

**Sanctuary Ocean Count:
Analysis of Humpback Whale Census and Behavior Data
2002-2010**

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For
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The data analysis and results contained in this report were under the direction of Jean Souza, Kauai's Program Coordinator, with the Hawaiian Islands Humpback Whale National Marine Sanctuary in Lihue, HI.



Jean Souza, Ashton Culum and sanctuary volunteer James Yamamoto discussing the final presentation poster.

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EXECUTIVE SUMMARY

HIHWNMS Sanctuary Ocean Count Project

The Sanctuary Ocean Count was initiated as a means to provide Hawaii residents and visitors with the opportunity to actively participate in the observing and monitoring of humpback whales in one of its most important breeding areas. The count serves to promote public awareness about humpback whales, the sanctuary and shore-based whale watching opportunities while generating census and behavioral data of the whales sighted.

The Sanctuary Ocean Count is a shore-based activity that is conducted from sixty sites around Oahu, Kauai, Hawaii and Kahoolawe on the last Saturday of every January, February and March. This project has been utilized since 1996 on Oahu and since 2002 on Kauai, Hawaii and Kahoolawe. Each site has a site leader and a group of trained volunteers who count the number of humpback whales and other species sighted from 8 am to 12:15 pm. The volunteers also identify and count how many surface behaviors the whale exhibit. These behaviors include blows, slaps (pec fin, head or tail), breach and dive.

Sanctuary Ocean Count: Analysis of Humpback Whale Census and Behavioral Data

The ocean count data was analyzed annually until 2005 by Dr. Daniela Maldini. Due to budget constraints, this internship project represents the first analysis of data since 2005, and incorporates some of the data dating back to 2002 through 2010. Of the three data sheets generated by the Ocean Count project (census sheet, behavior sheet and map), this internship project analyzed only the census and behavior data.

This internship project attempted to address the following questions:

- Question A: Does the Sanctuary Ocean Count census data from 2002-2010 at each site reflect a 5-7% annual increase in population growth for the North Pacific stock of humpback whales as reported by whale researchers?
- Question B: Which ocean count sites on each island are humpback whales sighted consistently from year to year?
- Question C: Are there similarities in the census data results among ocean count sites along the same coastline?
- Question D: How does the proportion of calves vary between the islands of Kauai, Oahu and Hawaii for the years 2002, 2007-2010?
- Question E: For the three selected surface whale behaviors (breaches, slaps and dives), how do the sites on every island compare in the number

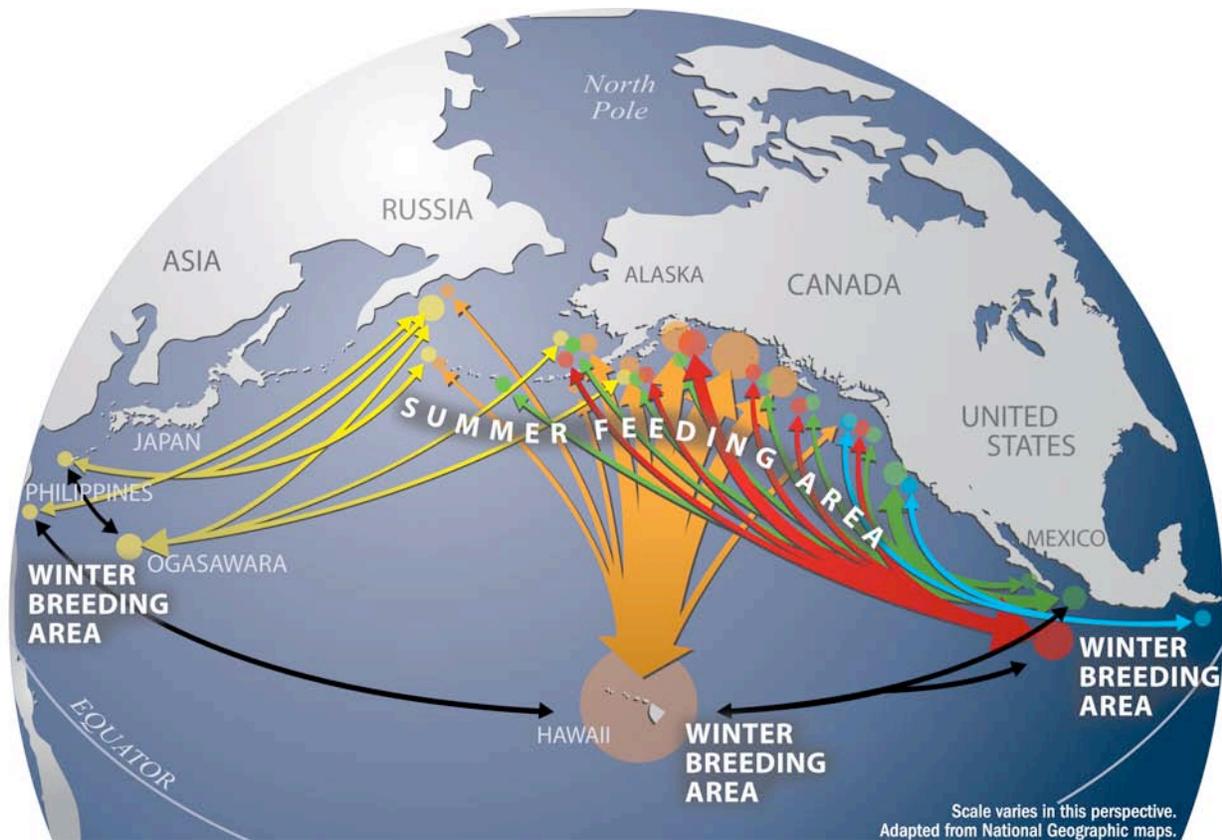
of sightings for each particular behavior from 2002-2010 in January,
February and March?

Recommendations for further analysis are identified.

Chapter 1: Sanctuary Ocean Count Project Background

Introduction

Every winter and spring the warm and shallow waters surrounding the main Hawaiian Islands constitute one of the world's most important humpback whale habitats. Scientists estimate that more than 50 percent of the entire North Pacific humpback whale population migrates to Hawaiian waters from their higher latitude feeding areas each winter to mate, calve and nurse their young (Calambokidis et al. 2008). The first whales to arrive in Hawaii are usually the juveniles and pregnant females followed closely by the mature adult animals. (Maldini, and Nilsson 18-28).



Humpback whale migration patterns from summer feeding areas to winter breeding areas.

Humpback whales prefer shallow waters to breed, give birth and raise their calves. Ninety to ninety-five percent of humpback whales are found in the waters within the 100-fathom isobath (600 foot depth). They are also known to be the most acrobatic of the great whales, exhibiting a number of behaviors while active at the surface. This makes the main Hawaiian Islands one of the best places to watch large whales from shore.



Humpback whale sightings in the 100-fathom isobath

Throughout most of the whale's life, they are alone. However, during mating and breeding season they tend to meet and form groups based on their intent for the season. Some known humpback whale formations include but are not limited to mother/calf, mother/calf/escort, singer/joiner or a competitive group including one female and a large group of sexually mature males (Darling 28-29). This particular type of group can cause competitive behavior between males leading to some injuries, quarrels and noticeable aggressive behaviors (Darling 96-99).

NOAA's Hawaiian Islands Humpback Whale National Marine Sanctuaries

Humpback whales were hunted commercially in the North Pacific until prohibited by the International Whaling Commission in 1966. During the whaling period, the humpback whale population was depleted to approximately 1,500 whales. Currently, humpback whales remain listed as "endangered" under the Endangered Species Act and are designated as "depleted" under the Marine Mammal Protection Act.

Therefore, Congress established the Hawaiian Islands Humpback Whale National Marine Sanctuary in 1992 via the Hawaiian Islands National Marine Sanctuary Act. The sanctuary protects humpback whales and their habitat in the main Hawaiian Islands. It also works to achieve this goal through scientific research, education, public outreach and by facilitating observance of federal and state laws that prohibit disturbing these endangered marine mammals.

HIHWNMS Sanctuary Ocean Count Project

The Sanctuary Ocean Count was initiated as a means to provide Hawaii residents and visitors with the opportunity to actively participate in evaluating the status of humpback whales in their breeding season. Although the census does not claim to provide scientifically accurate results regarding abundance and distribution patterns of humpback whales around the main Hawaiian Islands, it serves as a tool to supplement scientific information gathered from other research activities. The count also provides information on how whales use inshore waters on an average peak season day and it also serves to promote public awareness about humpback whales, the Sanctuary, and shore-based whale watching opportunities.

The first count was conducted in February 1996 on Oahu, with approximately 150 volunteers. In 1999, the Big Island was added to the effort. Kauai began participating in 2000 and Kahoolawe began participating in 2002. To date, the Sanctuary Ocean Count covers 60 sites on four islands, with an enlistment of over 2000 volunteers. In the future, the sanctuary hopes to expand this project to other islands.

The Sanctuary Ocean Count project uses trained volunteers to record ocean activity, mainly humpback whale activity, from sixty selected shore-based sites around Oahu, Kauai, Hawaii and Kahoolawe on the last Saturday of every January, February and March. Each site has a site leader and a legion of regular volunteers whose mission is to count the number of humpback whales and other species sighted during each 15-minute time interval beginning at 8:00 am with the last count of the day being taken from 12:00 to 12:15 pm. During this same time, the volunteers are also required to identify and count how many of the specified surface behaviors are observed. These behaviors include blows, slaps (pec fin, head or tail), breach and dive. Both the census and behavioral data have been collected every year since 2002 from the same sixty shore-based sites to provide reliable, sequential data.

Ocean count sites have various coastal orientations with different elevations, ocean depths, accessibility, visibility conditions and number of volunteers. Thus, each site is unique and therefore, important for the sanctuaries and the Ocean Count project.

Census counts have been taken every January, February and March in 2002-2010 from 25 sites on Oahu, 15 sites in Kauai, 20 sites in Hawaii and one site on Kahoolawe (Maldini and Nilsson 18-28). Over the ten year period in which census and behavioral data has been collected, the same sites have been used on the last Saturday of January, February and March unless bad weather or a natural disaster forces a cancellation.

Immediately following the last count period (1200-1215), the site leaders are required to call in preliminary census data to their respected HIHWNMS office. There are nine 15-minute count intervals in which the volunteers are only to document sightings and behaviors that fall in the particular time interval. The following shows the nine 15 minute count intervals: 800-815; 830-845; 900-915; 930-945; 1000-1015; 1030-1045; 1100-1115; 1130-1145; 1200-1215. The volunteers watch, count and record for 15

minutes and then break for 15 minutes during the course of the counting. The volunteers are trained not to start counting and recording before a time interval begins or after a time period has ended even if they observe whale activity and presence in the ocean. Every volunteer is responsible for the whole ocean and are usually paired together for one to watch and count and the other to record the data. This method also provides for reliable data and more accurate ocean counts.

Results

The following contain the data analysis results for the Sanctuary Ocean Count census and behavioral data. The program coordinators of Oahu, Hawaii and Kauai and research staff associated with the HIHWNMS helped formulate the research questions. The results encompass data collected from 2002 through 2010 from all sixty-three shore-based sites on Oahu, Hawaii, Kauai and Kahoolawe.

