Report to the University of Hawai‘i at Hilo Marine Option Program

Analyzing Interactions and Resulting Behaviors of Spinner Dolphins (*Stenella longirostris)* and Humans in Resting Bays on Hawai‘i Island

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Abstract

Hawaiian spinner dolphins, a species native to the main Hawaiian islands, are abundant on the west side of Hawai‘i Island, particularly in several sheltered bays, which are used by the dolphins for resting and by humans for boating, fishing, swimming, and snorkeling/scuba diving. This resting behavior is characterized by unihemispheric sleep and slow swimming in formation. The two bays used for data collection in this study are Hōnaunau and Kealakekua. Past studies demonstrated the primary occurrence of dolphins in the bays between the hours of 10 am and 2 pm, which followed hunting and foraging behaviors overnight. This study attempted to look at human and dolphin interactions to ascertain the degree of interruption occurring to this resting behavior due to humans. This is especially important because of recent NOAA recommendations that humans stay at least 50 yards (47 m) away from the spinner dolphins at all times, building on the Marine Mammal Protection Act, which protects them from harassment, killing, or capture. The focus of this study is to determine whether these recommendations are being heeded, and if they are not, to quantify the degree of interruption to the spinner dolphins based on observations of a variety of surface behaviors, which do not occur during resting. These surface behaviors were broken into three categories: moderate effort, high effort, and social behaviors specifically used for communication. However, ten observation days resulted in no dolphins seen, potentially indicating a decline in their presence in these resting bays. Past studies also show an apparent decrease in dolphin sightings in recent years. The results raise the question that the dolphins may be using the bays at different times or seasons, or moving to other locations entirely and whether a behavioral shift could be human caused. In order to understand if this is the case, a website was built known as the Hawai‘i Island Whale and Dolphin Tracker, which will allow the public to log their own sightings of dolphins, with the location, date and time, and length of observation. This kind of resource is not currently available on Hawai‘i Island, and will allow for a longer and broader study and hopefully more evidence to back up a decline in presence.

Table of Contents

Introduction:

The spinner dolphin (*Stenella longirostris),* called *nai'a* in Hawai'i, is an integral species in Hawaiian ecosystems, and on Hawai'i Island is primarily found on the western side (Lammers 2004). Hawaiian spinner dolphins are one of the four subspecies of spinners and are native to the main and northwestern Hawaiian islands (DLNR 2015). This subspecies functions as a top predator in ecosystems of the Hawaiian islands (Reeves et al. 2008). The population of Hawaiian spinner dolphins is estimated to be about 1,500, 607 of which inhabitat the coastal waters near Kona (NOAA Fisheries 2016, Tyne 2014). They feed primarily on small mesopelagic fish, squid, and shrimp (Reeves et al. 2008). During feeding, dolphins move offshore into deeper waters, where they dive to access these food sources. In Hawai'i, spinners exhibit a "fission-fusion" society, where they fuse into a much larger pod to feed offshore before separating into smaller groups of a few dozen to move into the resting bays (Reeves et al. 2008).

On Hawai'i Island, spinners rely on several of the bays on the leeward side of the island to rest, and because these resting bays are also popular recreational sites for humans, this presents challenges for the dolphins, given that resting is not a typical time for social interaction (Heenehan et al. 2017). This resting behavior occurs during the day after coming inshore from hunting, which occurs primarily at night (Reeves et al. 2008). Most resting behavior occurs between 10 a.m. and 2 p.m. (Tyne et al. 2015), which brings opportunities for human interaction and interruption, as these hours coincide with the prime time for snorkeling, boating, and other marine activities. Resting behavior is also done in less than 60 m of water and disproportionately over sandy substrate, which are the typical conditions of the fore reefs of bays on west Hawai'i Island (Tyne et al. 2015). Previous studies done by Tyne et al. (2015) and Norris & Dohl (1980) have shown that spinners are unlikely to rest outside of these sheltered bays, which essentially results in forced dolphin and human interaction, particularly as human use of these same bays is increasing.

