Chapter 5 Sea Turtles

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Green turtle. Photo credit: Mark Sullivan (NOAA NMFS/PIFSC/PRD)

ABSTRACT

*Five species of sea turtles occur in the Main Hawaiian Islands (MHI), all of which are protected under the Endangered Species Act (ESA). Of the five, green turtles (*Chelonia mydas*) are the most abundant and present year round. Hawksbill (*Eretmochelys imbricata*, also present year round), olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) are also found throughout the MHI, with varying types and degrees of activity. Basking, nesting, and stranding data were compiled by National Oceanic and Atmospheric Administration's (NOAA) Pacific Islands Fisheries Science Center (PIFSC) from a diversity of State and Federal agencies, as well as community organizations, volunteers and private citizens. These data were mapped in the context of shoreline cliffs and beaches to identify locations of turtle activity. Green turtles were reported basking at 62 locations around the MHI, with 34 percent of the reports from Oʻahu and 31 percent from the island of Hawaiʻi. Nesting locations by green (n=47), hawksbill (n=27), olive ridley (n=4) and leatherback (n=1) turtles were reported throughout the MHI. Kauaʻi had the highest number of nesting locations reported (19 of 47 or 40%). The majority of strandings are green turtles, with the largest proportions reported on Oʻahu (77%) and Maui (11%). Stranding causes varied among and within islands. These data may be used to document current spatial patterns and for comparison to future patterns post-wind farm installation. However, it is important to note that the density and frequency of reported sea turtle activities are biased by unequal survey effort. Effort was not consistently quantified and is presumably higher close to population centers and nearby beaches that were easily accessible. Future data collection efforts would benefit from island-wide monitoring that is controlled for effort as well as identification of foraging and offshore distributions of sea turtles throughout the entire MHI.*

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Sea Turtles

5.1. INTRODUCTION

Five species of sea turtles occur in the Main Hawaiian Islands (MHI). Green turtles (*Chelonia mydas*) are the most abundant and present year round. A small population of hawksbill turtles (*Eretmochelys imbricata*) nest and forage mostly around the island of Hawaiʻi and the Maui Nui area (Mangel et al., 2000; King et al., 2007; Parker et al., 2009; Seitz et al., 2012). Other species present, but rarely found, include olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta*). All sea turtles are long-lived, grow to large sizes, have specific diets, and spend the majority of their lives at sea (Table 5.1). With the notable exception of the basking behavior of green turtles on Hawaiian beaches (Balazs et al., 1980; Whittow and Balazs, 1982; Balazs et al., 2015), adult male sea turtles do not come ashore, and adult females come ashore only for nesting. Mature females nest seasonally (Table 5.1) every 2-3 years, laying several clutches of 50-200 eggs in sand cavities within a nesting season (Witzell, 1983; Dodd, 1988; Hirth, 1997; Balazs et al., 2015). After a 2-3 month incubation period wherein temperature determines sex, hatchlings emerge from nests, spend several years maturing in the ocean, and ultimately return to nest at natal beaches (Miller, 1996).

*Top: Green turtle (*Chelonia mydas*), Photo credit: Andy Bruckner (NOAA). Middle (L-R): Hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*); Photo credit: G.P. Schmahl (NOAA NOS/ONMS/FGBNMS). Bottom (L-R): leatherback (*Dermochelys coriacea*), Photo credit: Scott Benson (NOAA); and olive ridley (*Lepidochelys olivacea*), Photo credit: NOAA*

Development of offshore renewable energy platforms may potentially impact Hawaiian sea turtles in several ways. Female turtles utilize undeveloped beaches for nesting and can be disrupted when they encounter developed or artificially lit beaches (Witherington and Bjorndal, 1991). Emerging hatchlings use the brightest point on the horizon to navigate to the ocean. They may become disoriented if artificial beachfront lighting is brighter than the natural seaward horizon (Witherington and Bjorndal, 1991). It is estimated that only one in 1,000 hatchlings will survive to reproductive maturity (Frazer, 1986), so nesting success is important for maintaining the viability of sea turtle populations. Similarly, disturbances to basking beaches may have detrimental effects to sea turtles. Basking can be an important behavior for turtles to thermoregulate, avoid predators, accelerate metabolism and egg development, and to dry epiphytic growth on carapaces. All these factors contribute to turtle health and fitness (Whittow and Balazs, 1982; Spotila et al., 1996).

Sea turtle interactions with offshore renewable energy structures may occur. However, it is noteworthy that during the past 25 years of operating an extensive network of offshore Fish Aggregating Devices (FADs)

Table 5.1. Sea turtles present in the Main Hawaiian Islands (MHI), their species-specific life history traits and Endangered Species Act (ESA) status. Data sources: USFWS, 2015; NOAA PIRO, 2016

Scientific Name	*Caretta caretta*	*Chelonia mydas*	*Dermochelys coriacea*	*Eretmochelys imbricata*	*Lepidochelys olivacea*
Species Common Name	Loggerhead	Green	Leatherback	Hawksbill	Olive Ridley
ESA Status, HI	Endangered	Threatened	Endangered	Endangered	Threatened
Adult Size (average)	3 ft	4 ft	4-8 ft	3 ft	2.5 ft
Age at Maturity (estimated)	32-35 yr	25-35 yr	16 yr	20+ yr	10-18 yr
Diet	crustaceans, mollusks	seagrasses, algae	jellyfish	sponges	crustaceans
Clutch Size	100-126	75-200	80-85	140-200	100-110
Hawaiian Nesting Season	N/A	May-September	Year round (Jan-Jun, Jul-Dec)	May-September	June-December

throughout the MHI, there have been no reports of deleterious interaction with sea turtles. Consultations with local experts suggest that development of offshore wind energy in the MHI may have impacts to sea turtles that are similar to those caused by FADs (NOAA PIRO, 2016). In addition, the mechanisms by which sea turtles navigate are not well understood, but could be a combination of olfaction, sight and electromagnetic senses (Lohmann et al., 2007; Lusci et al., 2007). Disturbances to these, by construction and ongoing presence of offshore platforms and power transmission lines, may deleteriously affect sea turtles' ability to navigate especially in open-water (Lohmann et al., 2007; Lusci et al., 2007). Ongoing programs that monitor stranding of injured or dead turtles provide important time-series datasets that can be monitored during the construction and operation of offshore renewable energy facilities.

Biogeographic characterization of sea turtle activities will be an important part of planning for potential impacts from construction of offshore renewable energy facilities. Given this informational need, the objectives of this chapter are to: 1) identify beaches used for nesting, 2) identify beaches used for basking, and 3) document present spatial patterns and causes of stranding. Place names mentioned in this chapter are depicted in Figure 5.1.

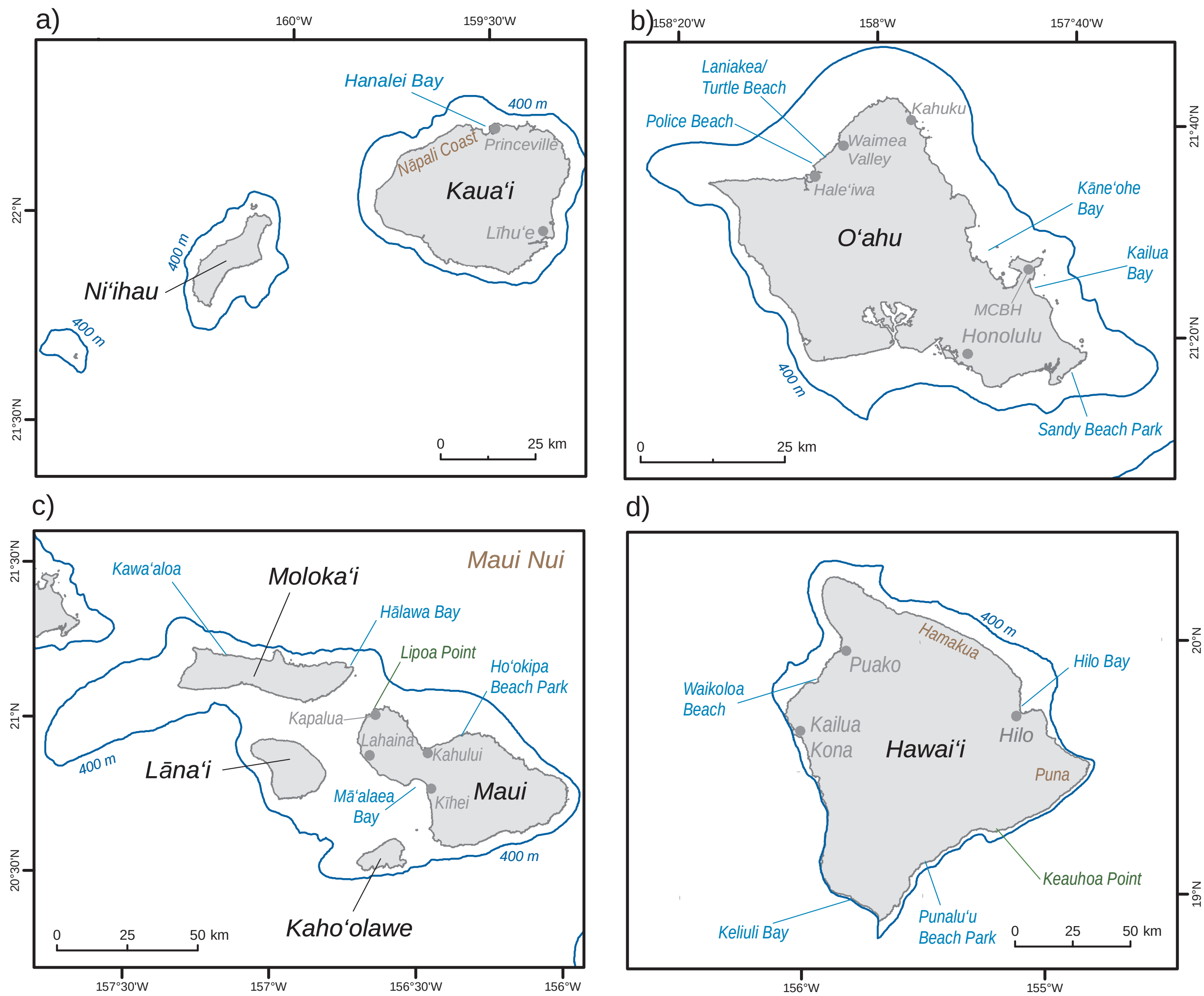

Figure 5.1. Key geographic features and place names around the Main Hawaiian Islands (MHI). These maps depict geographic features that are referenced in this chapter for: a) Niʻihau and Kauaʻi; b) Oʻahu; c) Maui Nui, which includes Molokaʻi, Lānaʻi, Maui and Kahoʻolawe; and d) Hawaiʻi. All depths are in meters. Data sources: shoreline (Battista et al., 2007), elevation (USGS, 2015), and depths (NOAA NCEI, 2005; GEBCO, 2008)

5.2. METHODS AND DATA DESCRIPTION

Sea turtle nesting, basking, and stranding data have been compiled by the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS), Pacific Islands Fisheries Science Center (PIFSC) from a diversity of State and Federal agencies, as well as community organizations, volunteers, and private citizens that report sea turtle sightings (e.g., Parker et al., 2015). Due to the varying level of monitoring effort and quantitative rigor among these groups and across the diverse islands and shorelines of the MHI, a semi-quantitative approach is used to convey the frequency and magnitude of sea turtle activities. Frequency refers to how often an activity is reported at a particular location (Table 5.2), and magnitude refers to the maximum number of incidences or individuals involved or reported (Table 5.3). Descriptors of nesting, basking, and stranding values are explained in Table 5.2. Stranding data are reported as events for individual turtles with location, turtle demographics, and cause described to the degree possible given the circumstances of each occurrence.

Table 5.2. Descriptors of sea turtle nesting and basking frequencies.

Frequency scale	Nesting	Basking
Regular	Annually (every year)	Daily – regularly sighted
Intermittent	Less than annual – (Not yearly, maybe every other year or similar)	Not Daily – sighted once a week to once a month
Rare	Sporadic nesting with multiple year gaps between nesting	Sighted once a year or greater
Unknown	Nesting noted, but nesting cycle unknown	Basking noted, but frequency unknown

Table 5.3. Nesting and basking magnitudes (individuals per year).

Green turtle		Hawksbill turtle
Nesting Magnitudes	Basking Magnitudes	Nesting Magnitudes
<1	1-5	<1
1-2	6-10	1-3
3-4	11-20	3-5
	30-50	

Nesting, basking, and stranding data were mapped onto the MHI shoreline, and patterns of distribution and abundance were visually evaluated. Any coordinates more than one kilometer inland or offshore were removed. Although sea turtles utilize Hawaiian waters more than one kilometer offshore, the focus of this report is the nearshore activities of the turtles. For stranding events, NMFS is notified via widely advertised hotline numbers. Experts recover the specimens, record the stranding location, and, if possible, determine the cause of the stranding event. For simplicity, the 115 unique causes for strandings in the database were combined into eight general categories. These were: boat impact, entanglement, fibropapillomatosis (FP), human-caused mortality, ingestion, natural predation, other illnesses and trauma. Reasons for stranding were summarized along coastlines of each island using pie charts. Unknown (n=864, all islands), pending (n=6, Oʻahu only), and hatchling mortality (n=19, Oʻahu only) counts were removed from totals used for the pie charts because reasons for stranding were not available. Hatchling mortality (n=19) data were also not used in Oʻahu stranding counts. Coastal segments varied in size depending on island shape, shoreline type, positions of coastal promontories, environmental exposure and stranding density. In cases where stranding records included multiple causes, only the primary cause was depicted in plots and used in summary figures.