Ocean Count Data Analysis

This internship project focused on answering the following questions through analysis of the Ocean Count data.

Research Questions	Data	Analysis Performed	Page Number
Question A: Does the Sanctuary Ocean Count census data from 2002-2010 at each site reflect a 5-7% annual increase in population growth for the North Pacific stock of humpback whales as reported by whale researchers?	CENSUS: Average number of humpback whales sighted	Sightings by island, 2006-2010	8
	CENSUS: Average number of humpback whales sighted	Sightings by island by year, 2006-2010	9
	CENSUS: Average number of humpback whales sighted	Sightings by island by count period, 2006-2010	10
	CENSUS: Average number of humpback whales sighted	Sightings by Ocean Count site, 2002-2010	11
Question B: Which ocean count sites on each island are humpback whales sighted more consistently from year to year?	CENSUS: Average number of humpback whales sighted	Sightings from the most consistent sites on each island, 2002-2010	79
	Question C: Are there similarities in the census data results among ocean count sites along the same coastline?	Sightings from the four major coastlines on each island, 2002-2010	84
Question D: How does the proportion of calves vary between the islands of Kauai, Oahu and Hawaii for the years 2002, 2007-	CENSUS: Proportions of calves	Proportions by island, 2002, 2007-2010	92
	CENSUS: Proportions of calves	Proportions by month for each island, 2002, 2007-2010	93
	BEHAVIOR: Average number of breaches sighted	Sightings by island, 2002-2010	161
Question E: For the three selected surface whale behaviors (breaches, slaps and dives), how do the sites on every island compare in the number of sightings for each particular behavior from 2002-2010 in January, February and March?	BEHAVIOR: Average number of slaps sighted	Sightings by island, 2002-2010	162
	BEHAVIOR: Average number of dives sighted	Sightings by island, 2006-2010	163
	BEHAVIOR: Average number of breaches, slaps and dives sighted	Sightings by ocean count sites, 2002-2010 & 2006-2010	164

Chapter 2: Island-by-Island Census Data Analysis

Question A: Does the Sanctuary Ocean Count census data from 2002-2010 at each site reflect a 5-7% annual increase in population growth for the North Pacific stock of humpback whales as reported by whale researchers?

The Ocean Count census data has been collected annually from 2002 through 2010 every last Saturday of January, February and March. A census sheet is normally filled out by the site leader at each site for each count date. This is the sheet that was used in the analysis of the census data.

Researchers report that the Hawaii sub-population of humpback whales has increased at an annual rate of 5-7 percent. The census summary for the ocean count data reflects a gradual overall population increase over the census period. However, the data does not appear to fully reflect the 5-7% annual population increase reported by whale researchers. The highly variable census counts from year to year can be partially attributed to weather and its affect on visibility conditions.

A trend noted in the ten-year census summary analysis indicated consistently higher sightings in January and February than in March. A possible explanation for lower whale counts in March is that some whales may have began their migration back to the feeding grounds in Alaska by the time of the March census. The census summary by island suggest that volunteers on Kauai saw the most whales over the five-year period in January and February while volunteers on Oahu counted the highest average in March. The islands of Kauai and Hawaii also have similar average census counts for each month with the volunteers on Oahu saw lower average counts.

In the census summary by year, volunteers on Kauai counted the most humpback whales on average in every year but 2010. This could be because in 2010, Kauai experienced numerous site closures due to bad weather, presence of a submarine around the island, as well as rescheduling the February count due to a tsunami warning. In the year 2007, all the islands have relatively close census averages (a difference of 0.67) as to suggest suitable viewing conditions on each island, each count period.

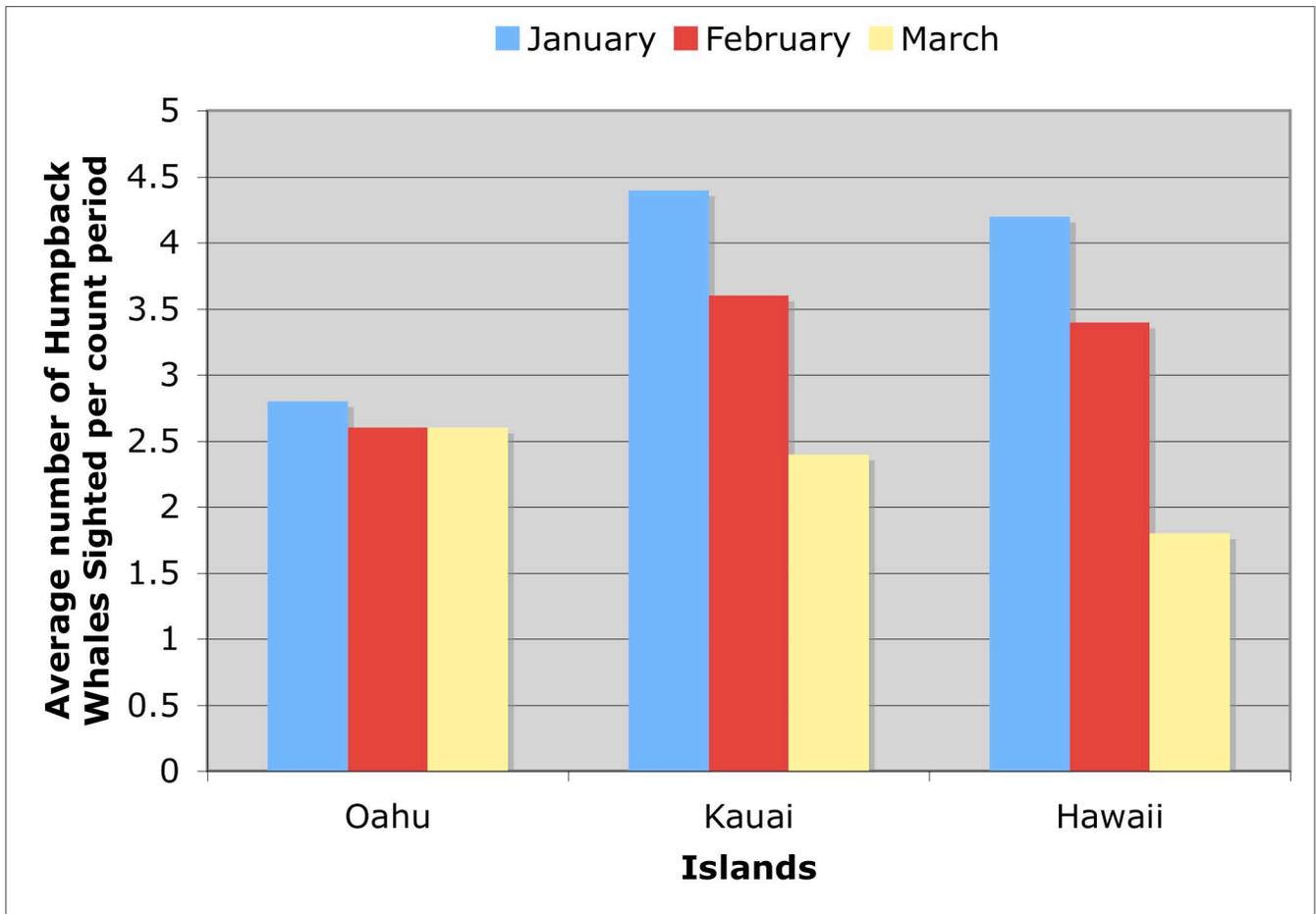
The following pages contain:

- The census summary comparing the islands of Oahu, Kauai and Hawaii with the average number of humpback whales counted per shore-based site per 15-minute time slots during the months of January, February and March 2006-2010.
- The census summary of the average number of humpback whale sightings per individual site per 15-minute count period in January, February and March over the years 2002-2010.
- The census summary containing the most consistent sites on average for whale sightings per 15-minute count period every January, February and March over the years 2002-2010.

- The census summary containing the comparison of the ocean count sites along the major coastlines surrounding Oahu, Kauai and Hawaii with the overall average of humpback whale sightings for the years 2002-2010.

Analysis: Average number of humpback whales sighted at each ocean count site per 15 minute count period during the months of January, February, and March 2006-2010 for the islands of Oahu, Kauai and Hawaii

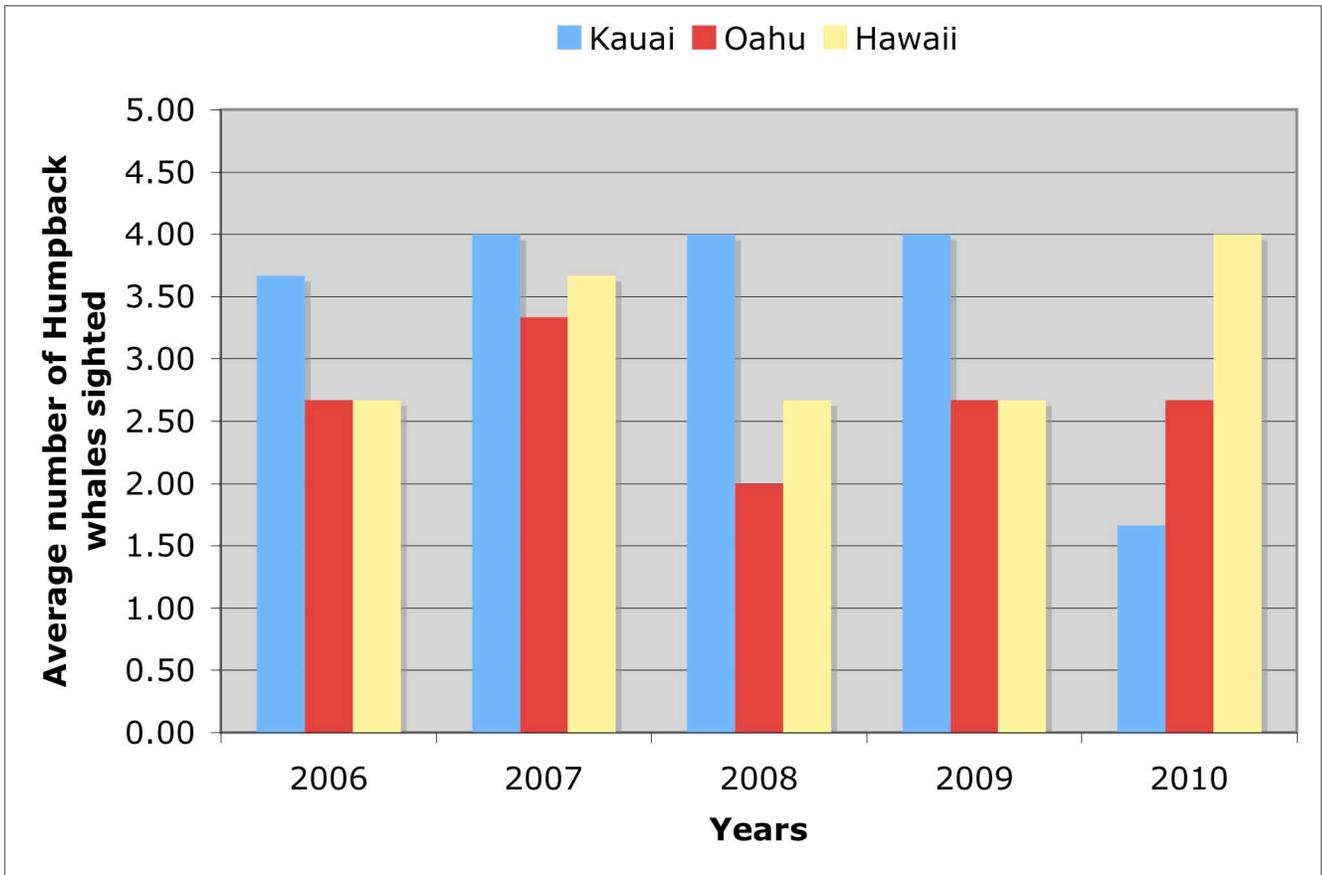
Island	January	February	March
Oahu	2.8	2.6	2.6
Kauai	4.4	3.6	2.4
Hawaii	4.2	3.4	1.8



Conclusion: As reported by Dr. Daniela Maldini in 2005 (for the years 2002 to 2005), the trend continues in 2006-2010 with the average number of humpback whales sighted were consistently higher in January and February than in March.

