Estimating reproductive traits of female bottlenose dolphins along the Israeli coast

Kim Kobo

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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University of Haifa
Faculty of Natural Sciences
Leon H. Charney School of Marine Sciences
The Department of Marine Biology

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Estimating reproductive traits of female bottlenose dolphins along the Israeli coast

Kim Kobo

Abstract

The reproductive output of common bottlenose dolphins *Tursiops truncatus* has been extensively explored worldwide. However, it remains largely undocumented in the Mediterranean Sea. The Mediterranean population represents a distinct subpopulation from its Atlantic counterparts and is listed as ‘Least Concern’ under the IUCN Red List of Threatened Species. However, as a coastal species, it is significantly impacted by anthropogenic activities, such as pollution, overfishing, and habitat degradation, which can directly impact female reproductive success and calf survival, especially in an area with unique environmental challenges, such as the eastern Levantine Sea. This study used data from a long-term mark-recapture and stranding monitoring program to estimate the life history traits of female bottlenose dolphins inhabiting the Israeli Mediterranean coast. Data were collected between January 2005 and December 2023 through 1192 boat-based surveys. During 244 sightings, 301 individual dolphins were recorded, excluding calves, based on the analysis of 13,585 high-quality dorsal fin photographs. From 1994 to 2022, 248 bottlenose dolphin strandings and bycaught were reported along the Israeli coast. Calving rate, fecundity, seasonality of reproduction, interbirth intervals, and weaning age were calculated using photo-identification methods. Cormack-Jolly-Seber models were used to estimate survival rates, and stranding counts were analyzed using a Generalized Linear Model. During 2005 and 2023, 517 individual identifications of 61 reproductive females and 114 dependent calves were made. Females with calves exhibited stronger site fidelity and were observed year-round. 79% (n = 192) of the sightings included females, and 53% (n = 129) included calves. Overall, 61% (n = 37) of these females were sighted with one calf, 16% (n = 10) with two calves, and 23% (n = 14) with three calves or more. The maximum number of calves produced by any known female was seven. The group size tended to increase in the presence of calves but was smaller while foraging from bottom-trawler nets. Although the sample size is limited, the results indicate a diffuse birth seasonality, with most births occurring during late spring and summer, associated with increasing water temperature. The calving rate was 0.2 (95% binominal CL 0.02 – 0.42) and fecundity was 0.11 ± 0.1. The mean inter-birth interval was 2.97 ± 0.96 years, falling within the lower range of values reported for similar dolphin populations. The weaning age was 2.61 ± 0.48 years, suggesting that dolphins in the study area tended to wean their current calf at about mid-pregnancy. Survival rates for both adults (0.80, n = 301) and calves (all calves: 0.52, n = 114; first-year calf survival: 0.73, n = 14) were lower than those reported in other studies, indicating that reproductive success may have a greater impact on population viability than survival rates in this population. The stranding rate has remained stable over the past 30 years, with a mean of eight individuals/year. A significant increase in stranding rates across all age classes was observed during the summer. These findings underscore the importance of understanding the life history traits to forecast population trends and responses to environmental stressors. The results highlight the critical need for long-term studies of long-lived species to gather individual- and population-level data for conservation and management purposes.

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1. Introduction

1.1 The importance of studying reproductive traits

Long-term photo-identification studies can provide valuable information on population health and abundance (P. S. Hammond et al., 1990b). In slow-reproductive species, the rate at which population abundance changes widely depends on the survival and reproductive potential of females, as most population dynamic models assume that some variation in male availability does not necessarily limit female reproduction in polygamous or promiscuous systems (Caswell, 2001; Fruet et al., 2015; Kellar et al., 2017). In long-lived mammals that produce just one infant at a time, the age at first reproduction, longevity, and the intervals between subsequent births are the primary determinants for fecundity (Baker et al., 2018; Fruet et al., 2015; Robinson et al., 2017). Female reproductive success is influenced by different parameters, such as birth rate, and survival of the offspring (Blasi et al., 2020; Mann et al., 2000), which in turn underlies complex interactions between biological, ecological, and social factors (Lindström, 1999). As apex predators, studying the health and population status can reflect the effects of the risk to the population themselves but also serve as sentinels of the health and status of lower trophic levels in the marine ecosystem (RandallS. Wells et al., 2004). The common bottlenose dolphin *Tursiops trucatus* is found across the globe in temperate and tropical waters and various habitats. As a result, different populations are subject to different ecological and environmental conditions and pressures (Sayigh et al., 1999). Considering the socio-environmental differences between demographically different populations, it is to be expected that reproductive parameters may vary among populations (Blasi et al., 2020).