Basking green turtles. Credit: Mark Sullivan (NOAA NMFS/PIFSC/PRD).

While managing a community-based call-in "hotline" for people to report sea turtle activities is a major undertaking and has several benefits (education opportunities, community participation and support, conservation), it also means that geographic specificity and survey effort are highly variable, if recorded at all. The density and frequency of reported sea turtle activities are biased by different amounts of survey effort and accessibility of locations surveyed. Therefore, to place the distribution of turtle records into context, human population density within census tracks, as well as shoreline types, including cliffs and beaches, were added to the maps. Human population density provides a proxy for monitoring effort. A higher density of people means greater potential to observe and report sea turtle activities. Human population density data were obtained from the State of Hawaiʻi (2010) and divided into five classes of individuals per square meter within each island. The 'natural breaks' function in ArcMap was used to identify break points that maximize differences between classes within each island. These data are displayed as relative human population data for each island to highlight the areas that were more populated on each island.

Shoreline type also influences the variety of sea turtle activities that can occur and be observed. Sand beaches are used for nesting, whereas basking and stranding can also occur in rocky areas. Beaches have easier access so reporting turtle activity by the public is easier in this area than in rocky areas or areas with steep cliffs. Shoreline attribute data were obtained from the Environmental Sensitivity Index, Hawaiʻi (NOAA ORR, 2001). Shore segments attributed as 'exposed rocky cliffs' (ESI Code 1A) and 'exposed wave-cut platforms in bedrock' (ESI Code 2A) were extracted to represent cliffs, and thus areas where stranded turtles most likely will not wash ashore. Beaches included shoreline segments attributed as 'fine- to medium-grained sand beaches' (ESI Code 3A), 'coarse-grained beaches' (ESI Code 4), and 'mixed sand and gravel beaches' (ESI Code 5), areas where nesting is most likely to occur, and may be where some basking occurs. Basking is also reported on flat, rocky shorelines (i.e., Kiholo and Kona Coast areas). Only those segments equal to or longer than 370 m are displayed on maps due to scale.

5.3. RESULTS AND DISCUSSION

5.3.1. Basking

There were basking activities reported for green turtles at 62 locations around MHI from 1990 to 2014. Of these 62 reports, 34 percent were from Oʻahu, and 31 percent from the island of Hawaiʻi (Table 5.4). These two islands have relatively high human population densities and, therefore, a higher likelihood of humans observing and reporting basking activity. Oʻahu reports were dominated by small numbers of turtles basking intermittently. In contrast, Hawaiʻi Island reports were dominated by larger numbers of turtles basking more regularly. Although Maui reported only 16 percent of total basking reports, Hoʻokipa Beach is a regular basking beach with a magnitude of 30-50. Similarly, Kauaʻi reported 13 percent of total basking reports, but has two northwest locations with regular basking and magnitudes of 30-50. Molokaʻi and Lānaʻi had the fewest reports of basking (two basking areas reported on each island). These two islands are sparsely populated, so more

*Table 5.4. Frequency, magnitude and number of basking activities by green turtles (*Chelonia mydas*) in MHI, 1990-2014. Frequency refers to how often an activity is reported at a particular location and magnitude refers to the number of incidences or individuals involved per year. Data source: Parker et al., 2015*

Frequency	Magnitude	Hawaiʻi	Kauaʻi	Lānaʻi	Maui	Molokaʻi	Oʻahu	Totals
Intermittent	1-5	4	3	1	8	2	12	30
	6-10	2	0	0	0	0	0	2
Regular	1-5	0	1	0	0	0	0	1
	6-10	4	1	0	0	0	4	9
	11-29	6	0	1	1	0	3	11
	30-50	3	2	0	1	0	0	6
Rare	1-5	0	0	0	0	0	2	2
Unknown	1-5	0	1	0	0	0	0	1
Totals		**19**	**8**	**2**	**10**	**2**	**21**	**62**
Percent of total		**31**	**13**	**3**	**16**	**3**	**34**	**100**

basking may occur on these islands than is reported. No basking has been reported on Ni'ihau and Kaho'olawe. Ni'ihau is privately owned with limited contact to people outside the island, and few scientific surveys have been conducted there. Kaho'olawe has no permanent human population, and access to the island is limited to cultural restoration and ordinance clearing. However, as access to both of these islands increases, reports of basking turtles may also increase.

O'ahu

On O'ahu, most basking activity was reported along the northwest coast (Figure 5.2) between Hale'iwa and Waimea Valley, where the aptly named Laniakea "Turtle" Beach is located. There was a secondary concentration of basking activities reported in the southeast, near Marine Corps Base Hawai'i (MCBH), in both Kāne'ohe and Kailua Bays. These locations offer a combination of good shoreline habitat and easy access for humans to observe and report basking.

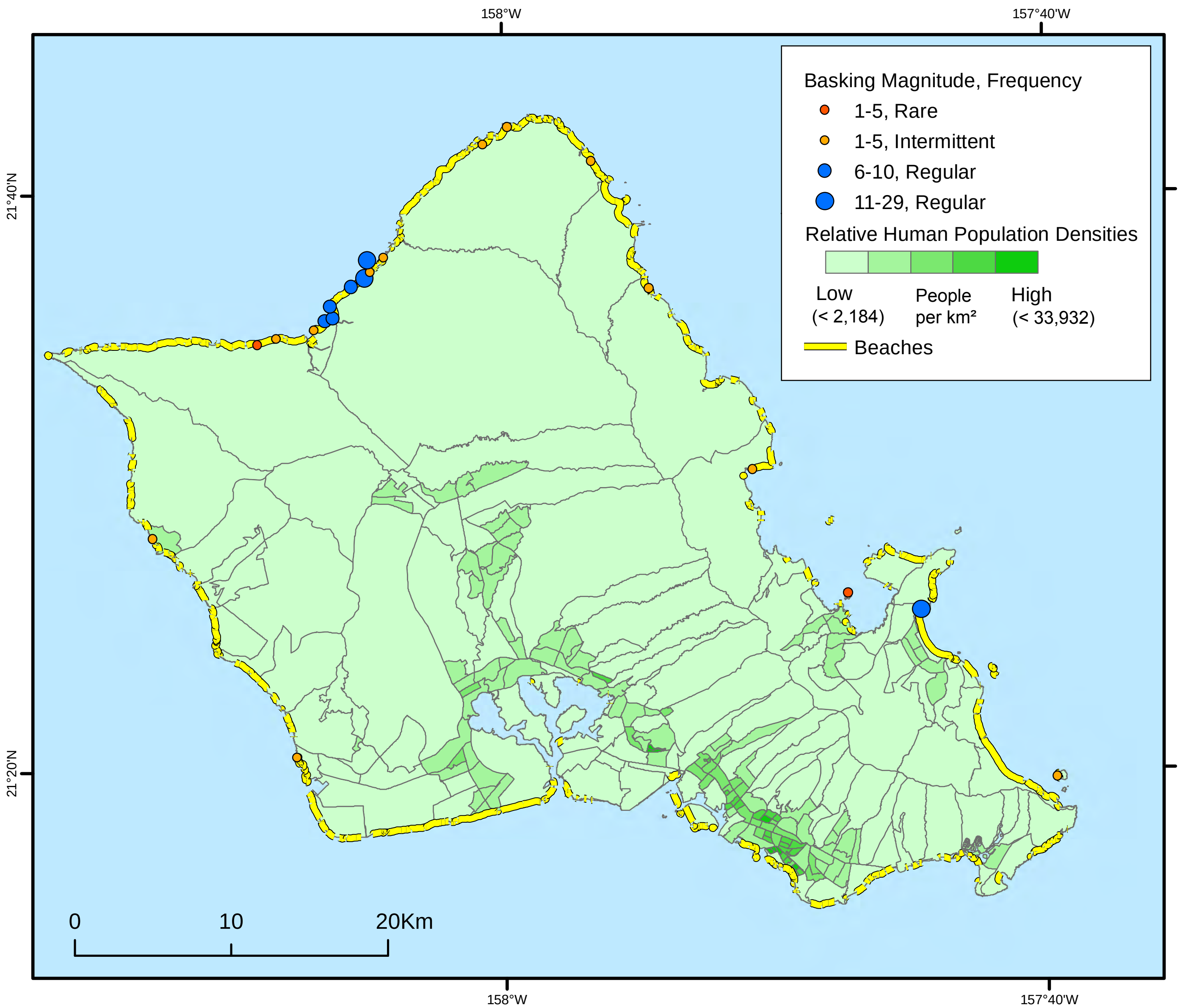

*Figure 5.2. Green turtle (*Chelonia mydas*) basking locations on O'ahu. Data show magnitude and frequency of reported basking, 1990-2014. Frequency refers to how often an activity is reported at a particular location, and magnitude refers to the number of incidences or individuals involved. Data sources: basking (Parker et al., 2015), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

Hawai'i

Hawaiʻi Island's basking activities were reported primarily along the west coast (Figure 5.3), along the Queen Ka`ahumanu Highway from Waikoloa Beach to Puako, with another concentration near Kailua-Kona. A third area of activity was reported along the east coast near Hilo. Again these areas correspond to good basking habitat that can be readily observed by humans.

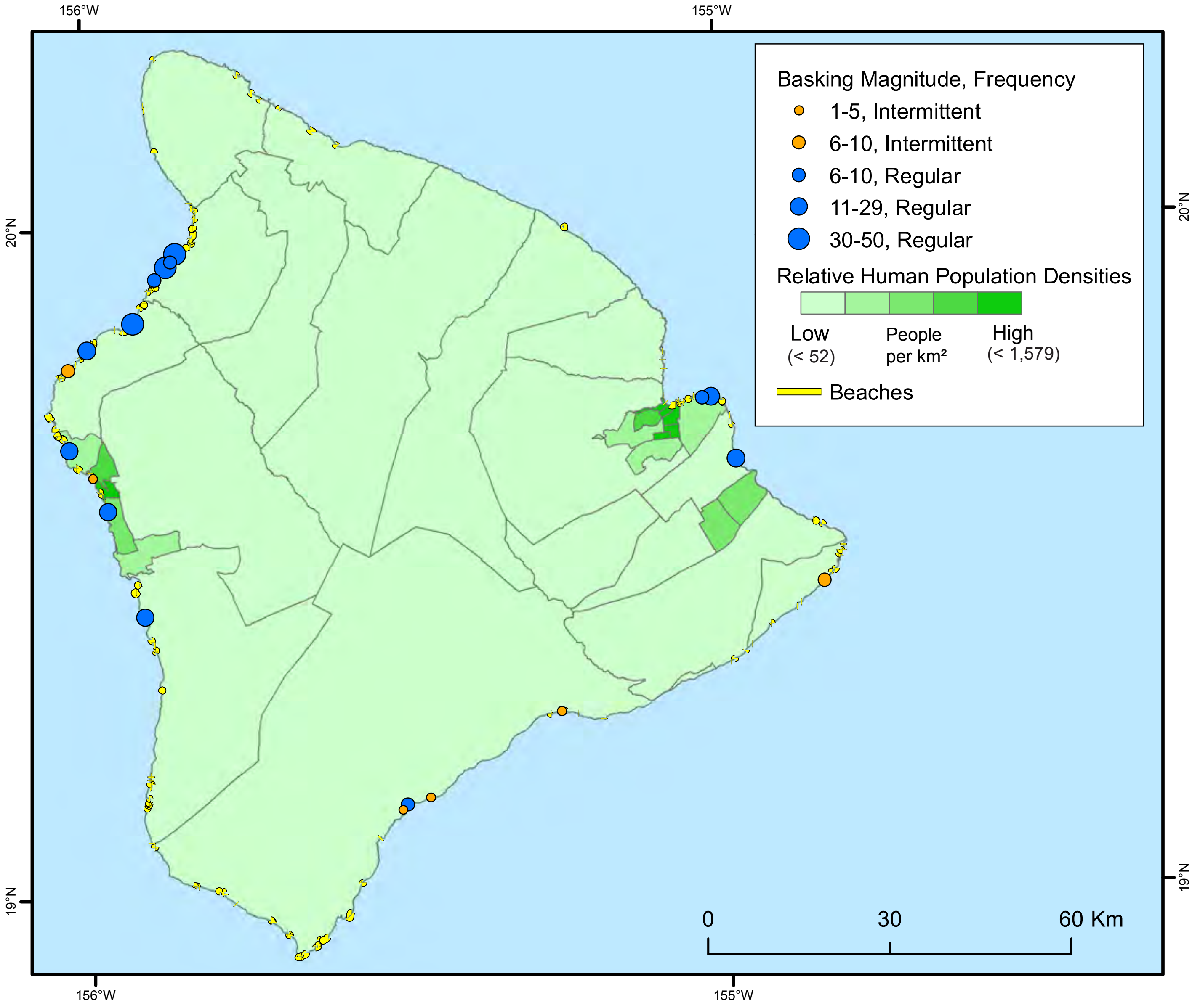

*Figure 5.3. Green turtle (*Chelonia mydas*) basking locations on the island of Hawaiʻi. Data show magnitude and frequency of reported basking, 1990-2014. Frequency refers to how often an activity is reported at a particular location, and magnitude refers to the number of incidences or individuals involved. Data sources: basking (Parker et al., 2015), human population (State of Hawaiʻi, 2010), and beaches (NOAA ORR, 2001)*

Maui

On Maui, most basking activity was reported in two areas: intermittent and regular basking in the northwest, south of Kapalua, near Napili Kai Beach Resort, and another concentration of regular basking in the north, near Ho`okipa Beach Park (Figure 5.4). Both areas have moderate relative human population densities and easy access to the coast, conditions that increase likelihood of reporting.

