

Twenty turtles (11.8% of 170) eventually stranded, including the 11 which were previously recaptured during in-water research. Therefore, nine turtles ultimately stranded with no previous recaptures or re-sightings (6 dead, 3 alive; Figures 2-3). Overall, these 20 turtles were found stranded 0.5-17.9 yrs (avg = 6.6 ± 5.7 yrs) after release (Figure 4). Of the 20 turtles which stranded, ten stranded dead, nine stranded alive, and one stranded first alive and then dead. Of the ten turtles which stranded dead, cause of stranding was undetermined for seven, with one turtle having collapsed lungs, another with a flattened carapace (along green turtle foraging habitat on the island of Lanai, 150 km from Mauna Lani; Figure 5), another with an excessive amount of liquid in its abdomen, and another two with moderate and advanced emaciation. Three other deaths were caused by vehicle impact, a combination of vehicle impact and shark attack (off of Hilo, 160 km from the release site), or by parasites. Of the nine turtles which ultimately stranded alive, all were re-released. Four of these nine strandings were due to unknown causes, fish hooks or line entanglement caused four of these strandings, and trauma from a propeller strike wound caused one stranding (in Honokohau, 45 km to the south of the release site). This last turtle also had two small external fishing hooks and one internal as revealed by x-ray. Four of these nine turtles required considerable veterinary treatment and captive rehabilitation by NMFS before being released a second time. None of these nine turtles were reencountered again after re-release. One turtle stranded twice, stranding alive 4.9 yrs after release due to a calcium carbonate rock in its eye, followed by rehabilitation and release, only to strand dead 0.3 yrs after re-release in an advanced decomposed state. Of the six turtles which were recaptured then ultimately stranded alive, five turtles stranded within five km of the release site, while one stranded 80 km south, in Honaunau. Of the five turtles which were recaptured then stranded dead, three stranded dead within the vicinity of the release site, while two eventually stranded dead 45 km to the south in Honokohau (Figure 5).

Overall, the majority of turtles were either recaptured or stranded within 11 km of the release site (Figure 5), suggesting that most turtles remained within the foraging ground vicinity surrounding Mauna Lani. However, this may not necessarily mean that all turtles are resident at this location. One captive-raised turtle satellite-tagged and released at Mauna Lani swam around the entire main Hawaiian Island chain before returning to the Mauna Lani site. This suggests that other turtles could have performed similar behavior.

The SCL growth rates could be calculated for 28 of the 43 re-encountered turtles (Figure 6). The other 15 turtles could not be used in the analysis for two reasons: 1) the turtle's SCL was not measured more than once, and 2) the initial and final SCL measurement are within one year of each other, leading to a greater possibility of human measurement error. The SCL growth rates of the 18 turtles (out of 23) recaptured and re-measured during in-water research ranged from 0.0 – 3.1 cm/yr (mean = 1.4 ± 0.9 cm/yr). This is similar to other studies of wild Hawaiian green turtles in the same size range (2.0 – 2.5 cm/yr, Zug et al. 2002; 0-2.5 cm/yr, Balazs and Chaloupka 2004), suggesting that these turtles are adapting well to their new surroundings once released. The turtle recaptured at Kaneohe Bay displayed the most rapid growth rate (3.1 cm/yr). Two other turtles displayed similar growth rates – a turtle at Puako, 5 km northeast from the release site (3.0 cm/yr), and a turtle at Honokohau (2.7 cm/yr). The recaptured turtles with the slowest growth rates were found at Puako (0.0, 0.4, 0.9 and 0.9 cm/yr) and Kiholo (0.6 cm/yr), approximately 11 km southwest of the release site. As the majority of turtles at Puako had slow

growth rates, it is possible the turtle with the growth rate of 3.0 cm/yr at this site may have travelled from elsewhere with better foraging habitat, but was captured at Puako.

The SCL growth rates of the ten turtles (out of 20) which eventually stranded ranged from 0.5 – 2.5 cm/yr (mean = 1.4 ± 0.7 , which is similar to, but slightly lower than the average for recaptured turtles; Figure 6). This can be broken further into one turtle which was recaptured and eventually stranded alive (out of six turtles; growth = 0.8 cm yr), four turtles which were recaptured and eventually stranded dead (out of five turtles; range = 0.5 – 2.5 cm/yr, mean = 1.8 ± 0.9 cm/yr), one turtle that stranded alive with no previous recaptures (out of three turtles, growth = 0.5 cm/yr), and four turtles that stranded dead with no previous recaptures (out of six turtles, range = 0.9 – 2.3 cm/yr, mean = 1.4 ± 0.6 cm/yr). Additionally, the average growth rates of recaptured turtles and stranded dead turtles are fairly similar, suggesting that up until near time of stranding, these Mauna Lani released turtles are growing in the wild at rates similar to those of wild-born turtles whether or not the turtle eventually strands. This suggests good adjustment to their wild surroundings after release.

Breaking the Mauna Lani released turtles into year-classes, based on the amount of years turtles have been in the wild, less than 3% of the population strands in each age class assuming that all recaptured turtles during in-water research and those that are never seen again do survive (Figure 7). As seven of the 20 (35.0%) stranded turtles were caused by human related activities (fishing or boating interactions), it appears as though these captive-raised green turtles have been adapting well to life in the wild. However, this is a higher percentage than wild-born green sea turtles that strand due to these same causes (14.5%, Chaloupka et al. 2008). This suggests that the captive-born turtles may be more inclined to hang around areas of higher human population as they may be more accustomed to human presence, and thus are more susceptible to these specific dangers.

CONCLUSION:

The captive-raised green sea turtles released at Mauna Lani Bay Hotel appear to be adjusting to life in the wild. Of the 170 turtles released since 1990, 127 have thus far not been seen again, while 23 have been recaptured during in-water research not yet to be seen again, and 20 turtles have stranded – 11 dead, and nine alive (all released and not yet seen again). Additionally, a fairly low number of turtles stranding each year, and 60% of all strandings occurred within the turtles' fifth year or later after being released, giving them ample time to have adjusted to the wild before stranding. Lastly, as all Mauna Lani released turtles have similar growth rates to wild Hawaiian green turtles, the captive-raised turtles are surviving well in the wild, as a whole, despite a few incidences of these turtles being hand-fed in the wild, and the eight turtles that did strand within 4 years of release.

REFERENCES:

Balazs, G.H. 1996. Behavioral changes within the recovering Hawaiian green turtle population. In J.A. Keinath, D.E. Barnard, J.A. Musick, and B.A. Bell (comps.), Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation, February 20-25, 1995, Hilton Head, South Carolina, p. 16-21. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-387.

Balazs, G.H., and M. Chaloupka. 2004. Spatial and temporal variability in somatic growth of green sea turtles (*Chelonia mydas*) resident in the Hawaiian Archipelago. *Marine Biology* 145, p. 1043-1059.

Balazs, G.H., M. Rice, S.K.K. Murakawa, and G. Watson. 1998. Growth rates and residency of immature green turtles at Kiholo Bay, Hawaii. *In* F.A. Abreu-Grobois, R. Briseño-Dueñas, R. Marquéz-Millán, and L. Sarti-Mártinez (comps.), Proceedings of the Eighteenth International Sea Turtle Symposium, March 3-7, 1998, Mazatlan, Sinaloa, Mexico, p. 283-285. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-436.

Balazs, G.H., S.K.K. Murakawa, D.M. Parker, M.R. Rice. 2002. Adaptation of captive-reared green turtles released into Hawaiian coastal foraging habitats, 1990-99. *In* A. Mosier, A. Foley, and B. Brost (comps.), Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation, February 29 – March 4, 2000, Orlando, Florida, p. 187-189. NOAA Tech. Memo. NMFS-SEFSC-477.

Bourke, R.E., G. Balazs, and E.W. Shallenberger. 1977. Breeding of the green sea turtle (*Chelonia mydas*) at Sea Life Park, Hawaii. *Drum and Croaker* (New England Aquarium), October, p. 4-9.

Chaloupka, M., T.M. Work, G.H. Balazs, S.K.K. Murakawa, and R. Morris. 2008. Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago (1982-2003). *Marine Biology* 154, p. 887-898.

Davis, E.E., M. R. Rice, K.A. Harrington, and G.H. Balazs. 2000. Green turtle diving and foraging patterns at Puako, Hawaii. *In* H. Kalb and T. Wibbels (comps.), Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation, March 2-6, 1999, South Padre Island, Texas, p. 153-154. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-443.

Harrington, K.A., M.R. Rice, and G.H. Balazs. 2002. Habitat use of mixohaline fish ponds by green turtles at Kiholo Bay, Hawaii. *In* A. Mosier, A. Foley, and B. Brost (comps.), Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation, February 29 – March 4, 2000, Orlando, Florida, p. 285-286. NOAA Tech. Memo. NMFS-SEFSC-477.

Rice, M.R., D.K. Kopra, G.H. Balazs, and G.C. Whittow. 2002. Ecology and behavior of green turtles basking at Kiholo Bay, Hawaii, USA. *In* A. Mosier, A. Foley, and B. Brost (comps.), Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation, February 29-March 4, 2000, Orlando, Florida, p. 153-155. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-477.

Zug, G.R., G.H. Balazs, J.A. Wetherall, D.M. Parker, and S.K.K. Murakawa. 2002. Age and growth of Hawaiian green sea turtles (*Chelonia mydas*): an analysis based on skeletochronology. *Fisheries Bulletin* 110, p. 117-127.

FIGURES:

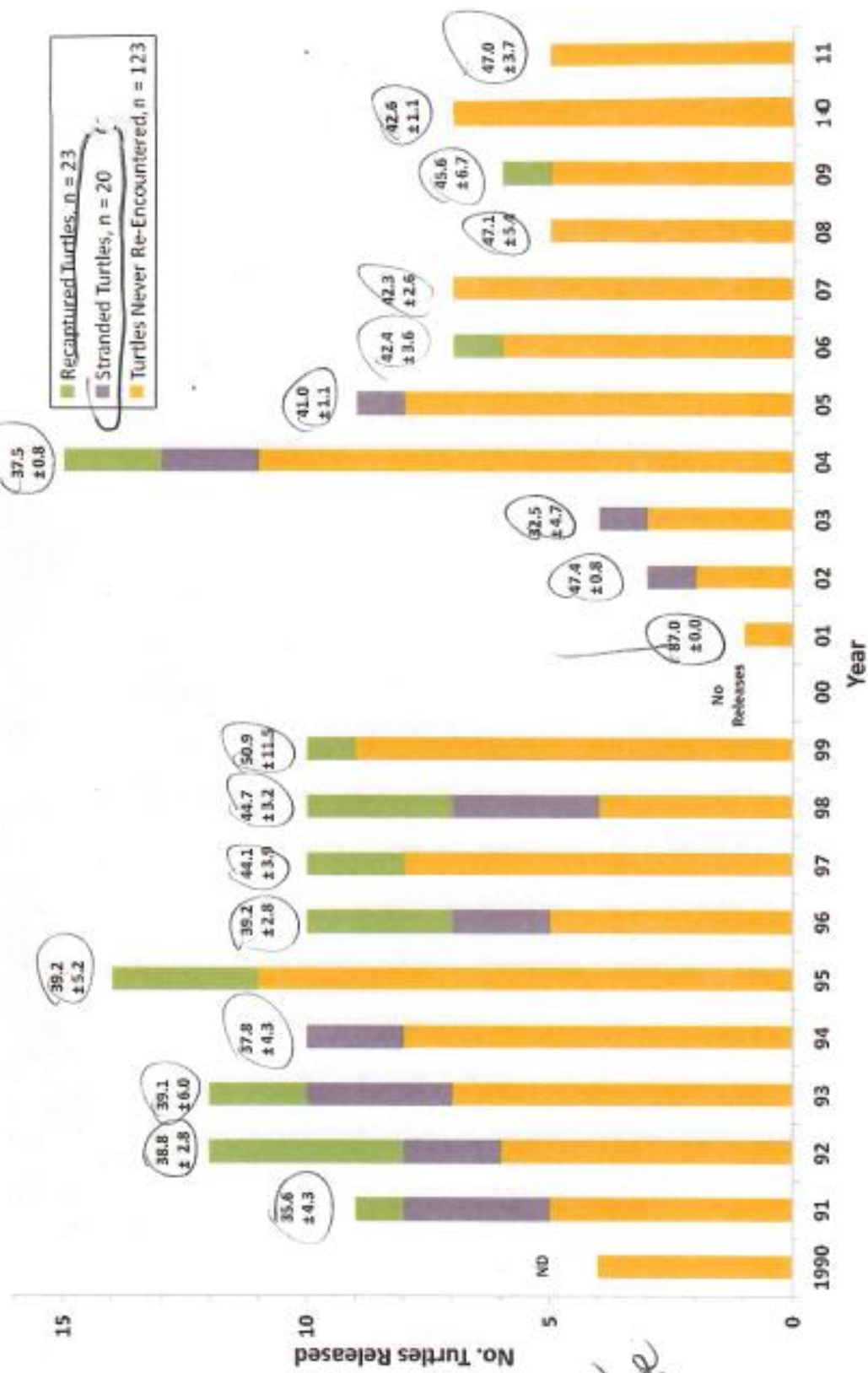
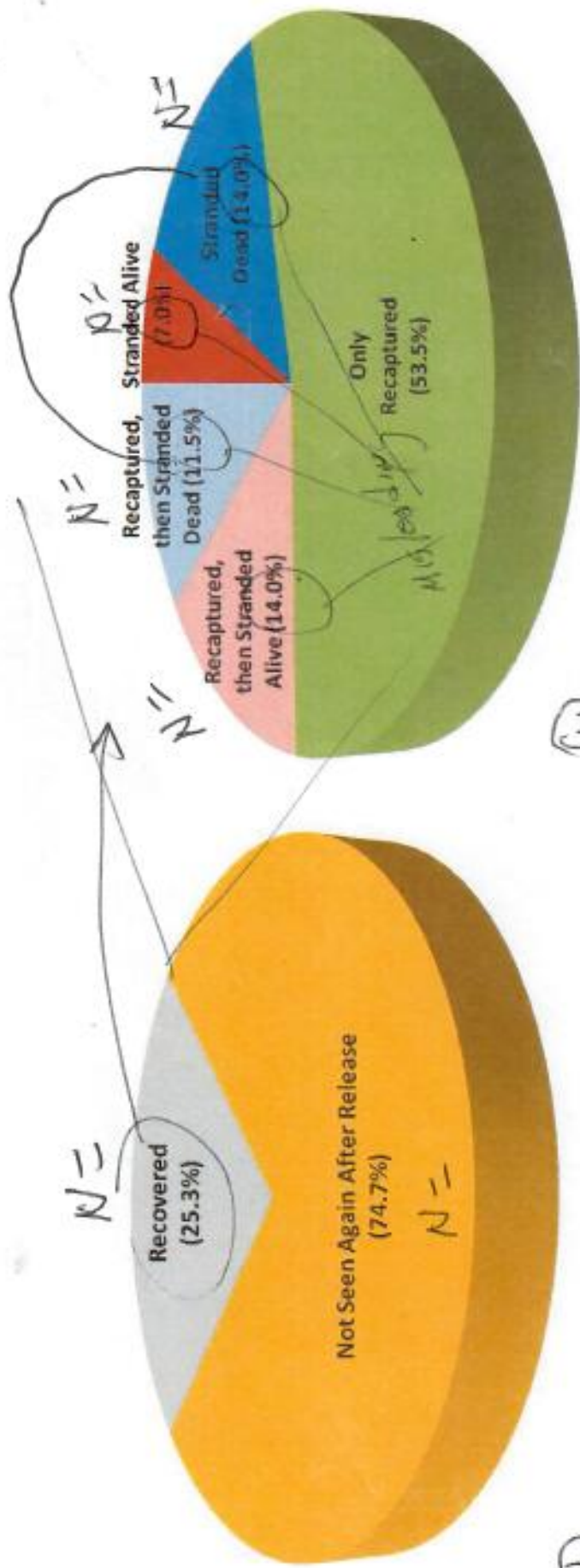


Figure 1. Number of captive-reared green turtles released annually at the Mauna Lani Bay Hotel. Yellow indicates the number of turtles release never seen again, purple indicates turtles released each year that eventually stranded, and green indicates turtles released in each year-class recaptured during in-water research. Numbers above each bar represent the average $SCL \pm 1$ standard deviation for all turtles released in each year-class.



(a) Outcome of green turtles released into the wild from Mauna Lani Bay Hotel (N = 102). (b) circumstances of ultimate recovery (N = 43).

$N=11$

- Stranded Dead, n = 6
- Stranded Alive, n = 3
- Recaptured, then Stranded Dead, n = 5
- Recaptured, then Stranded Alive, n = 6
- Only Recaptured, n = 23

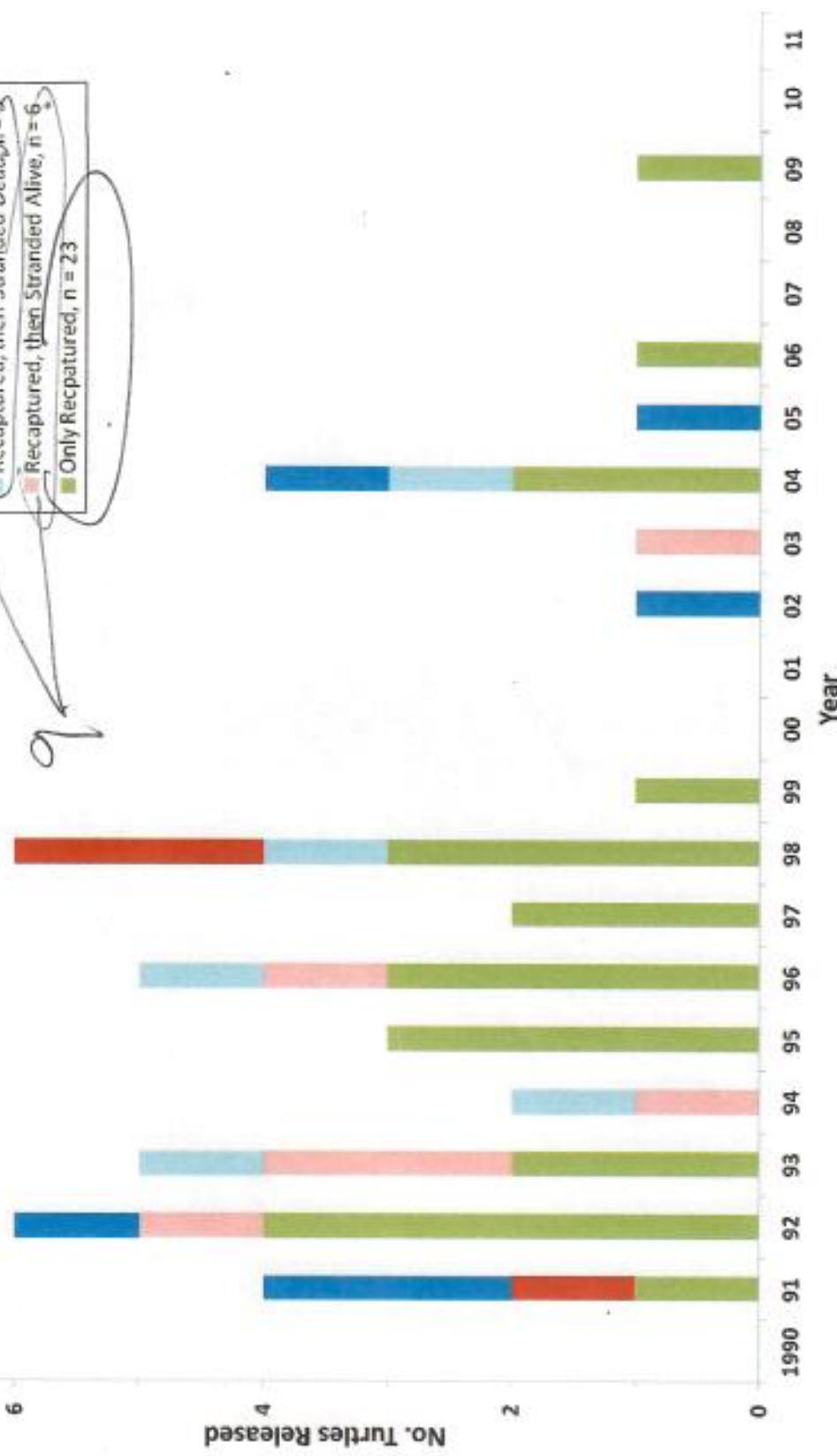


Figure 3. Number of green turtles released each year from the Mauan Lani Bay Heret that ultimately stranded dead (dark blue), ultimately stranded alive (dark red), were recaptured and then stranded dead (light blue), were recaptured and then stranded alive (pink), and turtles that were only recaptured without stranding (green) (total N = 43).

Too Small



Figure 4. The number of years from release at the Mauna Lani Bay Hotel to the ultimate stranding or recapture event for each recovered green turtle (N = 43). Dark blue triangle = ultimately stranded dead; dark red square = ultimately stranded alive; light blue diamond = recaptured and then stranded dead; pink diamond = recaptured and then stranded alive; green circle = recaptured without stranding.

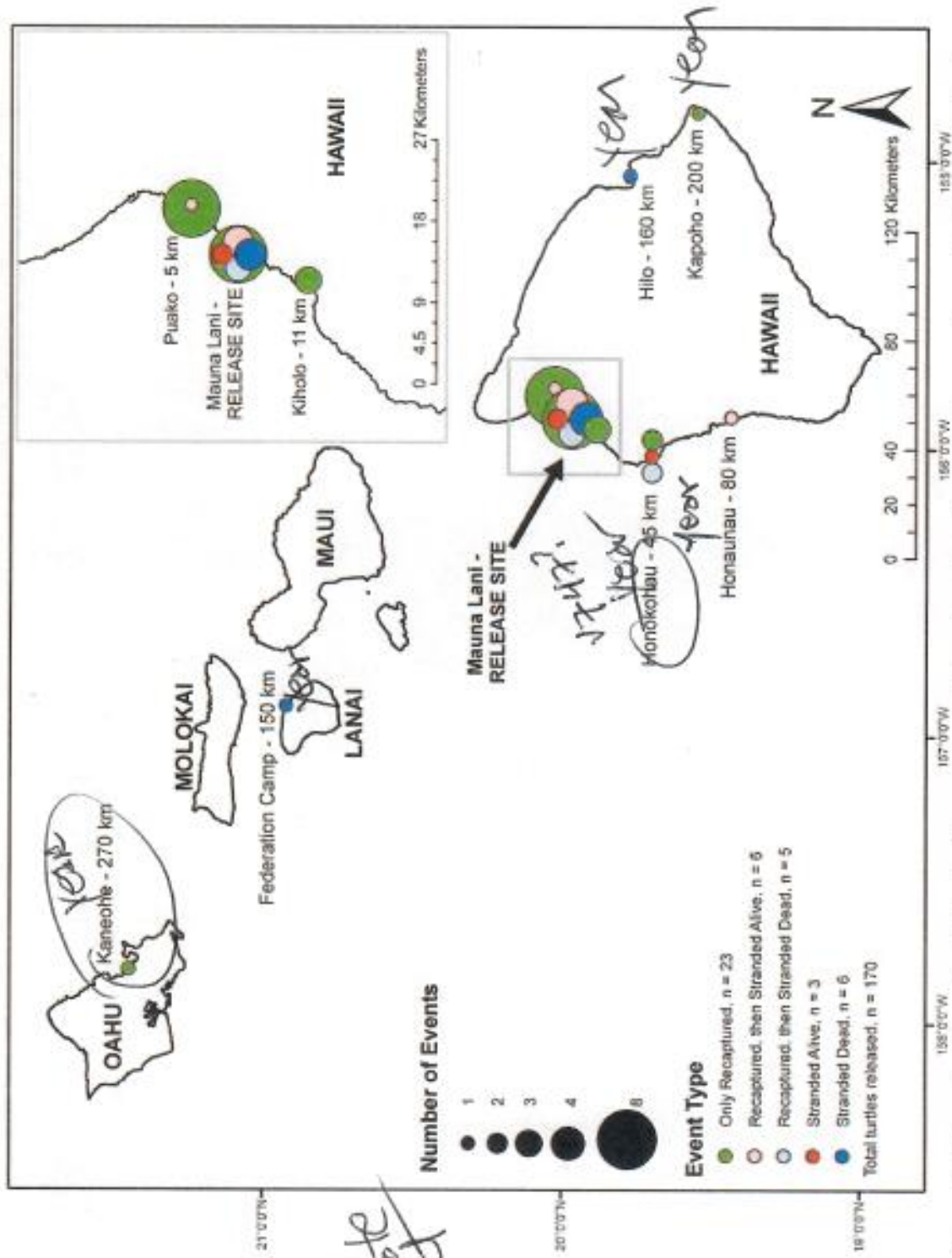


Figure 5. The main Hawaiian Islands. Recapture and stranding location and distances from the Mauna Lani release site. Dark blue = ultimately stranded dead ; dark red = ultimately stranded alive; light blue = recaptured and then stranded dead ; pink = recaptured and then stranded alive; green = recaptured without stranding.

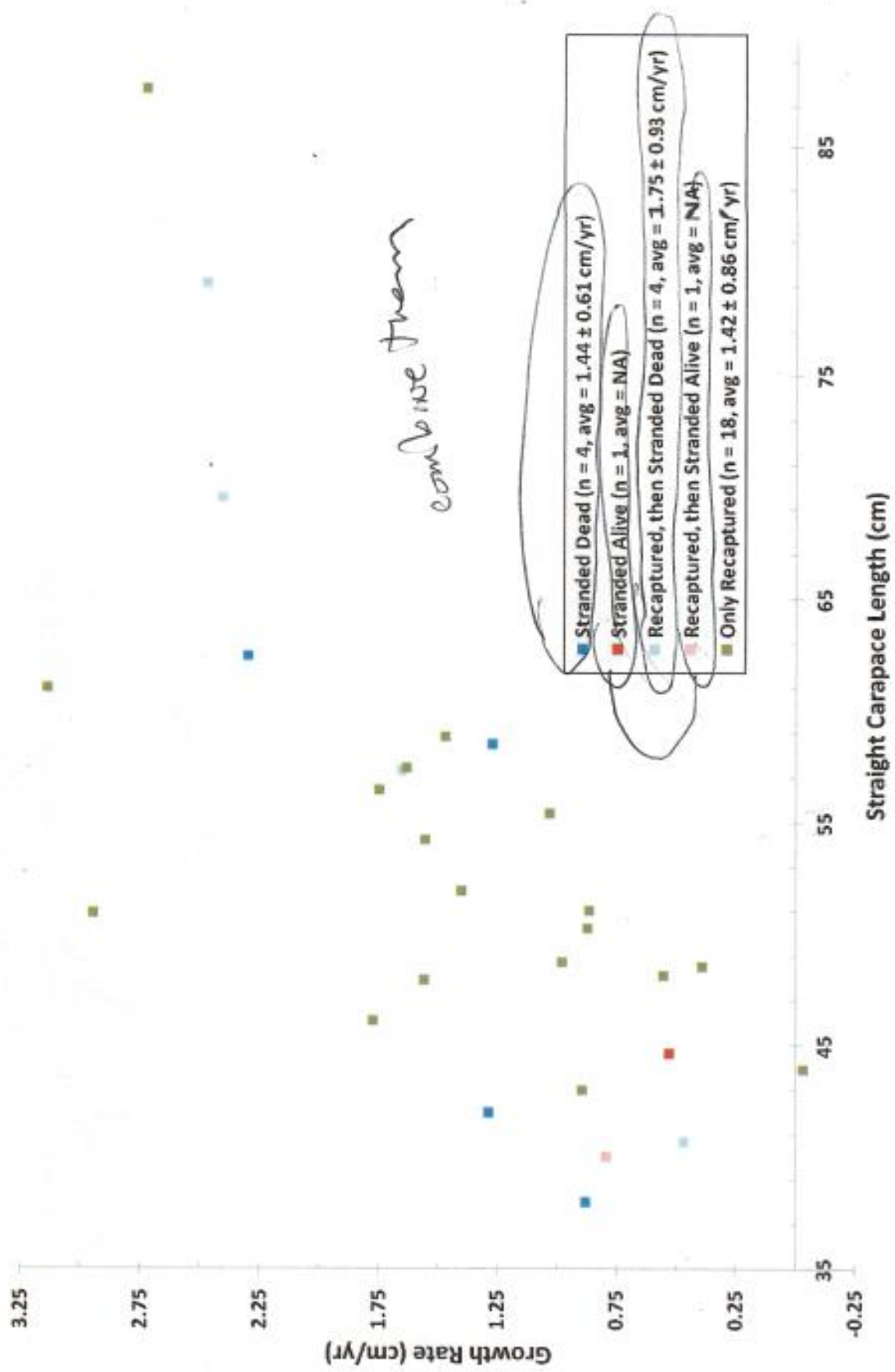


Figure 6. Wild growth rates of re-encountered captive-raised green sea turtles released at Mauna Lani Bay Hotel.

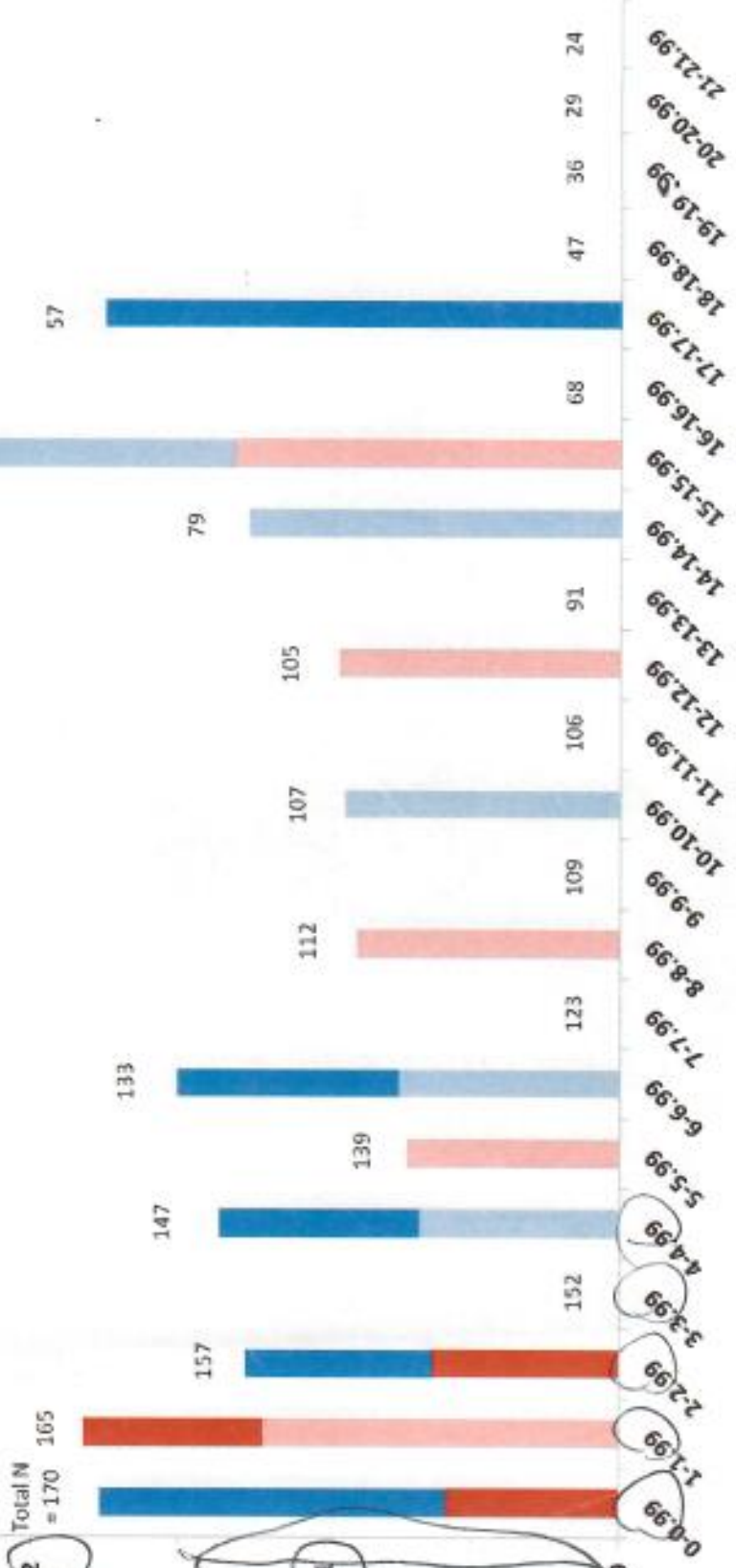
The Percent of Turtles Within Each Year After Release that Strand

3
 2
 1
 0

- Stranded Dead, n = 6
- Stranded Alive, n = 3
- Recaptured, then Stranded Dead, n = 5
- Recaptured, then Stranded Alive, n = 6

$N = 170$

Total N = 170



No. Years Since Release

Figure 2. Adaptability of captive-raised green sea turtles to the wild. The proportion (percent) of turtles within each year after release that strand. Numbers above each column represent the potential maximum number of Mauna Lani released turtles remaining in the wild, assuming all turtles recaptured or never re-encountered have survived to that point.

Removal of that survivors