Assessing Residency and Site Fidelity in Bottlenose Dolphins: A Literature Review and Bibliometric Analysis

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Supplemental Materials

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Supplemental Materials

Supplemental Material 1. Description of indicators and indices of residency and site fidelity ($n = 30$) cited in 117 studies explicitly dedicated to assess residency and site fidelity by dolphin species published in specialized scientific literature between 1990 and 2019

Author(s)	Textual description of the original documents
Ballance, 1990	(1) Occurrence (O) is the number of recaptures of an individual over a given period. (2) Permanence (P) is the time over which an individual was recorded, determined by the difference between their first and last sighting. (3) Periodicity is the average days between consecutive sightings.
Morteo et al., 2012	It is suggested that the periodicity parameter proposed by Ballance (1990) be defined as the recurrence of the individual, determined by the inverse of the average time between consecutive recaptures ($days^{-1}$).
Koelsh, 1997; Simões-Lopes & Fabian, 1999; Quintana-Rizzo & Wells, 2001; Lusseau, 2005; Lodi et al., 2008	Residency Index (RI) is the proportion of sightings of an identifiable dolphin relative to the total number of complete surveys carried out in a month.
Whitehead, 2001	Lagged Identification Rate (LIR): The probability an individual identified in a study area at time t is identified during a random identification in the study area at time t + T (time lag) later. In other words, it is the probability of reidentification after various times lags.
Pradel et al., 1997; Chan & Karczmarski, 2017	Pradel et al. (1997) adapted the Brownie & Robson (1983) trap-response model for studies in which unmarked animals are viewed as either "transients" or "residents." Transients are animals passing through the study area with negligible probability of again being in the area and available for capture at a subsequent sampling period. Residents, on the other hand, are animals with home ranges in the study area and typically are the animals of interest in capture-recapture studies (Williams et al., 2002).
Möller et al., 2002	Individuals were allocated to one of three categories according to the proportion of photo-identification surveys in which they were identified: (1) Low sighting rates (LSR) – sighted in less than 10% of the surveys with photographs taken (2) Moderate sighting rates (MSR) – sighted in between 10 and 30% of surveys with photographs taken (3) High sighting rates (HSR) – sighted in more than 30% of surveys with photographs taken In addition, individuals were assigned to three categories of residency status, according to their sighting rates and presence across seasons: (1) Residents (RES) – dolphins with moderate to high sighting rates and present in multiple seasons (2) Transients (TRS) – animals with low sighting rates and present in only one season (3) Occasional visitors (OCV) – those with low sighting rates but present in multiple seasons Calves and newborns were excluded from the above analyses.
Chabanne et al., 2012	For each individual observed, we calculated a monthly sighting rate (MSR) and a seasonal sighting rate (SSR). These rates reflect, respectively, the number of months or seasons that a dolphin was sighted at least once divided by the total number of months or seasons for the study. Seasons were defined according to the Australasian calendar: summer (December to February), autumn (March to May), winter (June to August), and spring (September to November). We categorized dolphins based on sighting rates and SSR using a modification of the criteria applied in Möller et al. (2002) and Fury & Harrison (2008). We classified dolphins using the following categories and criteria: (1) Resident – medium-high sighting rates (sighted in > 10% of surveys) and high SSR (> 0.75) (2) Occasional visitor – low sighting rates (< 10% of the surveys) but medium SSR (< 0.75 but > 0.125) (3) Transient – dolphins with low sighting rates (< 10% of the surveys) and low SSR (< 0.125)
Irwin & Würsig, 2004	Because resident animals regularly return to a specific site, resident designation during the intensive survey year required sightings in three seasons and subsequent presence in two seasons per year. We designated an animal as "status undetermined" if it was not sighted for three seasons in a row in the intensive survey year or four seasons in a row in low-level surveys. For the subsequent seasonal warm month surveys, resident classification required presence in at least two of these periods. Dolphins absent for more than two consecutive warm month periods would be given a status undetermined classification.
Martin & da Silva, 2004	To investigate the degree of residency within and between years, the observational records of all marked botos seen within the study area over a 3-y period (August 2000 to July 2003) were examined. A "resident" was a boto that was recorded in at least 7 of 12 mo in at least 1 of 3 y. "Permanent residents" met the criterion every year in which they were available to be identified, and "partial residents" met the criterion in one or more years but not in all. Marked botos that were seen at least once in the study area during the 3-y period but did not meet the residency criterion in any year were classified as "nonresidents."

