Four Decades of Green Turtle (*Chelonia mydas*) Strandings on Hawai‘i Island (1983–2022): Causes, Trends, and Future Mitigation

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Introduction

Although Chaloupka et al. (2008) reported that 6% of statewide strandings occurred on Hawai‘i Island from 1982–2003, long-term stranding data specifically from Hawai‘i Island have not been thoroughly analyzed previously. Hawai‘i Island merits additional scientific scrutiny of its green turtle stranding patterns with the most up-to-date, inclusive data available because of the island's large size (over half of total land area for the State of Hawai‘i), southernmost location in the archipelago, lowest human population density, and important turtle foraging and resting areas—recently proposed as critical habitat by the US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration. In the present study, a comprehensive analysis of 39 years of Hawai‘i Island green turtle strandings is presented to

1) identify the causes of strandings affecting green turtles around Hawai‘i Island,

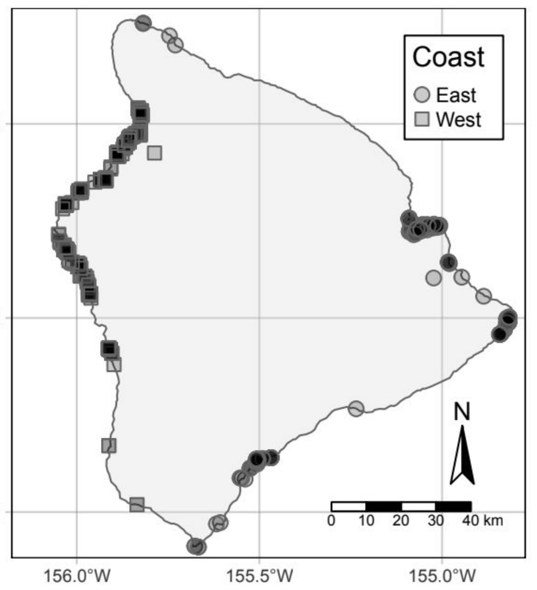
2) assess trends in strandings,

3) identify differences and similarities between West and East Hawai‘i strandings

4) provide information that can inform resource managers, policy makers, and the public about the various types and magnitudes of impacts, anthropogenic and natural, to green turtles so that mitigation measures can be put into practice.

Methods

Figure 1. Green turtle stranding locations in East and West Hawai‘i from 1983-2022



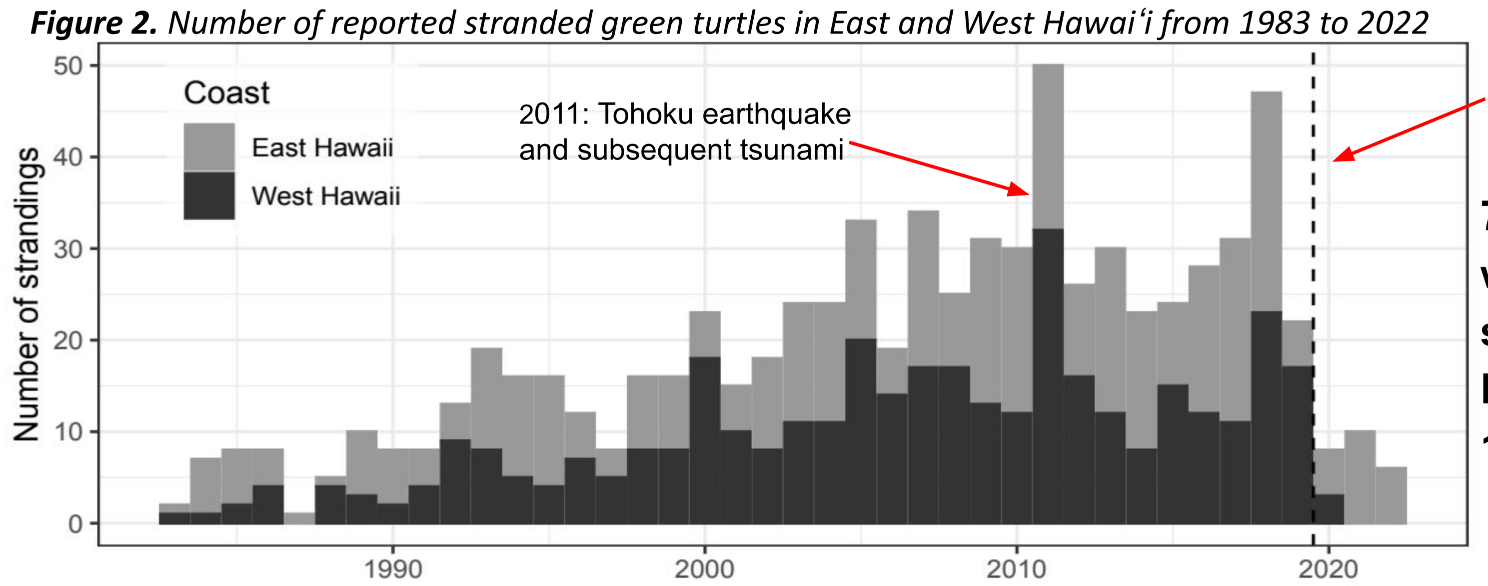
Data were collected on turtles stranded on Hawai‘i Island (19.6°N, 155.5° W with coastal circumference of 428 km) from 1983–2022 by members of the Pacific Islands Fisheries Science Center under the US National Marine Fisheries Service, the University of Hawai‘i at Hilo Sea Turtle Stranding Response Team, and the Hawai‘i Preparatory Academy Sea Turtle Research Program. The database used in this study was compiled from records available through field notebooks:https://georgehbalazs.com/wp-content/uploads/2023/10/1982-2018-Hawaii-Stranding-Data.pdf