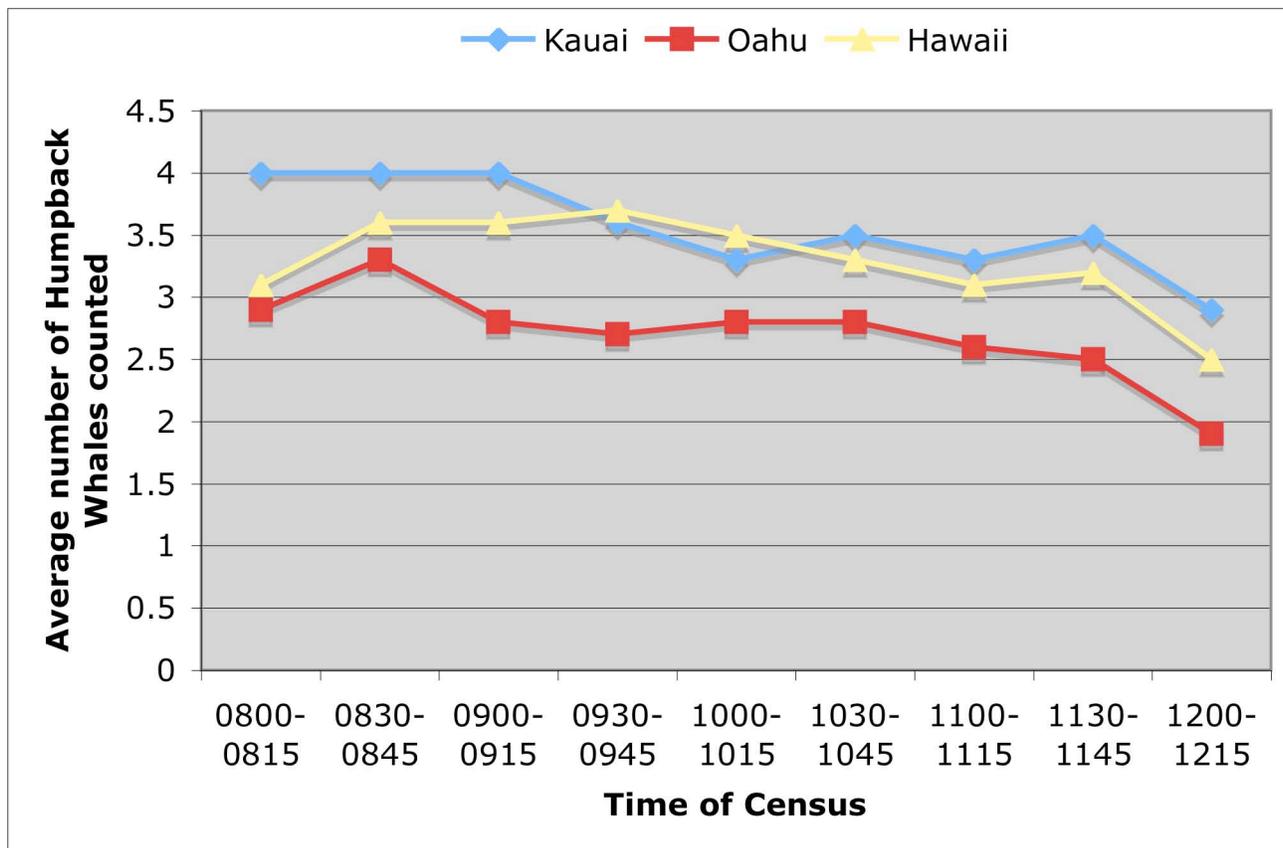
Analysis: Average number of humpback whales sighted per year between 2006 and 2010, during the months of January, February and March combined

Island	2006	2007	2008	2009	2010
Kauai	3.67	4.00	4.00	4.00	1.67
Oahu	2.67	3.33	2.00	2.67	2.67
Hawaii	2.67	3.67	2.67	2.67	4.00



Analysis: Average number of humpback whales counted per year between 2006 and 2010, during the months of January, February and March combined by 15 minute count period for the islands of Kauai, Oahu and Hawaii.

Island	0800-0815	0830-0845	0900-0915	0930-0945	1000-1015	1030-1045	1100-1115	1130-1145	1200-1215
Kauai	4	4	4	3.6	3.3	3.5	3.3	3.5	2.9
Oahu	2.9	3.3	2.8	2.7	2.8	2.8	2.6	2.5	1.9
Hawaii	3.1	3.6	3.6	3.7	3.5	3.3	3.1	3.2	2.5



Explanation: These graphs illustrates the average number of humpback whales counted per year between 2006 and 2010, during the months of January, February and March combined by each 15 minute count period for the islands of Kauai, Oahu and Hawaii. This graph also shows the best time for sightings humpback whales on average for each island over the years between 2006 and 2010.

Conclusion: The number of whale sightings are generally higher earlier in the morning and decline toward the end of the count day. Kauai's highest average count occurs between 0900-0915am; Hawaii's highest average count occurs between 0930-0945 am and Oahu's highest average count occurs between 0830-0845 am. Interestingly, all three islands have their lowest counts between 1200-1215 pm. The ocean count census data suggest that the largest amount of sightings will happen in the early morning hours between 0800-1015 am for all the islands. Thus, it is imparative to keep counting at all the sites from 0800-1015 am to track the population growth.

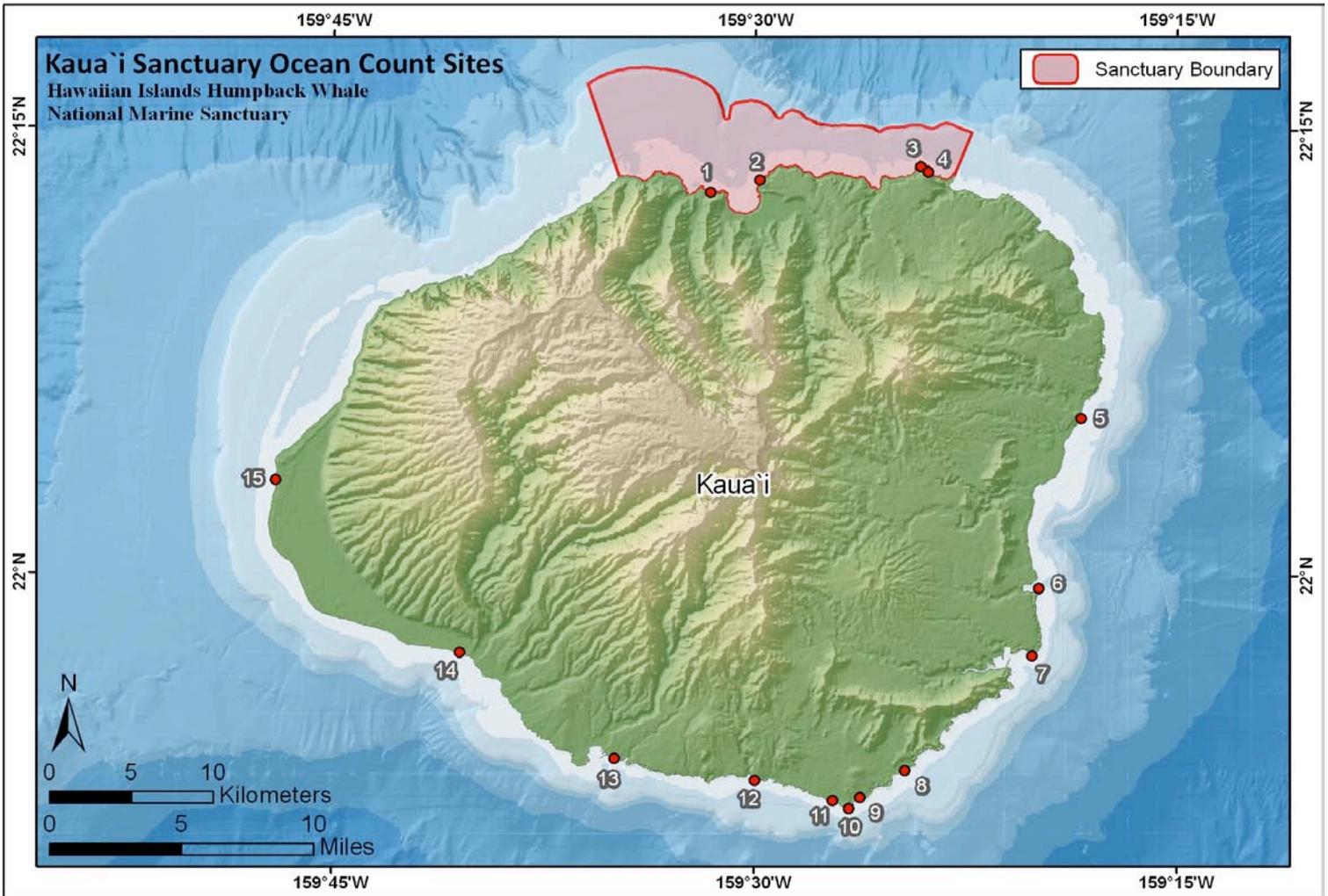
Chapter 3: Census Data Analysis by Site

The following pages illustrate:

- The average number of humpback whale sightings per 15-minute count period for sixty shore-based ocean count sites around Kauai, Oahu, Hawaii and Kahoolawe from 2002-2010 in January, February and March.

If a NA appears in the data table, it either signifies a site closure, lack of a census data sheet for the site or unreliable census data information. If a zero appears, there were no humpback whales sighted.