Hawaiian spinners frequent Kealakekua and Hōnaunau bays, which have both been integral sites of human and dolphin coexistence for centuries (Thorne et al. 2012). The hypothesized first spinner and human interactions date back to the first Polynesians to arrive on these islands more than 1,000 years ago (Kirch 2011). In the last century, with the explosion of the tourism industry, the possibility to 'swim with dolphins' has become a major draw to visitors, and human-dolphin interactions have increased greatly (Heenehan et al. 2014). A study looking at these interactions, as well as corresponding behavioral changes in both humans and dolphins, is not only currently scientifically relevant but also culturally relevant. The *nai'a* appears in the Kumulipo, which is a Hawaiian creation chant, and is an essential species in Hawaiian ocean

habitats, and one that has long benefited *Kānaka Maoli*, or Native Hawaiians, even assisting with fishing in some records (Kuamoʻo Henry 2020). Accounts by *Kānaka Maoli* describe a mutually beneficial relationship with the *naiʻa*, which is something that has potentially changed with the rise of tourism, as the interest in swimming with and viewing dolphins have increased simultaneously (Timmel et al. 2008).

In order to protect the spinner dolphins from the potential adverse effects of this increase in tourism and the wild dolphin viewing industry, NOAA recommends a distance of 50 yards from the dolphins by both boats and swimmers. The regulation was proposed in August 2016, but it has not yet made it into law due to opposition and controversy surrounding the proposition (NOAA Fisheries 2020). This motion is known as Dolphin SMART (NOAA 2016):

S: Stay back 50 yards from dolphins

M: Move away cautiously if dolphins show signs of disturbance

A: Always put your engine in neutral when dolphins are near

R: Refrain from feeding, touching, or swimming with wild dolphins

T: Teach others to be dolphin smart

However, spinner dolphins are already protected under the Marine Mammal Protection Act (MMPA), which prohibits any attempt to harass, capture, or kill a marine mammal (Bennington-Castro 2018). Close and intentional pursuit of dolphins by boats or swimmers falls under harassment; however, clearer regulations with established distances would be beneficial. There are tour operators throughout the islands offering interactions with the dolphins, and researchers have documented that on average, spinners in the resting bays on Hawaiʻ i island are near 13 tour boats and 60 snorkelers at any given time (NOAA Fisheries 2017). A study by the University of Hawaiʻi at Mānoa in collaboration with Duke and New York Universities revealed that in 2013, 77 wild dolphin tour companies in the main Hawaiian islands made a total revenue of $199.8 million, with $102 million on Hawaiʻi Island alone (Jensen 2020). Tyne et al. (2017) asserts that spinner dolphins experience the highest exposure rates ever for any cetacean. NOAA's publication of their recommendations began a 60 day period for public comment, but this has been extended and is still awaiting final review (NOAA Fisheries 2020). Signage is also posted at Hōnaunau Bay to inform the public of the 50 yard recommendation. The present study aims to analyze whether or not this recommendation is being followed, and if it is, if dolphins seem to still have negative repercussions from these unnatural interactions. The potential negative repercussions can be quantified via behaviors visible from the surface.

Spinner dolphins' resting behavior typically, and notably, lacks most, if not all, surface social behaviors. Typical surface behaviors range from medium to high effort and include those used for observation and communication, like tail slaps, spyhopping, and chases, as well as for

play, like breaching and porpoising. During a typical resting session, dolphins lay nearly motionless or swim slowly for four or five hours, breathing occasionally (NOAA 2020). In shallow water, dolphins may even rest on the substrate or sandy bottom, rising to the surface to breathe (WDC 2020). Unlike humans, breathing is not subconscious, so dolphins rest their brains uni-hemispherically, meaning that one side rests at a time to allow them to stay conscious and avoid suffocating or drowning (Whale and Dolphin Conservation (WDC) 2020). The side of the brain resting is alternated during the time spent resting, which also causes just one eye to be open at a time (WDC 2020). This is advantageous for defense, as literally sleeping with one eye open allows dolphins to continue to be aware of any external threats (Castro 2014). During a typical twenty-four hour period, dolphins will get about four hours of this uni-hemispheric "slow-wave" rest (Castro 2014). While resting is preceded and followed by social time (Norris & Dohl 1977), this type of rest is characterised by the lack of social interaction and surface behaviors, so observation of these will indicate that resting is not occurring or is being interrupted. These social behaviors have a profound effect on energy reserves for hunting and other necessary behaviors. The potential for interruption of this resting behavior occurs with human interaction, which is a previously existing effect but is becoming more common. Given this increase, it is important to analyze the effect these encounters have in order to better understand the ecosystem and humans' impact on it.