The Levantine basin in the Eastern Mediterranean Sea is undergoing profound alterations as high levels of anthropogenic pressures synergistically interact with the effects of climate change (Mannocci et al., 2018). Warming waters (particularly pronounced in the Eastern Mediterranean Sea) and extreme weather events linked to climate change, pollution, habitat destruction, fishing activities, and biological invasions (mainly through the Suez Canal) are some of the key anthropogenic impacts in this region that lead to population declining, ecological imbalance and shifts in community composition (La Manna et al., 2023b; Lejeusne et al., 2010; Micheli et al., 2013), whether the impact is top-down or bottom-up. Many Delphinids exhibit great flexibility in their foraging strategies (Chilvers & Corkeron, 2001), and they are opportunistic predators that can shift their dietary preferences according to available prey (Lewison et al., 2004), but it is unclear how changes in different communities will affect foraging efficiency and strategies. Establishing baseline life history parameters and assessing female reproduction along the Israeli coast is paramount to identifying the population's viability and formulating adequate conservation measures. Moreover, this will provide similar data to that collected in different populations, enabling comparisons across populations.

1.2 The Mediterranean Common Bottlenose Dolphin

The common bottlenose dolphin (*Tursiops truncatus*) in the Mediterranean Sea represents a distinct subpopulation characterized by unique genetic, ecological, and behavioral traits compared to their Atlantic counterparts (Bearzi et al., 2009). Within this subpopulation, there is evidence of fine-scale population structure between basins (Gaspari et al., 2013, 2015). Genetic analysis found population structure with boundaries that coincided with the transitions between different types of habitats. The different areas can be characterized by ocean floor topography and features such as surface salinity, productivity, and temperature (Natoli et al., 2005). Five populations were identified: Black Sea, eastern Mediterranean, western Mediterranean, eastern North Atlantic, and Scottish. Moreover, significant genetic differentiation was observed between populations from the eastern and western Mediterranean (Bearzi et al., 2009).

The semi-enclosed nature of the basin influences their ecology, impacting their distribution, prey availability, and interactions with human activities (Martin, 2018). Essential data on this sub-population show a marked preference for coastal habitats (Azzellino et al., 2008; Notarbartolo di Sciara, 2016), where they face considerable threats from pollution, overfishing, and maritime traffic. These factors contribute to a decline in their numbers (Bearzi et al., 2009; Canadas & Hammond, 2006) and lead to population fragmentation in some areas due to anthropogenic habitat degradation (Natoli et al., 2005; Notarbartolo di Sciara, 2016). According to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, they are assessed as “least concern” (Natoli et al., 2022).

1.3 Common Bottlenose Dolphin in Israel

There is still a lack of knowledge regarding the population status of bottlenose dolphins within the Levantine Sea (Akkaya Baş et al., 2016). In Israel, they have been observed and studied as part of a long-term monitoring study by the University of Haifa’s Israeli Marine Mammal Research & Assistance Center (IMMRAC) and the Morris Kahn Marine Research Station (MKMRS) for the last two decades (Galili et al., 2023; Kerem et al., 2013; Mevorach, 2021; Scheinin et al., 2010, 2014; Zuriel et al., 2023).

The Israeli coastline is 196 km long, north to south. The continental shelf narrows from 25-30 km wide off northeastern Sinai to less than 10 km off Rosh HaNikrah, on the border with Lebanon (Garfunkel & Almagor, 1985). Bottlenose dolphins inhabit the entire coastline and are mainly observed along the shallow continental shelf, between a bottom depth of 30 and 60 meters (Scheinin et al., 2010). This region, the southeasternmost corner of the Mediterranean Sea, is characterized by higher temperatures and salinity (Herut et al., 2000; Ozer et al., 2017). The sea surface temperature varied between 16°C in the winter and 30°C in the summer, and the salinity levels of the surface water exceeded 38.95% due to the combined effect of high evaporation and low runoff. During most of the year, nutrient values are extremely low (Ozer et al., 2022; Yacobi et al., 1995). Accordingly, the carrying capacity for top predators in the Levantine Basin is considered intrinsically low (Kerem et al., 2013). As a result of any one or the combination of the exceptional environmental factors, Sharir et al., 2011 demonstrate "Levantine nanism" in bottlenose dolphins when animals off the Israeli coast are significantly smaller than those on the West side.

