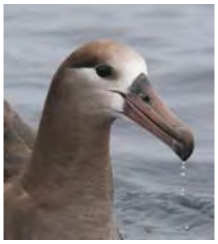

Synthesis of Habitat Use by Black-footed Albatross tracked from Cordell Bank National Marine Sanctuary (2004 – 2008) and Kure Atoll Seabird Sanctuary (2008)

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SUMMARY

Oikonos Ecosystem Knowledge, working with state and federal resource managers and university partners tracked the oceanic distribution and behavior of post-breeding and chick provisioning Black-footed Albatross (BFAL, *Phoebastria nigripes*) tagged at-sea within the Cordell Bank National Marine Sanctuary (CBNMS) and on the Kure Atoll colony within the Papahānaumokuākea Marine National Monument (PMNM) over a four year period (2004, 2005, 2007, 2008). The overarching goal of this project was to summarize the existing information to inform the management of this far-ranging protected species, in the context of static oceanic habitats (bathymetric domains and features), existing jurisdictions (U.S. National Marine Sanctuaries (NMS) and Marine Monuments), and international exclusive economic zones (E.E.Z.).

INTRODUCTION

The conservation status of North Pacific albatross populations warrants comprehensive efforts to understand their ecological requirements and to develop strategies to minimize the impacts of known and potential threats. The Black-footed Albatross (BFAL, *Phoebastria nigripes*) is listed as 'endangered' by the International Union for the Conservation of Nature (IUCN 2011) due to a projected population decline partly due to longline fisheries bycatch and high levels of plastic ingestion and organo-chlorinated pollutant loads (Croxall & Gales, 1998; Lewison & Crowder, 2003, Arata et al. 2009; BirdLife, 2011). Both IUCN and U.S. Fish & Wildlife Service consider tracking the at sea movements and distributions of this species a priority conservation action (BirdLife, 2004; Arata et al. 2009). In particular, there is a major information need concerning albatross movements and habitats during the far ranging post-breeding dispersal stage (July – October), when longline fisheries bycatch rates appear to be the highest (Cousins & Cooper, 2000; Hyrenbach et al. 2003). Also, there are large knowledge gaps in the important foraging areas for chick provisioning albatross from different breeding colonies throughout the Northwestern Hawaiian Islands and Japan. In particular, it is unknown to what extent BFAL from different colonies overlap with different fishery management organizations and national jurisdictions, forage in areas of high longline activity and marine debris concentration (e.g., eastern and western "garbage patches"), and make use of specific bathymetric features (e.g., seamounts, shelf-breaks). The ability to develop spatially-explicit maps of BFAL distributions and potential threats at-sea during different stages of their life cycle, is critical for evaluating the conservation status and the research priorities for the species (e.g., Cousins & Cooper, 2000; Arata et al., 2009).

BFAL breed on islands in the Northwestern Hawaiian Islands and three outlying islands off the coast of Japan, with recently documented breeding attempts on islands off Mexico and Wake Island in the Central Pacific (Pitman and Ballance, 2002). In 2005, the population was estimated at 61,000 breeding birds spanning 12 breeding localities (Arata et al. 2009; BirdLife, 2011). Adults and hatch-year birds leave breeding colonies in July, and sub-adults and breeding adults return to colonies by mid-October (McDermon & Morgan, 1993; Cousins & Cooper, 2000). Although BFAL are year-round residents off the West Coast of North America, highest densities occur off central California during the upwelling season (March-August; Briggs et al., 1987; NCCOS, 2003). Some albatross commute long distances from their breeding colonies in the central Pacific to forage in productive continental shelf – slope waters of the California Current System (CCS) during the chick-rearing season (February – June) (Hyrenbach et al., 2002, 2006). BFAL have also been documented in other productive habitats in the North Pacific (i.e. Aleutians, Western Pacific slopes) and large information gaps exist regarding albatross use of these U.S. and international waters. BFAL are surface feeders with a diverse diet, including epipelagic fish and squid, neustonic prey (e.g., flying fish eggs, gelatinous zooplankton), carrion, floating trash, and bait discards from fishing vessels (Harrison and Seki, 1987; Gould et al., 1997).

Herein, we summarize a dataset spanning 47 individuals tracked over a total of 2,236 days (Table 1), which characterizes albatross movements and distributions during the late chick-rearing (May - June) and the post-breeding season (July - October) by integrating data collected from two sites. Eleven breeding birds were tagged at Kure Atoll (Papahānaumokuākea Marine National Monument) in 2008 and 36 post-breeding birds were tagged at-sea within the Cordell Bank National Marine Sanctuary, off central California over four years (2004, 2005, 2007, 2008). Despite the disparities in seasonal and interannual coverage, these datasets provide two complementary perspectives of albatross movements within different periods of their life cycle and geographic locations. Furthermore, the coordinated analysis of albatross movements from multiple tagging locations allows the exploration of connectivity between breeding and post-breeding sites and the identification of potential "hotspots" or aggregations.

METHODS

Study Sites and Transmitter Deployments

This study spans the entire North Pacific, following the movements of the satellite-tracked Black-footed Albatross tagged at the Northwestern Hawaiian Islands and the central California continental shelf. Due to the large spatial scope of this study, we address two distinct spatial scales of importance for understanding and managing albatross habitats. On the basin-wide scale, we consider albatross movements with respect to national E.E.Z.s and three high-use areas in international waters separated into the Eastern (100 – 130 ^{o} W), the Central (170 ^{o} W – 170 ^{o} E) and the Western (160 – 120 ^{o} E) Pacific. On a regional scale, we focus on smaller-scale bathymetric habitats used by BFAL, including continental shelf-slope systems, seamounts, and U.S. National Marine Sanctuaries and a Marine National Monument.

In July – August of four years (2004, 2005, 2007, 2008), we attached satellite tags to 36 BFAL captured at sea within Cordell Bank National Marine Sanctuary (CBNMS) waters, approximately 38 km west off Bodega Bay, California (36.5-38.5 deg. N; 122-124 deg. W; Fig 1A). We determined the general age classes of the tagged birds by their plumage characteristics (Hyrenbach, 2002).

In May 2008, we tagged 11 BFAL that were rearing chicks at the breeding colony in Kure Atoll (28.4 ^{o} N, 178.3 ^{o} W), in the Northwest Hawaiian Islands. These birds were tracked during the late chick-rearing period of the breeding cycle (May – June; Fig 1B) and during their post-breeding dispersal (July-August; Fig 1C). We determined the gender of all the tagged birds from CBNMS and Kure Atoll using genetic methods.

We attached the Sirtrack Kiwisat 202 transmitters (54 g, 50 x 26 x 11 mm) with waterproof tape and small amounts of epoxy to the dorsal body feathers between the wings. We could not assess detrimental tag effects by comparing the behavior of tagged and control birds. It is unlikely, however, that the 54-gram package affected the flight or foraging performance of this surface-feeding species because it amounted to 1.5% - 1.9% of the average body mass (Harrison et al., 1983), within the recommended weight (<3% body weight; Phillips et al., 2003). The tags were programmed to operate continuously, or following one of three duty cycles designed to prolong battery life (Appendix 1, see Duty Cycle field).

Filtering and Processing of Location Data

We obtained individual bird locations using the ARGOS satellite-linked tracking system (CLS America, 2011) and archived the data via the Satellite Tracking and Analysis Tool (STAT; Coyne and Godley, 2005). We used STAT to flag and manually correct “mirror” locations and to remove duplicate records (i.e., when ARGOS returned two records with same time), and retained those records with location class (LC) quality of higher accuracy or the greater number of satellite messages. Remaining ARGOS data (LC-3 through LC-B) were filtered using a speed-distance-angle (SDA) filter (modified sdafilter function in the argosfilter package in R; Freitas et al., 2008) using a specified 70 km h^{-1} (or 19.4 m s^{-1}) speed threshold and the default settings for distances and angles (Freitas et al., 2008). Our speed threshold is slightly greater than the mean + 1 SE allometric prediction for flight speed over ground (15.9 m s^{-1}) among albatrosses flying with a 5 m s^{-1} tailwind (see Table 2 in Spear & Ainley, 1997).

Identifying Chick Provisioning Trips

Chick provisioning trips were first identified by visual observation of individual locations departing and returning to the nest site. During this late chick rearing period, adults spent less than 30 minutes at the nest site after feeding their chicks and this resulted in some tags not transmitting from the colony during the provisioning visit. To standardize the identification of colony visits, given the inherent positional errors of the satellite locations, we defined departure (arrival) locations as the first interpolated position outside (inside) a 3.12 km around the nesting colony that was followed (preceded) by at least three positions of equal or greater distance moving away (towards) the colony. This buffer was based on the circular error probable (CEP), which is related to the root mean square (RMS) of the kernel smoothing parameter ($RMS = CEP /(sqrt(pi/2)) = CEP / 1.25 = 3.12$). The CEP of a normal bivariate distribution, centered about the mean, is defined to include 50% of the sample. We selected a 3.12 buffer comparable with the previous methods of Kappes et al. 2010.

This approach allowed us to calculate descriptive statistics of each individual foraging trip (time, distance), after adding a start and end point at the nest site. Furthermore, the status of the chick determined whether a track was considered a foraging or a migration movement. The movements of parents with a live chick on the nest when they departed the colony were characterized as foraging birds, and only "closed" trips that started and ended at the colony were considered complete foraging trips.

To estimate time spent per area (e.g., bathymetric zones, jurisdictions), we used the SDA filtered data and generated hourly locations according to the linear method in Tremblay et al. (2006) for consecutive locations separated by < 8 hrs. Thus, the total distances traveled by BFAL calculated from these interpolated locations provide a minimum estimate, based on the assumption of straight line travel between consecutive interpolated locations.

Albatross Grouping Variables

We evaluated the movement data from individuals tagged at different sites (Cordell Bank, Kure Atoll) and during different stages of the breeding season separately (chick provisioning trips during the rearing stage, movements during the post-breeding migration). We also explored potential differences in BFAL movements due to sex (male / female) and tagging year (for

Cordell Bank only) (Table 1). Finally, to address potential biases due to the disparities in transmitter duty-cycles, we also tested for differences amongst birds equipped with continuous tags, and with transmitters operating on the three different duty-cycled tags (See Appendix 1). Because only males from Kure Atoll were equipped with tags operating on a 13:00 – 22:59 UTC duty-cycle, we were unable to evaluate potential interactions between sex and duty-cycle. Otherwise, we considered five comparisons involving single categorical grouping variables: Kure males / Kure females, Kure continuous / Kure duty-cycled, Cordell Bank by year, Cordell Bank males / Cordell Bank females, and Cordell Bank continuous / duty-cycled / discontinuous.

We performed these comparisons using Multi-response Permutation Procedures (MRPP) statistical tests. MRPP is a non-parametric (rank-transformed distance matrix), multivariate test of the difference in average within-group ranked distances, used to determine the statistical association within and across pre-defined groups. To prevent the undue influence of outliers, we used the Sørensen (Bray-Curtis) distance measure and the recommended group weighting method (n/sum(n)) with the PC-ORD software. MRPP yields the A statistic, which describes the "chance-corrected within-group agreement", and a matching p value to determine statistical significance (McCune & Grace, 2002; McCune & Mefford, 2006).

Habitat Utilization Kernels

First, we used the speed-distance-angle ARGOS filter (*SDAfilter* in the argosfilter package in R; Freitas et al. 2008) to winnow unrealistic location outliers. Second, we calculated 95% Brownian bridge utilization distributions (95UDs; Horne et al. 2007; function *kernelbb,* in the *adehabitat* package in R; Calenge, 2006) separately for individual foraging trips (Kure Atoll 2008), individual specific post-breeding dispersal from Kure Atoll (2008), and among individuals captured during the non-breeding season in the Cordell Bank NMS (2004, 2005, 2007, 2008). To create 95UDs, we specified the first (19.44 m) and second (2490 m) smoothing parameters which relate to albatross speed and ARGOS location estimate inaccuracy, respectively. Because the Brownian bridge movement model assumes a circular normal error distribution, the second smoothing parameter (2490 m) approximates the circular standard deviation estimated from the median circular error probable (defined here as the individually averaged, 68^{th} percentile ARGOS LC-specific locational errors from SDA-filtered data; see Costa et al. [2010]). These parameters yielded appropriate estimates of space-use at the scale of the ARGOS data and for the purposes of this study. To represent utilization distributions graphically we summed individual 95UDs according to three groupings: 1) birds tagged at Cordell Bank, 2) breeding birds provisioning for their chicks on Kure Atoll, and 3) breeding birds that departed Kure Atoll after completing chick rearing. We mapped the summed 95UD raster layers in ArcMap 9.3.1 (ESRI, Redlands, CA) using the World Mollweide equal area projection based on WGS 84 geoid data and displayed with a color gradient (blue to red = low to high use).