A study by Steckenreuter et al. (2011) showed that dolphin resting occurred significantly less when boats approached within 50 m than when kept to 150 m or more. Similar studies of bottlenose dolphins by Lusseau et al. (2004) and Bejder et al. (2006) also showed that the dolphins were beginning to avoid areas of high human activity. Forest (2001) reported that the incidence of surface behaviors of spinner dolphins in Kealakekua Bay is higher when they are within 10 m of humans. A study by Courbis et al. (2008) proposed that disruptions could cause long-term changes in behavior, population structure, and even individual mortality. The dolphins spend, on average, 76% of their time during daylight hours in one of the resting bays on the west side of Hawai‘i Island, 82.7% of which was within 100 m of people (Tyne et al. 2018).

The objective of this study was to measure the incidence of human and dolphin interactions in two Hawai‘i Island resting bays, and to document the resulting surface behaviors that may show that resting is not occurring. As these past studies took similar data, a further and more current study that more carefully breaks down surface behaviors and analyzes results directly within the NOAA recommended distance is important. This can help quantify if this distance is adequate, and if people seem to be heeding it. Collection of data on direct interactions between dolphins and humans (<10 m) are also important to show whether one species is changing its path to purposefully interact with the other or avoid the interaction. These data were

intended to be used to measure the percent of time spent within the bay and within direct proximity to people, which would allow a better analysis of the interruption of resting.

Hypotheses

- The effect of human interaction will be negative on the dolphins, which will be expressed in the form of energy wasting surface behaviors in response to human presence.
- People in the water will make a clear deviation in their original path to get closer to the dolphins, which will cause the spinners to respond by moving away.
- Of total time the spinners spend in the bays, >75% will be within 47 m of swimmers and/ or boats.

Methods

Study Site

Kealakekua and Hōnaunau bays are some of the most popular tourist sites on Hawai‘i Island. Kealakekua Bay is featured in countless tourism books for its great snorkeling and dolphin viewing, as well as its historical importance. Tours run to the bay year round, with a range of activities advertised, from sailing to snorkeling and dolphin watching. The bay also holds a great deal of cultural significance on Hawai‘i Island. Kealakekua, literally meaning “pathway of the god” (Nā Puke Wehewehe ‘Ōlelo Hawai‘i 2020), was made famous in Western literature as the site of the death of Captain James Cook in 1779. However, in the thousand years before that, it was an extremely important location for Hawaiians. Its location is 21 miles south of Kailua Kona, the largest town on the west side of Hawai‘i Island (Fig. 1), and its physical features attract the dolphins. Kealakekua, while open to waves on the west side, is protected by a spit of land that extends around a portion of the north side of the bay. It also features a large, crescent shaped reef that drops off precipitously, providing a perfect deep water habitat for spinner dolphin resting grounds. It is because of the abundant reef and protected waters that it has become a popular tourist attraction, with people flocking there every year to swim, kayak, and boat.

