Population-Level Assessment of Black-Footed Albatross Foraging Distributions and Habitat Use in the North Pacific

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Introduction

Black-footed Albatross (*Phoebastria nigripes,* BFAL) are wide-ranging, large pelagic seabirds that breed on 17 subtropical islands in the central and western North Pacific (see Flint and Fraiola, this report). Albatross spend 90% of their lives at sea but become central place foragers when tied to a colony for breeding (Warham 1990; Tickell 2000). This facet of their life history has facilitated our understanding of their at-sea distribution and behavior by deploying a suite of telemetry devices to record their movement and activity. Together, these perspectives provide valuable ecological insights into their distribution and habitat use patterns. Multiple visits to the colony while breeding have ensured high recapture rates (> 90% recovery) for recovery of deployed tracking devices. To date, BFAL have been tracked from Tern Island, French Frigate Shoals (23.9°N, 166.2°W), Midway Atoll (28.2°N, 177.4°W), Kure Atoll (28.4°N, 178.3°W), and several at-sea locations off California and Alaska. These studies have characterized movement patterns during 1) each phase of the breeding season (incubation, chick guard, and chick rearing), 2) the post-breeding dispersal of breeders, and 3) the year-round movements of non-breeders. Additionally, complementary analyses of tissue samples (blood, feathers) diet samples, morphometric data (e.g., body mass and skeletal dimensions), and demographic information (breeding success, breeding history, age, and sex) have facilitated the interpretation of the tracking data. Our results highlight differences in foraging distributions associated with distinct breeding phases within a given colony and colony-based differences in at-sea distribution during the breeding and post-breeding periods. These patterns provide an ecological and life-history context for the examination of BFAL interactions with the Hawaii longline fishery.

Methods

Over the last 20 years, BFAL have been tracked using a variety of tracking devices, each with different limitations on battery life, accuracy, and types of data provided. Between 1997 and1999, adult BFAL were tracked at Tern Island using conventional satellite platform terminal transmitters (PTTs) attached to feathers on the dorsal region between the scapula (Fernández et al. 2001; Hyrenbach et al. 2002). On average, these devices yield 12 locations per day, with an accuracy ranging from 150 m to several km. Additional tag deployments were conducted on adult BFAL at Tern Island from 2002 through 2011, using either satellite PTTs, geolocation loggers, GPS data loggers, or a combination of these tags (Shaffer et al. 2005; Kappes et al. 2010, 2015; Conners et al. 2015; Thorne et al. 2015, 2016; Žydelis et al. 2011). Geolocation loggers (hereafter GLS–global location sensor) yielded only 2 locations per day, with an accuracy of approximately 200 km (Phillips et al. 2004; Shaffer et al. 2005). However, these tags are ideal for recording continuous long term (several years) movements because they are mounted on field readable plastic bands and do not fall off during molt. More recently, GPS loggers, first deployed on adult BFAL at Tern Island in 2006 and then 2008–2011, have an accuracy of 3 m and a sampling frequency between 10 seconds and 10 minutes, yielding high resolution spatiotemporal data to delineate fine-scale foraging behavior (e.g., Conners et al. 2015). Both GLS and GPS loggers have been used to study the long range (GLS) and fine-scale (GPS) movements of adult BFAL at Midway (2012–2016, Gutowsky et al. 2014a, 2015) and Kure Atoll (2012–2013, Hester et al. in prep). Satellite PTTs were also used to study the movements of post-breeding adult BFAL captured and released at sea, off the coasts of California (Hyrenbach and Dotson 2001, 2003; Hyrenbach 2008) and the Aleutian Islands in Alaska (Fischer et al. 2009). Finally, satellite PTTs were deployed on fledgling BFAL at Midway Atoll from 2006 to 2008 (Gutowsky et al. 2014b).

Tracking data have been combined with satellite remotely-sensed environmental data to examine the movement patterns and distribution of BFAL in relation to oceanographic features, like sea surface temperature (SST), sea surface height (SSH), chlorophyll a concentration (chl-a), bathymetry, wind stress curl, eddy kinetic energy (EKE), and distance to transition zone chlorophyll front (distTZCF). Overall, these features partially explain (in part or in combination) the observed distributions and patterns of area restricted searching of BFAL (e.g., Hyrenbach et al. 2002; Kappes et al. 2010: Thorne et al. 2015). Finally, tracking data and oceanographic correlates have been used to examine linkages between BFAL distributions and fisheries (Fischer et al. 2009: Žydelis et al. 2011).