The west and east coasts of Hawai‘i Island are different in terms of climate (especially rainfall), terrain, currents, and population, so the data were analyzed for the island as a whole, as well as by coast. West Hawai‘i included locations from Miloli‘i north to Kawaihae; East Hawai‘i included locations from South Point north to Hawi (**Fig. 1**).

Data recorded for each stranded turtle: date of stranding, stranding location, stranding status (alive/dead), cause of stranding, sex, straight carapace length (SCL), curved carapace length, and the presence or absence of fibropapilloma tumors. Causes of stranding were classified into eight categories used previously by Chaloupka et al. (2008): hook-and-line fishing gear, net & gillnet fishing gear, boat impact, shark attack, fibropapillomatosis (FP), human-take, miscellaneous non-anthropogenic, and unknown. Chi-square goodness of fit tests were used to determine if there were equal proportions among months of stranding, stranding status, causes of stranding, and sex of stranded turtles for all of Hawai‘i Island. Contingency tables and chi-square tests of independence were used to compare West and East Hawai‘i. Multinomial linear models with Poisson error structures were fit using the nnet package and model selection was carried out using Akaike Information Criterion. These models produce a prediction function which may be interpreted as the class distribution π(t), allowing comparison of models with and without a dependence on time.

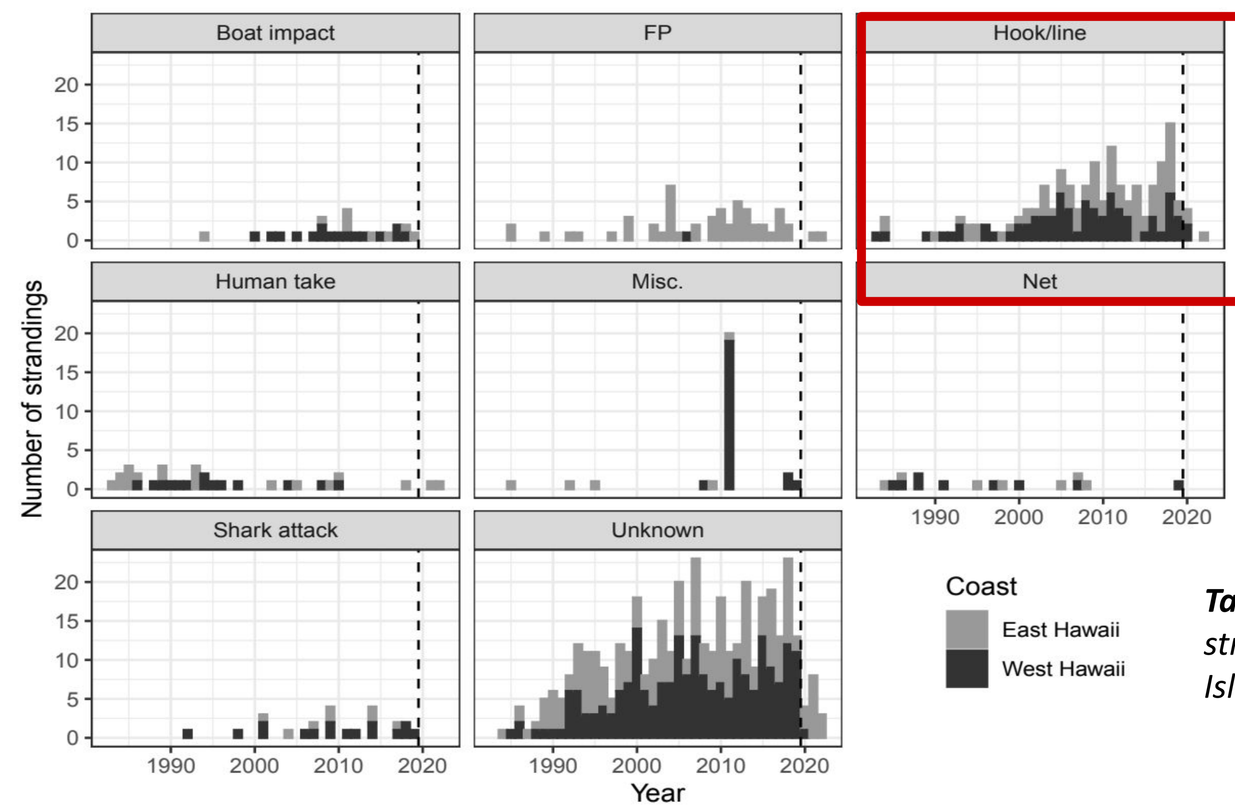
Results

Figure 2. Number of reported stranded green turtles in East and West Hawai‘i from 1983 to 2022



754 green turtles were recorded stranded on Hawai‘i Island 1983-2022

Figure 3. Number of reported stranded green turtles in East and West Hawai‘i from 1983 to 2022



Hook-and-line fishing gear was the most common known cause of stranding of green turtles on Hawai‘i Island. East and West sides of Hawai‘i Island had different distributions of stranding cause.