Association of Tracked Albatross with Management Jurisdictions

The data filtering and interpolation described above allowed us to produce maps of the time-at sea for individual birds, at a spatial scale fine enough to describe their overlap with bathymetric features and jurisdictions (e.g., E.E.Z.s). We followed a hierarchical approach to assess the overlap of BFAL movements and management jurisdictions. Over the basin-scale, we calculated the proportion of the time at-sea that each tracked BFAL spent within each national exclusive economic zone (E.E.Z.). Next, we focused on the time within U.S. waters and calculated the proportion of time individual BFAL spent within Marine National Sanctuaries and a Marine National Monument within U.S. territorial waters, including the Davidson Seamount management area of the Monterey Bay NMS and the CBNMS and GFNMS potential expansion areas. To avoid problems of statistical pseudo-replication, we performed these calculations for each individual, relative to the individuals' total tracking time, and averaged these proportions in the figures and tables.

Association of Tracked Albatross with Bathymetric Habitats

In addition to mapping albatross movements, we identified the bathymetric domains and habitats where these far-ranging seabirds spent their time at-sea. We matched each of the interpolated locations with depth values from the ETOPO 1-minute global relief grid (http://www.ngdc.noaa.gov/mgg/global/global.html) within a 2.3 km radius, determined by the 95% confidence interval of the post-filtered ARGOS error (Witt et al. 2010). To avoid problems of statistical pseudo-replication, we performed these calculations proportionally for each individual total tracking time, and averaged the individual results in the figures and tables.

We defined three bathymetric domains using the criteria of Briggs et al. 1987: (1) shelf (0 - 200 meter isobath surrounding a continent or the Aleutian archipelago); (2) slope (200 – 2,000 meter depth); (3) pelagic waters (> 2,000 meters depth). We also identified seamounts as features between 200 and 400 meters below the sea surface not connected to a landmass (Morato et al. 2008).

Fishing Effort in High-use Oceanographic Domains

To evaluate threats in pelagic regions of high-use by BFAL, we summarized the pelagic longline fishing effort and catch during the summer months (May – October) of four tracking years (2004, 2005, 2007, 2008) within three areas: Western pacific (WP), Central Pacific (CP) and Eastern pacific (EP). For each area, the number of hooks deployed (sum, yearly mean, yearly minimum and maximum, and the coefficient of variation) was reported. Catches were expressed as the mean (± SD) proportion of three different species-group numbers (Albacore Tuna, Big-eye and Yellowfin Tuna, Swordfish).

This SPC database represents the most complete longline data available to the Western and Central Pacific Fisheries Commission that can be disseminated into the public domain in accordance with the current “Rules and Procedures for the Protection, Access to, and Dissemination of Data Compiled by the Commission” (WCPFC 2012).

RESULTS

Study Sites and Transmitter Deployments

We obtained tracks from 47 individual BFAL, spanning 2,236 albatross tracking days (Table 1): 36 were tagged in Cordell Bank (2004, 2005, 2007, 2008) and 11 were tagged in Kure Atoll (2008). The mean tracking duration was 47.6 days (range: 21.3-74.0), during which albatross covered an average of 9,689 km (range: 2,396-19,244). Transmitter performance was excellent, without any premature failures. Transmissions ceased when batteries were exhausted or the tags were shed by molting birds (See Appendix 1).

The birds tagged in Cordell Bank were in the post-breeding dispersal period, free to roam unconstrained by duties at the breeding colony (Fig. 1A). All of the birds tagged at Kure were rearing chicks, and seven of them completed 14 foraging loops to provision their chicks in late May – early June (Fig. 1B). Eventually, all of these birds departed from the colony and ranged widely across the North Pacific from July-August (Fig. 1C). Thus, for all of the subsequent analyses we consider the provisioning trips during the chick-rearing period (May - June) separately from the post-breeding tracks (June - August). While the former are constrained by duties at the colony, the latter are not. Thus, the post-breeding movements from birds tagged at Cordell Bank and Kure Atoll are indicative of the unrestrained distributions of BFALs during the non-breeding season, when they range widely across the North Pacific and encounter widely-distributed and distant fisheries (Cousins & Cooper, 2000).

Albatross Grouping Variables

The MRPP tests revealed only one significant difference among the three sets of groups we considered, as revealed by the A statistic and the associated p-value. When $A = 0$, group differences are as expected by chance, and when $A = 1$ all sample units are identical (McCune et al. 2000). Year was the only significant grouping variable ($p < 0.02$), and the only one that yielded greater differences between groups than within groups ($A = 0.08$). These results suggest that the individual birds tagged from Cordell Bank changed their distributions from year-to-year. While this same analysis was not feasible for Kure, where only one year of tracking was completed to date, this result highlights the need for additional tracking to investigate inter-annual variability in BFAL movements and distributions from Kure Atoll. Thus, throughout this report we report the mean and SD for six groups (male and female combined): (1) Kure rearing in 2008, (2) Kure post-breeding in 2008, (3) Cordell Bank post-breeding in 2004, (4) Cordell Bank post-breeding in 2005, (5) Cordell Bank post-breeding in 2007, and (6) Cordell Bank post-breeding in 2008.

Association of Tracked Albatross with Management Jurisdictions

The tracked BFAL spent over half of their time within international waters, beyond national jurisdictions: post-breeding birds tagged in Cordell Bank (Fig 2A) and Kure Atoll (Fig 2B) averaged approximately 60% of their time in international waters (high-seas). The Kure chick-provisioning birds spent less time (~ 40%) in the high-seas. Despite the similarities in the overall use of waters under national jurisdiction, the time spent within specific range nations varied greatly (Table 2). The birds tagged in Cordell Bank entered the waters of five nations (Japan, Russia, Canada, Mexico and U.S.), and occurred in two of the three U.S. E.E.Z.s (West Coast and Alaska). Similarly, the post-breeding birds from Kure entered the waters of four nations (Japan, Russia, Canada, U.S.) and ventured into three U.S. E.E.Z.s (Hawai'i, West Coast, Alaska) (Fig. 3A). These results highlight the far-ranging habits of this species during the post-breeding dispersal period, and the shared responsibilities for its conservation. Conversely, the chick-rearing birds from Kure only ranged into the U.S. Hawai'i E.E.Z. surrounding their breeding site (Fig. 3B), highlighting the smaller-scale foraging movements during this period.

Once within U.S. waters, the tracked BFAL spent a variable amount of time within existing marine protected areas (Fig. 4). Namely, Kure birds spent on average 27% of their time within the Papahānaumokuākea Marine National Monument (PMNM) when foraging for their chicks. During the post-breeding dispersal stage, these birds quickly left the waters of the monument and dispersed widely. Only one of the 11 tracked individuals entered another sanctuary: the Olympic Coast NMS off Washington State (Table 3). These results contrast with the pattern for the 36 bids tagged in the central California continental shelf. These birds ventured into five West Coast sanctuaries: the three adjacent California sites, the Channel Islands NMS off southern California and the Olympic Coast NMS off northern Washington State (Table 3). Additionally, several (3/36 or 8%) of the birds tagged within the Cordell Bank NMS also entered the Davidson Seamount management area, offshore of the Monterey Bay NMS. Two of these visits occurred in 2004 and one in 2008. Overall, these three birds spent an average of 39.5% ($\pm$ 52.4 S.D.) of their time within the Davidson Seamount management area. This result highlights the connectivity between the central California shelf and this offshore bathymetric seamount.

Furthermore, we calculated the amount of time the tracked BFAL spent within the proposed extension zones of the Cordell Bank and the Gulf of the Farallones National Marine Sanctuaries. Twenty-six (72 %) and nine (25 %) of the birds tagged off Cordell Bank entered the proposed extensions of the Cordell Bank and the Gulf of the Farallones sanctuaries, respectively (Table 4). This result underscores the importance of areas adjacent to existing sanctuaries for post-breeding BFALs dispersing to the West Coast of North America.

Association of Tracked Albatross with Bathymetric Habitats

The tracked BFAL spent the majority of their time within the pelagic realm, over deep (> 2000m) oceanic waters, but also ventured into continental slopes / shelves and visited seamounts (Fig. 5 and 6). Yet, some individuals spent substantial amounts of time within shallower continental slopes and shelves, as evidenced by the high variability in the individual proportions of time spent within distinct bathymetric domains (Table 5).

The birds tagged in Cordell Bank spent varying amounts of time within the shallow shelf / slope waters off California, and also ventured into similar regions spanning from Oregon Washington (U.S.), Baja California (Mexico), British Columbia (Canada) (Fig. 1A).

Interestingly, the Kure adults provisioning chicks did not commute to shallow shelves, as previously documented for BFAL breeding on Tern Island, French Frigate Shoals (Hyrenbach et al. 2002, 2006). Rather, these birds remained within deep oceanic waters, where they visited seamounts and flew over shallow (depth < 200 m) waters only on their way to / from their breeding colony (Fig. 1B). Upon departing for the post-breeding dispersal, Kure birds ranged over deep pelagic waters, on their way to shallower shelf – slope regions on the periphery of the basin: off Japan (2 birds), Kuril Islands (1 bird), Aleutian Islands (3 birds), Gulf of Alaska (1 bird), and Washington – British Columbia (1 bird) (Fig. 1C).

A focused analysis of seamounts revealed that both the Kure and Cordell Bank birds used these bathymetric features (Table 6). Seven and 11 birds tracked from Kure during the chick-rearing and the post-breeding periods visited seamounts. In particular, the breeding birds seemed to focus on these features within the Emperor Seamount Chain, with some birds visiting them repeatedly. All seven tracked birds ventured to within 2.3 km of a major seamount, with individuals spending from 0.5% to 36.6% of their time in the vicinity of these features. Overall, when all the tagged breeding birds were considered, Kure BFAL spent an average of 14.6 ($\pm$ 5.1 S.D.) % of their time in the vicinity of seamounts.

Upon dispersing from the colony, seven of the eleven Kure BFAL tracked also visited seamounts, with these individuals spending from 0.3% to 34% of their time at sea in the vicinity of seamounts. Overall, when all the tagged post-breeding birds were considered, Kure BFAL spent an average of 12.3 ($\pm$ 5.0 S.D.) % of their time in the vicinity of seamounts. Despite the small sample size, this result underscores the ecological importance of these features for BFAL foraging, and highlights potential interactions with high-seas fisheries operating in the vicinity off these features (e.g., Yasui 1986; Wilson & Boehlert 2004).

While Kure BFAL use of the Emperor Seamount Chain was especially important, the tracked birds from Kure and Cordell Bank also used other seamounts in the central and western North Pacific. When the 36 BFAL tagged in Cordell Bank were considered, only 12 spent any time in the vicinity of seamounts. Yet, the amount of time these birds spent over seamounts varied widely, from 0.2 % to 13.3 %, highlighting the great degree of individual variability. In fact, the 12 birds that visited seamounts spent ample time around these features (5.0 ± 1.3 S.D.) % of their time in the vicinity of these features. Overall, 19 of the 47 BFAL tracked visited seamounts, with some individuals spending up to one third of the time they were tracked in the vicinity of these features (Table 6). Thus, this result suggests that some birds focused their foraging on seamounts, while others spent their time searching productive continental shelf / slope systems (Table 5).

Longline Fishing Effort

The distribution of fishing effort (hooks deployed) varied across the three North Pacific ocean domains used by BFAL (Table 7). The Western Pacific (WP) area was characterized by the highest number of hooks, with a yearly average of 1.26 billion hooks, despite a high degree of variability (CV = 163.2%). The catches within this area were dominated by deep-water tuna species (Big-eye and Yellowfin), which are targeted by daytime longline sets. The Central Pacific (CP) area was characterized by lower effort, with a yearly average of 1.01 billion hooks, that was less variable from year to year (CV = 34%). Catches within this area were dominated by albacore tuna, another shallower-water tuna species targeted by day-time longline sets. Swordfish catches, which are targeted by shallow night-time longline sets (He et al. 1997) were similar within both areas. Interestingly, the SPC data revealed no longline fishing effort within the Eastern Pacific (EP) area. While this complete lack of effort is likely caused by the inability to provide data due to the confidentiality agreements (at least three vessels need to operate within a given block on a given month), this pattern is consistent with the declining amount of effort previously reported between the 1980s and the 1990s for this area (Hyrenbach & Dotson 2003) and the closure of the "loophole" allowing Hawaii-based longline vessels to download their catch in West Coast ports. Thus, while some foreign and U.S. longlining is taking place in the eastern area, the magnitude of this fishing is markedly lower than in the central and western areas.