Their diet along the Israeli coast primarily includes fish, mainly Common pandora (*Pagellus erythrinus)* and Sand steenbras (*Lithognathus mormyrus)*, which are commercially important fish, and Balearic conger (*Ariosoma balearicum)*, a non-commercially fish (Scheinin et al., 2014). Hence, dolphins forage behind bottom trawlers to exploit the discarded bycatch and disturbed prey from the fishing nets, saving time and energy despite the risk of entanglement. In an environment with limited resources, taking advantage of easy food sources can be especially important for mothers with calves and may improve the chances of raising a healthy calf (Greenman et al., 2012).

According to Scheinin (2010), the bottlenose dolphin population size is approximated to be 360 individuals, supported by the thesis work of Yaly Mevorach (2021) with current data and abundance estimation. Individuals were identified using the photo-identification method (photo ID) (Würsig & Würsig, 1977a), based on distinctive natural markings on their dorsal fins, such as nicks, notches, and scars (Figure 1) (Würsig & Würsig, 1977b). This non-invasive technique is effective for individual identification and long-term monitoring of populations (P. S. Hammond et al., 1990a).

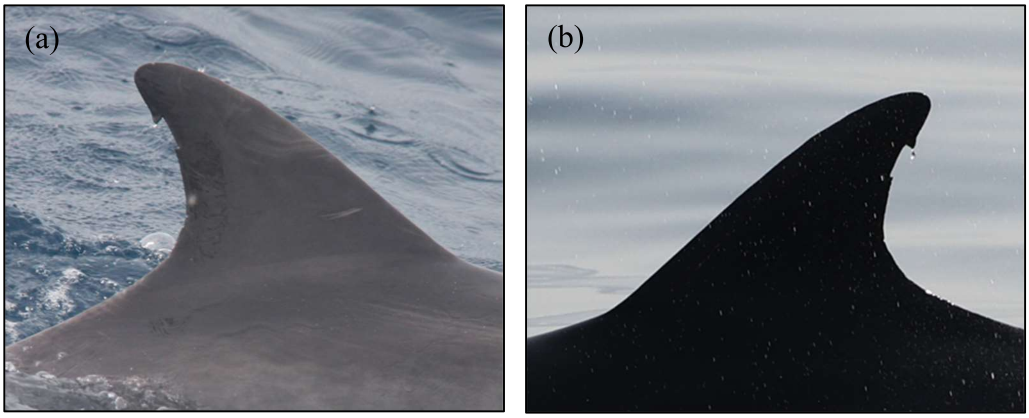


Figure 1: An example of photo ID: Photographs of Hooks (ID 1049), one of the most observed female bottlenose dolphins in 2014 (a) and 2023 (b). The unique marking on her dorsal fin allows for tracking over time. Photographs by Aviad Scheinin

As a coastal species, bottlenose dolphins are exposed to high anthropogenic pressure. The coast of Israel is highly impacted (Micheli et al., 2013), with rising coastal development and heavy marine traffic causing chemical and noise pollution, fishing activities that lead to food depletion and incidental mortality in fishing gear (Notarbartolo di Sciara, 2016), and climate change effects such as increasing temperatures and acidification. The annual mean temperature in Israel has increased by 1.4 C from 1950 to 2017, and the warming is more rapid in this part of the world (Price, 2020). Based on data collected in Israel over the last two decades, the coastal shelf waters of the Southeast Levantine Sea were declared an Important Marine Mammal Area (IMMA) by the IUCN for both bottlenose dolphins and the common dolphin (*Delphinus delphis*) that inhabits the southern region of the coastline (IUCN-MMPATF, 2017).