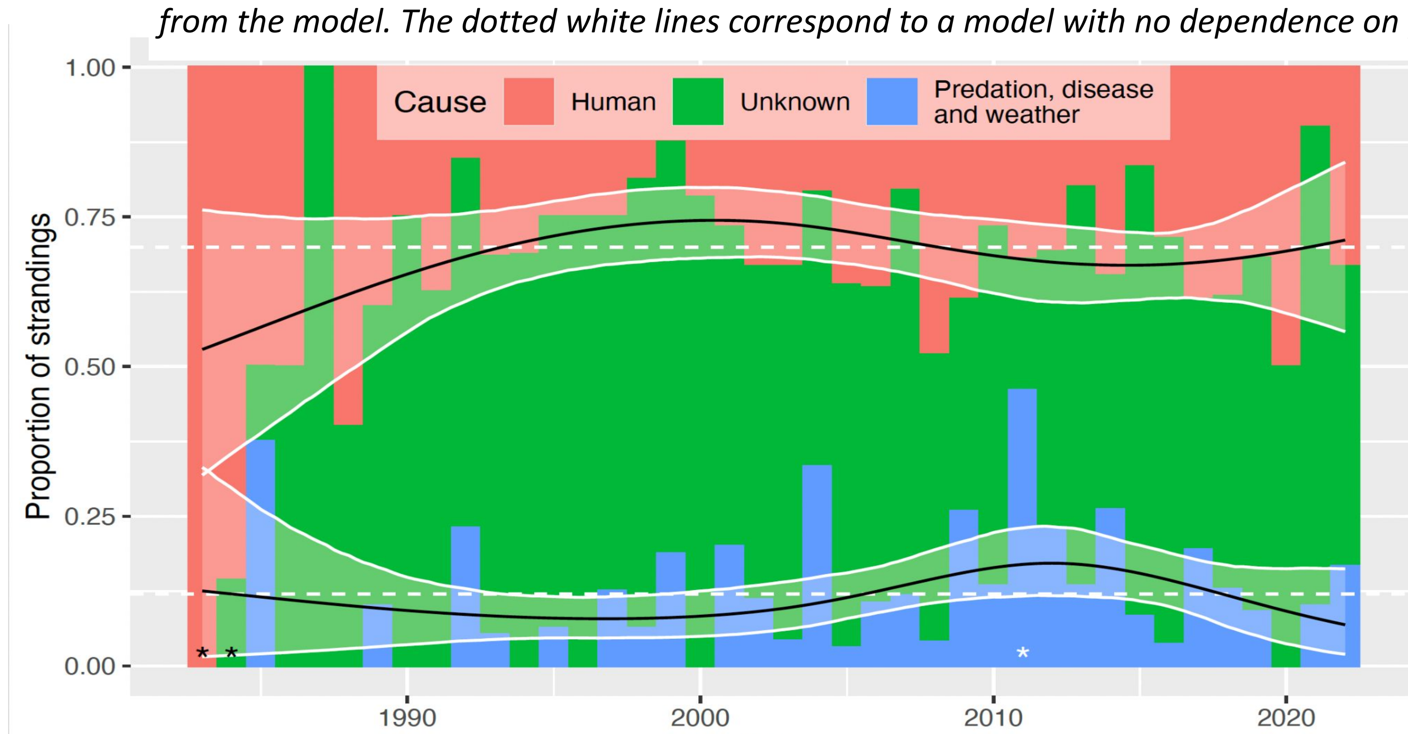
Table 1. Monthly strandings for Hawai‘i Island

Coast	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
East	29	31	32	38	33	42	37	30	25	33	25	24	379
West	24	27	45	36	42	40	42	39	16	30	16	18	375
Total	53	58	77	74	75	82	79	69	41	63	41	42	754

Table 2. Raw counts and proportions of stranding cause from 1983-2022 for Hawai‘i Island.