Hōnaunau bay, also in the district of south Kona, is a similarly popular tourist site. It is easier to access, with a large swath of lava rock that makes up its shoreline and easy water access with the feature that earned it its colloquial name, “two step.” It features another large coral reef that slopes into sand flats about 30 m off the shoreline. The bay is also adjacent to *Pu‘uhonua o Hōnaunau,* a historical site with rich cultural significance that has been turned into a national

park, receiving 421,027 visitors in 2016 (National Parks Service 2020). This *pu'uhonua,* or place of refuge, served this area before colonization as a location where people could seek atonement for the breakage of kapu, or the law of the gods, and be allowed to re enter into society. Hōnaunau sits another 12 miles down the coast from Kealakekua (Fig 1). Hōnaunau bay is less protected than Kealakekua, leaving it open to higher wave energy. Similarly to Kealakekua, this serves as another vital resting bay for spinner dolphins.

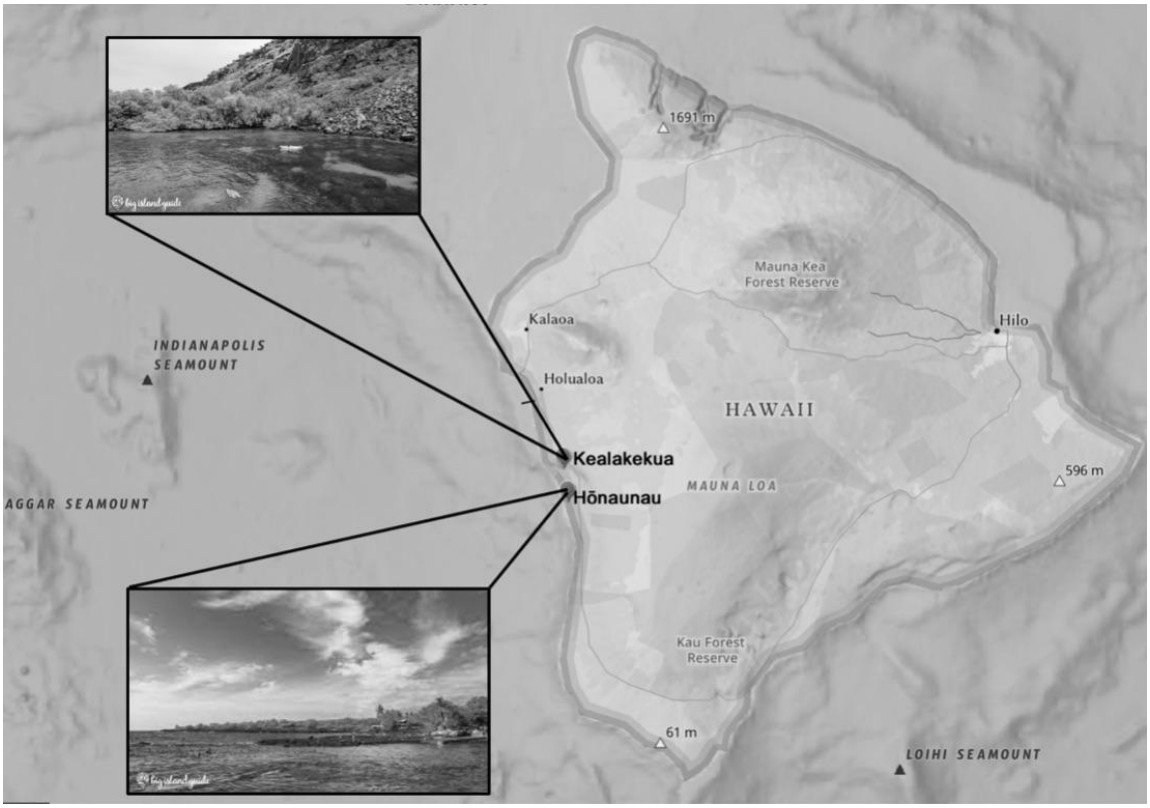

Figure 1. Map of Hawai'i Island with Kealakekua and Hōnaunau bays highlighted. Photo credits to Big Island Guide.