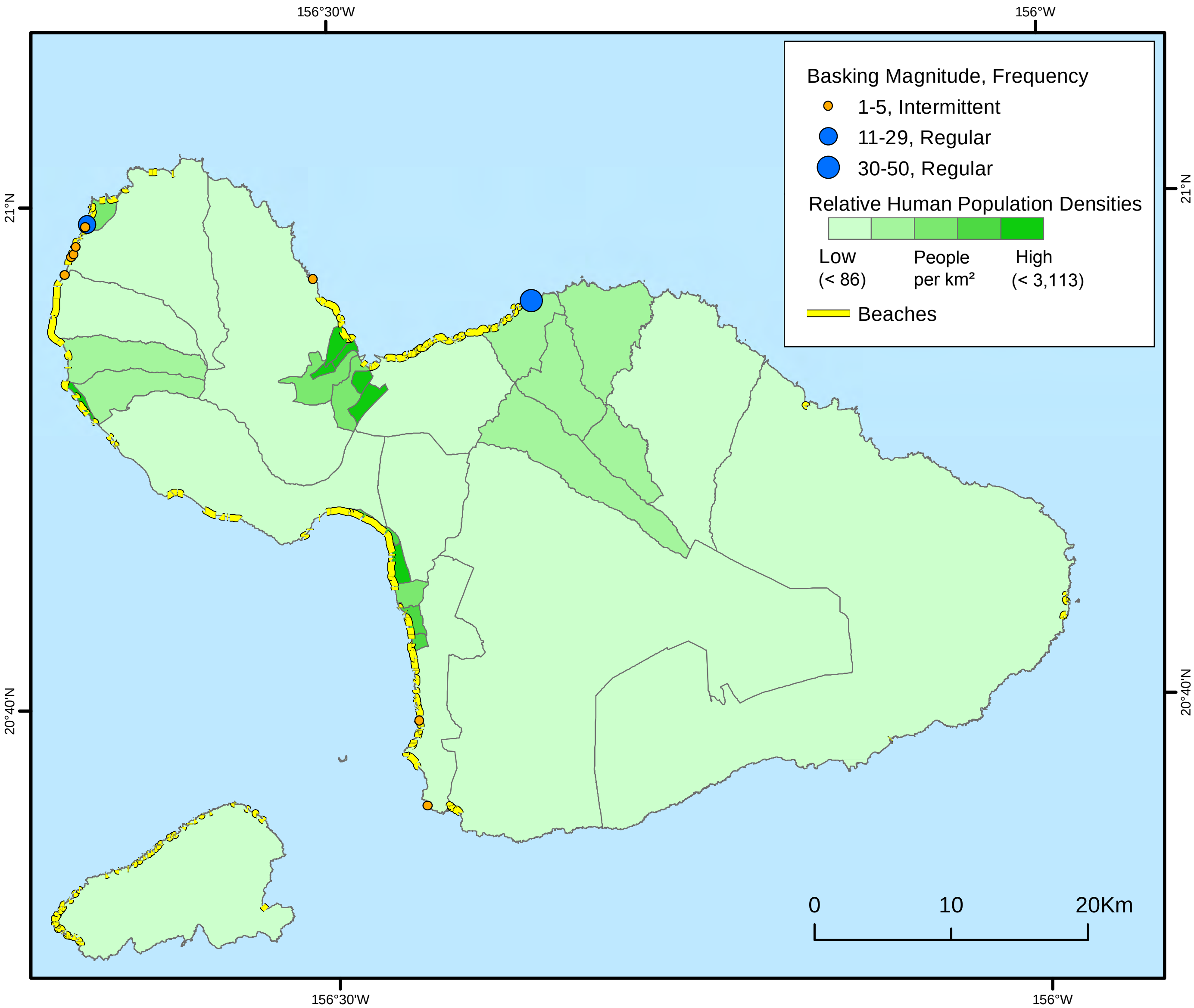

*Figure 5.4. Green turtle (*Chelonia mydas*) basking locations on Maui and Kaho'olawe. Data show magnitude and frequency of reported basking, 1990-2014. Frequency refers to how often an activity is reported at a particular location, and magnitude refers to the number of incidences or individuals involved. Data sources: basking (Parker et al., 2015), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

Kaua'i

Interestingly, of Kaua'i's eight reported basking locations, the two regularly reported locations, with magnitudes of 30-50, are not near beaches, nor are they near highly populated area (Figure 5.5). The island of Hawai'i's three regularly reported locations with magnitudes of 30-50 are similarly not near highly populated areas.

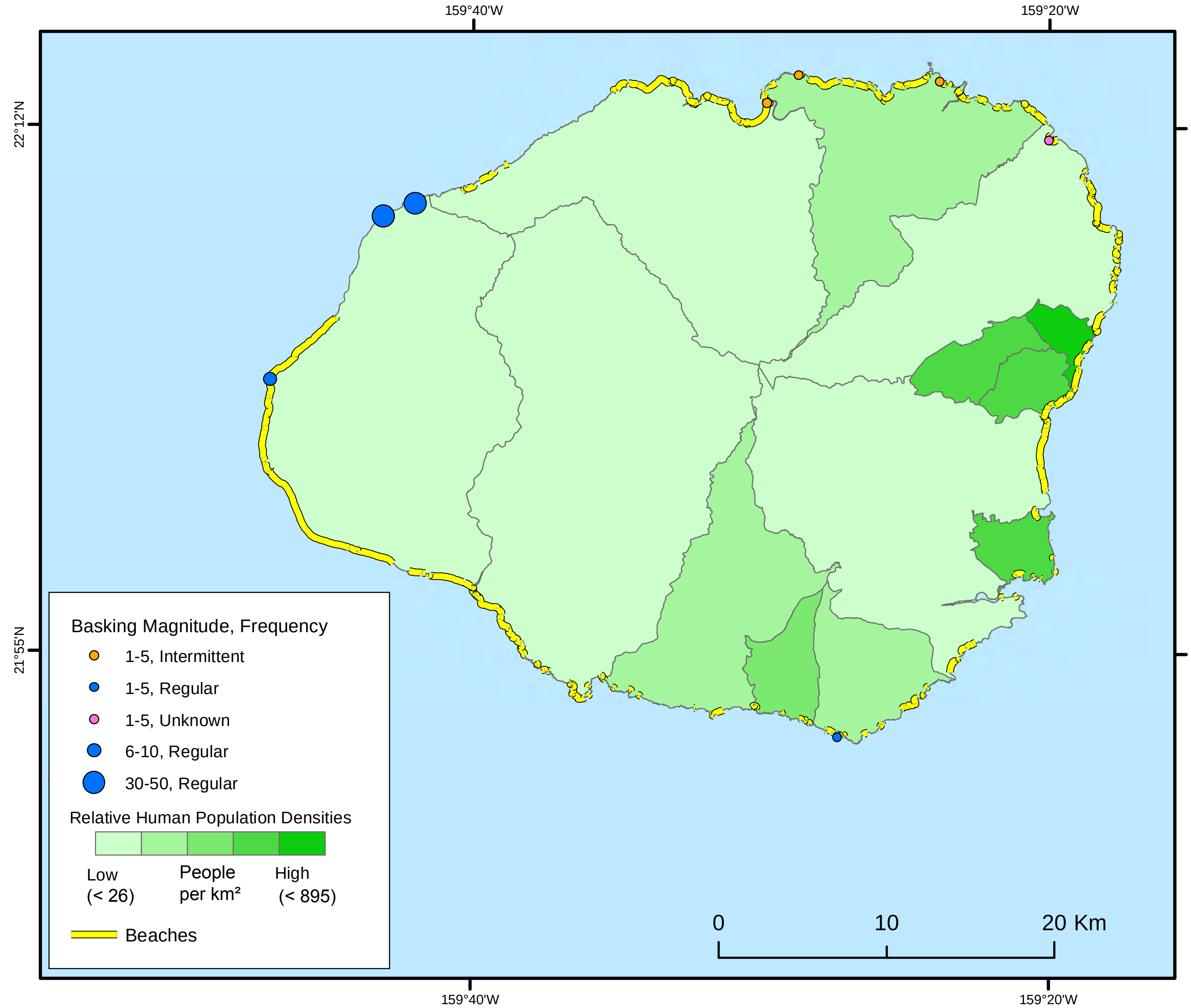

*Figure 5.5. Green turtle (*Chelonia mydas*) basking locations on Kaua'i. Data show magnitude and frequency of reported basking, 1990-2014. Frequency refers to how often an activity is reported at a particular location, and magnitude refers to the number of incidences or individuals involved. Data sources: basking (Parker et al., 2015), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

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Lānaʻi and Molokaʻi

There were very few reports of basking from Lānaʻi (Figure 5.6) and Molokaʻi (Figure 5.7). These islands both have relatively sparse human populations.

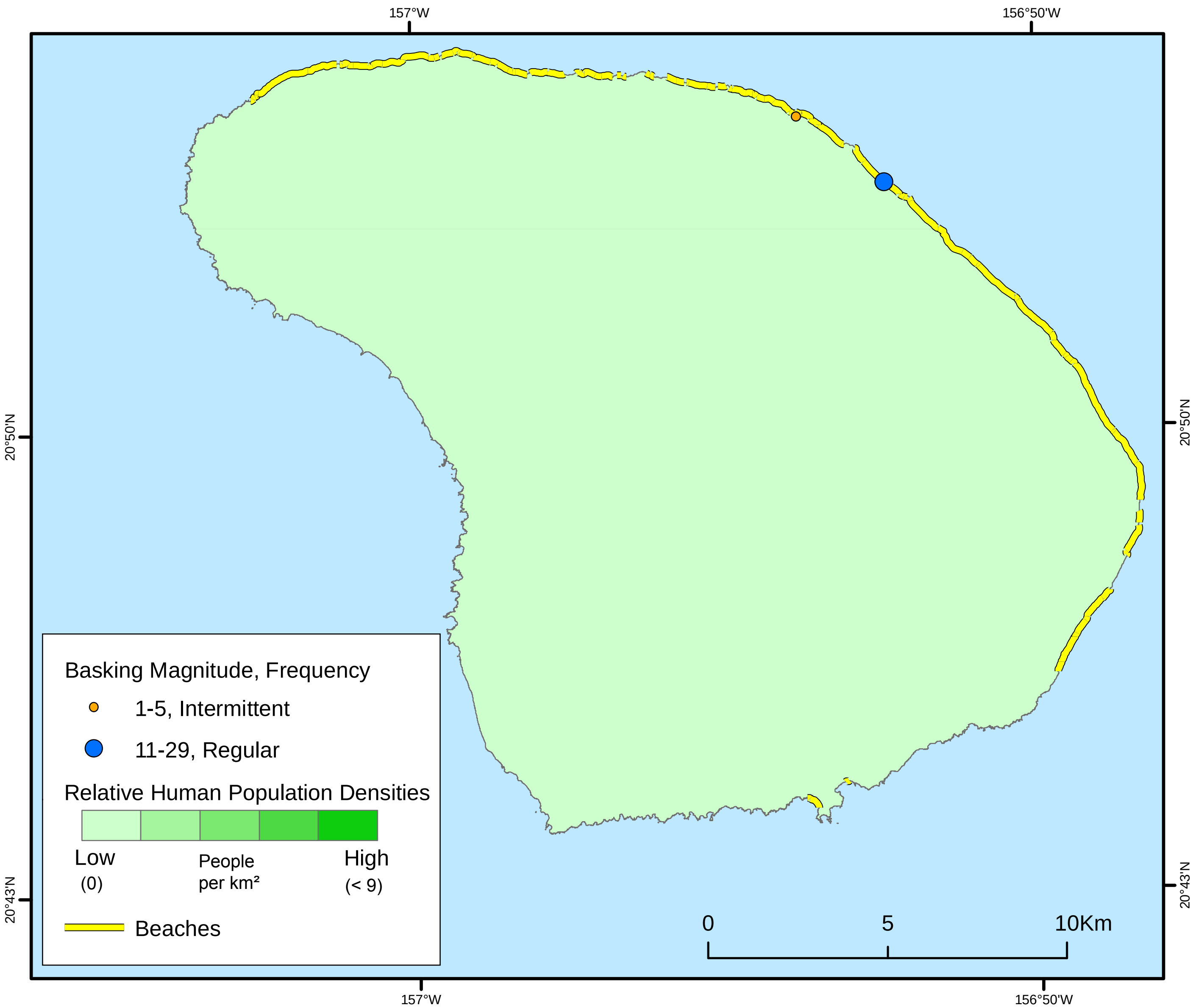

*Figure 5.6. Green turtle (*Chelonia mydas*) basking locations on Lānaʻi. Data show magnitude and frequency of reported basking, 1990-2014. Frequency refers to how often an activity is reported at a particular location, and magnitude refers to the number of incidences or individuals involved. Data sources: basking (Parker et al., 2015), human population (State of Hawaiʻi, 2010), and beaches (NOAA ORR, 2001)*