Habitat Utilization Kernels

To provide a map of proportional use of the marine environment, the kernel models facilitated an integrated perspective which incorporated all individuals and tracking years (Fig. 6). We highlight two specific contours to ease in the interpretation: (i) the habitat range used by the tracked birds, representing the 95% UD contour, is indicated by the dark blue shading (bottom of the color scale); and (ii) the core habitat used by the tracked birds, representing approximately 25% UD contour indicated by the red shades (top of the color scale).

The habitat use pattern of the Cordell Bank birds was characterized by three features: (i) a narrow and elongated high-use area, spanning the shelf-break / slope waters along the west coast of North America, from the Southern California Bight (to the south) to the Columbia River (to the north); (ii) a wider area of scattered use, spanning approximately from 105 – 130 ^{o} W and 25 – 35 ^{o} N; and (iii) a very wide area of very dispersed use, spanning from approximately 130 ^{o} W to Japan (Fig. 7). A closer inspection of the habitat use along the Northeast Pacific, reveals a large core area (depicted by red shading) within the three central California NMS and smaller disjunct areas spreading along the shelf-break / slope to the north and to the south (Fig. 8). Additionally, this more detailed perspective highlights a scattering of high use areas to the southwest not influenced by the tagging location bias.

The habitat use pattern of the Kure birds was characterized by two features: (i) breeding birds were characterized by a disjunct pattern, with high-use areas (depicted by the red shading) scattered around the colony and focused on seamounts (Fig. 9); and (ii) post-breeding birds were characterized by scattered high-use areas to the west of the dateline (spanning approximately from 120 – 160 ^{o} E); and (iii) larger high-use areas littered along the shelf-break / slope waters along the edge of the basin, spanning from Japan, Kuril Islands, Aleutian Chain, Gulf of Alaska, and British Columbia (Fig. 10).

DISCUSSION

Overview

The tracked BFAL spent considerable time in both U.S. E.E.Z waters and the international high-seas. These birds also ventured into national jurisdictions of Japan, Russia, Canada, and Mexico. However, their distribution varied by tagging site and period of the breeding season. Kure birds foraged relatively close to the colony during the late chick-rearing period (May – June) resulting in almost equal time spent within the U.S. E.E.Z. around Hawaii and unregulated high-seas areas. In contrast, after the breeding season (July – August) Kure adults dispersed into the high seas, especially in the northwest Pacific, with two birds venturing into the northeast Pacific (Gulf of Alaska and Canada). While Cordell Bank birds also traveled to the northwest Pacific, they used the waters of Canada, Mexico and U.S. (Alaska and West Coast) to a higher degree then the Kure birds.

The PMNM offered some protection to chick rearing BFAL (27% of their time commuting) while traveling to foraging destinations outside the monument. Birds tagged in the central California shelf used three contiguous National Marine Sanctuaries, and in one year (2008) ventured into other protected areas to the south (Channel Islands NMS) and to the north (Olympic Coast NMS).

While the tracking did not document extensive connectivity between the PMNM and West Coast NMS, it is worth noting that two birds tracked in 2008, one from Kure and one from Cordell Bank, ventured into the Olympic Coast NMS. Despite the small sample sizes, this result suggests that year-to-year variability in regional oceanographic conditions may attract far-ranging albatross from different locations to the same productive continental shelf regions.

With all the locations combined, the satellite-tracked BFAL spent the majority of their time within the pelagic realm, over deep oceanic waters, with some birds venturing into shallower continental slopes / shelves and visiting seamounts, especially during their post-breeding migration phase. For instance, the birds tagged in Cordell Bank spent a considerable amount of time within shallow shelf / slope waters off the West Coast, ranging from British Columbia (Canada) to the north to Baja California (Mexico) to the south. Yet, every bird ventured into pelagic waters (> 2000m deep), with most (53 %) returning to shallow continental shelves: either along the West Coast (17 of 36) or in the Northwest Pacific (off northern Japan and the Kuril Islands; 2 of 36).

Interestingly, the Kure birds foraging for their chicks did not commute to shallow shelves, like has been previously documented for BFAL breeding in Tern Island, French Frigate Shoals (Hyrenbach et al. 2002, 2006). Rather, these birds commuted to seamounts (depth < 2000 m) to the NW of their breeding site, and largely occupied deep oceanic waters. During the post-breeding dispersal, these birds travelled over pelagic waters, with over half (6 / 11 or 54%) visiting shallower shelf – slope regions on the periphery of the basin.

While the Black-footed Albatross is a far-ranging species, with a basin-wide distribution, the tracking data reveal some specific patterns with important implications for management and conservation. First, BFAL range across management jurisdictions both during the breeding and the non-breeding seasons and spend a significant amount of their time at-sea in international waters with unregulated fisheries. Second, post-breeding birds from both tagging locations ventured into the territorial waters of several range nations (Canada, Japan, Mexico, Russia, United States), highlighting the shared responsibilities for BFAL conservation and need for international collaboration. Third, the tracking data revealed that BFAL do not use the North Pacific in a homogeneous fashion; rather, they seem to focus on specific areas associated with bathymetric features.

Despite the inherent biases underlying the habitat utilization functions due to the inevitable emphasis on the tagging sites, our four years of tracking data highlighted six high-use areas, worthy of additional assessment. Potential specific management actions are described below:

West Coast Continental Slope: In addition to the high-use area off central California, currently within existing NMS waters, BFALs high-use areas are scattered along a narrow region spanning shelf-break / slope waters from the Southern California Bight to British

Columbia (Fig. 7), a vast area spanning the California Current System (CCS). This finding reinforces previous results from the analysis of vessel-based surveys off California – Oregon and Washington, which indicated that BFALs concentrate along shelf-break and slope waters (Briggs et al. 1987, NCCOS 2003). Management and conservation actions for this area could involve: (i) continued monitoring of BFAL abundance and beach deposition by NMS; (ii) ongoing monitoring by NOAA fisheries of bycatch in demersal longline vessels operating in this region; (iii) potential strengthening of BFAL protections by expanding current NMS waters and jurisdictions to consider potential impacts within existing sanctuaries (e.g., bycatch, oil spills) and high-use areas outside of existing sanctuaries (e.g., northward expansion of central California sanctuaries, creation of an Oregon sanctuary).

Gulf of Alaska and Aleutian Slope: High-use areas appeared north of Vancouver Island (Canada) and, spread along the shelf-break / slope in a counter-clockwise fashion, spanning the Alaska Peninsula and the Aleutian Chain. Oceanographically, this area is characterized by the Alaska Current, which forms a counterclockwise gyre in the Gulf of Alaska and in the vicinity of Kodiak Island. This warm-water current flows southwest along the Alaska Peninsula and eventually enters the Bering Sea. Smaller–scale productive oceanographic features are superimposed on these current systems. In the Gulf of Alaska, large clockwise eddies at two predictable sites: west of the Queen Charlotte Islands ("Queen Charlotte Eddy" or "Haida Eddies" and west of Sitka ("Sitka Eddy"). Along the Aleutians, several dynamic passes support high localized productivity and concentrations of the highly-endangered Short-tailed Albatross (*Phoebastria albatrus*) (Ladd et al. 2005, Jahncke et al. 2005, Piatt et al. 2006).

Because the high-use areas documented here are based on the movements of two Kure birds, this result should be interpreted with caution. Yet, this result reinforces previous findings of BFAL aggregation along the Gulf of Alaska slope (Hunt et al. 2005) and use of Aleutian passes by post-breeding BFALs satellite-tracked at sea (Suryan et al. 2007). Thus, management actions for this region could include investigating albatross use of Aleutian passes and slope waters of the Gulf of Alaska, to better characterize their seasonal distribution and abundance.

Western North Pacific Slope / Shelf Waters: The same way that BFAL forage along the CCS shelf / slope waters, this study revealed several similar high-use areas along the continental shelf / slope waters of the Northwest Pacific. Namely, three birds from Kure dispersed to waters off central Japan (off Tokyo Bay) and off the Kuril Islands. This result suggests that individual birds visit specific areas of the shelf – slope, where they spent the summer months of the post-breeding dispersal. Yet, additional tracking from Kure is needed to determine whether these areas are re-visited over multiple years. Thus, management actions for this region would include: (i) investigating albatross use of continental shelf / slope waters, to better characterize their seasonal distribution and abundance, and (ii) working with Japanese and Russian fisheries agencies to explore potential albatross bycatch in demersal longline vessels and gillnets operating in their E.E.Zs. Namely, while gillnets have been prohibited within international waters since 1991 (U.N. Resolution 46/215), these fisheries are, however, still permitted to operate within 200 nautical miles of the coast—within a nation's Exclusive Economic Zone (E.E.Z.). For example, a large salmon driftnet fishery continues to operate in the Russian Federation's E.E.Z. The Russian fleet accounts for about half of the total catch, with the remainder taken by Japanese vessels. The seabird mortality associated with the fishery is considerable. Between 1993 and 1999 about 482,500 seabirds, predominately Procellariids and Alcids, perished in nets set by Japanese boats alone (Spiridonov & Nikolaeva 2004). Developing bycatch monitoring and mitigation measures for this fishery is thus of the highest importance (e.g., Bull 2007).

Northwestern Pacific Seamounts: Breeding birds from Kure foraged within a fairly restricted high seas area, spanning from 180 – 170 ^{o} E, and 30 – 40 ^{o} N (Fig. 1B), where they spent a substantial proportion of their time in the vicinity of seamounts (Fig. 7, Table 6). In principle, specific protective measures could be focused on high-use seamounts, bearing in mind the logistical difficulties inherent in enforcement in international waters. Otherwise, the scattered high-use areas in deep oceanic waters will require large-scale conservation measures, such as monitoring of longline fisheries effort and bycatch (Fig. 10). Thus, management and conservation actions for this area could involve: (i) continued monitoring of BFAL abundance and survivorship by PMNM; (ii) ongoing monitoring by NOAA fisheries of bycatch in pelagic longline vessels operating in this region; (iii) consideration of strengthened BFAL protections by collaborating with other the fishery management agencies of other range nations (e.g., Japan, Korea, Taiwan) and with international longline fishery management bodies (Western & Central Pacific Fishery Management Council). In particular, seamounts are targeted by longline, pole and line and troll fisheries for tuna (e.g., Yasui 1986).

Pelagic Northwest Pacific: Post-breeding birds from Kure ranged within a vast area, spanning from 160 – 120 ^{o} E, and 30 – 45 ^{o} N (Fig. 1C), with high-use areas scattered in the vicinity of the Emperor Seamount Chain and in deep oceanic waters (Fig 7). Additionally, four male BFALs tagged in Cordell Bank ventured through this area, during their post-breeding dispersal from the West Coast (Fig. 1A). Yet, the scattered high-use areas will require large-scale conservation measures, such as monitoring of longline fisheries effort and bycatch. Management and conservation actions for this area could involve: (i) continued monitoring of BFAL abundance and survivorship by PMNM; (ii) ongoing monitoring by NOAA fisheries of bycatch in pelagic longline vessels operating in this region; (iii) consideration of strengthened BFAL protections by collaborating with other the fishery management agencies of other range nations (e.g., Japan, Korea, Taiwan) through the relevant international longline fishery management body (Western & Central Pacific Fishery Management Council).

California Current Transition Domain: The birds tagged in Cordell Bank traversed the broad oceanographic transition zone, where the cool and fresh waters of the southern-flowing California current mix with warmer and saltier subtropical waters to the south and west, spanning approximately from 105 – 130 ^{o} W and 25 – 35 ^{o} N (Fig. 8). This result also reinforces the notion that post-breeding BFAL forage in an area targeted by pelagic longliners fishing for albacore tuna (*Thunnus alalunga*) and swordfish (*Xiphias gladius*) and characterized by high bycatch rates in the past (Hyrenbach & Dotson 2003).

Yet, the scattered high-use areas will require large-scale conservation measures, such as monitoring of longline fisheries effort and bycatch. Management and conservation actions for this area could involve: (i) continued monitoring by NOAA fisheries of bycatch in pelagic and longline vessels operating in this region; and (ii) consideration of strengthened collaborating with other the fishery management agencies of other range nations (e.g., Japan, Korea, Taiwan) through the relevant international longline fishery management body (Inter-American Tropical Tuna Commission) to continue the monitoring of potential fishery interactions in this region.

Future Research

The synthesis of our tracking data has highlighted four areas where additional research is needed: (i) inter-annual variability in BFAL movements, (ii) BFAL use of small-scale habitats during chick provisioning, (iii) individual differences in BFAL use of specific features, and (iv) overlap of BFAL movements with high-seas fisheries in the NW Pacific Ocean.