Data Collection

Data were collected over 10 days during the months of January-March, 2021. Data were taken randomly for 2-4 hours at a time from 9:00 am to 4:00 pm from the shore immediately adjacent to the water of Hōnaunau, and both the northern and southern shores of Kealakekua bay. Weather was documented at the beginning of each observation period, including conditions, temperature, and wind, and all subsequent counts were done every hour, on the hour. In the instance that dolphins came into the bay, they would be counted immediately at their entrance, and data taken continuously through their entire time spent within the bay. All observations were done with a view of the entire bay, and the 50 yard (47 m) distance was estimated using

binoculars and camera zoom lenses. Social surface behaviors were broken into three categories: moderate effort, where less than half of the dolphin's body left the water (spyhopping, backslap, pectoral slap); high effort, where the entire body left the water (breaching); and social behaviors specifically used for communication (tail slaps and chases). These behavioral categories were utilized from the Lammers (2004) study. Besides behaviors, the number of dolphins and humans was to be counted, as well as boats, both machine and man powered. In order to directly analyze dolphin-human interactions, any incidents where they got within 10 m of each other were counted, and the resulting behaviors from both marked for each interaction. This included whether the dolphins or the humans were the one to approach the other, and if this interaction resulted in avoidance by either species. Spotting was done with the naked eye, binoculars, and telephoto camera lenses. All encounters were photographed using a Nikon D5600 camera with Nikkor 18-15 mm and 70-300 mm lenses.

Data Analysis and Website Creation

The number of motor and man powered boats and swimmers were compared between the two bays and within the bays by observation day. The data were analyzed for normality using shapiro wilks tests. To compare the means of each, one way ANOVAs were done by observation day and by hour within each bay against the three human presence variables. Unpaired two sample t-tests were then conducted for the comparison of each variable between the two bays.

There were no dolphins observed during the study. Had there been, the number of surface behaviors by observation day would be analyzed using an analysis of variance (ANOVA). Surface behaviors were broken down by category, and the frequency compared using an ANOVA. The same would be done with the numbers of dolphins present in the resting bays (analyzed for variance by day). A t-test would've been used to compare incidence of close interactions (<10 m) and incidence of these interactions resulting in a clear avoidance of one species by the other. Number of dolphins and surface behaviors would be analyzed for any correlation between that and the number of people and boats, as well as proximity to dolphins. Correlations were used to determine if there was a relationship between the percent of time spent in the bay and percent of time the dolphins spent within 50 yards of humans or boats. Regression analyses would've been also conducted using the same variables to analyze causation. This causation could be used to assess whether human interaction is the cause of surface behaviors and increased social communication. The significance of these tests were measured using an alpha value of p=0.05. The statistical application RStudio Version 1.1.463 – © 2009-2018 was used to conduct statistical analyses.

A website (the Hawai‘i Island Dolphin and Whale Tracker) was built in order to broaden the study beyond the current one, which was done using Wix and Google Maps to allow the public to add their own dolphin observational data in the form of both locational pins on a public

map and entries that detail interactions (longitude and latitude, surface/water based, location, number of individuals, and proximity), which will be compiled in a larger database to continue the observation of both spinner dolphins and other cetacean species on Hawai‘i Island.

Results

Hōnaunau Bay

There was a significant difference in the mean number of observations of man powered boats by hour (Fig. 1). No significant differences were found in mean swimmer or motorized boat observations by hour, or with any of the mean observations by day. The most common sighting was by far humans, with motorized and man-powered boats less common in the bay.