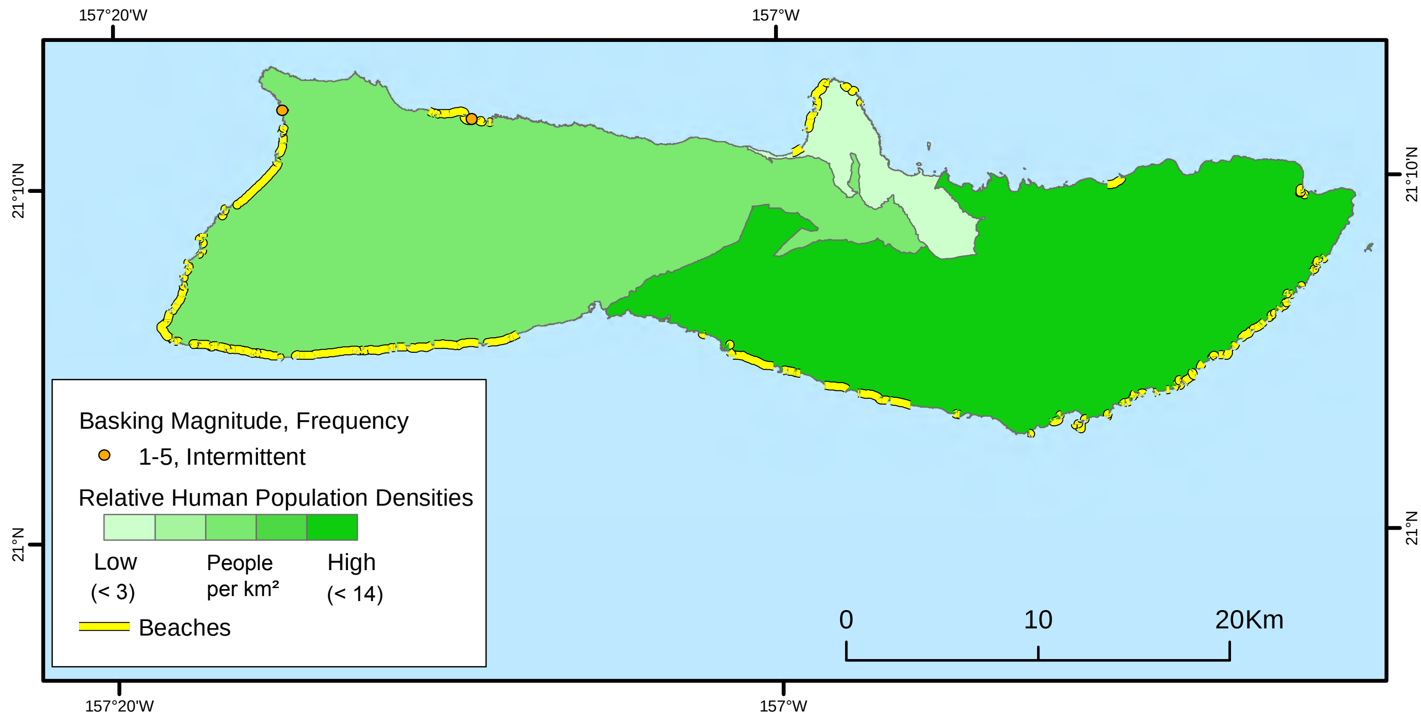

*Figure 5.7. Green turtle (*Chelonia mydas*) basking locations on Moloka'i. Data show magnitude and frequency of reported basking, 1990-2014. Frequency refers to how often an activity is reported at a particular location, and magnitude refers to the number of incidences or individuals involved. Data sources: basking (Parker et al., 2015), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

5.3.2. Nesting

There were 79 locations with reported nesting activities for sea turtles around the Main Hawaiian Islands between 1900 to present. Of these 79 reports, 47 (60%) were green turtle nestings, 27 (34%) were hawksbill, 4 (5%) were olive ridley, and one (1%) was leatherback (Tables 5.5 and 5.6).

For green turtles, Kaua'i had the highest number of nesting locations reported (19 of 47 or 40%) despite having relatively low human population density, however, nearly 50 percent of these were rare sightings (Table 5.5). Maui and O'ahu each accounted for 23 percent (11 of 47) of reports. Most nesting reports consisted of intermittent or rare frequency and only 1-2 individuals for each event. In contrast, Moloka'i had the highest magnitude of regular nesting locations reported, with 3-4 individuals seen on a regular basis but only at one location. The islands of Hawai'i, Kaho'olawe and Lāna'i had few reports of nesting locations, always in the lowest frequency (rare) and smallest magnitude (<1). There were no reports from Ni'ihau. As stated previously, Ni'ihau and Kaho'olawe have limited scientific access. However, as access to both of these islands increases, reports of nesting turtles may also increase.

*Table 5.5. Frequency, magnitude, and number of nesting locations by green turtles (*Chelonia mydas*) in the MHI, 1900-2014. Frequency refers to how often an activity is reported at a particular location, and magnitude refers to the estimated number of individuals involved per year. Data source: Parker et al., 2015*

Species	Island	Frequency	Magnitude	# Locations
Green	Hawai'i	rare	<1	1
	Kaho'olawe	rare	<1	1
	Kaua'i	regular	1-2	2
		intermittent	<1	7
		unknown	<1	10
	Lāna'i	rare	<1	1
	Maui	intermittent	<1	11
	Moloka'i	regular	1-2	1
		regular	3-4	1
	O'ahu	regular	1-2	3
		intermittent	<1	8
		rare	<1	1
Total Green turtle nesting activities				**47**

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Reports of green turtle nesting locations around Kaua'i (Figure 5.8) are distributed around the island, with the fewest reports along the north Nāpali Coast to Princeville. This may be partly due to a lack of roads along the coastline in the area, and the relatively low human population density. This coastline has a few small pocket beaches where nesting activities may occur, but go unreported in this low-accessibility, sparsely-populated area. In contrast, to the east of Princeville, relative human population is denser, and more nesting activities are reported. Along the south coast, there are several beaches, accessibility is easy due to a shoreline highway, and human density increases. There are more nesting reports of regular frequency from this area of the island.

*Table 5.6. Magnitude and number of nesting locations by hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*) sea turtles in MHI, 1900-2014. Magnitude refers to the number of incidences or individuals involved. Data source: Parker et al., 2015*

Species	Island	Magnitude	# Locations
Hawksbill	Hawai'i	<1	6
		1	10
		3	1
		5	1
	Maui	<1	5
	Moloka'i	<1	2
	O'ahu	<1	2
Leatherback	Lāna'i	<1	1
Olive	Hawai'i	<1	1
	Maui	<1	1
	O'ahu	<1	2
Total other species nesting activities			**32**

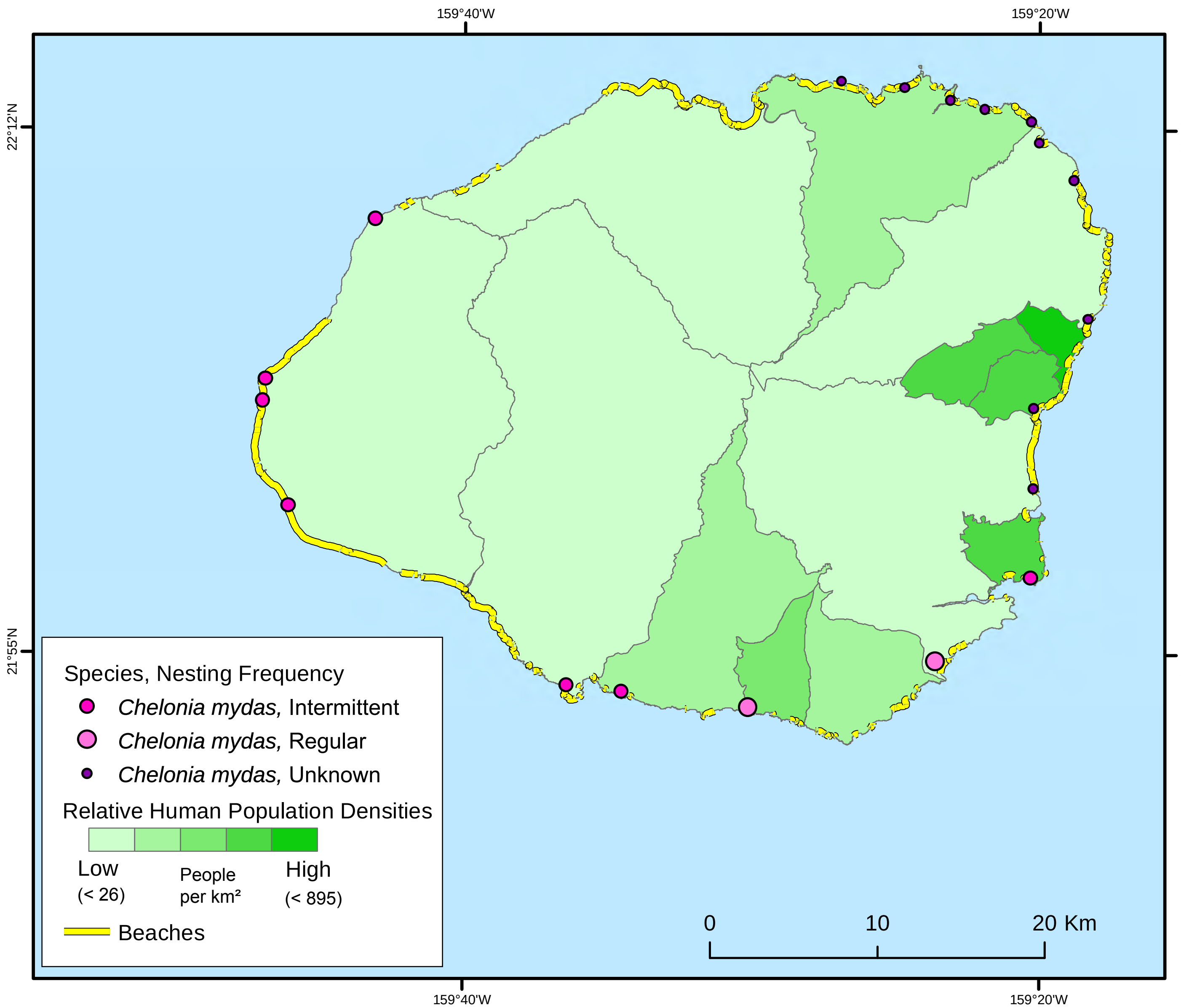

*Figure 5.8. Sea turtle nesting locations on Kaua'i. Data show species and frequency (*Chelonia mydas *only) of reported nestings, 1900-2014. Data sources: nesting (NOAA MTBAP, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

Green turtle nesting reports were distributed somewhat evenly around O'ahu, with concentrations of regular nesting frequencies reported at Police Beach, near Kahuku in the north, and Sandy Beach Park in the southeast (Figure 5.9). These areas of regularly reported activities are, also, areas frequented by sight-seers, increasing the likelihood of reports.

Green sea turtle, Chelonia mydas. *Photo credit: Bryan M. Costa (NOAA NOS/NCCOS)*

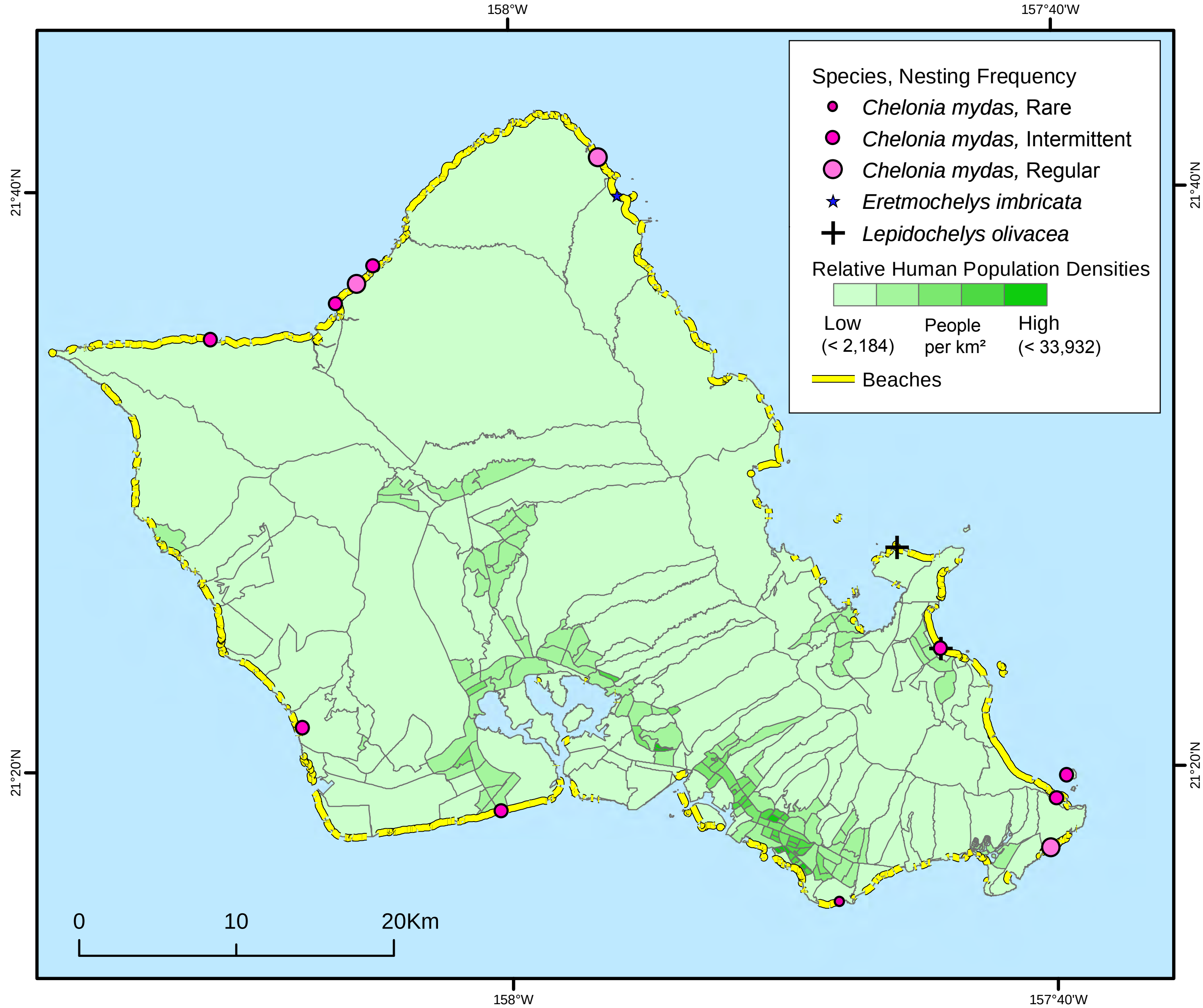

*Figure 5.9. Sea turtle nesting locations on O'ahu. Data show species and frequency (*Chelonia mydas *only) of reported nestings, 1900-2014. Data sources: nesting (NOAA MTBAP, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

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Nesting activity around Maui (Figure 5.10), including green, hawksbill, and olive ridley turtles, is concentrated in three locations: Kahului to Ho`okipa Beach in the northeast, Mā`alaea Bay off Kīhei, and the northwest coast from near Lāhainā to Lipoa Point. Each of these sites is near human population centers, offers people easy access to beaches, and provides good nesting habitat for turtles.