<u>Inter-annual variability:</u> Cordell Bank tracking data revealed year-to-year differences in BFAL distributions and more extensive analysis is needed to describe environmental drivers such as wind and pressure systems at several scales (MacLeod et al. 2008, Adams and Flora 2010). We were not able to test for similar inter-annual differences for the Kure tracking. Thus, top research priorities are to repeat the Kure tracking for multiple years and further analyze the Cordell Bank movement data to understand variability during periods of contrasting oceanographic conditions.

<u>Use of small-scale habitats</u>: The pilot year of Kure tracking revealed that breeding birds were commuting to seamounts to the Northwest of the Hawaiian archipelago. Yet, this analysis was inhibited by the inherent positional errors of the satellite-tracking data (~ 10s km). Thus, we are initiating a fine-scale tracking study using archival Geographic Positioning system (GPS) tags at Kure in 2012, to better elucidate the degree to which breeding birds make use of seamounts and other small-scale oceanographic features within their foraging range. Completing this small-scale study over multiple years is another top research priority.

<u>Individual differences</u>: Once multiple years of tracking data have been collected, it will be critical to quantify how individual bird movements and distributions vary, and whether certain

individuals may be specializing on specific static and dynamic (i.e. winds; Adams and Flora 2010) habitat features. In particular, our preliminary data indicate great individual-level variability in the use of seamounts and shelf-breaks. Understanding the degree of individual variability is critical for determining how many birds need to be tracked to fully characterize the movements of birds from a given colony.

<u>High-seas fisheries in the NW Pacific Ocean</u>: One of the most striking research gaps identified by this research is the need to collaborate with U.S. and international fisheries management agencies to investigate the extent of fishing operations and albatross bycatch within the high-use areas used by breeding and post-breeding BFAL. The U.S. Hawaii longline fishery has shifted efforts to the north of albatross breeding colonies and the increased bycatch rates warrants close monitoring (NOAA unpublished data, Zydelis et al. 2011). In addition, other potential fisheries of interest include high-seas pole and line fishing for tuna (Emperor Seamount Chain), and coastal gillnet fisheries targeting salmon (Coastal Japan and Russian waters).

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TABLES

Table 1. BFAL satellite tracking data, summarized by year and tagging site. Tracking distance refers to the minimum distance traveled by tagged albatross, assuming a straight path between consecutive satellite locations.

			Days Transmitting			Tracking	Sex Ratio
Tagging Location	**Year**	**# Birds**	**Total**	**Mean**	**Min-Max**	**Distance (km)**	**Males:Females**
Cordell Bank	2004	9	388.9	43.2	28.9 - 56.8	90,920	4:5
Cordell Bank	2005	9	347.3	38.6	21.3 - 55.7	67,320	5:4
Cordell Bank	2007	10	443.0	44.3	28.0 - 64.0	56,755	7:3
Cordell Bank	2008	8	460.4	57.6	35.0 - 74.0	100,795	1:7
Kure Atoll	2008	11	596.4	54.2	35.9 - 65.9	139,585	8:3
Total		47	2236.0			819,830	25:22

Table 2. BFAL overlap within territorial waters (200-mile E.E.Z.s), summarized by year and tagging site. The mean (SD) proportional time (hrs) individual BFAL spent within each range nation's territorial waters are shown. Russia / Japan denotes a disputed territorial claim. Note: *na* (not applicable) denotes a lack of a SD, due to no use of that specific E.E.Z.

		Japan	Russia / Japan	Russia	Canada	US Hawaii	US Alaska	US West Coast	Mexico
Cordell Bank	2004	0.1	0.4	0	0	0	0.4	37.1	0.2
	Migration	*(0.1)*	*(0.4)*	*na*	*na*	*na*	*(0.4)*	*(5.4)*	*(0.2)*
	2005	0	0	0	0.7	0	0	45.3	0
	Migration	*na*	*na*	*na*	*(0.69)*	*na*	*na*	*(10.0)*	*na*
	2007	0	0	0	0	0	0	52.9	0.4
	Migration	*na*	*na*	*na*	*na*	*na*	*na*	*(7.4)*	*(0.4)*
	2008	0	0	0	0.7	0	4.3	32.8	6.4
	Migration	*na*	*na*	*na*	*(0.5)*	*0*	*(3.1)*	*(5.7)*	*(6.0)*
Kure Atoll	2008	0	0	0	0	51.8	0	0	0
	Foraging	*na*	*na*	*na*	*na*	*(12.64)*	*na*	*na*	*0*
	2008	12.7	0	4.7	2.9	2.1	17.9	0.8	0
	Migration	*(8.6)*	*na*	*(4.7)*	*(2.9)*	*(0.4)*	*(9.7)*	*(0.8)*	*na*

Table 3. BFAL overlap with U.S. National Marine Sanctuaries and a Marine National Monument, summarized by year and tagging site. The mean (SD) of the proportional time within U.S. waters that individual BFAL spent in each sanctuary are shown. Six sanctuaries are considered: Papahānaumokuākea Marine National Monument (PMNM), Olympic Coast National Marine Sanctuary (OCNMS), Cordell Bank National Marine Sanctuary (CBNMS), Gulf of the Farallones National Marine Sanctuary (CBNMS), Monterey Bay National Marine Sanctuary (MBNMS), and Channel Islands National Marine Sanctuary (CINMS). Note: *na* (not applicable) denotes a lack of a S.D. due to small sample size (birds < 2).

		PMNM	**OCNMS**	**CBNMS**	**GFNMS**	**MBNMS**	**CINMS**
Cordell Bank	2004	0	0	7.1	7.7	5.0	0
	Migration	*na*	*na*	*(2.3)*	*(3.6)*	*(2.8)*	*na*
	2005	0	0	6.7	1.8	9.1	0
	Migration	*na*	*na*	*(2.0)*	*(0.6)*	*(5.4)*	*na*
	2007	0	0	23.5	6.1	2.3	0
	Migration	*na*	*na*	*(5.5)*	*(1.5)*	*(2.3)*	*na*
	2008	0	0.7	3.1	4.6	3.5	0.2
	Migration	*na*	*(0.4)*	*(1.0)*	*(1.1)*	*(1.7)*	*(0.2)*
Kure Atoll	2008	27.6	0	0	0	0	0
	Foraging	*(13.0)*	*na*	*na*	*na*	*na*	*na*
	2008	0.8	0.1	0	0	0	0
	Migration	*(0.2)*	*(0.1)*	*na*	*na*	*na*	*na*

Table 4. BFAL overlap with the proposed extensions of the Cordell Bank National Marine Sanctuary (CBNMS) and the Gulf of the Farallones National Marine Sanctuary (CBNMS), showing the number of birds that entered each area and the mean (S.D.) time spent within the area. Note: *na* (not applicable) denotes a lack of a S.D. due to small sample size (birds < 2).

Year	Sanctuary	# Birds	Mean (S.D.)
2004	CBNMS	9	3.11 (1.8)
	GFNMS	1	0.6 (*na*)
2005	CBNMS	8	2.35 (1.74)
	GFNMS	1	3.43 (*na*)
2007	CBNMS	8	7.77 (6.32)
	GFNMS	7	7.45 (7.27)
2008	CBNMS	1	0.45
	GFNMS	0	*na*
Total	CBNMS	26	3.03
	GFNMS	9	1.56

Table 5. BFAL overlap with different bathymetric domains, summarized by year and tagging site. The mean (SD) of the proportional time within shelf (< 200 m), slope (200 – 2000m) and pelagic (>2000 m) waters was calculated using the average depth of the ETOPO 1-minute global relief data within a 2.3 km radius of interpolated locations (based on Witt et al. 2010).

		Avg. % Interpolated hr of Individual BFAL		
		Shelf	**Slope**	**Pelagic**
Cordell Bank	2004	6.4	16.2	77.4
	Migration	(1.73)	(4.04)	(4.86)
	2005	6.4	17.1	76.4
	Migration	(2.44)	(4.51)	(6.57)
	2007	28.1	19.5	52.4
	Migration	(5.39)	(3.93)	(7.79)
	2008	2.0	9.2	88.8
	Migration	(0.86)	(3.51)	(3.38)
Kure Atoll	2008	5.3	29.1	65.6
	Foraging	(3.54)	(8.18)	(9.73)
	2008	8.9	19.3	71.9
	Migration	(1.32)	(4.69)	(5.84)

Table 6. Summary of the proportion of total tracked time that tagged BFAL spent associated with seamounts. The incidence, mean, SD, and range of time spent in the vicinity of features between 200 and 400 meters below the sea surface (not connected to a continental shelf or island), during chick provisioning and post-breeding migration from 2004 to 2008 by tagging site. Bathymetry was calculated using the average depth of the ETOPO 1-minute global relief data within a 2.3 km radius of interpolated locations (based on Witt et al. 2010).

	Incidence of Seamount Association	Mean % Seamount Time	SD	Range
Chick Provisioning				
Kure Atoll	100% (all 7 birds provisioning chicks)	14.6	5.1	0.5 - 36.6
Post-Breeding Migration				
Kure Atoll	64% (7/11 birds)	12.3	5.0	0.3 - 34.0
Cordell Bank	33% (12/36 birds)	5.0	1.3	0.2 - 13.3
Tagging Sites Combined	40% (19/47 birds)	7.6	2.1	0.2 - 34.0

Table 7. Summary of pelagic longline fishing effort and catch during the summer months (May – October) of four tracking years (2004, 2005, 2007, 2008) within three high-use BFAL areas: Western pacific (WP), Central Pacific (CP) and Eastern pacific (EP). For each area, the number of hooks deployed (sum, yearly mean, yearly minimum and maximum, and the coefficient of variation) is reported. Catches are expressed as the mean (± SD) proportion of three different species-group numbers (Albacore Tuna, Big-eye and Yellowfin Tuna, Swordfish) (WCPFC 2012).

			Effort - Hooks (X1000)					Catches - % Fish		
Area	**Longitude**	**Latitude**	**Sum**	**Mean**	**Min**	**Max**	**CV (%)**	**Albacore**	**BE&YF Tuna**	**Swordfish**
WP	120 E - 160 E	25 - 40 N	505113.1	126278.3	4399.8	434672.5	163.2	30.6 +/- 16.3	42.9 +/- 9.6	26.4 +/- 11.8
CP	170 E - 170 W	25 - 40 N	406481.9	101620.5	71776.4	147032.5	34.2	51.9 +/- 20.6	26.3 +/- 11.4	21.7 +/- 16.6
EP	130 W - 100 W	25 - 40 N	0	0	0	0	0	-	-	-

FIGURES

Figure 1A. North Pacific basin, showing the post-breeding period (July - October) movements of 36 BFAL tagged at Cordell Bank National Marine Sanctuary (yellow star) over four years (2004, 2005, 2007, 2008). The tracks are superimposed on the extent of national jurisdictions, U.S. national sanctuary and monument boundaries, and ETOPO 1-minute bathymetry (highlighting specific seamount locations and the 200m and 2000m isobaths).