Kauai Ocean Count Sites



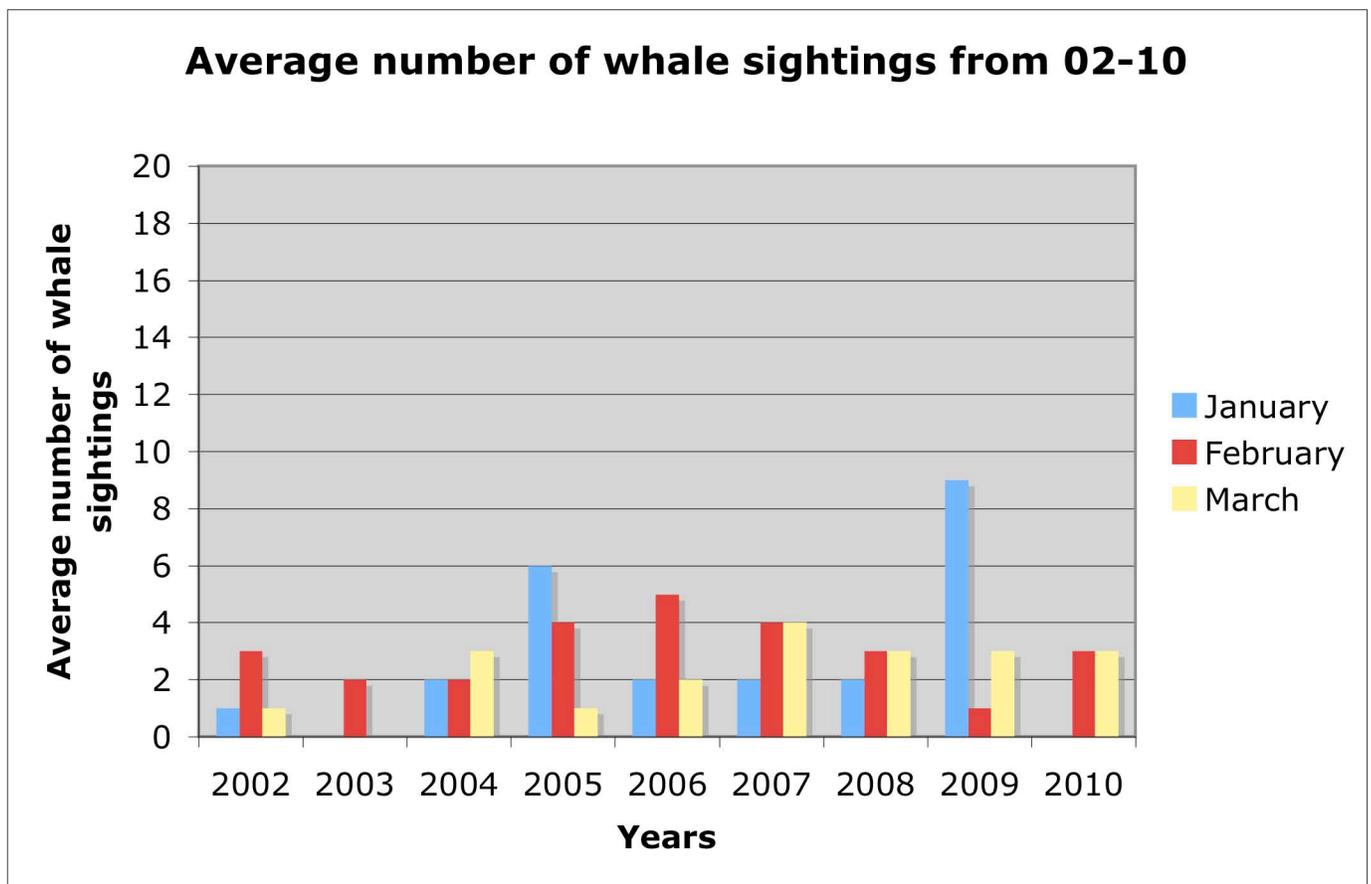
Island: Kauai

Site#1 : Lumahai Lookout

Elevation: 120 ft

Coastline: North Shore

Years	January	February	March
2002	1	3	1
2003	NA	2	0
2004	2	2	3
2005	6	4	1
2006	2	5	2
2007	2	4	4
2008	2	3	3
2009	9	1	3
2010	0	3	3



Analysis:

This graph depicts the average number of humpback whale sightings per 15-minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Lumahai Lookout on the island of Kauai.

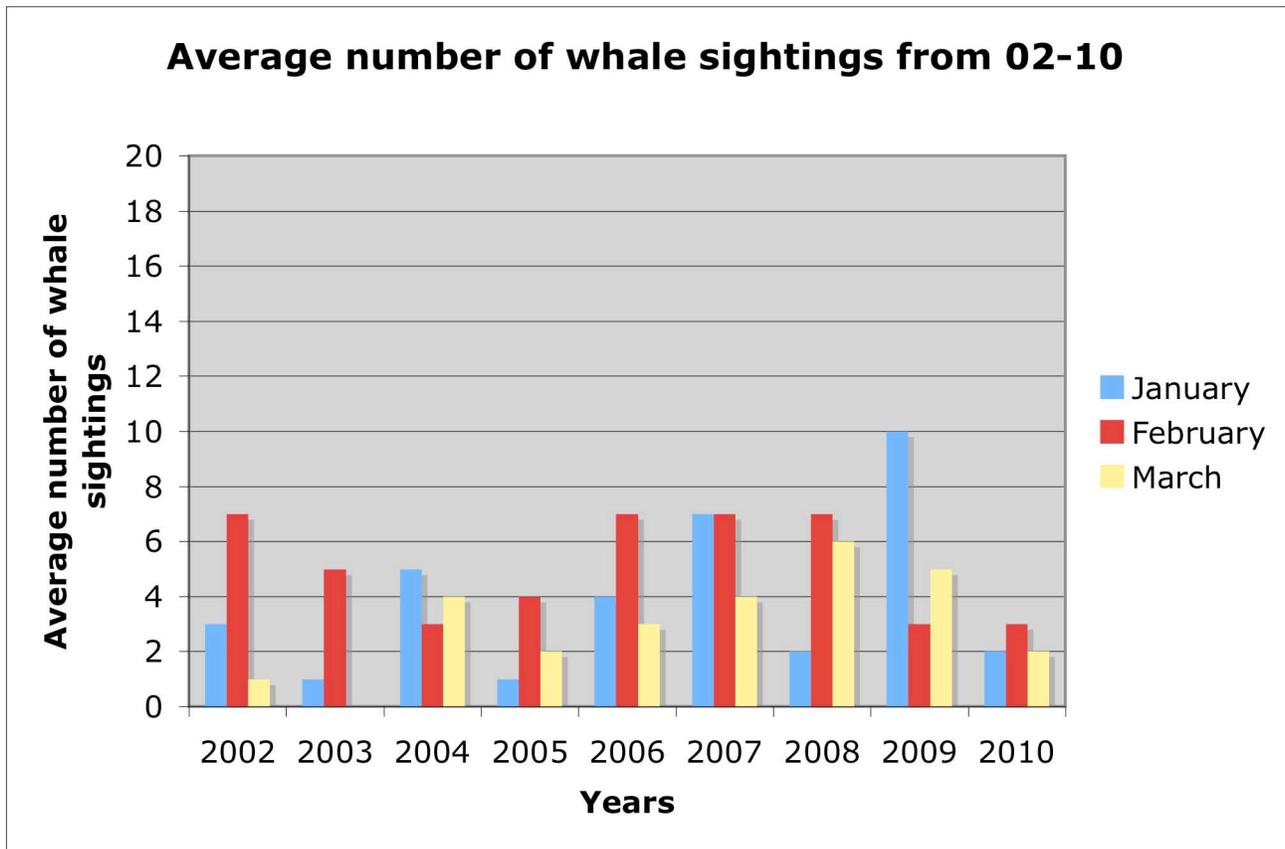
Island: Kauai

Site# 2: Princeville Hotel

Elevation: 120 ft

Coastline: North Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	3	7	1
2003	1	5	0
2004	5	3	4
2005	1	4	2
2006	4	7	3
2007	7	7	4
2008	2	7	6
2009	10	3	5
2010	2	3	2



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Princeville Hotel on the island of Kauai.

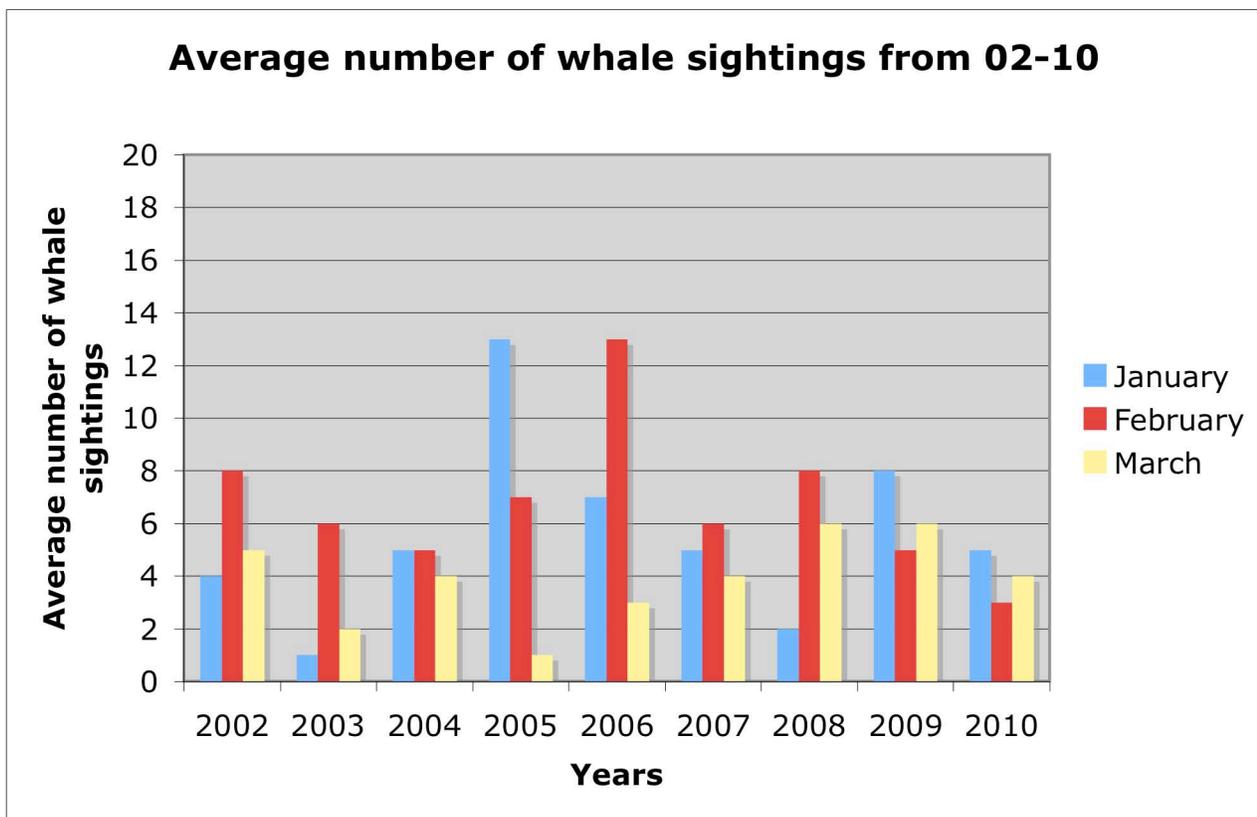
Island: Kauai

Site# 3: Kilauea Point National Wildlife Refuge

Elevation: 180 ft

Coastline: North Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	4	8	5
2003	1	6	2
2004	5	5	4
2005	13	7	1
2006	7	13	3
2007	5	6	4
2008	2	8	6
2009	8	5	6
2010	5	3	4



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Kilauea Point National Wildlife Refuge on the island of Kauai.