Olive ridley turtle. Photo credit: Reuven Walder (Turtle Island Restoration Network)

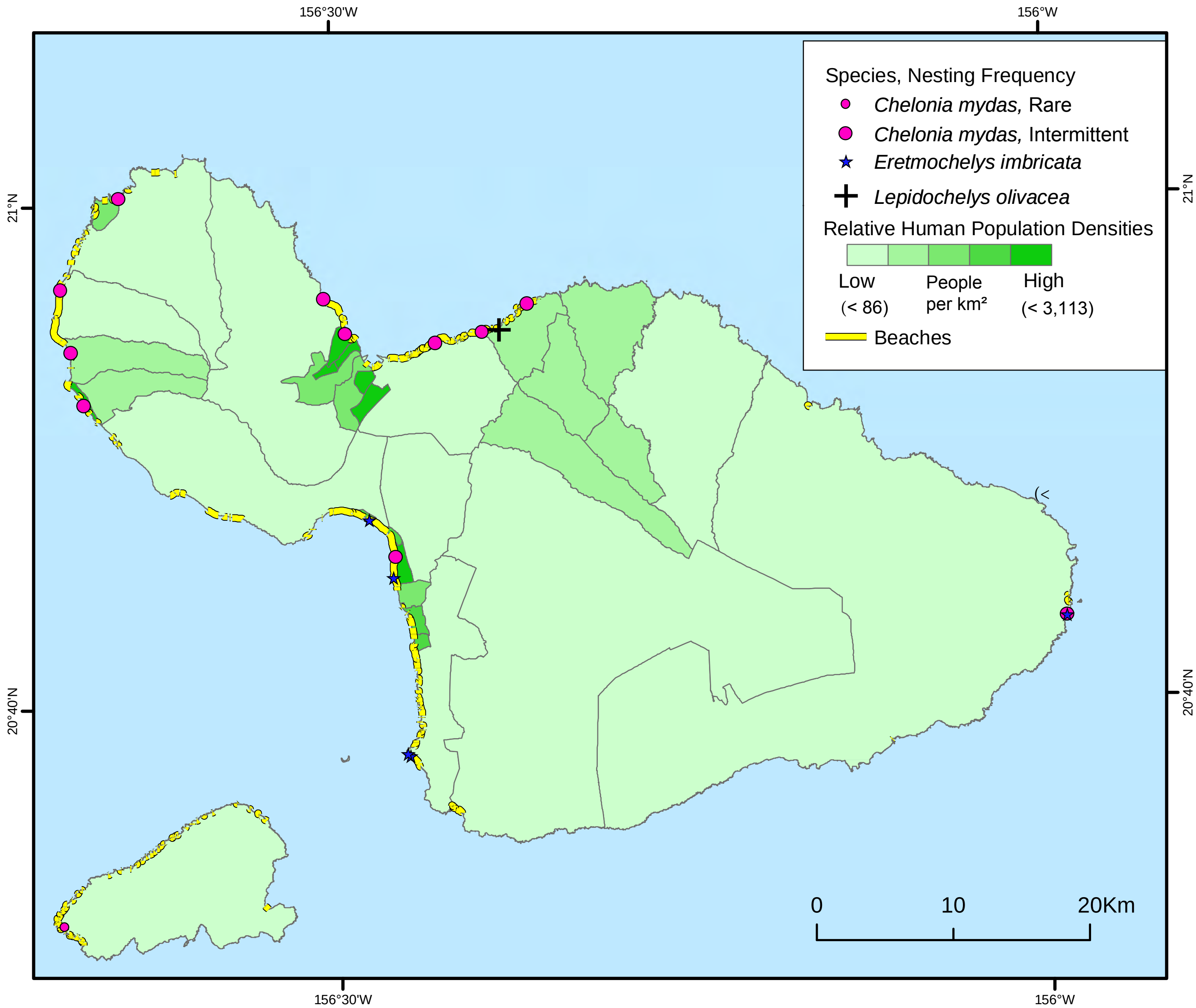

*Figure 5.10. Sea turtle nesting locations on Maui and Kaho'olawe. Data show species and frequency (*Chelonia mydas *only) of reported nestings, 1900-2014. Data sources: nesting (NOAA MTBAP, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

Of the other three species of sea turtles (hawksbill, olive ridley, and leatherback) for which nesting locations were reported (Table 5.6), hawksbill sea turtles were most commonly reported from the island of Hawai'i, with smaller numbers from Maui, Moloka'i, and O'ahu. Hawksbill nesting locations were reported around Hawai'i Island's southern coast (Figure 5.11), with concentrations near Keliuli Bay, near Punalu`u County Beach Park, and in the pocket beaches of Hawai'i Volcanoes National Park near Keauhoa Point. Of note, fewer than 20 hawksbills nest each year (Seitz et al., 2012; Snover et al., 2013). Given its 'endangered' status under the ESA (Table 5.1), there is great need to monitor the population closely and make strides toward conservation. The hawksbill telemetry study by Parker et al. (2009) indicates the nesters (n=3) from Hawai'i's Kamehame nesting area may forage around the Hamakua Coast, and that the hawksbills (n=3) nesting on beaches near Kīhei, Maui, also forage along Hawai'i's Hamakua Coast.

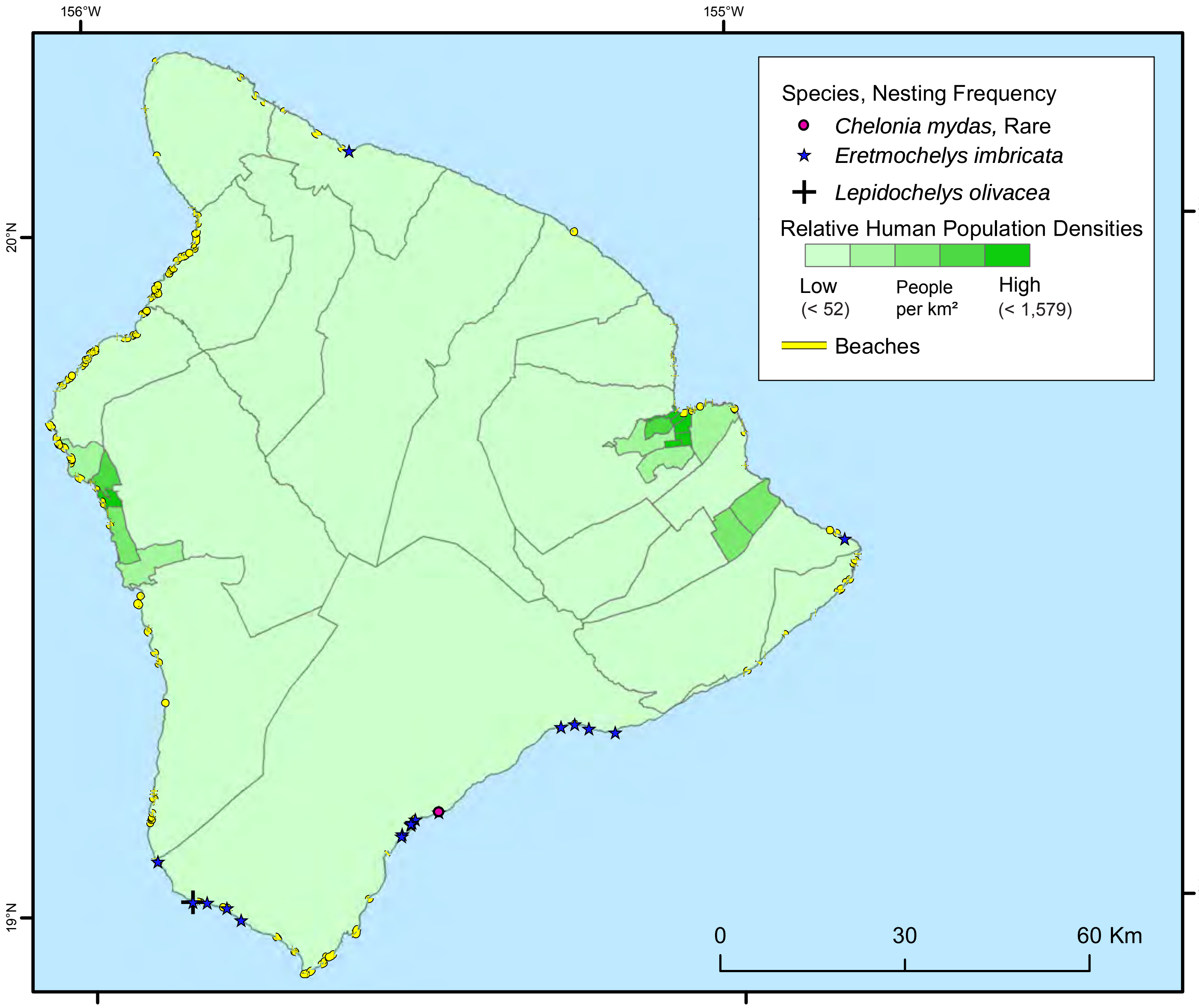

*Figure 5.11. Sea turtle nesting locations on the island of Hawai'i. Data show species and frequency (*Chelonia mydas *only) of reported nestings, 1900-2014. Data sources: nesting (NOAA MTBAP, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

Sea Turtles

On rare occasions, other species have been observed. Four olive ridley nests were reported on the islands of Hawai'i (1), Maui (1), and O'ahu (2). There has been only one leatherback nesting report in the MHI, which occurred on Lāna'i (Figure 5.12). Few nesting reports are received around Moloka'i despite the presence of good beach habitat (Figure 5.13). Placing all of these nesting magnitudes and frequencies for the MHI into context, it should be noted that green turtles regularly nest each year at French Frigate Shoals in the Northwestern Hawaiian Islands at magnitudes of greater than 200 individuals per year (Nurzia Humburg and Balazs, 2014).

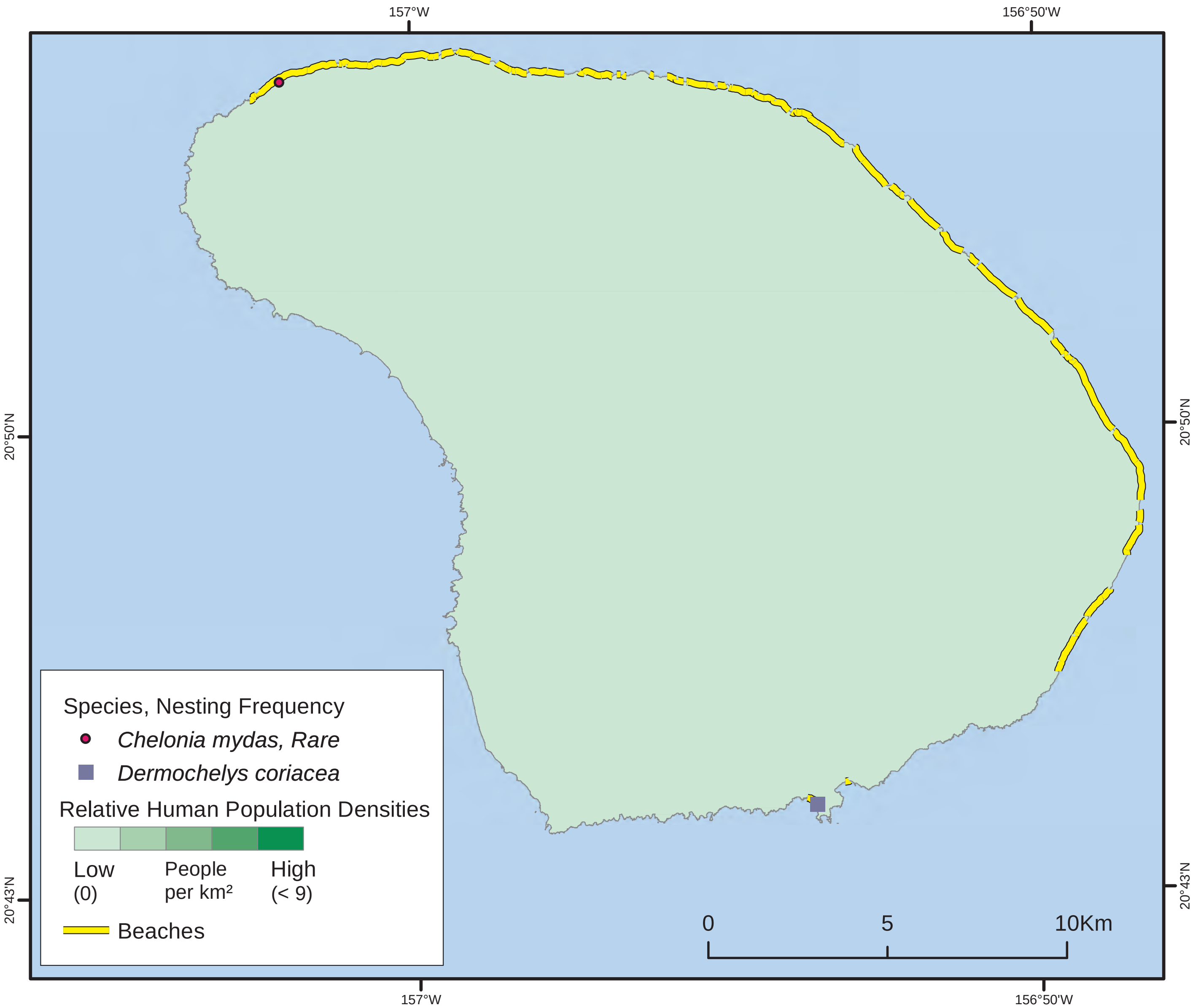

*Figure 5.12. Sea turtle nesting locations on Lāna'i. Data show species and frequency (*Chelonia mydas *only) of reported nestings, 1900-2014. Data sources: nesting (NOAA MTBAP, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)*