Key findings

The published tracking studies underscore two patterns of at-sea distribution related to the timing of their breeding cycle and the location of the breeding colonies.

1) BFAL distribution and movement patterns vary according to breeding phase. During the incubation phase, foraging trips frequently extend beyond 10 days in duration and range over 2,000 km from the colony to pelagic waters northeast of Tern Island (Kappes et al. 2010, 2015). After hatching, BFAL parents brood their chicks for about 3 weeks and are most constrained because chicks require frequent, small meals. Therefore, foraging excursions are typically less than 3 days in duration and occur within 300–400 km of the colony (Table 7). As parents' transition to rearing larger chicks, both male and female BFAL often travel to productive waters off the continental U.S. and Canada, extending their foraging ranges to nearly 3,000 km for durations of two weeks. Although foraging behavior varies widely across breeding phases, BFAL from Tern Island forage within or transit through the fishing grounds of the Hawaii deep-set longline fishery (see Wren and Polovina, this report). On the other hand, BFAL from Kure Atoll venture into the NW Pacific and may overlap with Japanese and Taiwanese longline fisheries (Hyrenbach et al. 2017).

2) Population-level differences in distribution exist among BFAL colonies of the Northwest Hawaiian Islands. Tracking studies reveal population-level differences in foraging distribution among the three BFAL colonies where birds have been tracked: Tern Island, Midway Atoll, and Kure Atoll. GPS tracking data collected during the late incubation and chick-brooding periods at Tern and Midway reveal spatial segregation of birds from these two colonies at-sea (Figure 16). Nevertheless, this result needs to be interpreted with caution since the number of tracked individuals is quite small relative to the total population at each colony. Thus, more tracking information is needed to fully evaluate whether fine-scale segregation occurs for these and other colonies.

Nevertheless, the GPS tracking data suggest that BFAL from Tern Island likely overlap more with the core fishing grounds of the Hawaiian deep-set longline fishery (25–30 ° N, 150–165 ° W) (Table 7). Population-level differences in core habitat and home ranges of BFAL from multiple colonies are also evident throughout the year (Figure 16). Long-range movement patterns show minimal overlap of core habitats during 3 of the 4 quarters, whereby Tern Island birds exhibit a distinct easterly bias from the colony and Midway birds exhibit a westerly bias. The greatest overlap in distribution occurs during Quarter 3, when birds have completed breeding and are no longer tied to the colony (Figure 16).

Table 7. Distributional ranges of foraging Black-footed Albatross from Tern Island and French Frigate Shoals during the breeding phases (Kappes et al. 2015). In addition to foraging ranges, geographic coordinates of core habitat, trip durations, trip duration and range, and azimuth (Az) to the maximum distance location from the colony are also displayed. Means ± SDs are reported.

Phase of Breeding	Dates	Max. Range Latitude Longitude	Core Habitat Latitude Longitude	Trip Duration (days)	Trip Range from Colony (km)	Az to Maximum Distance Location (deg)
Incubation	early Dec – late Jan	17°N–52°N	21°N–41°N	13.30	2,045	22.8
		166°E–121°W	175°W–155°W	± 5.07	± 1,035	± 32.5
Brooding	late Jan – late Feb	22°N–27°N	23°N–25°N	2.67	313	47.4
		170°W–158°W	169°W–165°W	± 0.87	± 144	± 65.7
Rearing	early Mar – late Jun	17°N–60°N	22°N–52°N	14.40	2,883	31.9
		165°E–130°W	169°W–138°W	± 5.14	± 998	± 35