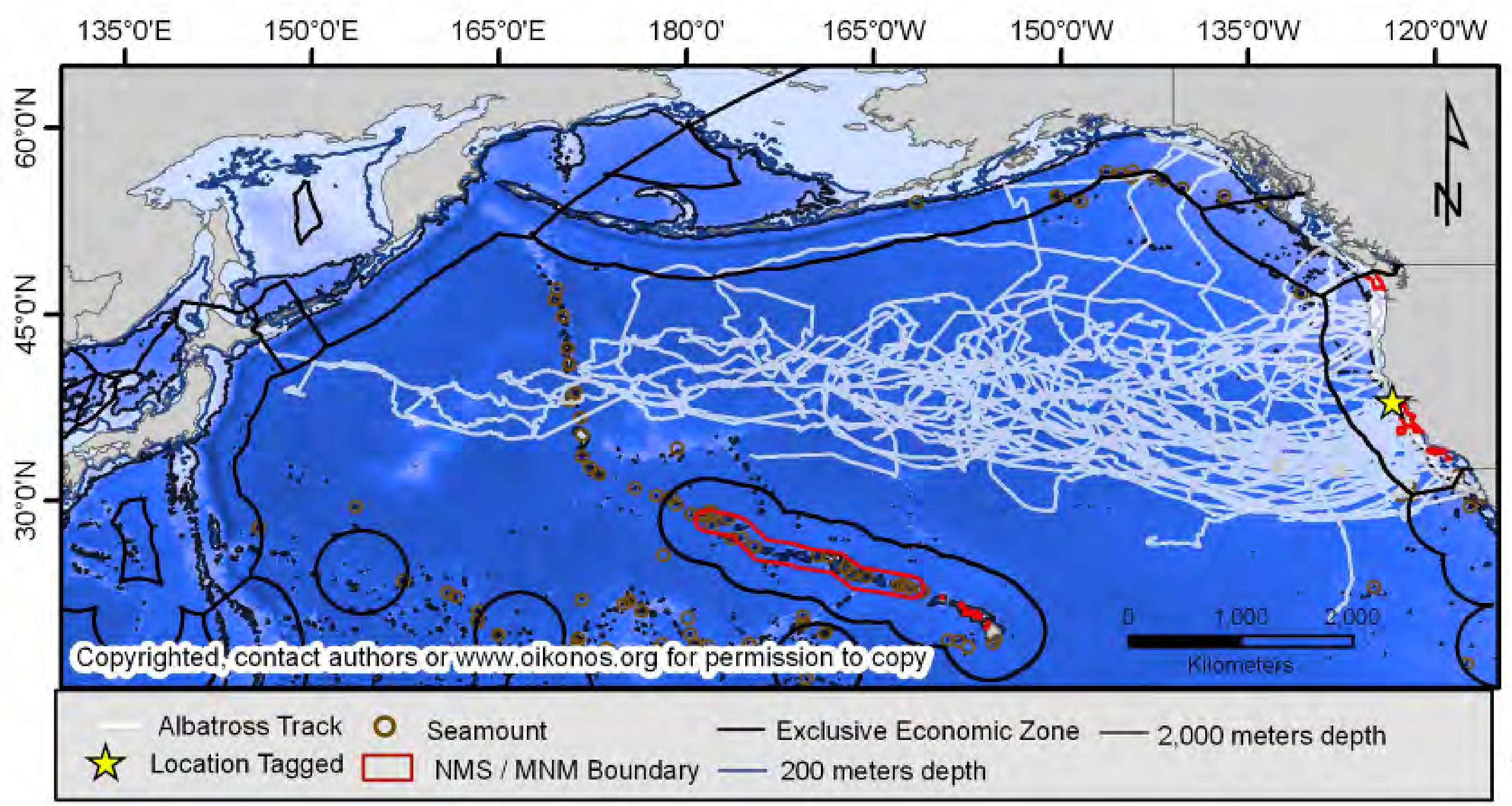


Figure 1B. North Pacific basin, showing the tracks of 14 foraging trips by 7 BFAL tagged at Kure Atoll (star) during the chick-rearing period (May – June) of 2008. The tracks are superimposed on the extent of national jurisdictions, U.S. national sanctuary and monument boundaries, and ETOPO 1-minute bathymetry (highlighting specific seamount locations and the 200m and 2000m isobaths).

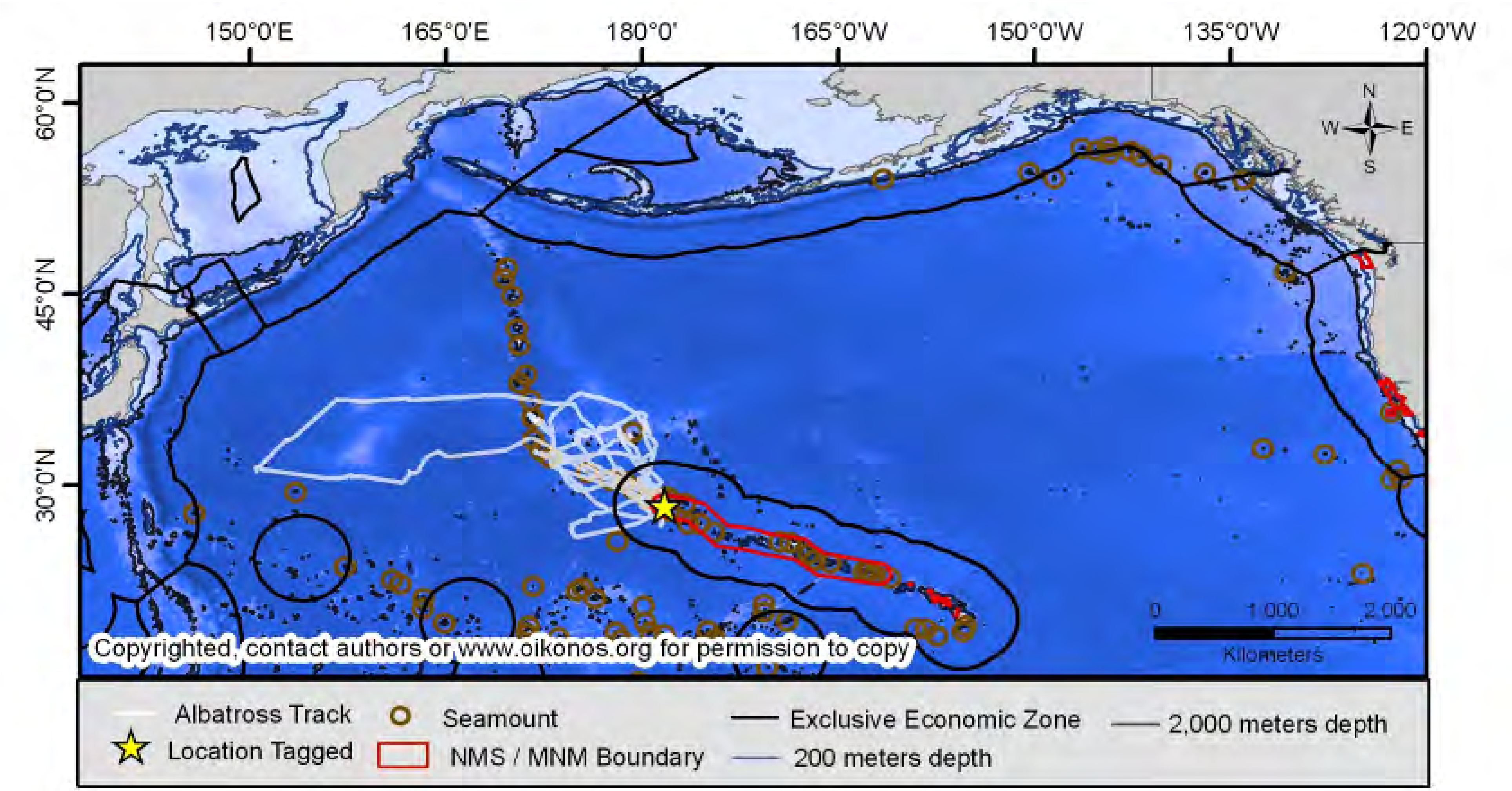


Figure 1C. North Pacific basin, showing the post-breeding (July – August) movements of 11 BFAL tagged at Kure Atoll (star) in 2008. The tracks are superimposed on the extent of national jurisdictions, U.S. national sanctuary and monument boundaries, and ETOPO 1-minute bathymetry (highlighting specific seamount locations and the 200m and 2000m isobaths).

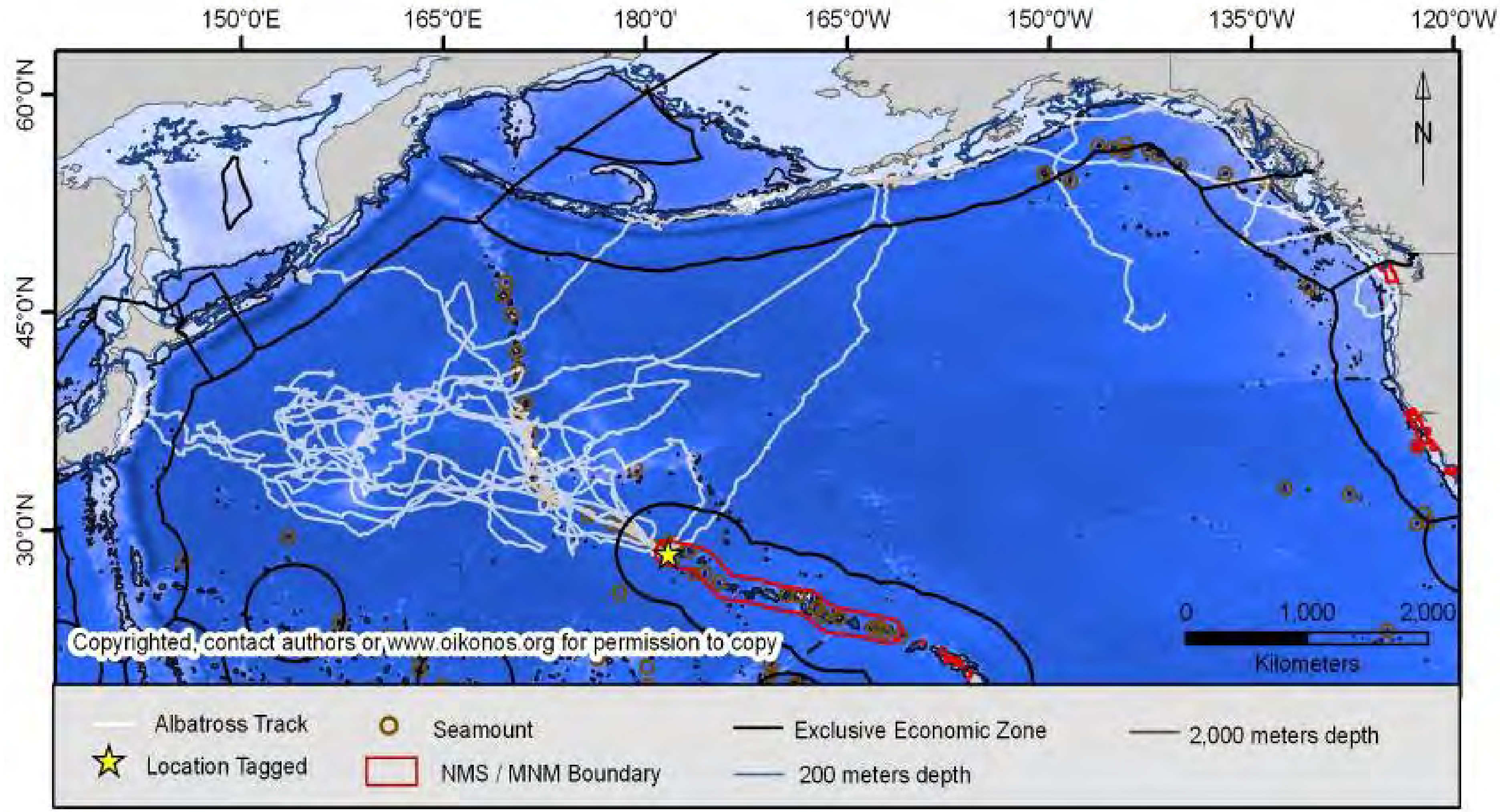


Figure 2. BFAL overlap with different basin-scale jurisdictions: international waters (high- seas) and national 200-mile Exclusive Economic Zones (E.E.Z.), summarized by year and tagging site: Cordell Bank (2004, 2005, 2007, 2008) (A: left panel) and Kure Atoll (2008) (B: right panel). The mean (+SD) of the proportional time spent by each individual bird within each nations' territorial waters are shown.

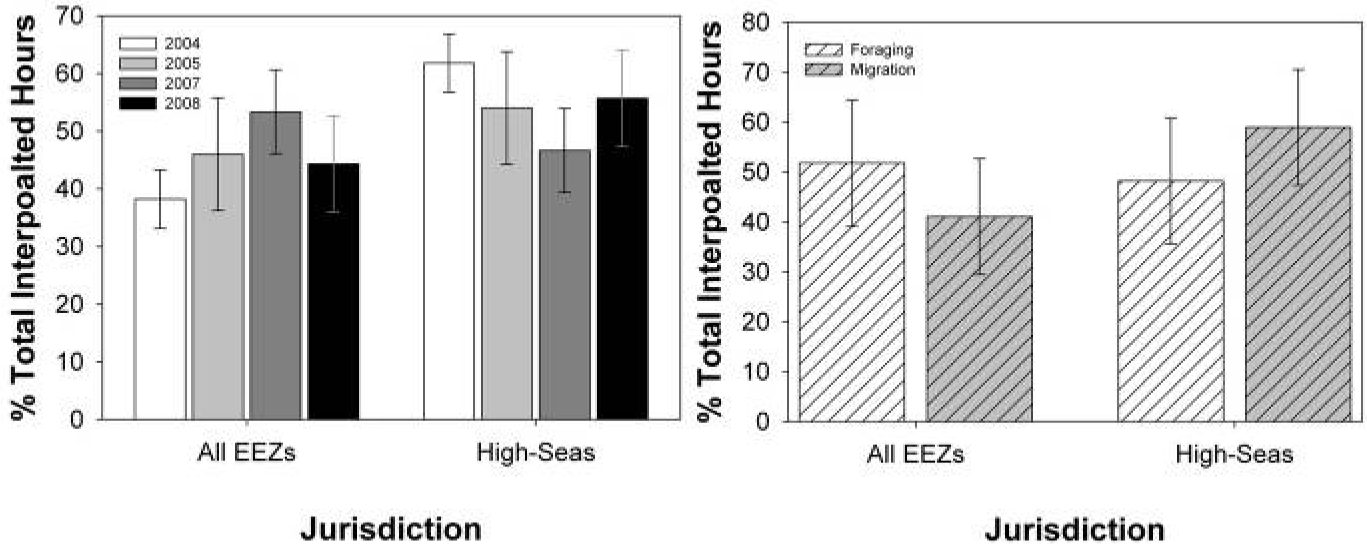


Figure 3. BFAL overlap with national 200-mile Exclusive Economic Zones (E.E.Z.), summarized by year and tagging site: Cordell Bank (2004, 2005, 2007, 2008) (A: left panel) and Kure Atoll (2008) (B: right panel). The mean (±SD) of the proportional time spent by each individual bird within each nations' territorial waters are shown. Asterisks (*) denote E.E.Z.s with no albatross overlap (See Table 2).