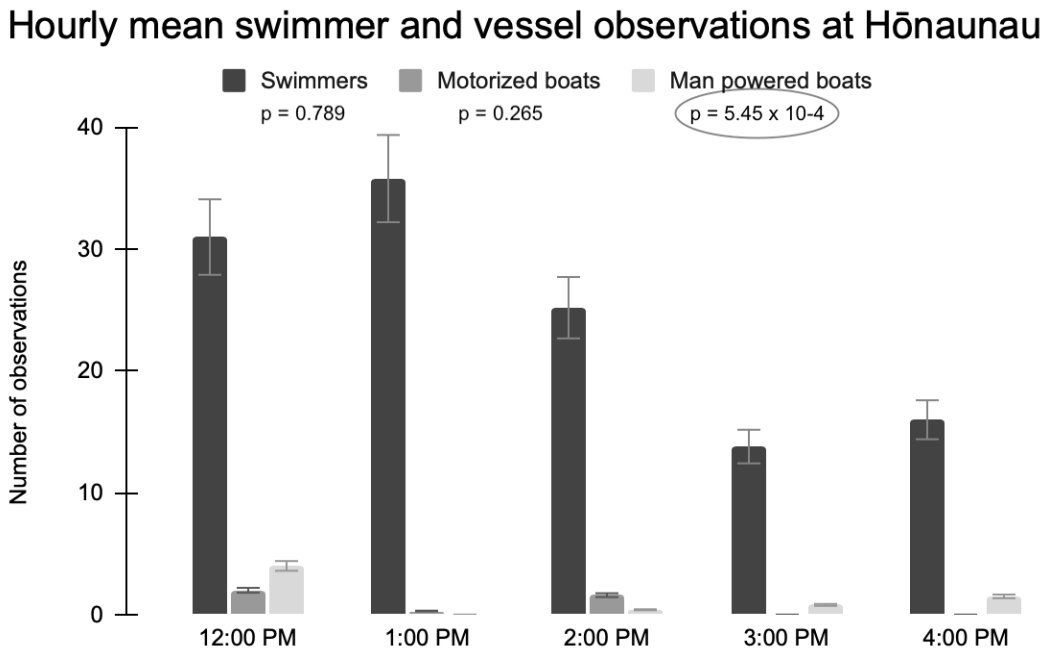

Figure 2. Mean observations (±SE) of each of the three human presence variables by hour at Hōnaunau. Data were taken from Hōnaunau Bay, HI between January 24 and February 28, 2021. Results from one way ANOVAs are shown on the figure.

Kealakekua Bay

Similar to Hōnaunau, the only significant difference was in the mean number of observations of man-powered boats by hour (Fig 2). Again, no significant differences were found in mean swimmer or motorized boat observations by hour, or with any of the mean observations by day. The most common sighting here, however, was man-powered boats, which was mostly made up by tour boats running snorkeling and dolphin swim trips into the bay.