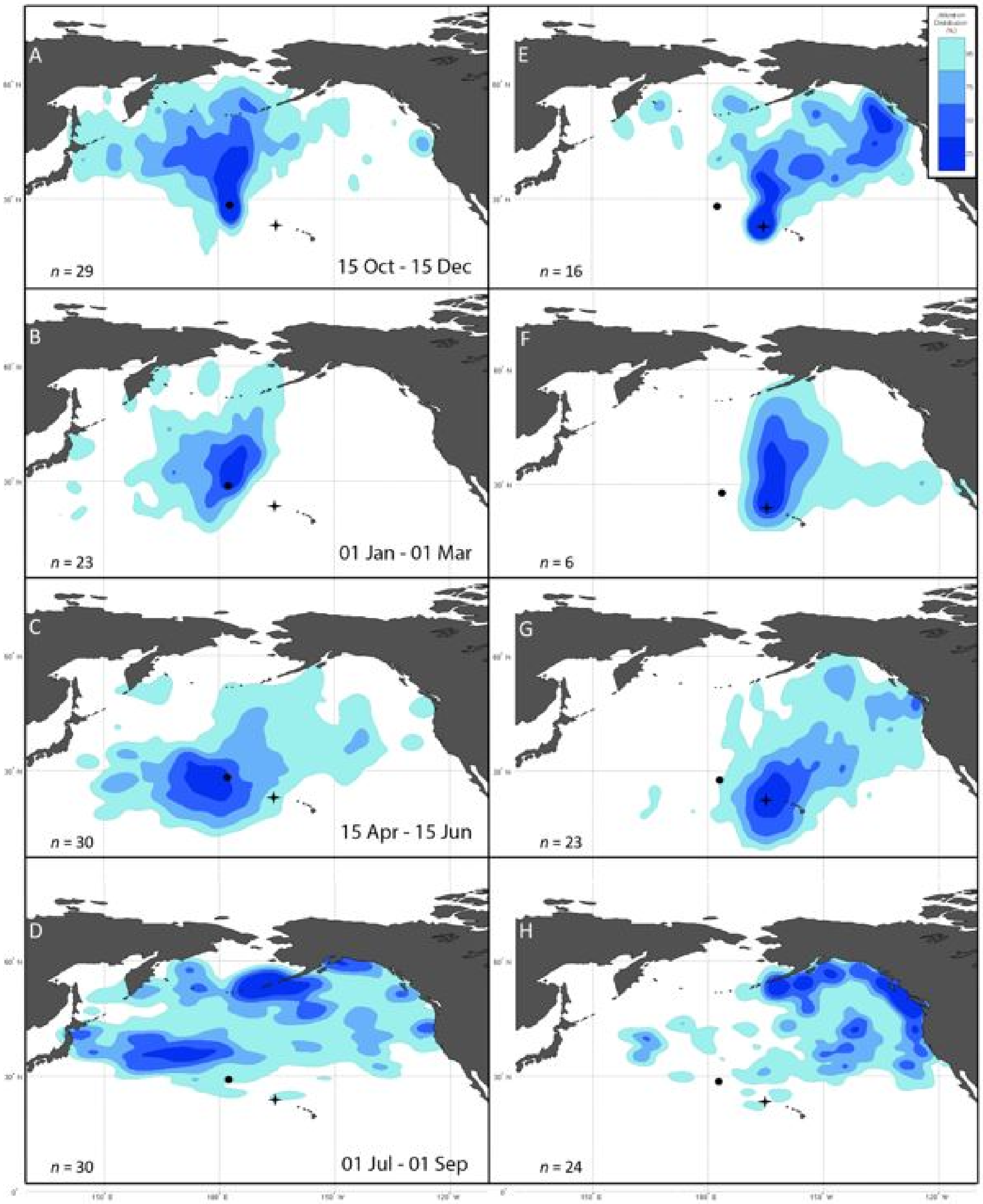

Figure 16. Colony-level differences in at-sea distribution of BFAL from Midway Atoll (panels A–D) and Tern Island (panels E–H). Panels for each population represent quarters of the calendar year, beginning when birds first return to their colony in October. BFAL were tracked throughout the year using GLS loggers deployed on birds attending a nest at Midway (2008–2013) and Tern (2008–2010). Each panel shows four kernel utilization distributions (95%, 7. Each panel shows four kernel utilization distributions (95%, 75%, 50%, 25%) based on the legend in panel E.

Next steps

The patterns documented by tracking BFAL at three sites (French Frigate Shoals, Midway Island, Kure Atoll) account for 48.4% of the global breeding population. However, additional tracking studies are needed to assess the spatial distribution of BFAL from other major breeding sites, which account for a substantial proportion of the BFAL global population. In particular, Laysan Island, Pearl and Hermes, and Lisianski Island are key sites; they comprise 35.0%, 8.7%, and 3.0% of the global population, respectively (see Flint and Fraiola, this report). Thus, a comparative multi-colony study spanning the entire breeding season and the post-breeding dispersal would allow analysis of inter-colony segregation and overlap with the Hawaii deep-set longline fishery (Figure 17).