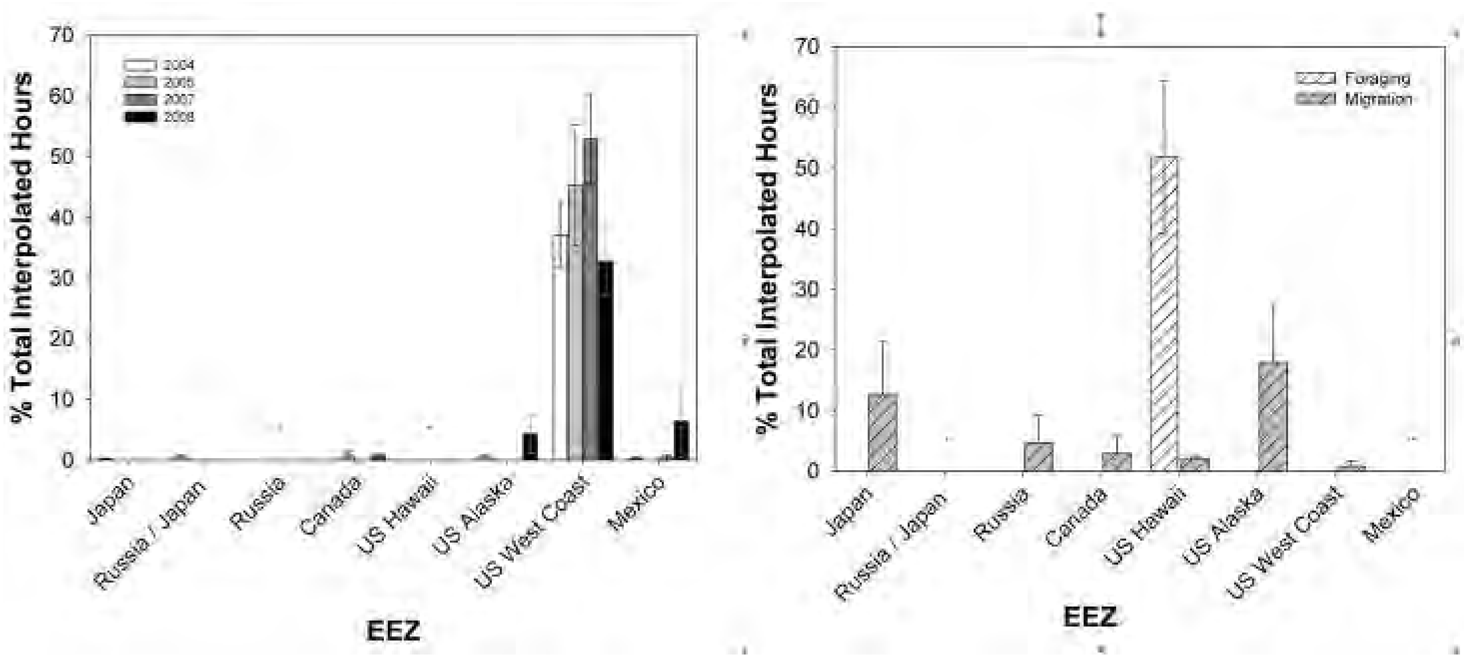
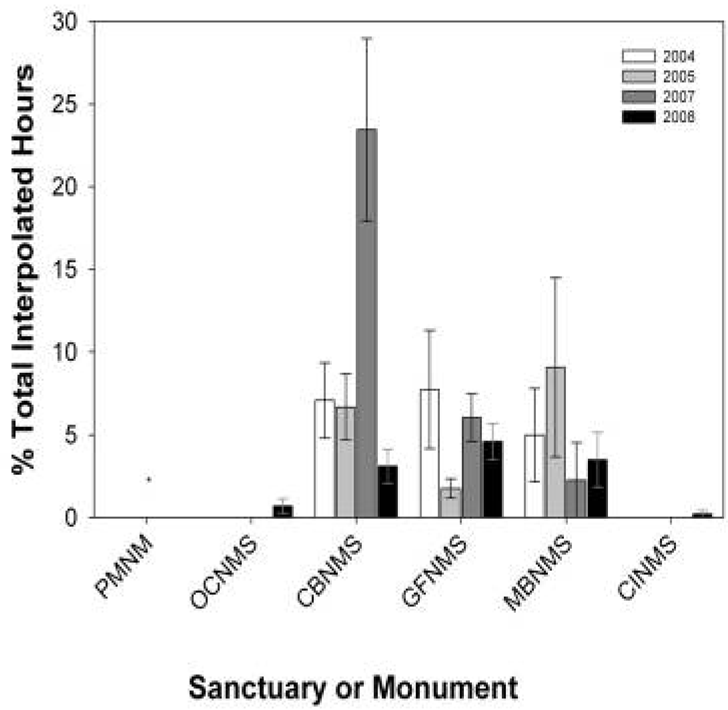


Figure 4. BFAL overlap with U.S. National Marine Sanctuaries and a Marine National Monument, summarized by year and tagging site: Cordell Bank (2004, 2005, 2007, 2008) (A: left panel) and Kure Atoll (2008) (B: right panel). The mean (SD) of the proportional time within U.S. waters that individual BFAL spent in each sanctuary are shown. Asterisks (*) denote Sanctuaries or Monument with no albatross overlap (See Table 2). See Table 3 for sanctuary acronyms.



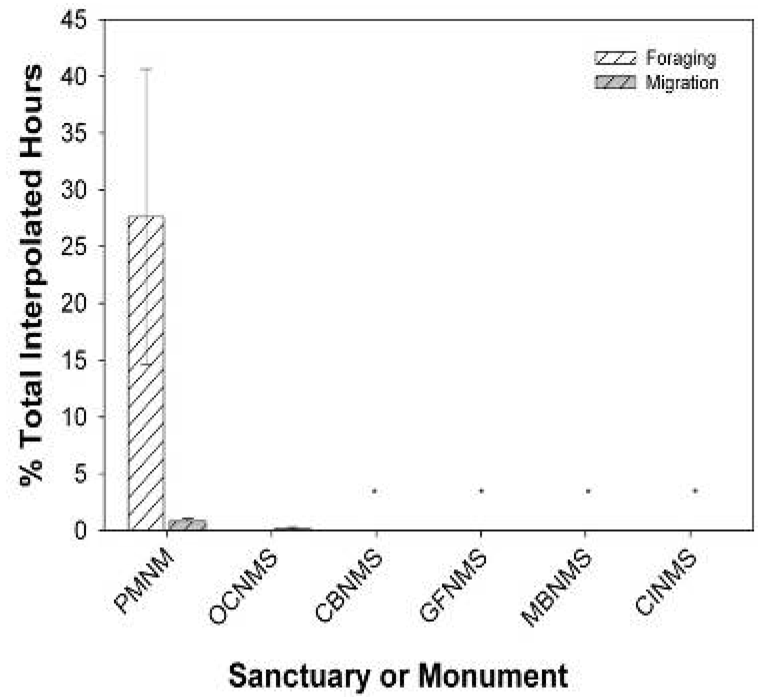


Figure 5. BFAL use of different bathymetric domains, shown by color-coding albatross tracking locations according to three depth ranges: continental shelves (0 – 200 m), continental slopes and seamounts (200 – 2000 m) and oceanic waters (> 2000 m).

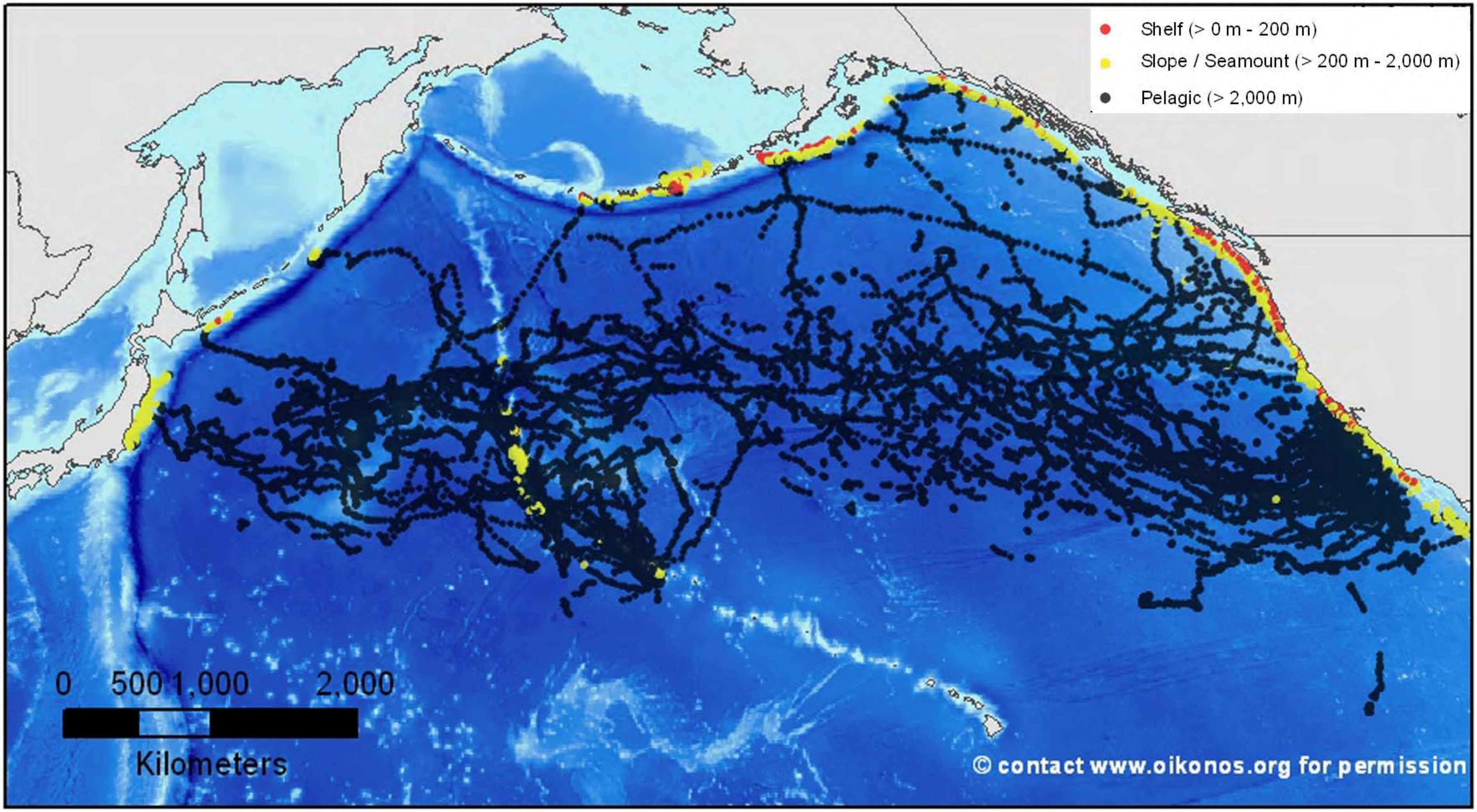


Figure 6. Integrated picture of basin-wide habitat utilization by 36 BFALs tagged in Cordell Bank (2004, 2005, 2007, 2008) and 11 BFALs tagged at the Kure Atoll breeding colony (2008) and tracked during the late breeding and post-breeding season (May - October), superimposed on a bathymetric map. The albatross utilization function kernels are depicted by the color gradient, spanning from blue (low use) to red (high use).