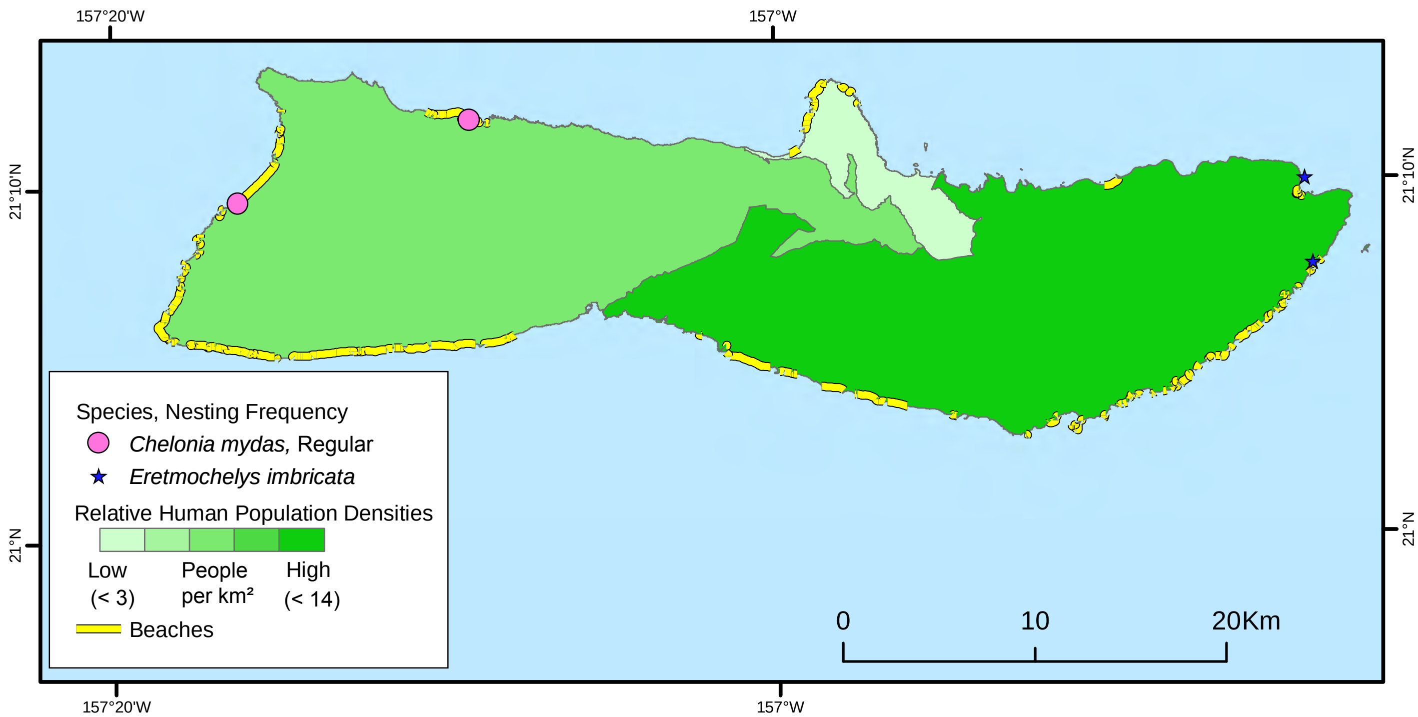

*Figure 5.13. Sea turtle nesting locations on Molokaʻi. Data show species and frequency (*Chelonia mydas *only) of reported nestings, 1900-2014. Data sources: nesting (NOAA MTBAP, 2014b), human population (State of Hawaiʻi, 2010), and beaches (NOAA ORR, 2001)*

5.3.3. Stranding

There were 3,433 reports of sea turtle strandings throughout MHI from 1977 through July 2014, including 889 records with an unknown or pending cause of the stranding (includes 19 related to hatchling mortality; Table 5.7). Of the 3,433 stranding reports, 77 percent were from Oʻahu, 10 percent from Maui, eight percent from the island of Hawaiʻi, and four percent from Kauaʻi. Lānaʻi and Molokaʻi both had less than one percent; Kahoʻolawe and Niʻihau had no reports. The magnitude of these values corresponds closely to the magnitude of the human population of each island. Higher human populations result in more stressors and potential causes of strandings, as well as more people to observe and report stranding events when they occur.

Table 5.7. Number of sea turtle strandings by primary cause reported in MHI, 1975-July 2014 (Murakawa, 2014a, 2014b).

Cause of Stranding	Hawaiʻi	Kauaʻi	Lānaʻi	Maui	Molokaʻi	Oʻahu	Totals
Boat Impact	12	5	0	4	0	88	109
Entanglement	32	22	1	16	2	406	479
Fibropapillomatosis (FP)	54	35	2	218	2	1,120	1,431
Human-caused mortality	14	5	2	10	0	42	73
Ingestion	14	5	2	9	0	102	132
Natural predation	15	6	2	21	1	98	143
Other illnesses, etc.	38	9	0	7	0	55	109
Trauma	9	3	0	7	1	67	87
Unknown	96	57	10	60	7	640	870
Totals	284	147	19	352	13	2,618	3,433

Fibropapillomatosis, or FP, is a debilitating transmissible disease in sea turtles which causes growth of bulbous tumors on soft tissues (Balazs et al., 2000), and may be linked to nutrient-rich, polluted waters (Van Houtan et al., 2014; Herbst and Klein, 1995; Arthur et al., 2008; Work et al., 2014). FP accounted for 42 percent of all strandings reported (Table 5.8), and is the main cause of strandings of green turtles in the MHI (Chaloupka et al., 2008). Entanglement was the second highest stranding event, with 14 percent reported; natural predation and ingestion accounted for four percent each. Human-caused mortality (apart from boat strikes) was the least reported reason for strandings, with two percent. Strandings attributed to boat impacts were only three percent of total strandings reported. Analyses in subsequent sections are segmented along island shorelines and include only those strandings with known cause (n=2,563).

Table 5.8. Percent of sea turtle strandings causes reported in MHI, July 6, 1977-July 26, 2014 (Murakawa, 2014a, 2014b).

Cause of Stranding	Percent
Boat impact	3
Entanglement	14
Fibropapillomatosis	42
Human-caused mortality	2
Ingestion	4
Natural predation	4
Other illnesses, etc.	3
Trauma	3
Unknown	25

O'ahu

O'ahu stranding reports were from most shores around the island, with some strandings even being reported from areas with cliffs (Figure 5.14). FP accounted for 56 percent of O'ahu strandings. FP far outnumbered any other reasons for strandings on all quadrants of O'ahu except in the southwest, where entanglement (n=89) accounted for nearly one-third of reported strandings (n=277). Eighty-five percent of all entanglements reported were from O'ahu. Across all islands, O'ahu reports accounted for 58 percent of all human-caused mortality reports, however, this cause was O'ahu's lowest count category. On O'ahu, four percent of all reported strandings were attributed to boat impacts, with southeast O'ahu having the highest percentage at seven percent. Although FP accounted for the majority of strandings, a recent study focused on the larger Hawai'i and insular Pacific region found that the majority of 230 turtles died from fishing-induced or boat strike trauma (Work et al., 2015).

Green turtle severely afflicted with fibropapillomatosis. Photo credit: Peter Bennett and Ursula Keuper-Bennett (Wikipedia)

Maui

On Maui, strandings were heavily reported along the north-central and south-central coasts, as well as the northwest coast (Figure 5.15). The majority of strandings were reported in areas without cliffs. Of all Maui strandings reported, 75 percent were attributed to FP. Maui reported the highest percentage of strandings due to FP and few differences among coastal regions.

Hawai'i

On the island of Hawai'i, strandings were reported heavily in three main clusters: on the west coast near Puako and near Kailua-Kona, and on the east coast near Hilo (Figure 5.16). The majority of strandings on the east coast were attributed to FP (57%, 49 of 86), whereas strandings on the west coast were caused primarily by other illnesses (29%, 30 of 102), but, also, many were attributed to other causes, including boat impacts, entanglements and natural predation. Presence of cliffs around the island of Hawai'i did not seem to exclude stranding reports.

Kaua'i

On Kaua'i, strandings were reported from around the island, except in areas with cliffs (Figure 5.17). Strandings were attributed primarily to entanglement in the northeast (41%, 20 of 49) and to FP in the southwest (63%, 26 of 41).

Lāna'i and Moloka'i

On Lāna'i and Moloka'i, only a few strandings were reported and those were from coasts without cliffs. Lāna'i's stranding reports were mostly from the beaches along the east coast (Figure 5.18), and Moloka'i's were from the south shore (Figure 5.19).

In conclusion, basking, nesting, and stranding data may be used to document current spatial patterns and avoid important habitats during wind-farm planning. Incidences of turtle activities are not expected to change following wind farm development; however, describing present patterns will provide an important biogeographic baseline to detect any changes.

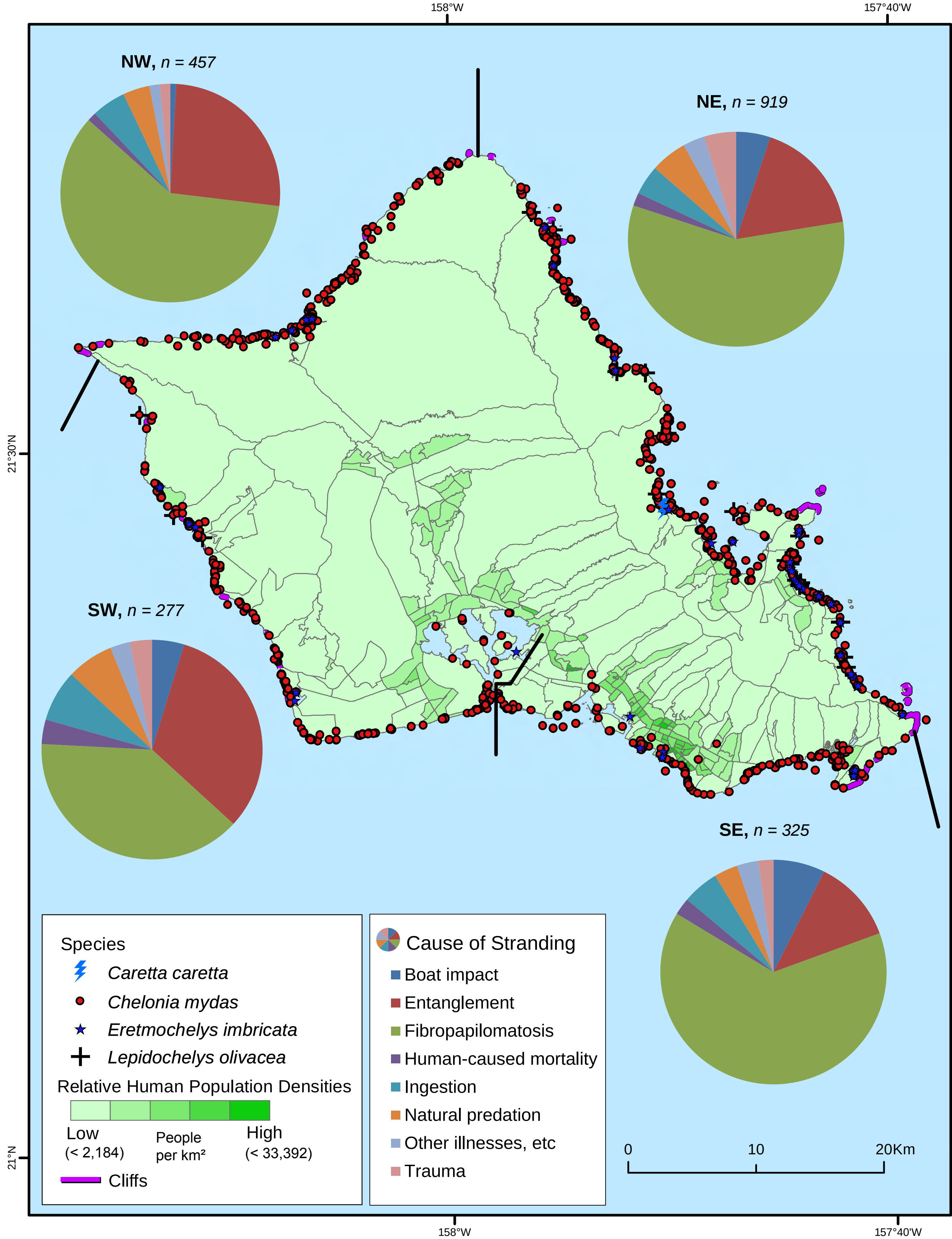

Figure 5.14. Sea turtle strandings on O'ahu. Data show species and location of reported strandings, 1978-2014. Data sources: strandings (Murakawa, 2014a, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)