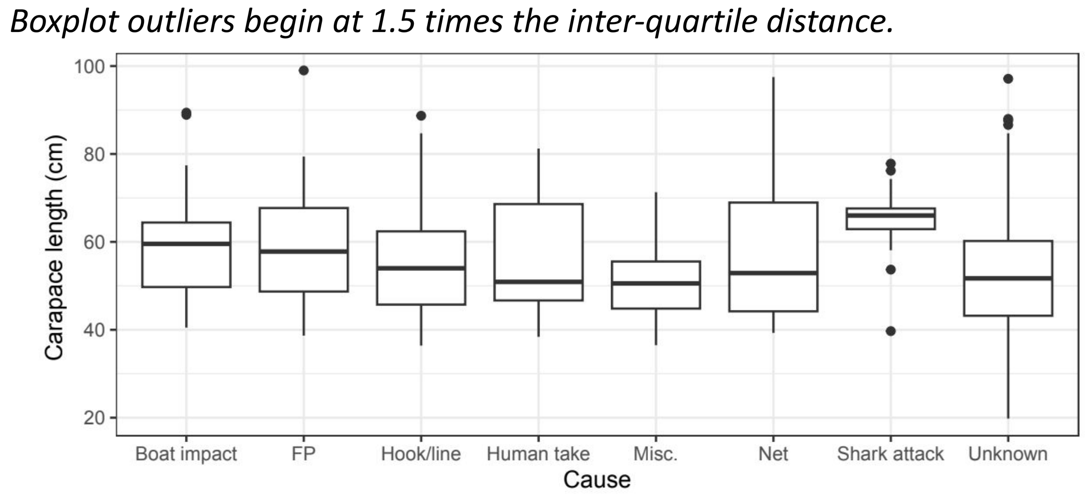
	East		West		Total	
Cause	n	%	n	%	n	%
Boat impact	9	2.4	16	4.3	25	3.3
FP	53	14.0	1	0.3	54	7.2
Hook/line	85	22.4	76	20.3	161	21.4
Human take	19	5.0	14	3.7	33	4.4
Misc.	5	1.3	23	6.1	28	3.7
Net	7	1.8	9	2.4	16	2.1
Shark attack	8	2.1	16	4.3	24	3.2
Unknown	193	50.9	220	58.7	413	54.8