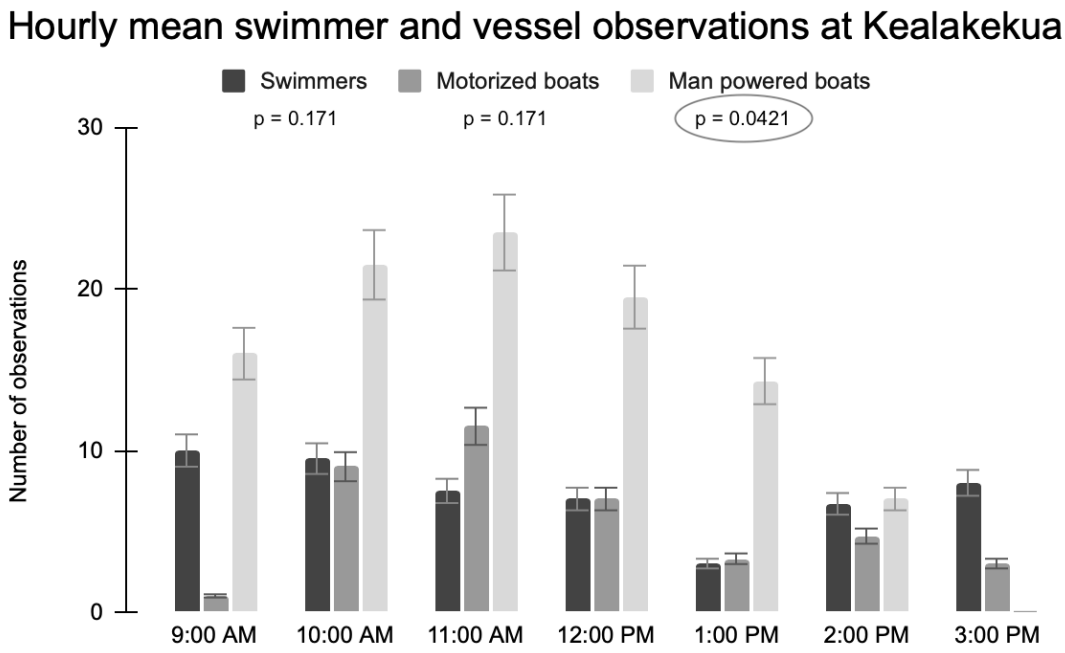

Figure 3. Mean observations (±SE) of each of the three human presence variables by hour at Kealakekua. Data were taken from Kealakekua Bay, HI between March 8 and April 3, 2021. Results from one way ANOVAs are shown on the figure.

Comparison between the bays

Hourly observations of swimmers, motorized boats, and man-powered boats were found to be significantly different between the two sites (Fig. 3). Hōnaunau had a higher mean hourly swimmer abundance than Kealakekua, at 23.12 (±2.91) as compared to just 6.42 (±1.09). However, motorized and man-powered boats were more common at Kealakekua, with the biggest difference in man-powered boats. Hōnanau had an average of just 0.76 (±0.309), while Kealakekua had 12.96 (±2.08).

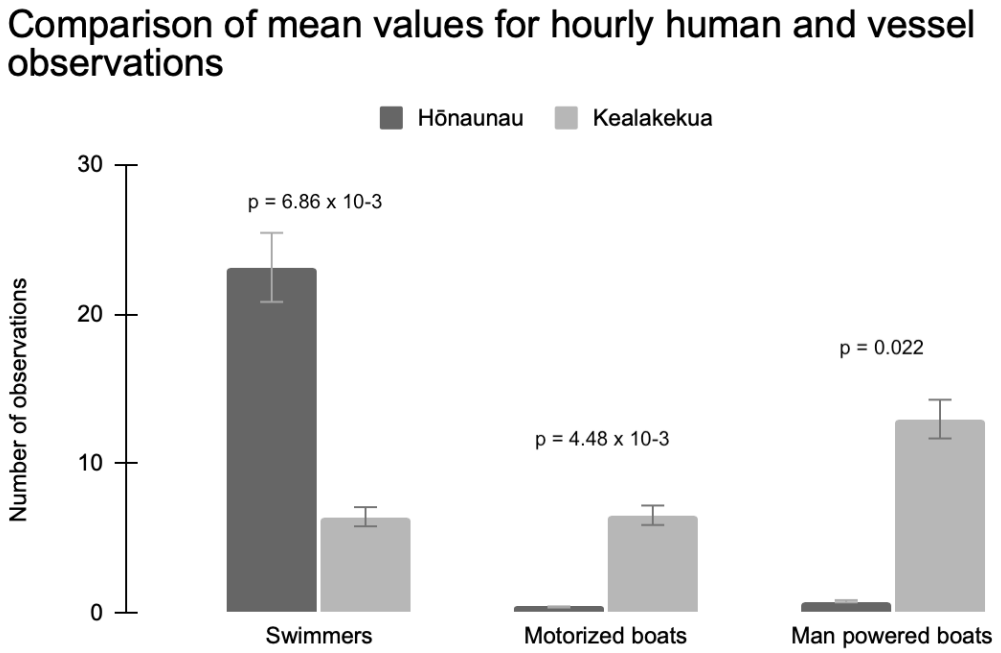

Figure 4. Mean observations (±SE) of each of the three human presence variables between the two sites. Data were taken from Kealakekua Bay and Hōnaunau Bay, HI between January 24 and April 3, 2021. Results from two sample t-tests are shown on the figure.

Dolphin behaviors

Over a total of approximately 25 hours spread over 10 observation days, no spinner dolphins were observed in either of the bays. In an attempt to explain this possible causation, Kealakekua was looked at alone, as there was more consistent data over time. Past studies from the bay were analyzed, and nine tour companies were contacted in order to identify any short term decrease in sightings. These included kayak, motorized boat, and dolphin swim tours. Three companies responded and none saw a recent decline in dolphin presence.