Kerr et al., 2005	Evidence for site fidelity was evaluated by examining sighting frequencies within and between the three study years. Dolphins sighted two or more times in each of the three study years, or four or more times in two successive years, were labeled as residents and comprised 30% of the identified population.
Parra et al., 2006	To investigate the presence of identified individuals in the study area over time, we calculated (1) the number of months a dolphin was identified as a proportion of the total number of months in which at least one survey was conducted (i.e., monthly sighting rate) and (2) the number of calendar years a dolphin was identified as a proportion of the total surveyed (i.e., yearly sighting rate).
Díaz-López, 2012	To investigate the presence of identified individuals in the fish farm area over time, two different temporal sighting rates were calculated on a seasonal and yearly basis (Parra et al., 2006). A seasonal occurrence rate was defined as the number of seasons a recognisable dolphin was identified as a proportion of the total 21 seasons. A yearly occurrence rate was defined as the number of calendar years a dolphin was identified as a proportion of the five surveyed years. Individual dolphins were divided subsequently into four arbitrary categories based on their temporal occurrence rates: (1) ''Farmers'' category – bottlenose dolphins seen in the fin fish farm most often, with both annual and seasonal occurrence rates ≥ 0.5. This category contained 10 identified adult bottlenose dolphins (3 males and 7 females), accounting for 20% of the total 49 identified individuals. (2) ''Frequent visitors'' category – bottlenose dolphins with seasonal occurrence rates lower than 0.5 and higher (or equal) than 0.25. This category contained five identified bottlenose dolphins (2 adult females and 1 adult male, one male calf, and one newborn), accounting for 10.1% of the total 49 identified individuals. (3) ''Occasional visitors'' category – bottlenose dolphins with seasonal occurrence rates lower than 0.25 but yearly occurrence rates higher than 0.25. This category contained 10 identified bottlenose dolphins (7 adult females, one male, and two immatures), accounting for 20% of the total 49 identified individuals. (4) ''Sporadic visitors'' category – bottlenose dolphins rarely seen in the study area, with both annual and seasonal occurrence rates lower than 0.25. This category contained 24 bottlenose dolphins (20 unsexed adults, 2 male immatures, and 2 newborns), accounting for 49.9% of the total 49 identified individuals.
Ananias et al., 2008	''[A] 'year-round resident' was defined as a dolphin resighted in more than five months during a year; a 'seasonal resident' as a dolphin resighted between three and five months, and a 'transient' was defined as a dolphin resighted less than two months during a one-year period (Ananias et al., 2008)'' (cited in Di Giacomo & Ott, 2016, p. 157).
Rosel et al., 2011	A practical definition for the "resident population" would be individuals that spend greater than 50% of their time in an estuary in a given year.
Keith et al., 2002	Identified individuals were categorized as "transients" and "residents" to the area, with a resident being an individual who was photographed and identified at least four times during the study period.
Daly et al., 2014; Zanardo et al., 2016	To distinguish groups or "clusters" of individuals with similar degrees of site fidelity, we incorporated seasonal and monthly sighting rates, and site fidelity indices into an agglomerative hierarchical cluster (AHC) analysis. A dendrogram of the AHC analysis separated clusters of southern Australian bottlenose dolphins based on three measures of site fidelity: (1) seasonal sighting rate, (2) monthly sighting rate, and (3) site fidelity indices. Dissimilarly, threshold (cut-off point) was 2.19, resulting in three clusters: Group 1 – occasional visitors, Group 2 – seasonal residents, and Group 3 – year-round residents.
Simpfendorfer et al., 2011; Bond et al., 2012; Hunt et al., 2017	Additionally, site fidelity indices were calculated as the ratio between the number of recaptures for each individual and the number of s-periods from an individual's first capture to its last capture (modified from Simpfendorfer et al., 2011; Bond et al., 2012). A site fidelity index value of 1 indicates an individual was captured in all sampling periods from its first capture to its last capture. Conversely, a value of 0 indicates an animal was only sighted once during the sampling period.
Zolman, 2002	Residency patterns were examined based on the seasonal presence or absence of individually identifiable dolphins. A survey year was divided into four seasons: (1) fall (October to December), (2) winter (January to March), (3) spring (April to June), and (4) summer (July to September). Dolphins identified in the study area during all four seasons (regardless of year) were defined as residents. Dolphins identified in the study area during the same season in consecutive years but not during intervening seasons were defined as seasonal residents. Dolphins identified in the study area during only one season or in two consecutive seasons were defined as transients.
Silva et al., 2008	The monthly sighting rate was calculated as the proportion of months a certain individual was seen in relation to the number of months surveyed during the years it was observed in the area. This value was then averaged across the years the individual was seen, resulting in a mean monthly sighting rate. This index, therefore, reflects the degree of fidelity during the periods when the individual frequented the area and is independent of the number of years it was seen.
Balmer et al., 2008	To define a site fidelity index for individual dolphins in the St. Joseph Bay region, the total number of sightings of each catalogued animal was determined. Then, for each mark-recapture photo-ID survey period, each observed individual was placed into one of five bins, based upon the total number of times it was sighted. The optimum bin size for each survey period was determined as where IQR = the interquartile range of the number of sightings, and n = the total number of animals sighted This estimator has been found to generate histograms that reliably represent the underlying density distribution of the data (Freedman & Diaconis, 1981). These bins were used as the site fidelity index.