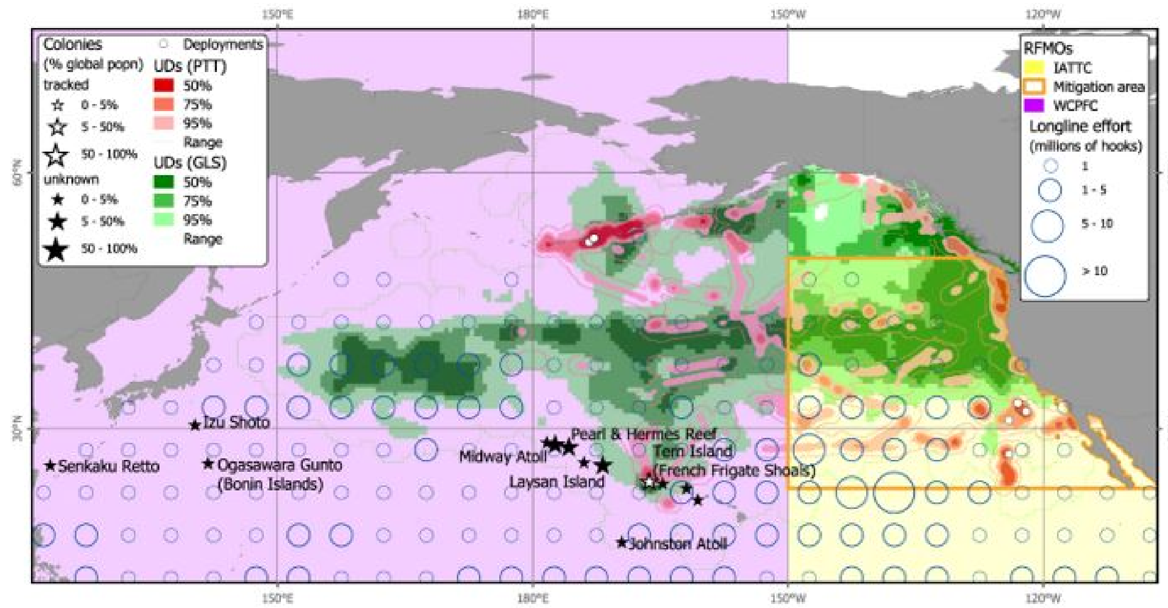

Figure 17. At-sea distribution of BFAL overlaid on longline fishing effort across the North Pacific. Shown are kernel utilization distributions from a combination of tracking data from multiple research programs (e.g., Shaffer, Hyrenbach, and Suryan labs). The data are not parsed by colony origin, sex, or temporal period (i.e., year or quarter). Instead, they show BFAL distributions and hotspots overlaid on fishing effort. Image courtesy of BirdLife International.

Two other ancillary analyses would further inform population-level impacts of longline fisheries mortality on BFAL. First, due to the potential impacts of differential age-specific and sex-specific mortality on population-level impacts, investigating the at-sea distribution of birds of different age classes and sexes would inform the observed demographic composition of the bycatch (see Russell et al., this report). While some age- and sex-specific differences in at-sea distribution have been observed, more data are needed to fully resolve these observations.

Additionally, another key area of research entails quantifying the degree to which BFAL rely on the longline fishery in terms of their aggregation at vessels and their ingestion of bait and discards. New analyses using biochemical assays of diet samples from tracked BFAL confirm the consumption of longline associated prey. Analysis of wet diet from BFAL has not been performed since Harrison et al. (1983). Thus, more than 30 years have passed without any comprehensive analysis of albatross diets from the Northwest Hawaiian Islands. Conners et al. (2018) recently analyzed stomach oil samples collected from BFAL adults tracked at Tern Island. Each bird was tracked using GPS loggers prior to sampling stomach oil so behavior and diet were collected simultaneously. Stomach oil was analyzed using quantitative fatty acid signature analysis (QFASA) and compared to the QFASA of a known prey library. The analysis revealed that overall, < 10% of pooled diets contained fisheries associated prey. However, the incidence of fisheries-associated resources was highest during the 2009–10 breeding season when there was a moderately strong central Pacific El Niño. The diets from a few individual birds contained almost entirely fisheries-associated resources, suggesting some specialization.

Together with the tracking data, these dietary analyses can be used to explore individual-level, sex-based, and age-based variability in the degree of BFAL overlap and reliance on the longline fishery. These metrics could then inform the demographic composition of the BFAL bycatch (see Russell et al., this report) and survivorship rates (see Kendall et al., this report)

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Cover: A Black-footed Albatross taking off from the sea surface in waters north of Hawaii. Photo courtesy of David Hyrenbach.