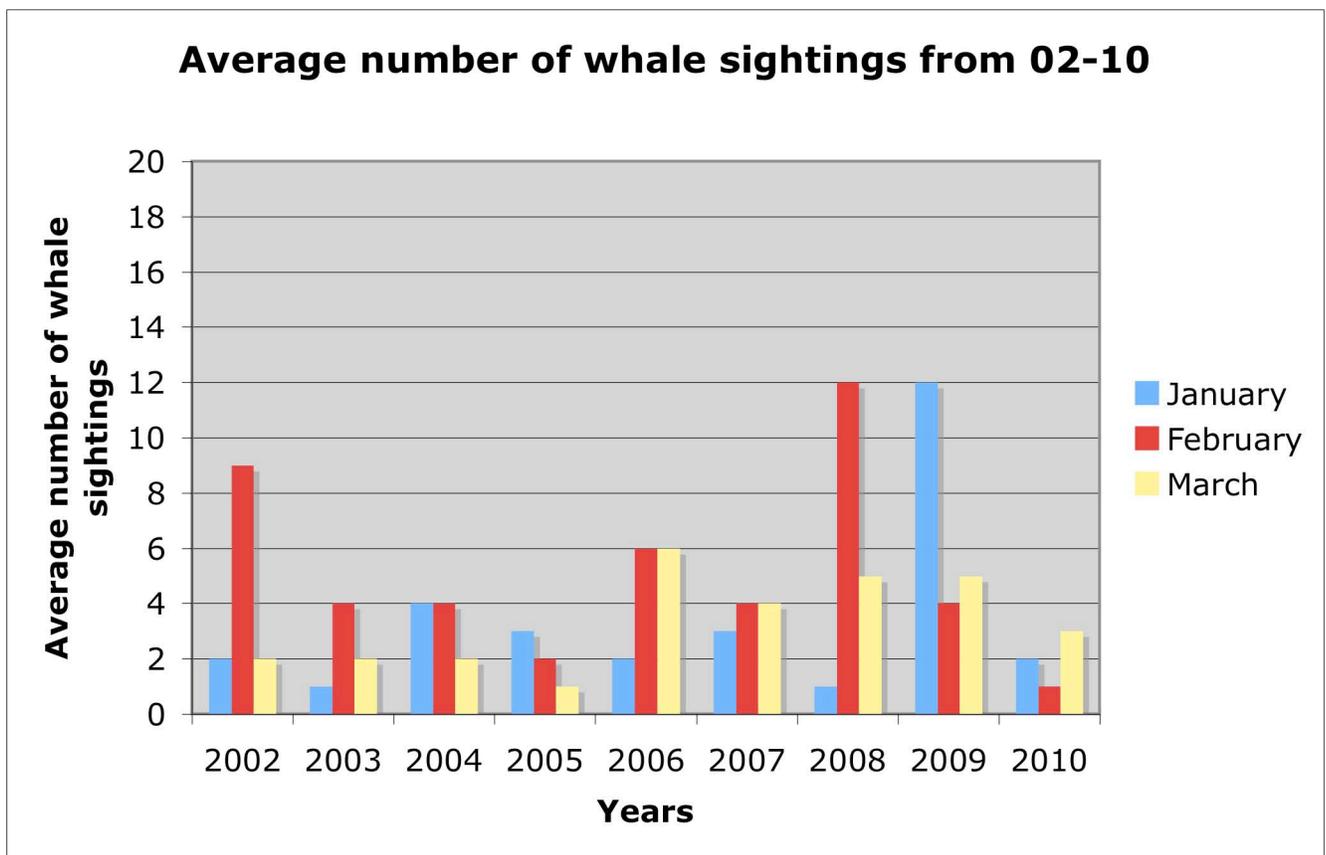
Island: Kauai

Site# 4: Crater Hill

Elevation: 250 ft

Coastline: North Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	2	9	2
2003	1	4	2
2004	4	4	2
2005	3	2	1
2006	2	6	6
2007	3	4	4
2008	1	12	5
2009	12	4	5
2010	2	1	3



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Crater Hill on the island of Kauai.

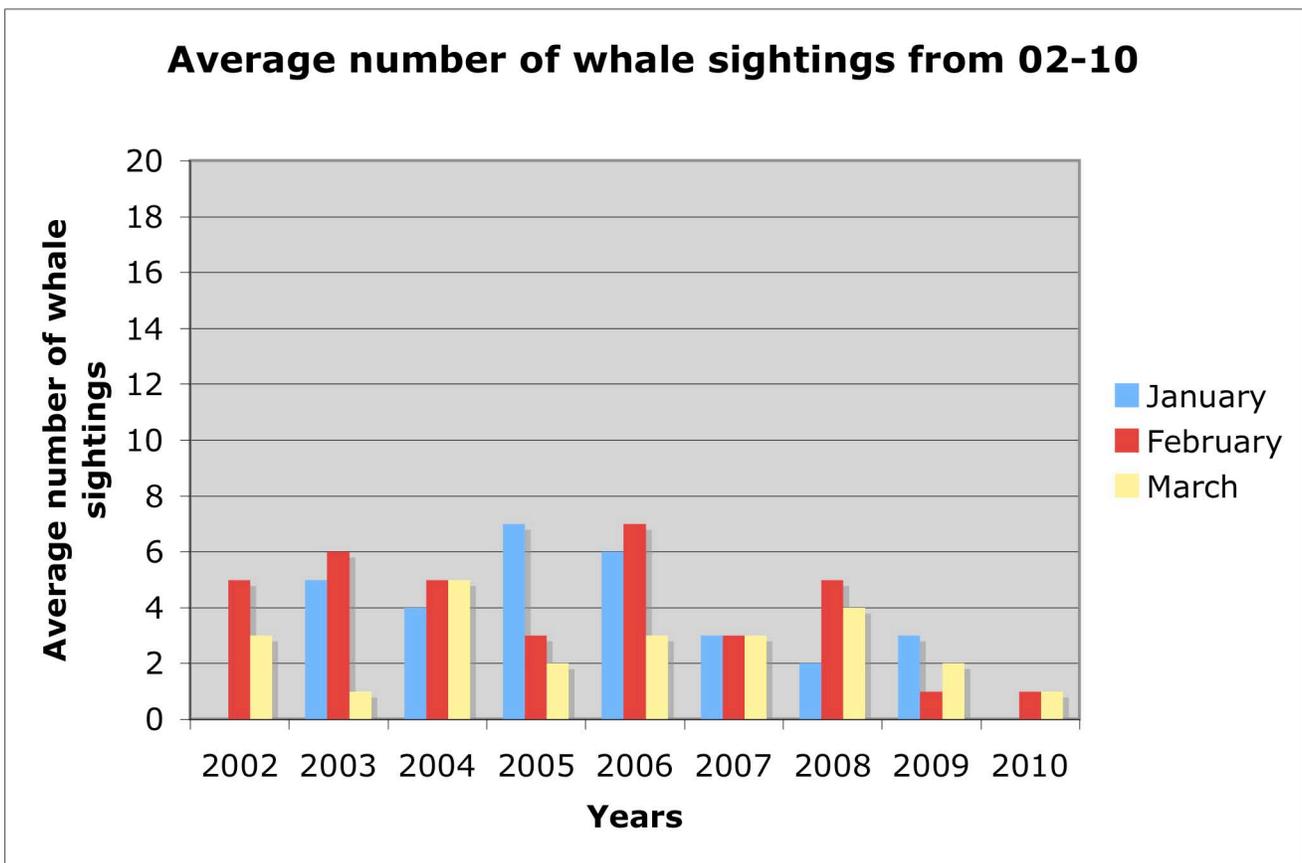
Island: Kauai

Site# 5: Kapaa Lookout

Elevation: 40 ft

Coastline: East Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	0	5	3
2003	5	6	1
2004	4	5	5
2005	7	3	2
2006	6	7	3
2007	3	3	3
2008	2	5	4
2009	3	1	2
2010	0	1	1



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Kapaa Lookout on the island of Kauai.

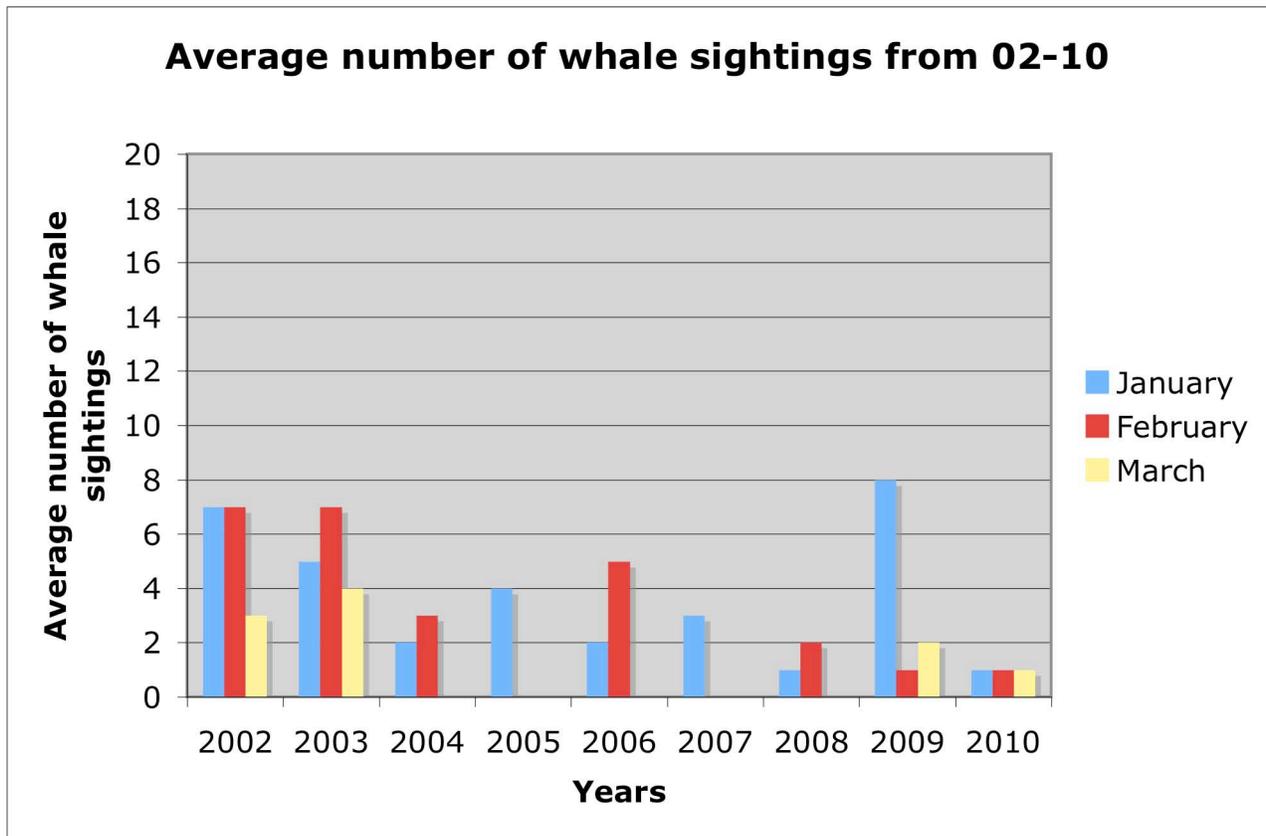
Island: Kauai

Site# 6: Ahukini State Recreation Pier

Elevation: 0 ft

Coastline: East Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	7	7	3
2003	5	7	4
2004	2	3	0
2005	4	0	0
2006	2	5	0
2007	3	0	0
2008	1	2	0
2009	8	1	2
2010	1	1	1



Analysis:

This graph depicts the average number of humpback whales sightings per 15-minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Ahukini State Recreation Pier on the island of Kauai.