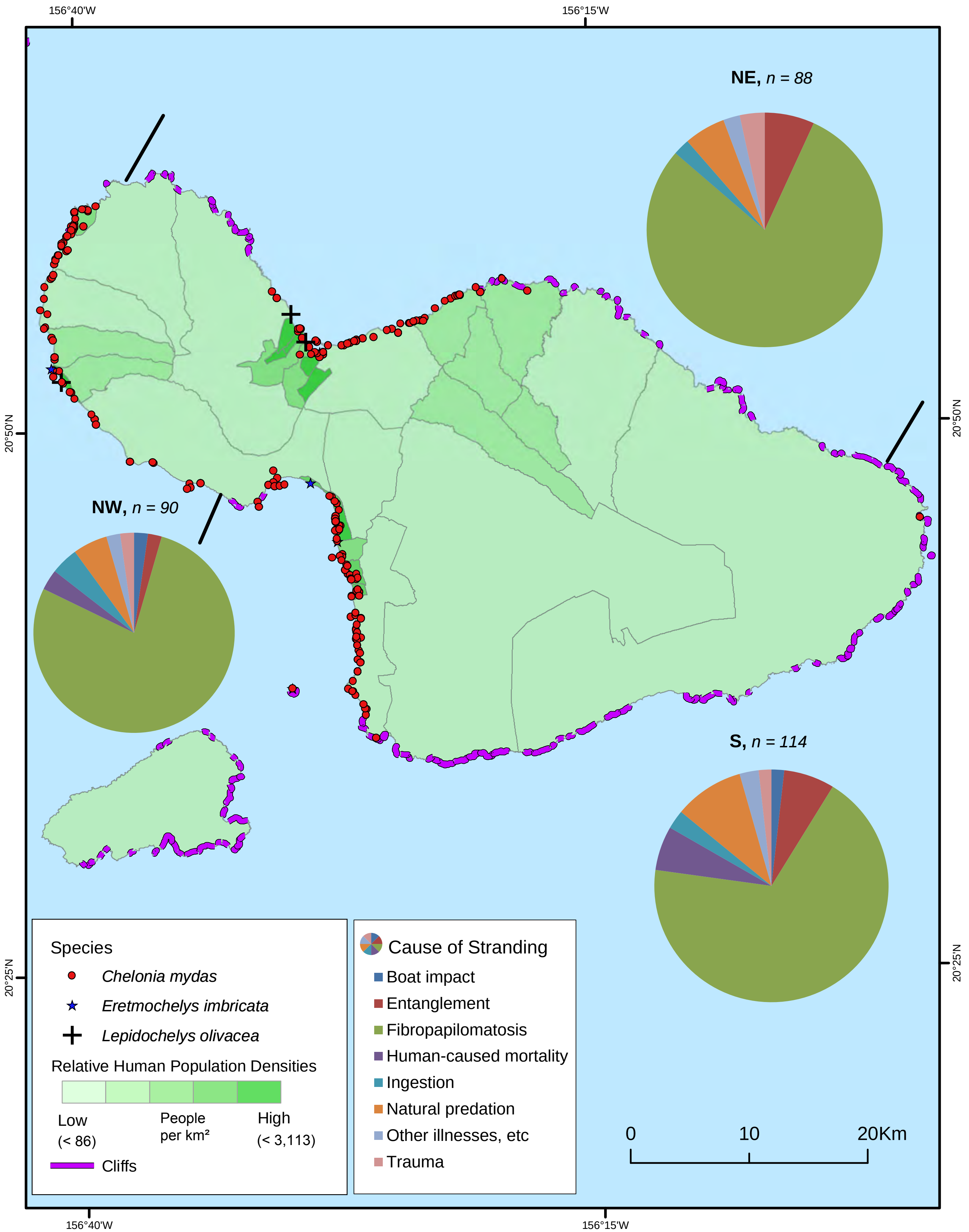

Figure 5.15. Sea turtle strandings on Maui and Kaho'olawe. Data show species and location of reported strandings, 1978-2014. Data sources: strandings (Murakawa, 2014a, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)

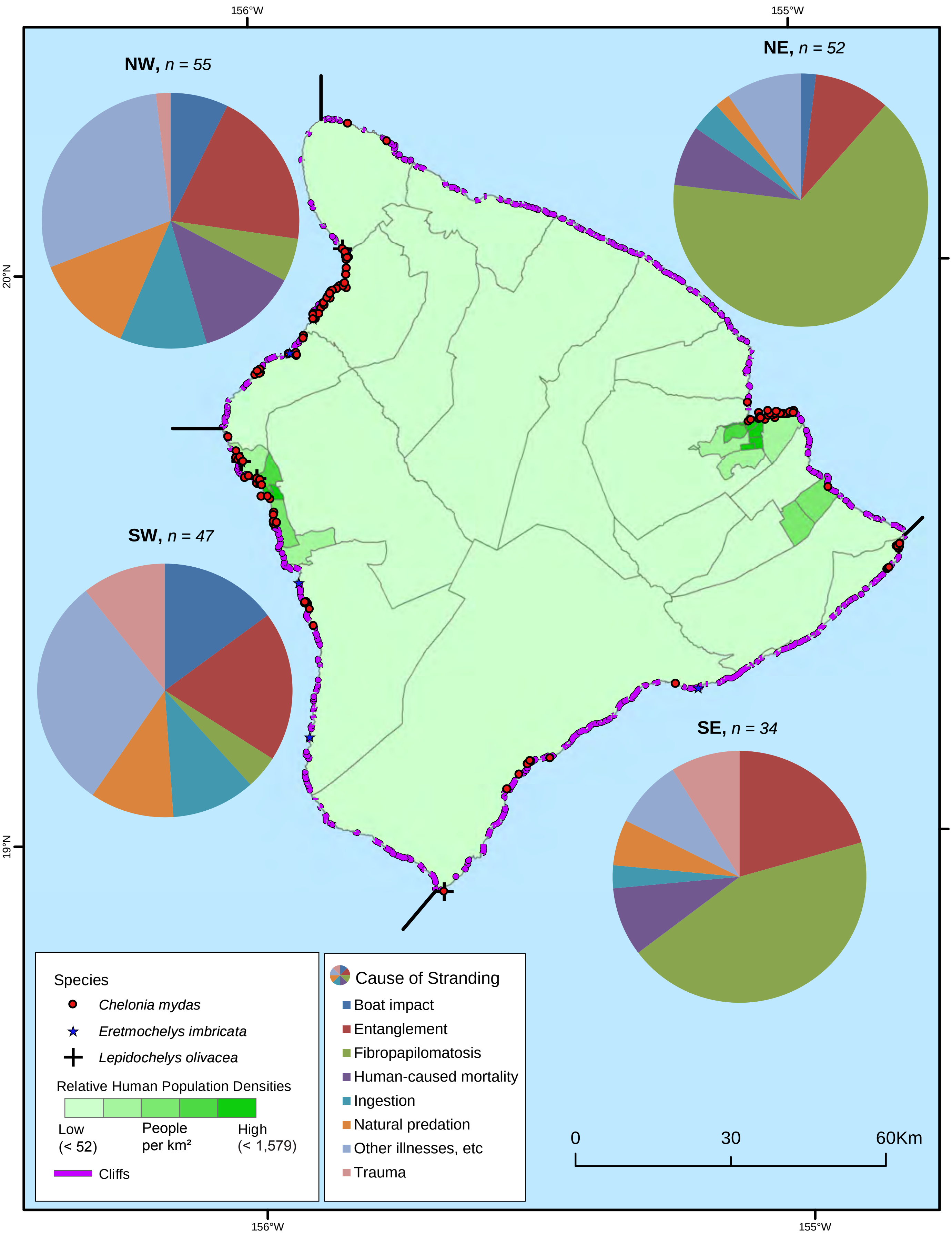

Figure 5.16. Sea turtle strandings on the island of Hawai'i. Data show species and location of reported strandings, 1978-2014. Data sources: strandings (Murakawa, 2014a, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)

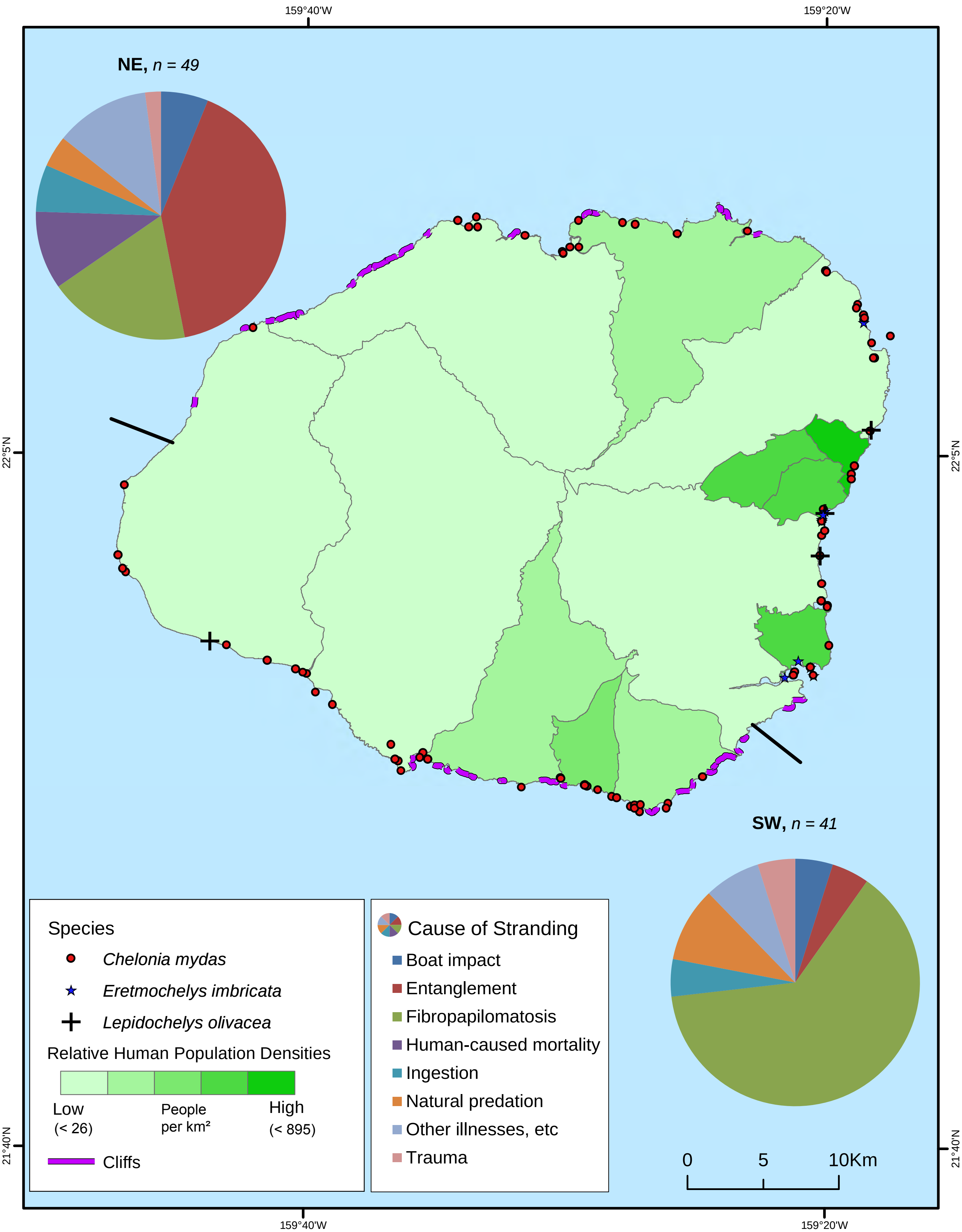

Figure 5.17. Sea turtle strandings on Kaua'i. Data show species and location of reported strandings, 1978-2014. Data sources: strandings (Murakawa, 2014a, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)