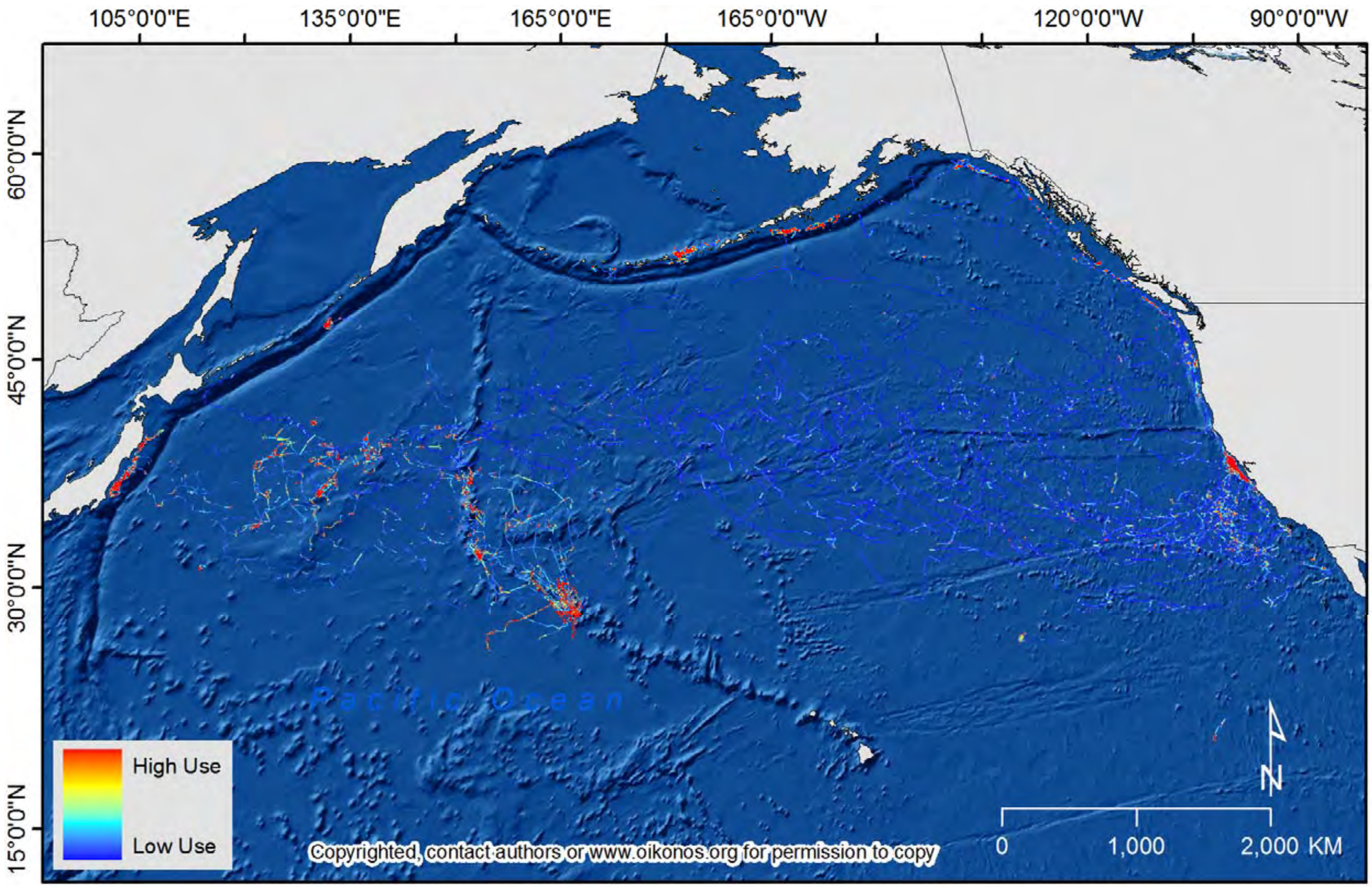


Figure 7. Basin-wide habitat utilization by 36 BFALs tagged over four years (2004, 2005, 2007, 2008) at CBNMS and tracked during the post-breeding season (July – October). The albatross utilization function kernels are depicted by the color gradient, spanning from blue (low use) to red (high use).

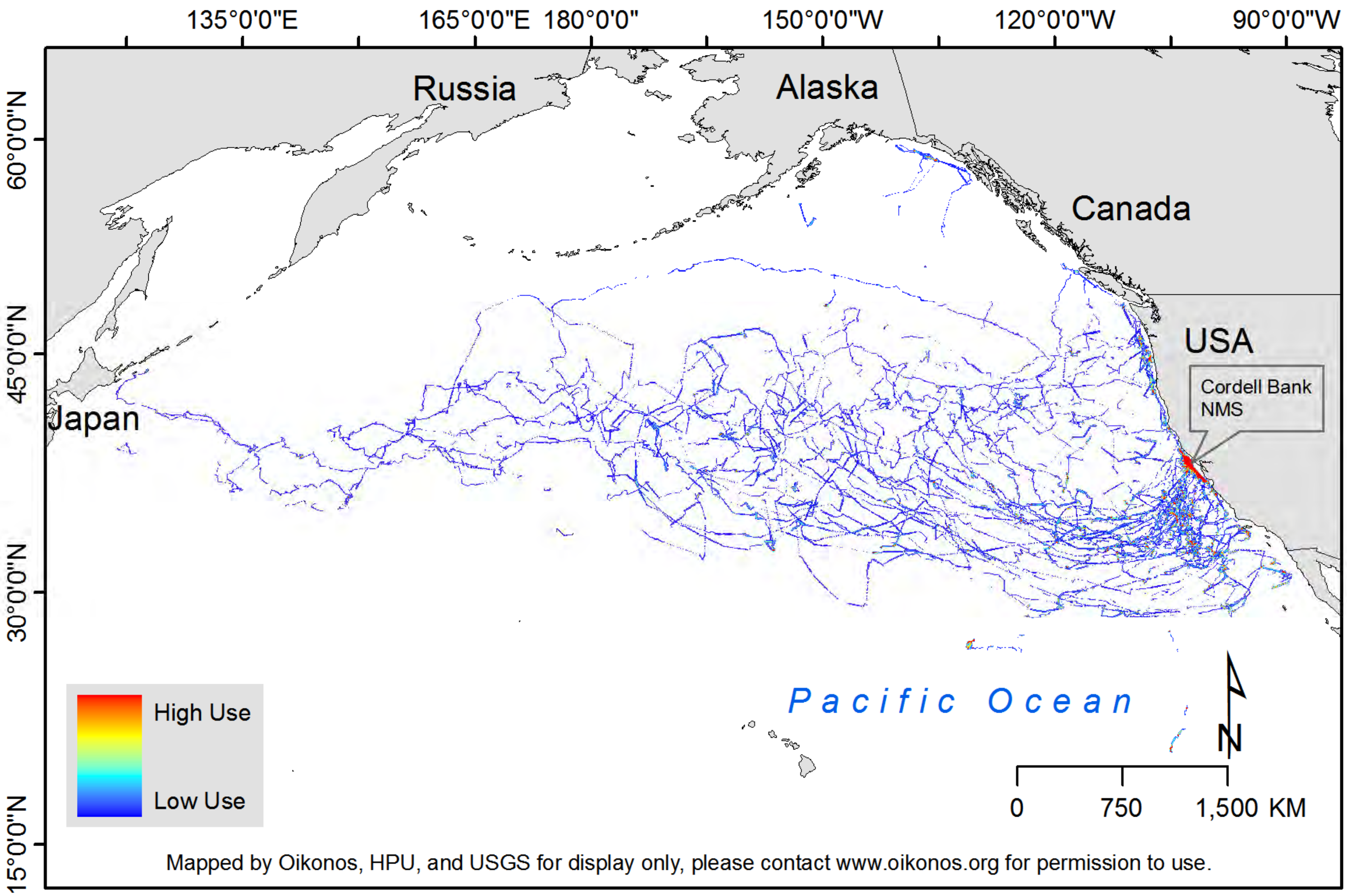


Figure 8. Northeast Pacific habitat utilization by 36 BFALs tagged over four years (2004, 2005, 2007, 2008) at CBNMS and tracked during the post-breeding season (July – October). The albatross utilization function kernels are depicted by the color gradient, spanning from blue (low use) to red (high use).

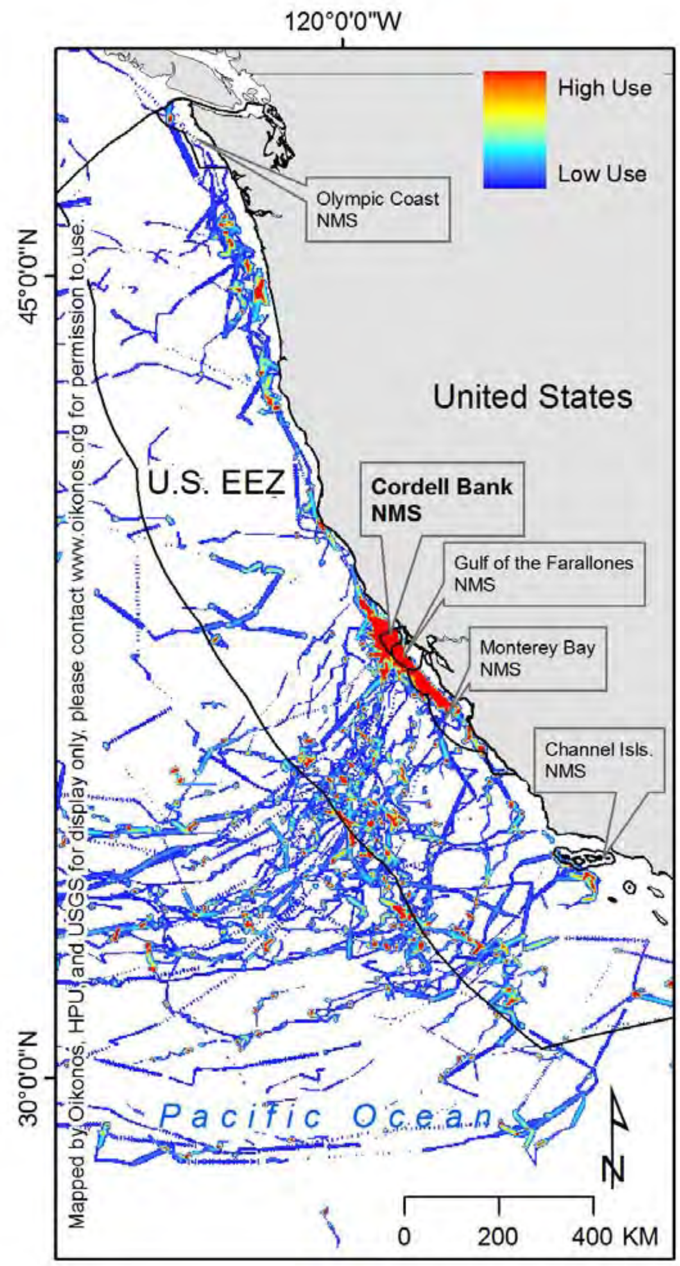


Figure 9. Basin-wide habitat utilization by 11 BFALs tagged in 2008 at the Kure Atoll breeding colony and tracked during the late breeding season (May – June). The albatross utilization function kernels are depicted by the color gradient, spanning from blue (low use) to red (high use).

