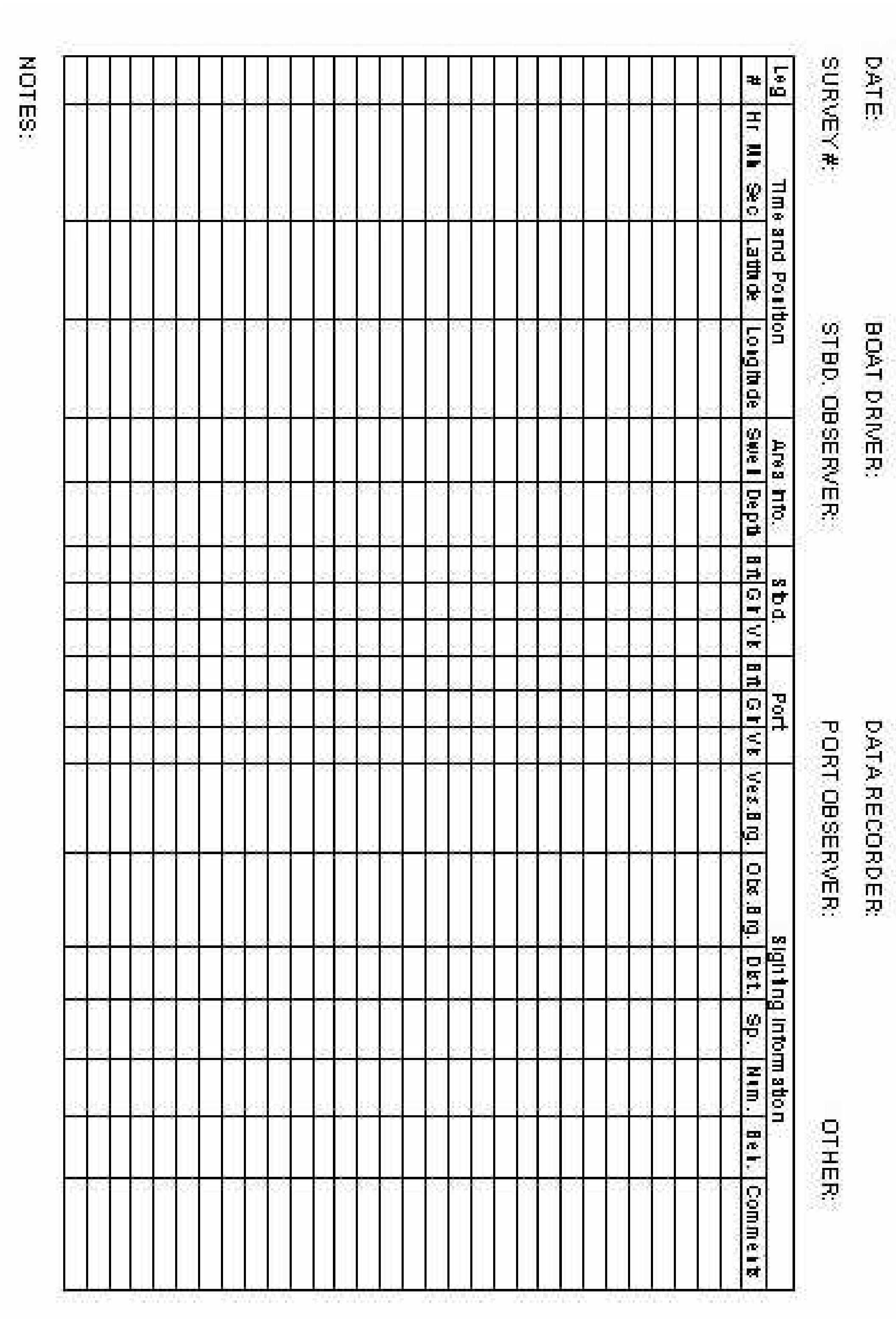
APPENDIX 1 – SURVEY DATA SHEET



DATE:

BOAT DRIVER:

DATA RECORDER:

SURVEY #:

STBD. OBSERVER:

PORT OBSERVER:

OTHER:

Leg	Time and Position			Area Info.		Stbd.			Port			Sighting Information						
#	Hr Min Sec	Latitude	Longitude	Swell	Depth	Bft	Glr	Vis	Bft	Glr	Vis	Ves.Brg.	Obs.Brg.	Dist.	Sp.	Num.	Beh.	Comments

NOTES: