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Seabird Entanglement in Marine Debris and Fishing Gear in the Main Hawaiian Islands (2012 - 2020)

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Quantifying Seabird Entanglement in Anthropogenic Materials

Seabirds are susceptible to entanglement and entrapment in marine debris, including lost and discarded lines, ghost nets, and other derelict fishing gear. Moreover, it is often difficult to distinguish entanglement with discarded fishing gear and incidental fishing interactions (Shomura & Yoshida, 1985; Laist, 1997). Nevertheless, because interactions with active fishing gear (bycatch), lost or discarded fishing gear (ghost fishing), and marine debris can result in injury and death, all of these materials threaten seabirds (Dau et al., 2009; Moore et al., 2009; Ryan, 2018). Thus, this review documents entanglement of Hawaiian seabirds with a variety of anthropogenic materials, regardless of their origin.

While images of entangled seabirds are sad and disturbing, it is difficult to assess the prevalence and magnitude of this mortality. Overall, published entanglement rates, calculated as the proportion of the observed beach-cast seabirds with evidence of entanglement, range from 0.2% to 1.2% in California, Oregon, and Washington (Moore et al., 2009; Donnelly-Greenan et al., 2019). Nevertheless, estimating species-specific entanglement rates, expressed as a percentage of the population, is inherently difficult for three reasons: (i) interactions can be rare and difficult to observe, (ii) an unknown proportion of the interactions taking place is actually documented, and (iii) the lack of population abundance data inhibits estimates of the relative number of individuals affected.

Systematic efforts to quantify wildlife entanglement rates and associated mortality are inhibited by the inability to detect all entangled individuals, and ascertain their fate (Laist, 1997). These limitations are especially problematic for seabirds, which disperse widely, and do not return to land during the juvenile stage and the non-breeding season. Moreover, seabirds that become entangled and die may sink quickly or be consumed by scavengers at sea, before they can be observed. Most seabird entanglements involve beach-cast individuals, sightings by fishery observers at-sea, and observations by biologists working at breeding colonies. Additionally, because many species (gulls, boobies, noddies, frigatebirds) are increasingly using marine debris to construct their nests, colony surveys often document entangled chicks and adults (Votier et al., 2011; Thiel et al., 2018). Recently, the advent of community science programs and wildlife rescue centers have allowed researchers to examine trends in entanglements over time, and to inform resource managers about wildlife impacts from fishery interactions and marine debris (Moore et al. 2009; Donnelly-Greenan et al. 2019).

What Do We know About Seabird Entanglement Globally

While seabird entanglement has been documented globally since the early 1970s (Shomura & Yoshida, 1985), recent scientific publications underscore the growing scope of this problem, which affects an increasing number of species throughout the Pacific Ocean. The first comprehensive review of marine debris wildlife impacts published in 1997 listed 19 seabird species with records of entanglement in the U.S. (Laist, 1997). More recently, beach monitoring programs in the West Coast (Moore et al., 2009) and the East

Species	Observation	Location	Study Year(s)	Debris Type	Reference
Laysan Albatross	At-sea Carcass	North Pacific	1979	Monofilament driftnet	DeGange & Newby, 1980
Masked Booby	Colony Carcass	Nihoa (NWHI)	1981	Trawl net	Conant, 1984
Black-footed Albatross	Beach-Cast Carcass	Central California	1997 – 2017	Line and balloons	Donnelly-Greenan et al., 2019
Black-footed Albatross	Beach-Cast Carcass	Central California	2001 – 2005	Rope	Moore et al., 2009

Table 1. Published entanglement records of Hawaiian seabird species, organized chronologically

Coast (Harris et al., 2006), documented an additional 22 and 3 species susceptible to entanglement, respectively. Altogether, this results in 44 seabird species suffering entanglement in U.S. waters.

Globally, the proportion of seabird species with published entanglement records increased from 16% in the 1990s (Laist, 1997) to 25% in the 2000s (Kühn et al., 2015). Moreover, Kühn and colleagues (2015) concluded that all seabirds were at risk of entanglement, and that the list of affected species would increase over time. Ryan (2018) expanded the global entanglement list from 25% to 36% of all seabird species, using published scientific records and publicly available images posted on the internet. Ryan's (2018) review documented that all seabird orders are affected by entanglement, and underscored the prevalence of fishing gear (line and netting) and consumer-items (balloon and kite strings, rope, sixpack holders, packing strips, lid rings, plastic bags), which were documented entangling 88% and 39% of the observed species, respectively.