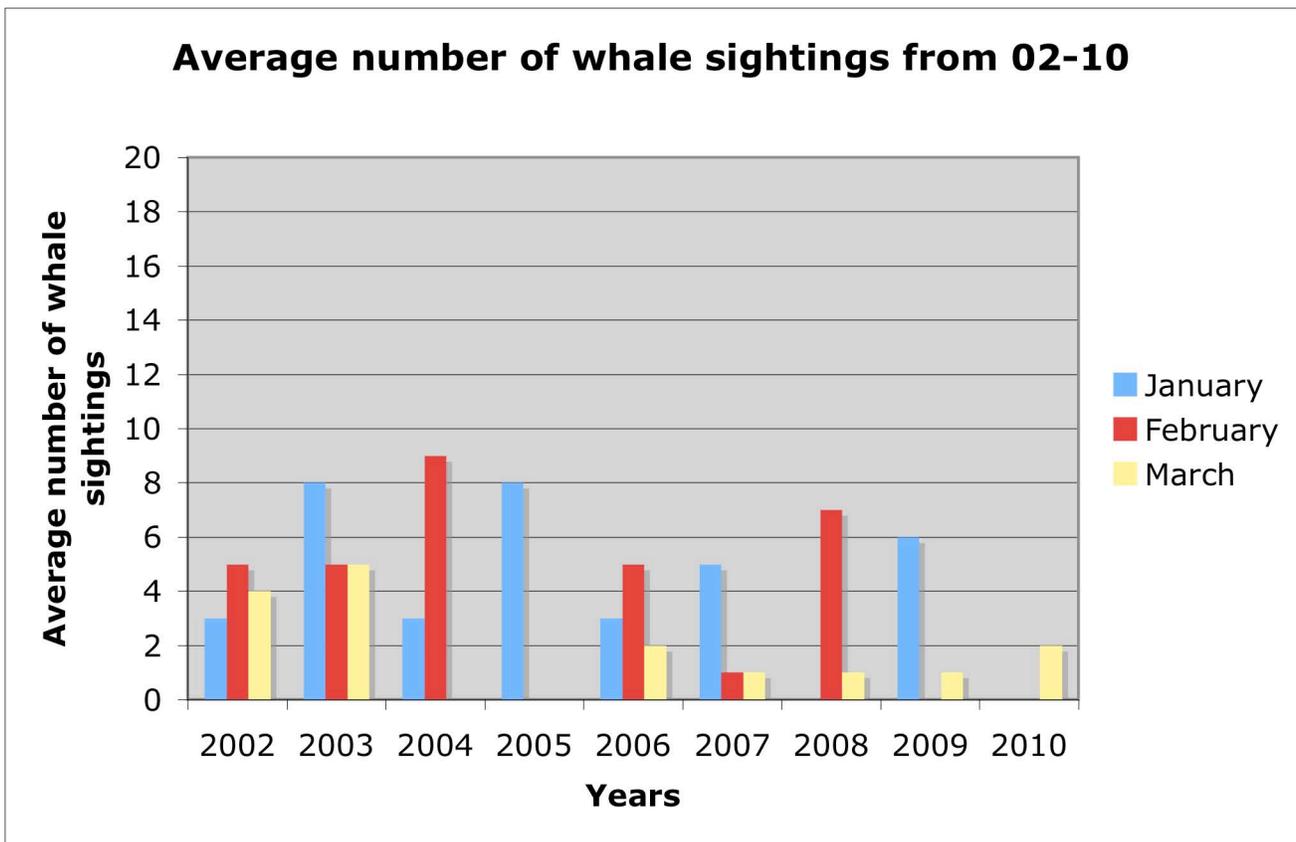
Island: Kauai

Site# 7: Ninini Lighthouse

Elevation: 10 ft

Coastline: East Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	3	5	4
2003	8	5	5
2004	3	9	0
2005	8	0	0
2006	3	5	2
2007	5	1	1
2008	NA	7	1
2009	6	0	1
2010	0	0	2



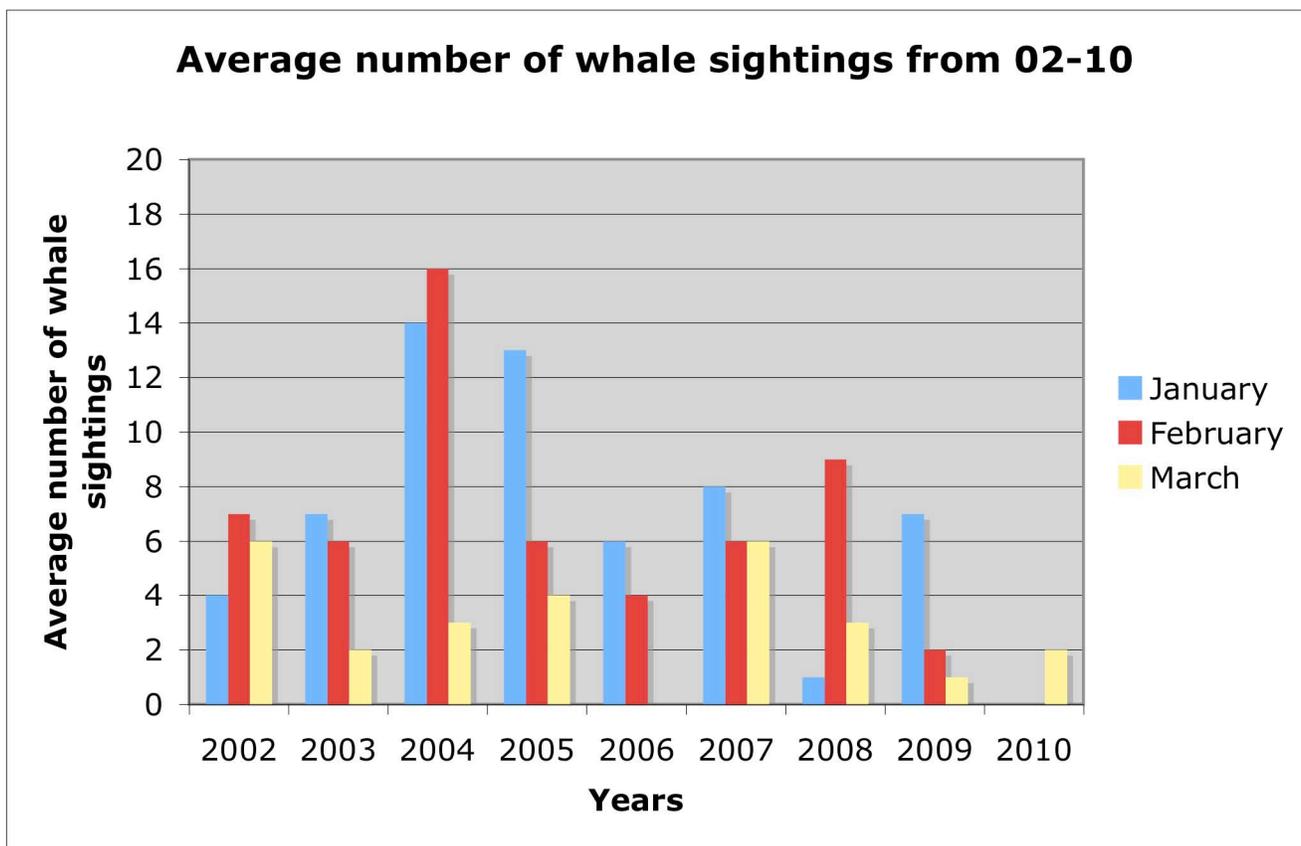
Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Ninini Lighthouse on the island of Kauai.

Island: Kauai
Elevation: 25 ft

Site#8 : Mahaulepu Haula
Coastline: South Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	4	7	6
2003	7	6	2
2004	14	16	3
2005	13	6	4
2006	6	4	NA
2007	8	6	6
2008	1	9	3
2009	7	2	1
2010	NA	NA	2



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Mahaulepu Haula on the island of Kauai.