Discussion

The findings were initially surprising, as past studies provided strong evidence that the dolphins were present during most of the hours studied (on average, ~80% of the time), which were during the day for all of those I looked at, as resting behavior is a morning and early afternoon behavior. However, there could be a host of potential reasons for the lack of human-dolphin interactions found in the present study. The first and most basic is the time invested. I spent 25 hours combined at both locations, a number that is about ten times less than that of most other well-cited studies in the field. However, this did not seem to completely explain it. To

begin, I looked at the work of Ken Norris in the 1970s-1990s, as he was one of the first scientists to study the Hawaiian spinner dolphins, and his primary location for the years-long research was Kealakekua Bay. He was quoted in the early 80s as saying “Kealakekua's waters are a reserve now, but many boats continue to use the bay…and if their number increases, if the dolphins' needs are not considered, the animals will leave and their span of tenancy, which began before that of any man will end as they quietly slip away into the offshore sea.” This is a poignant quote, and seems to be an accurate prediction of what could be happening now and in the years to come.

NOAA identified boat traffic as a major threat to the wellbeing of the spinners, as there are many documented negative effects on their resting behavior. Norris was the earliest to note this in 1985, observing that if there was too much boat traffic entering the bays in the morning, the dolphins would continue coastal travel instead of resting, which could have long term effects on their energy budget over time. This energy budget could be similarly impacted with more surface behaviors, which were also more common within close proximity (<10 m) of humans (Forest 2001). Courbis and Timmel (2008), Tyne et al. (2018), Forest (2001), and Timmel et al. (2008) all documented an increase in tourism since the 1980s, and Wiener (2016) found a 23% growth in the dolphin tourism industry between 2007 and 2016. The scale of the industry is staggering, with Wiener (2020) documenting a total of 14,235 boat trips per year in Kailua Kona over 38 tour companies and 30% of visitors to Hawai‘i Island participating in some boat based marine mammal activity.

This is especially important for Kealakekua, as Heenehan (2017) found the highest occurrence of vessel and swimmer traffic in Kealakekua of any of the resting bays. Tyne (2018) and Heenehan (2017) also noted that dolphins spent more time both in total and resting in Makako, a bay that had significantly less vessel traffic than Kealakekua. Overall, abundance of the dolphins has declined in Kealakekua, with Tyne (2017) noting that abundance numbers in 2011-2012 were lower than estimates from 1979-1981, 1989-1992, and 2003. Studies from 1977-2018 showed a decline in percent presence in the bay during the observation time of these studies and while there was no data from the 1970s-1990s on human-dolphin proximity, data from the ten years from 2008-2018 shows an increase in percent time spent in close proximity (within 100 m) with humans while in the bays

All of this evidence seems to suggest that dolphin abundance and occurrence is decreasing and that vessel traffic is the main cause. The continued increase of the tourism industry could cause massive changes to their population, driving them either to more rapid decline or disappearance from the coast as the energetic challenges become too great to survive. Over time, without the vital time they spend resting, foraging could become increasingly challenging, until energy stores are low enough that mortality rates skyrocket. This impact on resting is of huge importance for the protection of these animals, an issue that starts first with

education. The public is not well informed about this, as when the public was asked about laws surrounding the dolphins, only 30-40% of people were correct in Kealakekua and Hōnaunau bays, between both tourists and guides (Donnelly 2011). This underlines the challenges of the progression of the NOAA Dolphin SMART program, as its passage relies on public comment, which makes it nearly impossible when the public is not well informed about pre existing regulations (namely, the MMPA).

So, in order for the vital protection laws by NOAA to be passed, education must come first.That is the ultimate goal of the Hawai‘i Island Whale and Dolphin Tracking site, as it can both provide the public with the insight on why these animals need to be protected, how to protect them, and build a database to learn more about their presence and generate even more evidence for the passage of NOAA regulations. Hopefully with the continuation of studies like these, the spinners can be protected before it is too late, and the communities of Hawai‘i Island can continue to enjoy their presence respectfully, and from a distance.

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