There is growing concern about seabird entanglement in marine debris, nationally and internationally. For instance, a twenty-year (1997-2017) study in central California (Donnelly-Greenan et al., 2019) underscores the pervasive nature of entanglements, which affected 26 species with diverse foraging methods (surface foragers, plungers, and divers) and distributions (coastal and pelagic). While the overall incidence across all species was low (0.5%), with only 357 cases of entanglements among 65,604 documented beach-cast carcasses, some species were more susceptible than others. The five most abundant species documented in beach surveys accounted for 61% of the entanglement records: Common Murre (23.7%), Brandt's Cormorant (13.3%), Western Gull (9.6%), Sooty Shearwater (7.9%), and Brown Pelican (6.8%). However, the most vulnerable species were those frequently documented entangled, despite their low overall deposition numbers. For instance, the Black-footed Albatross was involved in 0.56% of all observed entanglements (2 of 357), but only contributed 0.04% (24 of 65,604) of the beach-cast carcasses documented. However, this species had a high entanglement rate (8.3%), with 2 of the 24 beach-cast Black-footed Albatross being entangled.

Another publication from the south Pacific documented seabird interactions with marine debris on Rapa Nui (Easter Island), by merging published and unpublished records, photographs, and opportunistic field observations (Thiel et al., 2018). Three species (Red-tailed Tropicbird, Grey Noddy, and Great Frigatebird) used marine debris in their nests and were also occasionally entangled. The Polynesian Storm-petrel used marine debris in their nests, and the Peruvian Booby was entangled, despite not using this nesting material. While this study did not calculate species-specific entanglement rates, it underscores the widespread incidence of entanglement, which affected species with diverse foraging methods and distributions.

Together, these studies illustrate the value of opportunistic observations of beach-cast birds and nesting colonies to document entanglements, and the ability of community science programs and wildlife rescue centers to track entanglement rates over time (Moore et al. 2009; Donnelly-Greenan et al. 2019). While a long-term monitoring program does not exist in the Main Hawaiian Islands, the Hawai‘i Wildlife Center (HWC) rescues and rehabilitates injured seabirds, and Hawai‘i Marine Animal Response (H-MAR) responds to reports of injured wildlife. The records from these two organizations provide critical information about species-specific incidence and rates of entanglement.

What Do We know About Seabird Entanglement in Hawai‘i

An initial way to assess the scope of these interactions entails compiling a list of those species for which

individuals have been documented entangled, and characterizing the type of marine debris involved in these interactions (Laist, 1997; Thiel et al., 2018). In this report, we develop a list of affected species by integrating three data sources: (i) historical records published in the scientific literature, (ii) systematic intake records from the HWC and H-MAR, and (iii) recent unpublished opportunistic observations from the State of Hawai‘i, Department of Fish and Wildlife (DOFAW) and Hawai‘i Pacific University’s (HPU) Pelagicos lab.

Historical Records Published in the Literature

A review of the literature reveals that only three of the 22 locally-breeding species in Hawai‘i have been observed entangled, based on published records since the 1970s (Table 1). An immature masked Booby (*Sula dactylatra)* was entangled in a scrap of trawl net on Nihoa Island (Conant, 1984), two entangled Black-footed Albatross (*Phoebastria nigripes*) were found dead on Central California beaches (Moore et al., 2009; Donelly-Greenan et al., 2019), and a Laysan Albatross (*P. immutabilis*) was observed entangled in a large derelict fishing net in the North Pacific (DeGange & Newby, 1980). While Laist (1997) listed personal observations by USFWS personnel of Black-footed Albatross and Sooty Terns (*Onychoprion fuscatus*) entangled in breeding colonies, these records were not included in this review due to the lack of proper documentation. Additionally, Great Frigatebirds (*Fregata minor*) become entangled in discarded fishing line, or take baited hooks, which often become entangled in bushes (Gauger Metz & Schreiber, 2020). Yet, while entanglements of Great Frigatebirds have been reported in Florida and the Caribbean, they have not been observed in Hawai‘i or Johnston Atoll (Betty Ann Schreiber, personal communication).