Quintana-Rizzo & Wells, 2001; Culloch, 2004	Dolphins were classified into one of four arbitrary categories (modified from Wilson et al., 1997): (1) "common" – dolphins sighted during 8 mo, (2) "frequent" – dolphins sighted during 6 or 7 mo, (3) "occasional" – dolphins sighted during 3 to 5 mo, and (4) "rare" – dolphins sighted during 1 to 2 mo. Culloch (2004): Based on the number of recaptures, to examine the site fidelity of individuals using the study area, the dolphins were separated into four categories of occurrence: (1) dolphins occurring 12 or more times throughout the study period were classed as common, (2) those recorded eight to 11 times were classed as frequent, (3) those recorded four to seven times were classed as occasional, and (4) those recorded three or fewer occasions were classed as rare.
Tschopp et al., 2018	Construction of eight indices according to three selected indicators and using the mathematical structure of the arithmetic and harmonic mean.
Speakman et al., 2006	A starting point for addressing such area-specific questions was to examine photo-ID data for possible evidence of fidelity to, or higher occurrence within, specific subareas by individual dolphins. Adjusted sighting proportions (ASP), which reflect an individual's sighting frequency in a subarea relative to other subareas after adjusting for survey effort, were analyzed to evaluate dolphin spatial occurrence.
Levine, 2002	We used the *CrimeStat* spatial statistics software to measure the standard distance deviation (SXY) to investigate if individual dolphins displayed site fidelity toward specific areas within Cleveland Bay (Parra et al., 2006). The standard distance deviation is the spatial equivalent to the standard deviation (Levine, 2002).
Bell & Kramer, 1979; Spencer et al., 1990	Two measures were used to determine the existence of site fidelity: (1) mean squared distance from the center of activity (MSD; Calhoun & Casby, 1958; equivalent to the r^2 of Schoener, 1981) measured dispersion of use around the home-range centroid, and (2) a Linearity Index (LI = linear distance between the endpoints of an animal's path divided by the total distance traveled, where linear paths yield LI = 1, and values < 1 indicate nonlinear, meandering paths; Bell & Kramer, 1979) measured shifts in the home range. MSD and LI were calculated for the actual path traversed by an animal for movement over both daily and multi-day periods. A mean and standard error were calculated for MSD and LI from the 100 randomly generated paths for each animal (normality of these data was determined with g1 and g2 tests; Sokal & Rohlf, 1981, p. 114). If MSD or LI, based on actual movements, were significantly less (using 95% confidence intervals) than the mean of these measures for the 100 random paths, an individual was judged to exhibit site fidelity.
Rossi-Santos et al., 2007	To investigate the presence of marked animals in the study area throughout the study period, we calculated (1) the number of months in which the individual was captured (photo-identified). (2) the residency rate or the number of months in which the animal was photo-identified/total number of sampled months × 100. (3) total residency time or the maximum month interval between captures.
Weir, 2015	Site fidelity analysis was restricted to individuals of DV1 (deep nicks and cuts; evident even in poor-quality images) or DV2 (small but still obvious nicks; evident in moderate- and high-quality images only) because resighting rates are more representative of well-marked animals (Weir et al., 2008). The site fidelity value (SFV) was the number of encounters in which a dolphin was photographed as a proportion of the total on-effort photographic encounters—that is, for five on-effort encounters, it could range from 0.2 (present in one encounter) to 1.0 (present in all five encounters).
Di Giacomo & Ott, 2016	We used two measures to investigate the residency patterns of the common bottlenose dolphin. First, we counted the number of days each marked individual had been identified during the study period (January 2009 to February 2010), defined as a residency index. Second, we analyzed the degree of multi-year residency (i.e., long-term site fidelity) using a large period dataset (1991 to 2010). In the first analysis, a "year-round resident" was defined as a dolphin resighted in more than 5 mo during a year; a "seasonal resident" was defined as a dolphin resighted between 3 and 5 mo; and a "transient" was defined as a dolphin resighted less than 2 mo during a 1-y period (Ananias et al., 2008). In the second analysis, "multi-year resident" was considered to be a dolphin recorded in at least two different years in the region.
Dinis et al., 2016	The term "resident" was used to designate dolphins that were seen regularly during the study period in the study area (during three seasons in a year and in more than two consecutive years). Following the nomenclature used in capture-recapture studies, "transient" dolphins were defined as those seen just once in the main area (Pradel et al., 1997). Dolphins seen more than once, but in non-consecutive years, were considered "migrants" (Kendall et al., 1997).
Conway, 2017	Residency was determined using a modified version of Rosel et al.'s (2011) suggested definition in which residents are individuals who spend greater than 50% of their time in an estuary in a given year. In this study, residents were defined as individuals who were sighted in at least 50% of the sampling periods during the survey year or were sighted in more than 50% of seasons (three or more of the four seasons).