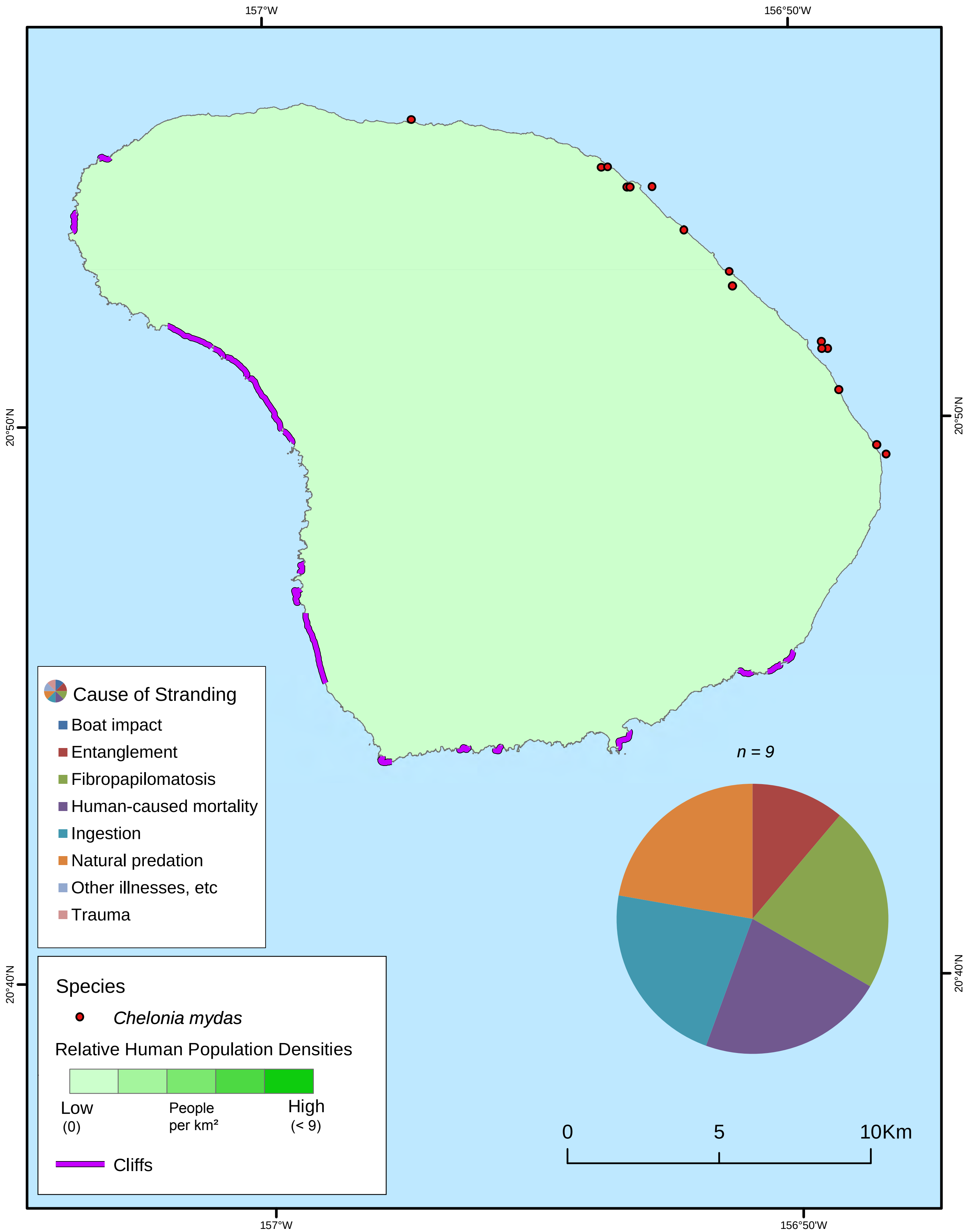

Figure 5.18. Sea turtle strandings on Lāna'i. Data show species and location of reported strandings, 1978-2014. Data sources: strandings (Murakawa, 2014a, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)

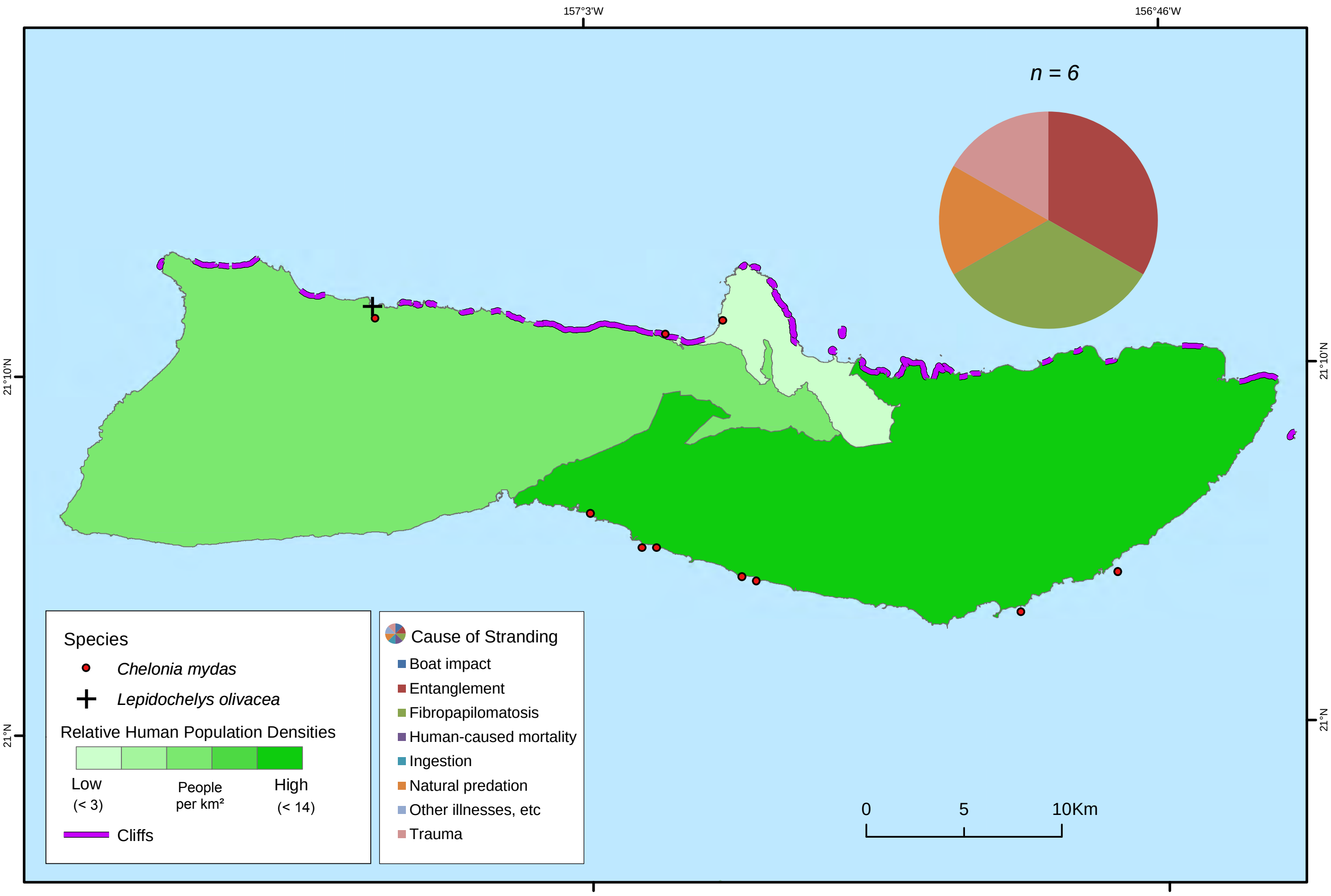

Figure 5.19. Sea turtle strandings on Moloka'i. Data show species and location of reported strandings, 1978-2014. Data sources: strandings (Murakawa, 2014a, 2014b), human population (State of Hawai'i, 2010), and beaches (NOAA ORR, 2001)

5.4. DATA LIMITATIONS AND INFORMATION GAPS

Data compiled by PIFSC for nesting, basking, and stranding turtles along coastlines of the MHI rely on a mixture of regular monitoring by trained professionals at some beaches, irregular assessments at others, and casual observations and reporting by community groups or the public for most areas. Although this maximizes the amount and extent of sea turtle information, it does not include a standardized measure of effort for calculating the density of sea turtle activities. As a result, rather than the amount of turtle activities actually taking place, values reported here are significantly influenced by the amount and spatial distribution of human effort to report them.

Literature review and consultation with local sea turtle researchers highlight additional data gaps limiting our present understanding of sea turtle distributions. Most notably, there are no comprehensive monitoring programs on either the distribution of sea turtles' inshore foraging areas or incidences farther out at-sea. Monitoring programs to identify broad scale distributions of turtle activities throughout the MHI are not funded at present, even for the critical life history phase of nesting. There have been localized investigations on the foraging behavior, habitats, and movement patterns of sea turtles using satellite tags and *in situ* observations (Parker et al., 2009), however, these have all been quite limited in sample size and geographic scope and cannot be used to provide a regional characterization for the MHI.

Loggerhead turtle bycatch. Credit: Mike Tork (NOAA)

At-sea survey data for birds and cetaceans (Chapter 6: Marine Mammals and Chapter 7: Seabirds) almost never include sea turtle sightings. Sightings that do occur are not controlled for effort, and species identifications are questionable. Bycatch data from longline fisheries were also considered but, due to the ESA status of sea turtles, fisheries bycatch thresholds are set extremely low and result in a shut-down of fisheries if even small numbers of turtles are taken. For example, prior to November 2012, Hawaiian shallow-set longline fishermen were allowed to catch only 16 leatherback or 17 North Pacific loggerhead sea turtles per year (Federal Register 50 CFR Part 665; Federal Register, 2012). This is a substantial disincentive to accidentally catch turtles or report them when interactions occur, resulting in very few catch records. Another recent analysis sought to reconstruct the offshore turtle fishery based on historical data (Kittinger et al., 2013; Van Houtan and Kittinger, 2014). Unfortunately, it, too, may not be applicable for estimating distributions today for several reasons: 1) it is questionable if today's distribution patterns would be consistent with historical observations; 2) the analysis was limited to Hawai'i's Division of Aquatic Resources (DAR) statistical reporting framework and, therefore, has limited spatial resolution (Chapter 4, Figure 4.3); and 3) catch patterns are partly confounded with the distribution of fishing effort rather than turtle abundance (e.g., higher catch observed near population centers with convenient access to fishable waters).

Only a few turtles have been tracked to evaluate broad scale navigation through the MHI. There is ongoing research of satellite-tagged green, loggerhead, leatherback (Benson et al., 2011) and olive ridley turtles that is focused on migration patterns, pelagic foraging and/or reduction of fishery-turtle interactions (NOAA PIFSC, 2016). However, due to limited sample size and the geographic scope needed for planning offshore wind farm developments, those few turtle tracks are not included in this report.

There have also been localized studies of foraging behavior (Balazs, 1994), but the spatial distribution of foraging sites is not monitored at the scale of the MHI. A small number of hawksbills have been tracked using satellite transmitters to evaluate foraging sites around Hawai'i Island and Maui Nui (Parker et al., 2009). Those data suggest that the Hamakua coast of northeast Hawai'i Island may be an important foraging area. However, further studies of their forage and habitat needs are necessary if their distribution and abundance are to be comprehensively addressed (D. Parker, pers. obs.).

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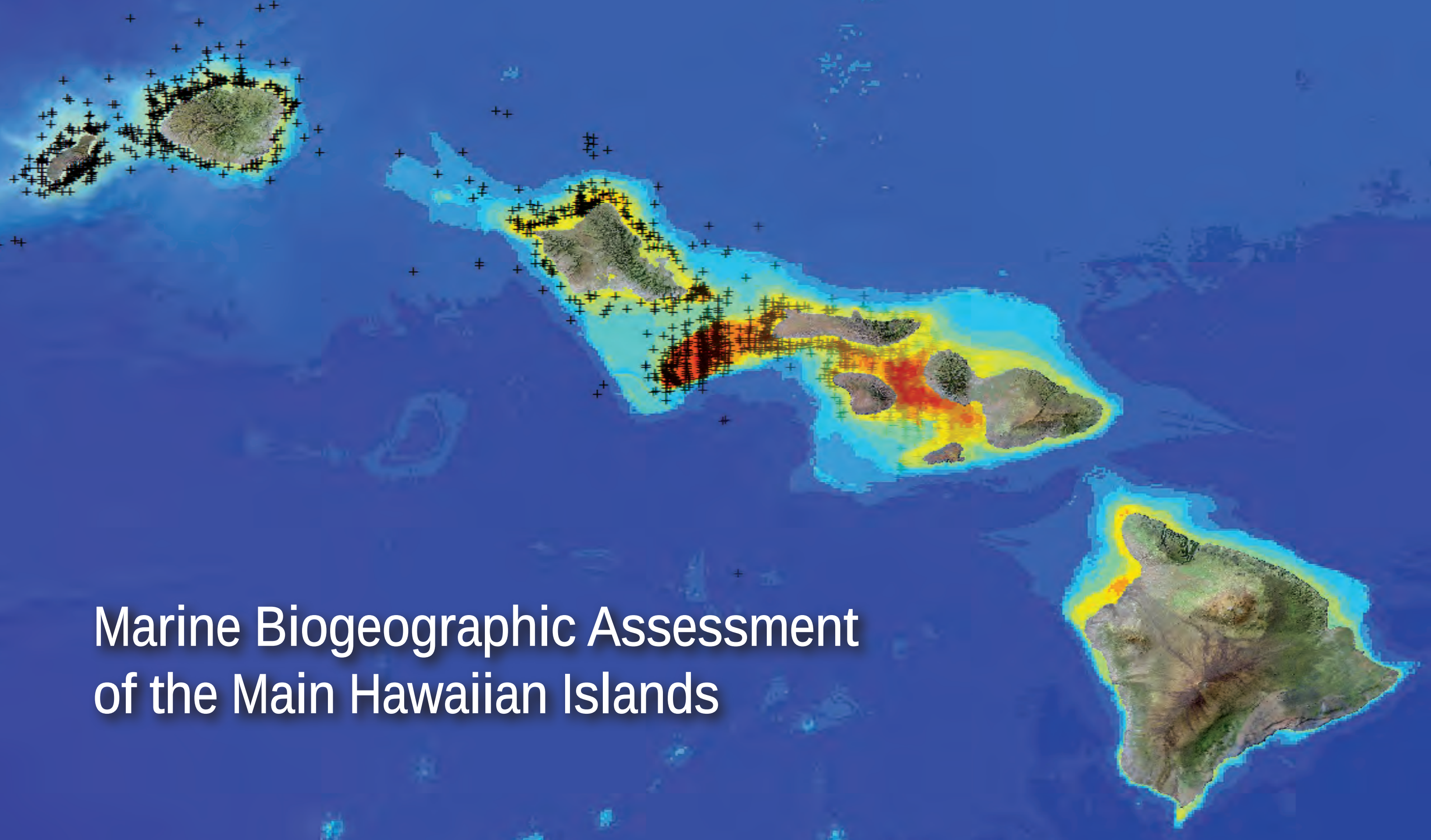

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We dedicate this report to the memory of our friend and colleague John Rooney.

Marine Biogeographic Assessment of the Main Hawaiian Islands

A collaborative investigation by

National Oceanic and Atmospheric Administration's National Centers for Coastal Ocean Science and Bureau of Ocean Energy Management's Pacific Outer Continental Shelf Region

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