Contemporary Records

We augmented the global compilation by Laist (1997) with unpublished entanglement observations from HWC intake records (January 2012 - June 2020), and from other opportunistic observations from a variety of sources (2013 - 2020). The HWC dataset encompassed eight entanglement records, all involving fishing gear (monofilament line or hooks), which were removed by the fishers or the rescue responders (Table 2). These records allowed us to estimate species-specific entanglement rates, calculated as the proportion of the examined specimens that had been entangled. Yet, these rates varied widely, highlighting the difficulty of comparing species that are commonly or rarely rescued. While a staggering 50.0% (2 of 4 specimens) of Black-footed Albatross and 66.7% (1 of 3 specimens) of Masked Boobies were entangled, only 1.1% (6 of 526 specimens) of Wedge-tailed Shearwaters were entangled.

Interestingly, there were no entanglement records for Laysan Albatross (0 of 7), Brown Boobies (0 of 9), or Red-footed Boobies (0 of 17). Additionally, we compiled seven opportunistic observations of entanglement and entrapment involving four species: Wedge-tailed Shearwaters, Brown Booby, Red-footed Booby, and White Tern (Table 3).

Species	HWC ID	Location	Year	Debris Type	Disposition
Wedge-tailed Shearwater	14-27	Hilo, Hawai‘i Island	2014	Fishing line, Wing injury	Euthanized
Wedge-tailed Shearwater	17-24	Kihei, Maui	2017	Fishing line, Wing injury	Dead on Arrival
Black-footed Albatross	17-134	Kona, Hawai‘i Island	2017	Lower mandible hook injury	Died in Care
Masked Booby	19-23	Kona, Hawai‘i Island	2019	Hooked in bill	Released
Wedge-tailed Shearwater	19-57	Poaki Bay Beach Park, O‘ahu	2019	Entangled in twine	Released
Wedge-tailed Shearwater	19-75	Kaiwa Beach, O‘ahu	2019	Wing entangled in fishing line	Released
Wedge-tailed Shearwater	19-99	Unknown Location, O‘ahu	2019	Wing entangled in fishing line	Released
Black-footed Albatross	20-33	Kona, Hawai‘i Island	2020	Entangled in fishing line and lure	Died in Care

Table 2. Entanglement records from Hawai‘i Wildlife Center (January 2012 – June 2020), organized chronologically.

Species (Number)	Year	Location	Impact (Debris Type)	Photo Credit	Source
Red-footed Booby (14)	2013	Lanikai (Oʻahu)	Entrapment (Fish box)	Ann Dewey	Siddiqi (DLNR)
Wedge-tailed Shearwater (10)	2013	Offshore (West Oʻahu)	Entanglement (Net)	(DLNR)	Siddiqi (DLNR)
Brown Booby (1)	2018	Haleiwa (Oʻahu)	Entanglement (Net)	David Hyrenbach	Dauterman (H-MAR)
Wedge-tailed Shearwater (5)	2019	Kailua Beach (Oʻahu)	Entanglement (Net)	David Hyrenbach	Hyrenbach (HPU)
Red-footed Booby (1)	2019	Marine Corps Base Hawaiʻi (Oʻahu)	Entanglement (Monofilament fishing line)	Sarah Donahue	Hyrenbach (HPU)
Wedge-tailed Shearwater (1)	2020	Kailua Beach (Oʻahu)	Entanglement (Net and Line)	Jenn Urmston	Dauterman (H-MAR)
White Tern (1)	2020	Beretania St., Honolulu (Oʻahu)	Entanglement (Monofilament fishing line)	Hui Manu o Ku	Elliott (HWC)

Table 3. Opportunistic records of entanglement and entrapment in marine debris, organized chronologically. Images of these records are available at: www.pelagicos.net/entanglement.htm

The Way Forward

Previous reviews have documented pervasive seabird entanglement, with 36% of species affected globally. In particular, several seabird families found in Hawaiʻi have high proportions of entangled species (Ryan, 2018): 60% of frigatebirds (3 of 5 species, family Fregatidae), 60% of boobies and gannets (6 of 10 species, family Sulidae), 57% of albatrosses (12 of 21 species, family Diomedeidae): 33% of tropicbirds (1 of 3 species, family Phaethontidae), 33% of terns (13 of 39, family Sternidae), 16% of petrels and allies (15 of 96, family Procellariidae), and 12% of northern storm-petrels (2 of 17, family Hydrobatidae). By far, the anthropogenic materials most frequently reported in seabird entanglement records were monofilament line and nets, highlighting the risks associated with discarded fishing gear and accidental hookings (Shomura & Yoshida, 1985; Laist, 1997, Ryan, 2018).