Supplemental Material 2. Classification of the definitions of residency and site fidelity that used a temporal scale, sorted by type of metric (n = 30), that were cited in 117 studies published in specialized scientific literature between 1990 and 2019 that explicitly assessed residency and site fidelity in 17 dolphin species

Author(s)	Type	Short	Seasonal	Intra-annual	Inter-annual
Ananias et al., 2008	Frequency		X	X	
Ballance, 1990	Frequency	X			
Balmer et al., 2008	Frequency	X			
Di Giacomo & Ott, 2016	Frequency			X	X
Dinis et al., 2016	Frequency		X	X	X
Irwin & Würsig, 2004	Frequency		X	X	X
Keith et al., 2002	Frequency	X			
Kerr et al., 2005	Frequency	X			X
Martin & da Silva, 2004	Frequency			X	X
Morteo et al., 2012	Frequency	X			
Quintana-Rizzo & Wells, 2001; Culloch, 2004	Frequency			X	
Rossi-Santos et al., 2007	Frequency			X	
Zolman, 2002	Frequency		X	X	X
Pradel et al., 1997; Chan & Karczmarski, 2017	Model	X			
Whitehead, 2001	Model	X			
Chabanne et al., 2012	Proportion		X	X	
Conway, 2017	Proportion		X	X	
Díaz-López, 2012	Proportion		X	X	X
Koelsh, 1997; Simões-Lopes & Fabian, 1999; Lusseau, 2005; Lodi et al., 2008	Proportion	X			
Möller et al., 2002	Proportion		X	X	
Parra et al., 2006	Proportion			X	X
Rosel et al., 2011	Proportion			X	
Silva, 2008	Proportion			X	X
Simpfendorfer et al., 2011; Bond et al., 2012	Proportion	X			
Speakman et al., 2006	Proportion	X			
Tschopp et al., 2018	Proportion	X			
Weir, 2015	Proportion	X			
Daly et al., 2014; Zanardo et al., 2016	Other	X			
Levine, 2002	Other	X			
Bell & Kramer, 1979; Spencer et al., 1990	Other	X			

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