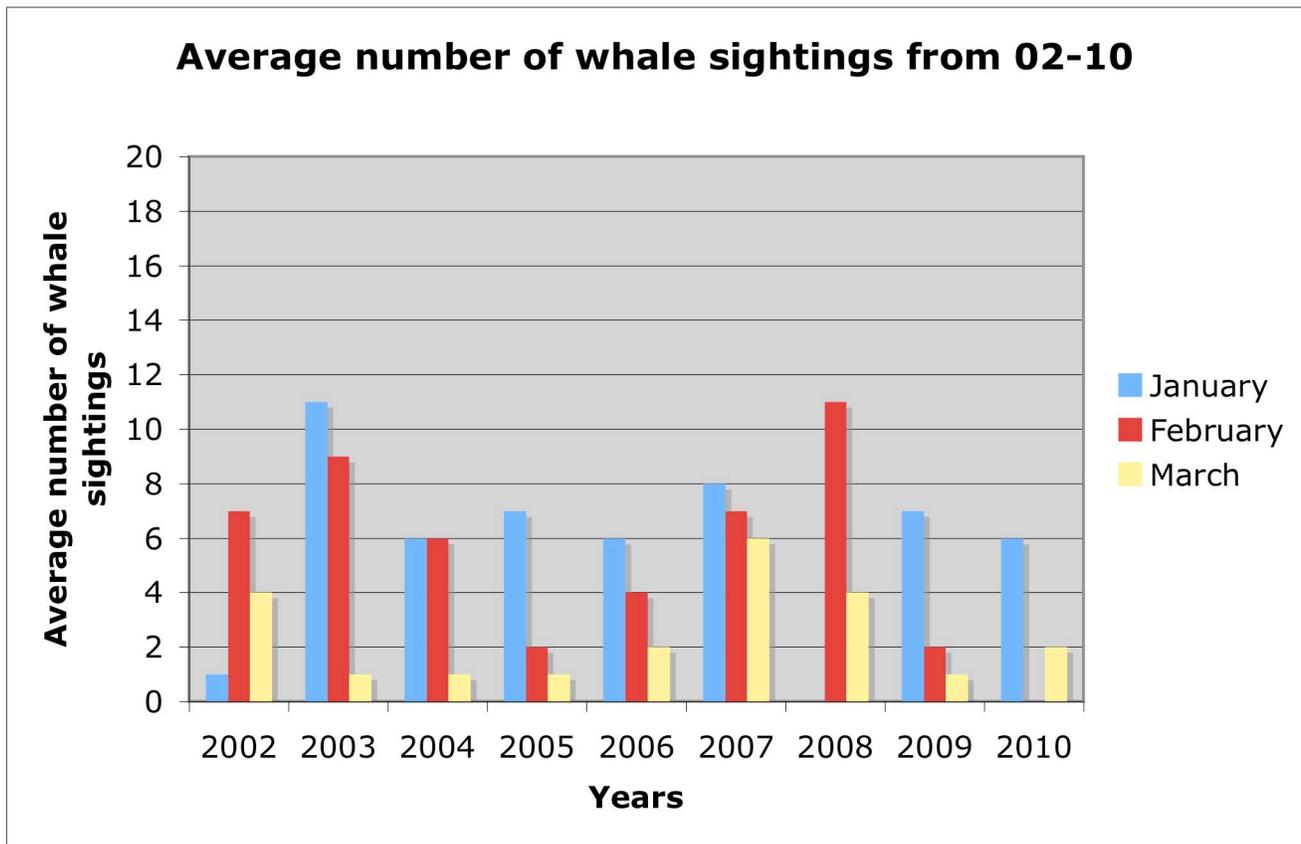
Island: Kauai

Site# 9: Mahaulepu Makawehi

Elevation: 40 ft

Coastline: South Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	1	7	4
2003	11	9	1
2004	6	6	1
2005	7	2	1
2006	6	4	2
2007	8	7	6
2008	NA	11	4
2009	7	2	1
2010	6	0	2



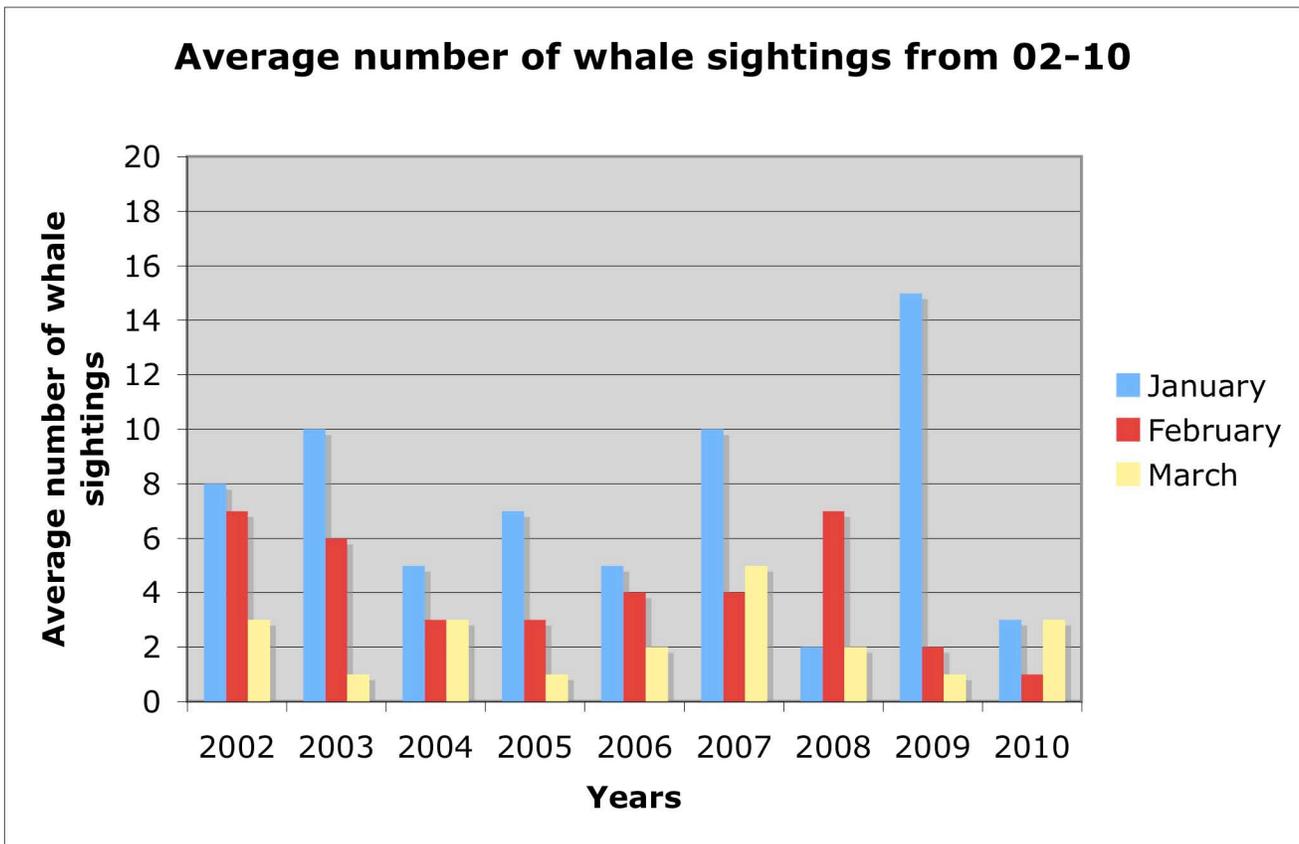
Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Mahaulepu Makawehi on the island of Kauai.

Island: Kauai
Elevation: 30 ft

Site#10: Makahuena Point
Coastline: South Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	8	7	3
2003	10	6	1
2004	5	3	3
2005	7	3	1
2006	5	4	2
2007	10	4	5
2008	2	7	2
2009	15	2	1
2010	3	1	3



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Makahuena Point on the island of Kauai.

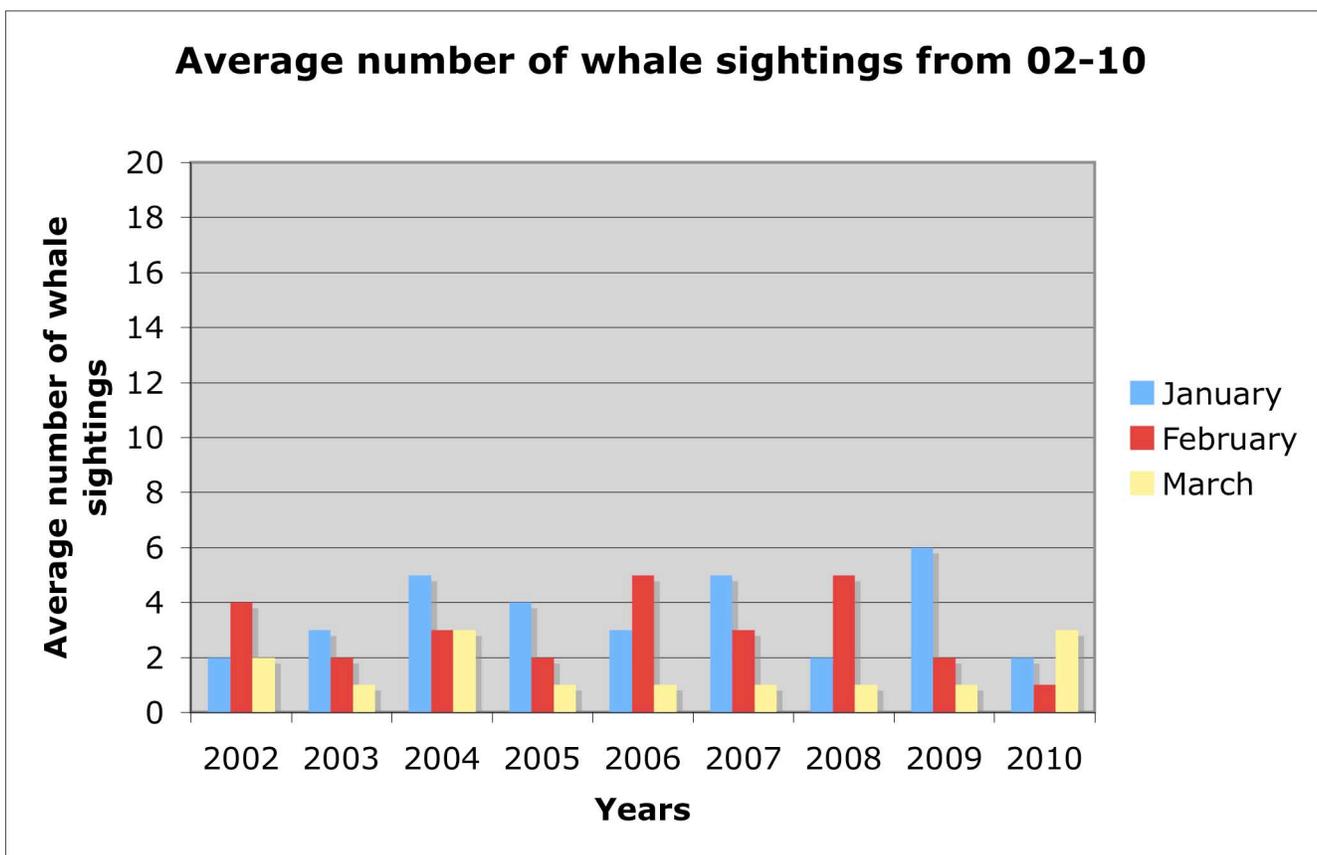
Island: Kauai

Site# 11: Poipu Beach Park

Elevation: 0-10ft

Coastline: South shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	2	4	2
2003	3	2	1
2004	5	3	3
2005	4	2	1
2006	3	5	1
2007	5	3	1
2008	2	5	1
2009	6	2	1
2010	2	1	3



Analysis:

This graph depicts the average number of humpback whales sightings per 15-minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Poipu Beach Park on the island of Kauai.