Figure 4. A multinomial regression fit using natural splines with 3 degrees of freedom. 95% confidence bands are constructed by bootstrapping. Records from years with asterisks (*) are excluded from the model. The dotted white lines correspond to a model with no dependence on year.



The distribution of the three consolidated causes has been relatively stable since the early 1990s–no evidence of any major shifts in the relative risks between direct human causes and other categories.

Figure 5. Straight carapace length of stranded green turtles plotted by cause. Boxplot outliers begin at 1.5 times the inter-quartile distance.



The majority of stranded green turtles on Hawai‘i Island were juveniles (SCL < 65 cm). No gender-bias of stranded green turtles existed: male to female ratio = 1:1.06.

Discussion

- Overall increase in strandings on Hawai‘i Island between 1983 and 2022 (**Fig. 2**).
- Green turtle populations in the Hawaiian Islands have increased since 1974 protection by the State of Hawai‘i and 1978 protection under the US Endangered Species Act.
- Mixed interactions affecting rate of strandings: increased green turtle population, increased human presence linked to the risk of hazard from fishing activity and gear (**Fig. 3**) and increased human presence raises probability of a person reporting a stranding
- Increase in turtle population size will directly lead to additional observed stranding events, even if the risk to an individual turtle remains constant over time. Additionally, the human population increase on Hawai‘i Island and rise in visitor numbers at the shoreline increase the chance of encountering and reporting a stranding.
- Number of Hawai‘i Island hook-and-line strandings may be greater than estimated. Necropsies (postmortem autopsies) on stranded turtles throughout the Pacific: 48% of foreign body ingestion cases (mostly associated with fishing gear) showed no external sign of fishing line interactions (Work et al. 2015). Fishing gear was the top cause (81%) of stranding for green turtles on Maui in 2022 (Cutt et al. 2023).
- Higher spring and summer stranding patterns (**Table 1**) may reflect seasonal differences in water temperature which affects carcass decomposition rates (Cook et al. 2021), periodic shifts in shoreline human activity and stranding reporting, or cyclical changes in surf, currents, and winds that push carcasses to or from shore.
- Interpretation of the model (**Fig. 4**): the increased numbers of strandings over time can be explained entirely by the growth in turtle populations and increases in reporting by the public. Although keeping the proportion of human-caused strandings constant over time may be regarded as a minor conservation success story, given the significant growth in human population and coastal activity over the same time period, humans remain a significant source of danger to turtles.
- Larger number of shark attack strandings on West Hawai‘i (**Table 2**) possibly related to larger population of tiger sharks along the west coast (Meyer et al. 2009). Stranded turtles with the highest SCL values were result of shark attacks (**Fig. 5**); small turtles may be completely consumed and do not wash ashore.
- West Hawai‘i tourism industry (snorkel, diving, and wildlife watching) operates in coastal waters that green turtles use for foraging. Increased boat presence accompanied with high vessel speeds, varying water depth, and times of poor visibility can all factor into a higher proportion of boat impact strandings (**Table 2**) on West Hawai‘i.
- Contribution of hook-and-line fishing gear to strandings emphasizes need for additional mitigation efforts: barbless hooks and effective line removal techniques.
- In Hawai‘i, high level of public awareness of sea turtles; however, more information is needed on appropriate actions to take when hooking or encountering a hooked or entangled sea turtle.
- Continued monitoring of turtle strandings and careful data collection on stranded individuals are critical to the conservation of green turtles.
- **For full article and references, please see: Dentlinger et al. 2024. Four decades of green turtle (*Chelonia mydas*) strandings on Hawai‘i Island (1983–2022): Causes and trends. Zoological Studies 63:16 doi:10.6620/ZS.2024.63-16**

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