In this review, we compiled published reports, intake records, and opportunistic observations of entangled specimens (Figure 1). Altogether, these observations documented entanglement and entrapment in seven species of Hawaiian seabirds: three boobies, three petrels (one shearwater and two albatrosses), and one tern. Four of these observations (Wedge-tailed Shearwater, Brown Booby, Red-footed Booby, White Tern) were new species records that augment those in the literature. These findings reinforce the notion that entanglement affects many seabird species with diverse ecologies, including some (like the Black-footed Albatross) that occur at sea and likely go unaccounted for. Therefore, these observations only provide a minimum index of the number of species and individuals adversely affected.

To provide a more complete perspective of the magnitude of seabird entanglement in Hawaiʻi, we call for the systematic collection of observations via three avenues: (i) compilation of opportunistic sightings and anecdotal reports from naturalists and the public at large, (ii) recovery of beach-cast specimens for examination of entanglement and associated injuries, and (iii) targeted surveys of highly-susceptible species to compare the number of entangled and unentangled specimens at colonies (Laist, 1997; Thiel et al., 2018).

First of all, opportunistic sightings and recoveries of beach-cast carcasses and discarded fishing gear would help document the occurrence of entanglement across all species (Thiel et al., 2018, Ryan 2018). Additionally, systematic surveys of beach-cast seabirds would provide information about seasonality, inter-annual variability, and longer trends, based on the encounter rate of entangled specimens (Moore et al., 2009; Donelly-Greenan et al., 2019).