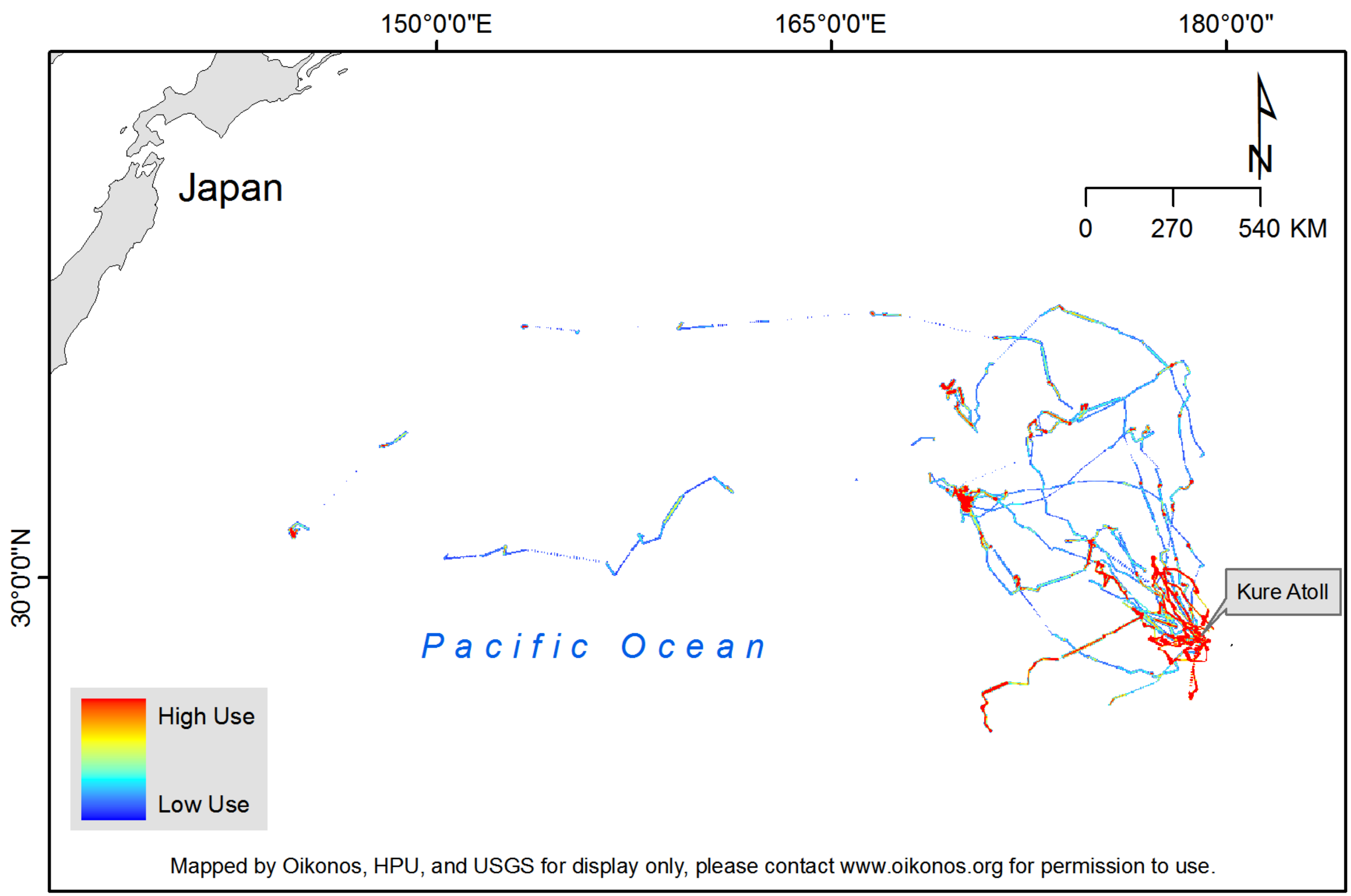
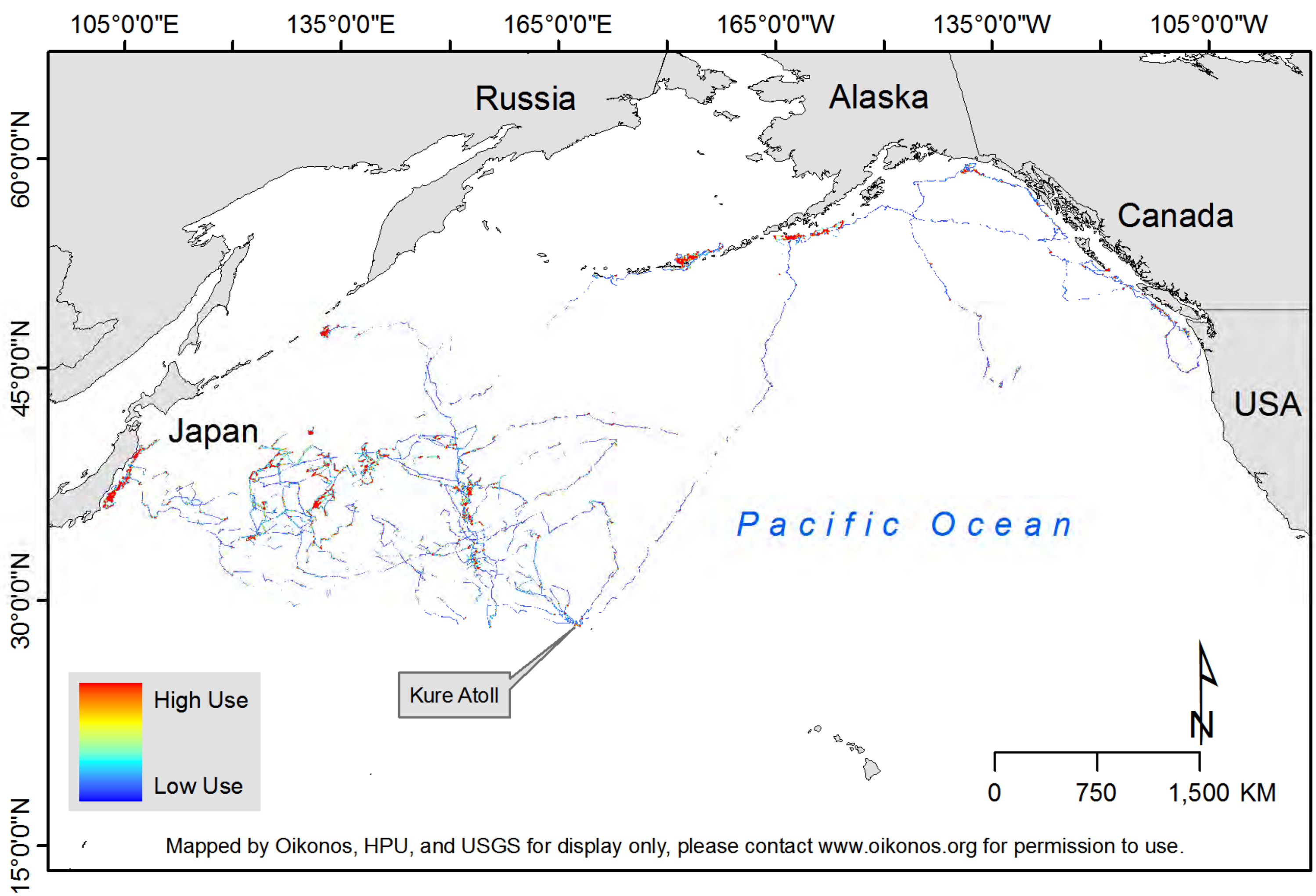


Figure 10. Basin-wide habitat utilization by 11 BFALs tagged in 2008 at the Kure Atoll breeding colony and tracked during the post-breeding season (July - October). The albatross utilization function kernels are depicted by the color gradient, spanning from blue (low use) to red (high use).



Appendix 1. BFAL tracking summary by individual (unique ID), showing the sex (male / female), tagging location, (CB / KU), year and duration of each track. Total distance and rate of movement are minimum estimates assuming a straight path between consecutive filtered and interpolated points (# Locations). Transmitters operate continuously (Cont) or on a duty cycle (hours On / Off).

Tag Loc	Year	Albatross ID	Sex	# Locations	Start	End	# Days	Distance (km)	Rate (km/day)	Duty Cycle
CB	2004	36338	f	1246	26-Jul-04	16-Sep-04	51.9	19,244	371	Cont
CB	2004	36336	m	1177	9-Aug-04	27-Sep-04	49.0	12,122	247	Cont
CB	2004	36337	f	1012	9-Aug-04	20-Sep-04	42.2	9,083	215	Cont
CB	2004	36339	m	1340	9-Aug-04	3-Oct-04	55.8	19,244	345	Cont
CB	2004	36340	f	769	9-Aug-04	10-Sep-04	32.0	4,836	151	Cont
CB	2004	36341	f	343	10-Aug-04	8-Sep-04	29.0	2,948	102	24on/24off
CB	2004	36634	f	374	10-Aug-04	10-Sep-04	31.0	4,362	141	24on/24off
CB	2004	36635	m	668	10-Aug-04	6-Oct-04	56.8	12,141	214	24on/24off
CB	2004	36636	m	497	10-Aug-04	20-Sep-04	41.2	6,938	168	24on/24off
CB	2005	57704	m	917	19-Jul-05	27-Aug-05	38.2	12,951	339	Cont
CB	2005	57705	f	854	19-Jul-05	24-Aug-05	35.5	7,788	219	Cont
CB	2005	57706	f	1045	19-Jul-05	1-Sep-05	43.5	7,108	163	Cont
CB	2005	57707	f	789	19-Jul-05	21-Aug-05	32.8	3,592	109	Cont
CB	2005	57708	m	1337	19-Jul-05	13-Sep-05	55.7	12,407	223	Cont
CB	2005	57709	m	840	19-Jul-05	23-Aug-05	35.0	6,870	197	Cont
CB	2005	57712	f	1014	19-Jul-05	5-Sep-05	47.7	4,888	103	Cont
CB	2005	57710	m	512	20-Jul-05	11-Aug-05	21.3	2,397	112	Cont
CB	2005	57711	m	903	20-Jul-05	27-Aug-05	37.6	9,319	248	Cont
CB	2007	66513	m	327	10-Jul-07	12-Sep-07	64.0	11,129	174	6hrON/18hrOFF
CB	2007	66514	f	268	10-Jul-07	2-Sep-07	53.9	2,808	52	6hrON/18hrOFF
CB	2007	66515	m	141	10-Jul-07	7-Aug-07	28.0	2,793	100	6hrON/18hrOFF
CB	2007	66516	m	249	10-Jul-07	1-Sep-07	53.9	8,747	162	6hrON/18hrOFF
CB	2007	66517	m	164	10-Jul-07	12-Aug-07	32.0	3,774	118	6hrON/18hrOFF
CB	2007	66519	m	209	10-Jul-07	21-Aug-07	42.0	5,863	139	6hrON/18hrOFF
CB	2007	66520	f	188	11-Jul-07	20-Aug-07	40.1	3,022	75	6hrON/18hrOFF
CB	2007	66521	m	189	11-Jul-07	21-Aug-07	41.1	5,585	136	6hrON/18hrOFF
CB	2007	66522	m	185	11-Jul-07	15-Aug-07	35.0	2,421	69	6hrON/18hrOFF
CB	2007	66518	f	247	12-Jul-07	2-Sep-07	52.9	10,613	200	6hrON/18hrOFF

Appendix 1. Continued…

Tag Loc	Year	Albatross ID	Sex	# Locations	Start	End	# Days	Distance	Rate (km/day)	Duty Cycle
KU	2008	84320	m	1192	26-May-08	16-Jul-08	51.4	15,529	302	cont
KU	2008	84323	f	1575	26-May-08	31-Jul-08	65.9	17,180	261	cont
KU	2008	84319	m	1449	27-May-08	26-Jul-08	60.4	15,029	249	cont
KU	2008	84321	f	1192	28-May-08	18-Jul-08	51.2	11,411	223	cont
KU	2008	84317	m	861	29-May-08	4-Jul-08	35.9	9,391	262	cont
KU	2008	84322	m	1150	29-May-08	16-Jul-08	48.7	8,449	174	cont
KU	2008	84318	m	1404	30-May-08	29-Jul-08	59.2	11,398	193	cont
KU	2008	84316	f	1442	31-May-08	30-Jul-08	60.1	14,174	236	cont
KU	2008	66529	m	478	1-Jun-08	28-Jul-08	57.6	15,062	261	On 13:00 - 22:59 UTC all days
KU	2008	66534	m	512	1-Jun-08	26-Jul-08	55.5	13,090	236	On 13:00 - 22:59 UTC all days
KU	2008	77030	m	402	1-Jun-08	21-Jul-08	50.6	8,872	175	On 13:00 - 22:59 UTC all days
CB	2008	85539	f	181	5-Aug-08	9-Sep-08	35.0	7,870	225	6hrON/18hrOFF
CB	2008	85540	f	305	5-Aug-08	9-Oct-08	64.9	14,085	217	6hrON/18hrOFF
CB	2008	85541	f	391	5-Aug-08	18-Oct-08	74.0	15,318	207	6hrON/18hrOFF
CB	2008	85542	m	238	5-Aug-08	20-Sep-08	45.2	9,647	213	6hrON/18hrOFF
CB	2008	85543	f	212	5-Aug-08	17-Sep-08	42.1	4,471	106	6hrON/18hrOFF
CB	2008	85544	f	339	5-Aug-08	9-Oct-08	65.0	15,187	234	6hrON/18hrOFF
CB	2008	85545	f	314	5-Aug-08	8-Oct-08	64.0	18,610	291	6hrON/18hrOFF
CB	2008	85546	f	348	5-Aug-08	15-Oct-08	70.1	15,606	223	6hrON/18hrOFF
		Mean	-	*676.00*	-	-	*47.6*	*9,689*	*195*	-
		(Max-Min)	-	*(141-1,575)*	-	-	*(21.3 -74.0)*	*(2,396 - 19,244)*	*(52-371)*	-