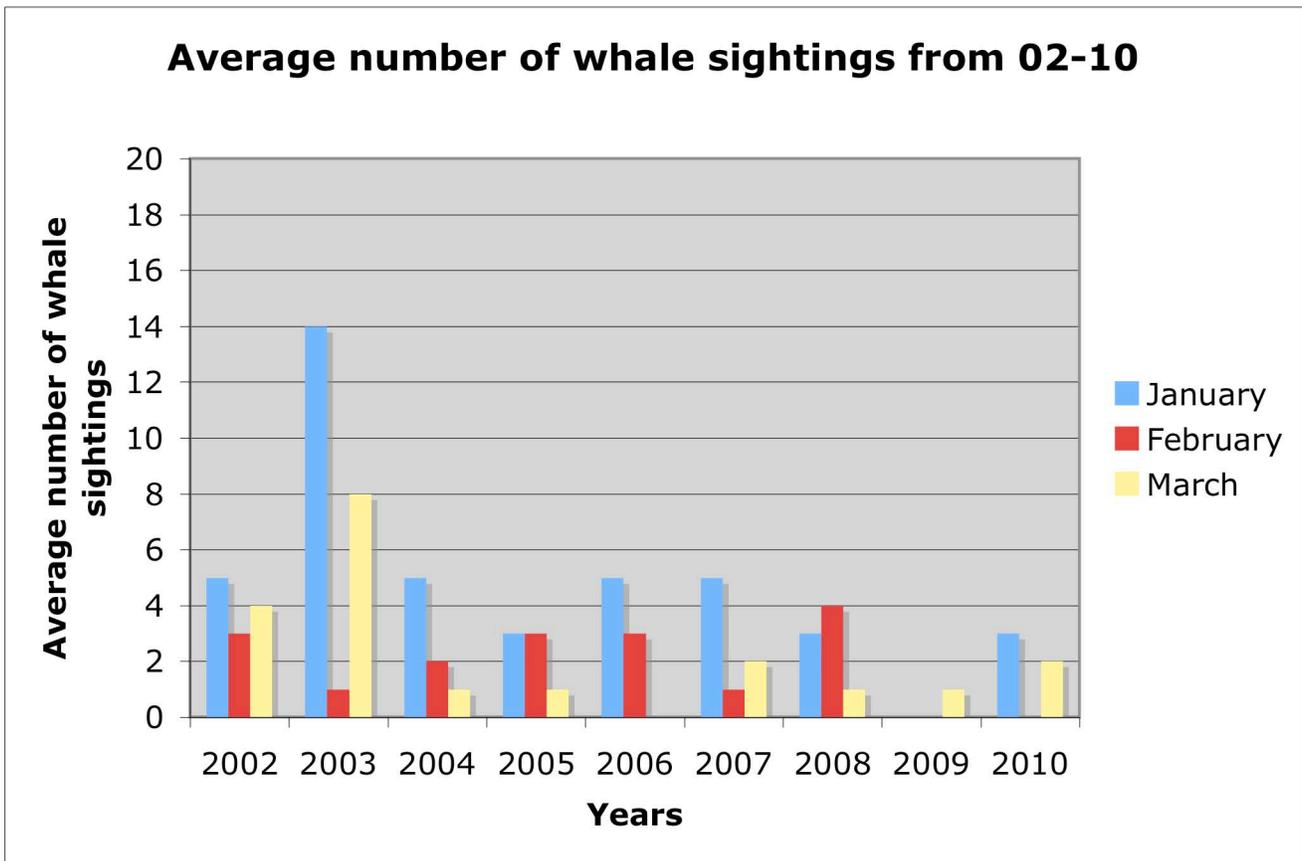
Island: Kauai

Site# 12: Kaiwa Point

Elevation: 40-50 ft

Coastline: South Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	5	3	4
2003	14	1	8
2004	5	2	1
2005	3	3	1
2006	5	3	0
2007	5	1	2
2008	3	4	1
2009	NA	NA	1
2010	3	0	2



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Kaiwa Point on the island of Kauai.

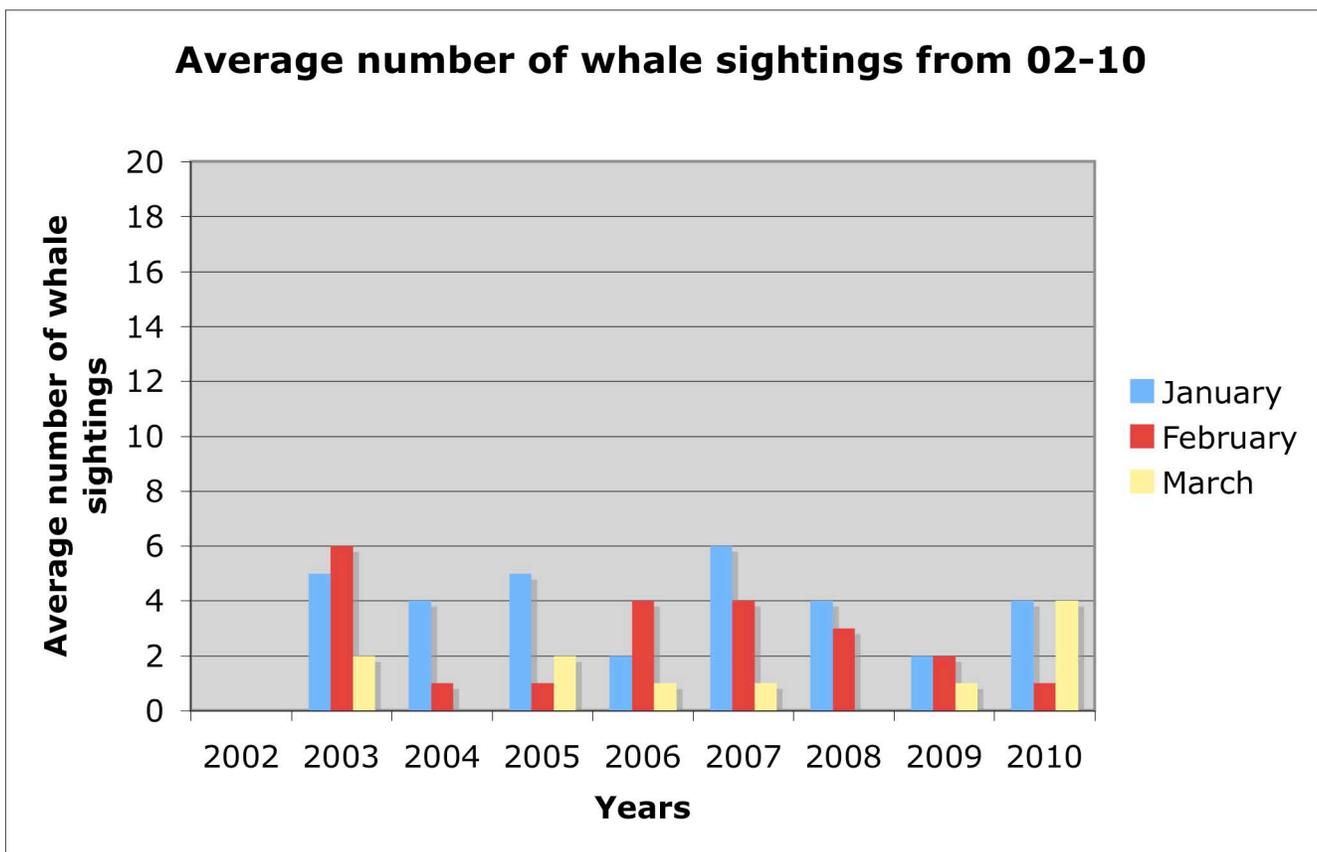
Island: Kauai

Site# 13: Port Allen Cemetery

Elevation: 30 ft

Coastline: West Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	NA	NA	NA
2003	5	6	2
2004	4	1	0
2005	5	1	2
2006	2	4	1
2007	6	4	1
2008	4	3	0
2009	2	2	1
2010	4	1	4



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Port Allen Cemetery on the island of Kauai.

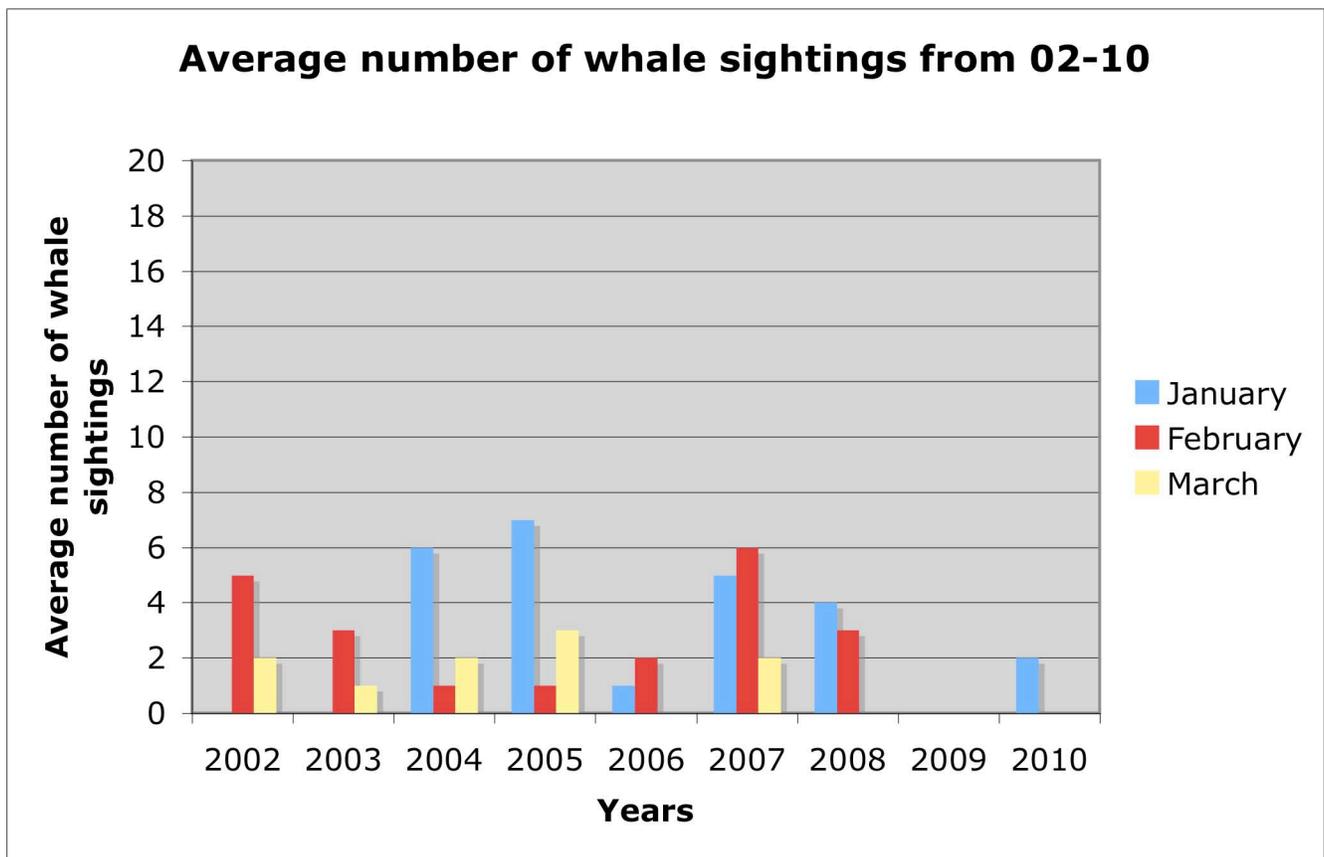
Island: Kauai

Site# 14: Waimea Canyon Drive

Elevation: 200 ft

Coastline: West Shore

Average number of whale sightings from 2002-2010			
Years	January	February	March
2002	NA	5	2
2003	0	3	1
2004	6	1	2
2005	7	1	3
2006	1	2	NA
2007	5	6	2
2008	4	3	0
2009	NA	NA	NA
2010	2	NA	0



Analysis:

This graph depicts the average number of humpback whale sightings per 15 minute count period (0800-1215) in January, February and March over the years 2002-2010 observed from the shore-based site Waimea Canyon Drive on the island of Kauai.