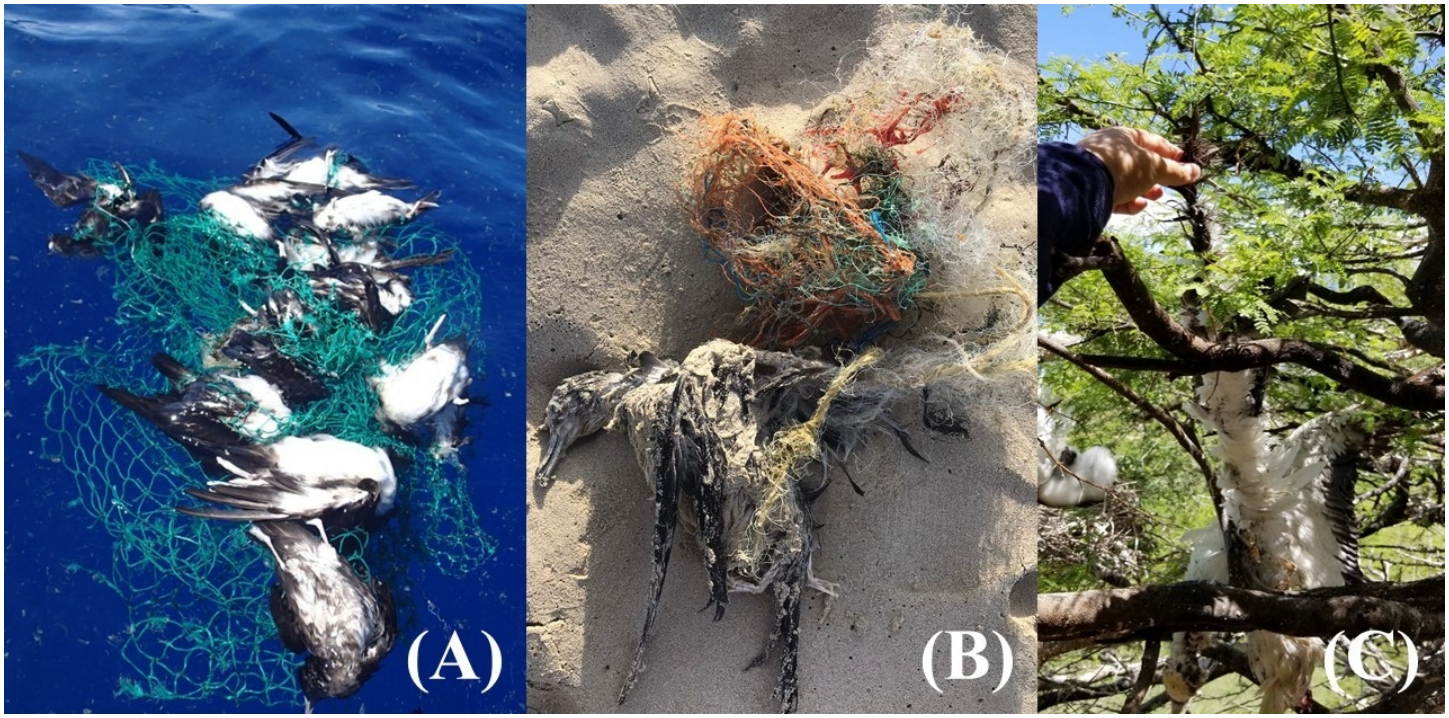

Figure 1. Examples of opportunistic observations of entangled seabirds: 10 Wedge-tailed shearwaters entangled in a net floating at sea (A), a beach-cast Wedge-tailed Shearwater entangled in line and rope, (B), and a Red-footed Booby entangled in fishing line on a colony tree (C).

Moreover, future comparisons of entanglement rates from beach-cast seabirds should take into account the overall ability to find seabird carcasses, by considering the shape and length of the shorelines being surveyed, and the rate of carcass loss due to scavenging (e.g., Amend et al., 2020).

A logical next step would entail developing quantitative metrics of species-specific incidence of entanglement or associated wounds and scars, relative to the total number of grounded or beach-cast individuals. In particular, the data from existing seabird rescue and rehabilitation programs can identify heavily-affected species and estimate minimum entanglement rates. For highly-susceptible species, focused colony surveys could provide more detailed information needed to develop threat assessments.

Although injury and mortality of individual seabirds is of concern, the potential effects of entanglement on populations is also of conservation interest. Thus, insights on entanglement effects at a population level can shed light on the efficacy of mitigation strategies and inform future management decisions. To this end, three pieces of information are needed to assess population-level impacts: (i) the rate of entanglement, expressed as the proportion of individuals in a population that are entangled, (ii) the rate of entanglement-related mortality, expressed as the proportion of entangled individuals that die, and (iii) the demographic structure of the population, involving the relative age (chicks, immature, mature) composition of the affected individuals (Laist, 1997; Thiel et al., 2018).

The goal of this review is to raise public awareness and to stimulate naturalists, fishers, and photographers to report and submit observations of seabird entanglement and hookings. Readers can help, by reporting injured and entangled seabirds needing help.

Report injured sebirds to Hawai‘i Wildlife Center at (808) 884-5000. Instructions on how to rescue an injured seabird can be found at: https://www.hawaiiwildlifecenter.org/rescue-injured-bird.html

Report sightings of injured, deceased, or entangled seabirds statewide to H-MAR (http://h-mar.org/) at 888-256-9840.

For additional contact information and resources from the State of Hawai‘i, visit: https://dlnr.hawaii.gov/wildlife/downed-wildlife-contact-details/

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121st Audubon Christmas Bird Count

Due to the ongoing COVID-19 pandemic, the National Audubon Society (NAS) recently released guidelines for this year's Christmas Bird Count (CBC).

Audubon fully supports any compiler who decides to cancel their count for this year. If a compiler would like to proceed with the CBC, they must abide by the guidelines below:

Option 1: Run a COVID-19 safe and socially distanced CBC, if local rules allow. If you chose this option, you have to

- Wait until November 15 at the earliest to confirm CBC will take place (in order to better understand status of COVID outbreak in your region), if local regulations allow.
- Cancel all in-person compilation gatherings.
- Social distancing and/or masking are required at all times in the field.
- Carpooling may only occur within existing familiar or social "pod" groups.
- Activities must comply with all current state and municipal COVID-19 guidelines.

Option 2: If option 1 is not possible, cancel this season's CBC for your location.

More information on the guidelines can be found on https://www.audubon.org/news/christmas-bird-count-compiler-announcements.

Efforts to coordinate dates and locations with compilers, who wish to conduct counts under the mandatory NAS guidelines, will be led by HAS Board member Colleen Soares. Following these guidelines, updates on the Hawai'i CBC will be available on the HAS website **no earlier than November 15**.