1.4 Group size

Bottlenose dolphins exhibit a fission-fusion society characterized by fluid group compositions that frequently change in size and membership (Kerth, 2010). This flexible social structure is considered an efficient strategy to overcome the costs of group living (Lehmann et al., 2007). Group size can vary significantly, influenced by variations in habitat structures and activity patterns (Shane, 1986) and seasonal-related variables (La Manna et al., 2023a). Seasonal variations in group size have been observed, though these patterns are inconsistent across different locations. Increases in group size during the winter have been reported in Argentina and Florida (Odell & Reynold, 1980; Wursig, 1978). On the contrary, in Texas, there was a slight decrease in group size during the winter (Shane, 1977). Among the main factors that influence group size in bottlenose dolphins are foraging strategy, presence of calves, and presence of predators (La Manna et al., 2023a). Groups with calves are generally composed of other females who assist the mother in caring for her calf, and thus, they tend to be larger than those without calves (Díaz López et al., 2018). Similarly, larger groups may increase the protection of vulnerable calves (Methion et al., 2023). Adult female groups occur in networks of more individuals with lower association rates, while in some areas, male bottlenose dolphins tend to form groups of two or three animals that live in almost constant association (Connor, Wells, et al., 2000). In areas with high predation risk, the group size tends to be larger as a defensive strategy (Heithaus & Dill, 2002). Moreover, prey availability and environmental changes also influence group dynamics (Bearzi et al., 1999). In Israel, bottom-trawler fisheries are a major adjunct food resource for bottlenose dolphins, as they exploit similar ecological niches (Scheinin et al., 2014). Previous studies worldwide have shown how trawler fisheries affect group size and composition. In the Spencer Gulf, South Australia, the presence of trawlers led to variations in group size, with dolphins forming larger groups at specific sites with higher trawling activity (Svane, 2005), as well as in the Adriatic Sea (Bonizzoni et al., 2023). In Moreton Bay, Australia, they formed two distinct social communities, "trawler" and "nontrawler" dolphins, based on their interactions with commercial prawn trawlers. These two communities merged when trawling was reduced due to legislative changes, showing increased associations and a more compact social network (Ansmann et al., 2012). In Israel, groups of dolphins observed while interacting with trawlers were smaller (Scheinin et al., 2010), probably due to high competition for limited resources. According to previous work made by Mevorach, 2021, the mean group size for the entire population was 5.1 ± 4.5, which is compatible with other coastal populations worldwide and in the Mediterranean Sea (Benmessaoud et al., 2013; Blasi & Boitani, 2014; Pace et al., 2012).

1.5 Females' reproductive parameters

Like many social mammals, bottlenose dolphins exhibit extensive maternal investment with prolonged mother-infant relationships (Blasi et al., 2020), demonstrating different patterns of maternal behavior (Hill et al., 2007). Age of sexual maturity varies by region (R. S. Wells & Scott, 2009), but in general, females reach sexual maturity at around 5 to 13 years of age (Mcbride & Kritzler, 1951; Peddemors, 1989; Perrin & Reilly, 1984), and produce a single offspring (Mcbride & Kritzler, 1951) after a gestation period of approximately 12 months (Steinman et al., 2016). Studies of dolphins in captivity report an 18-month lactation period (Cockcroft, 1989; O'Brien & Robeck, 2012), although field studies report approximately twice that duration (Mann et al., 1998). In Shark Bay, Australia, an area with high predation risk, the weaning age ranged from 2.7 to 8 years, and most calves were weaned by their fourth birthday (Mann et al., 2000). In the Patos Lagoon estuary, Brazil, an area characterized by abundant food resources and minimal predatory risk, the weaning age was around two years (Fruet et al., 2015). In the Mediterranean Sea, a mean weaning age of 3.2 ± 0.6 years was calculated in the Aeolian Archipelago (Blasi et al., 2020), an overfished area (Blasi & Boitani, 2014). Females might wean before the next pregnancy to regain their body condition. Alternatively, they might wean during pregnancy and, if a fetal loss occurs, continue nursing their dependent calf for another year. This could potentially explain some of the variation in the age of weaning (Mann et al., 2000). The average interbirth interval (IBI) also varies among regions and is profoundly influenced by the survival of the previous calf (Henderson et al., 2014). Few studies have reported an interbirth interval of < 3 years for a surviving calf, whereas intervals of about 3−5 years were found to be more common. IBI is shorter in regions with favorable environmental conditions, such as shallow waters with higher prey density or specialized foraging strategies. Conversely, longer intervals are observed in regions with harsher environmental conditions or higher latitudes (Bearzi, 1997; Bezamat et al., 2020; Blasi et al., 2020; Cornell et al., 1987; Mann et al., 2000; Robinson et al., 2017). Birthing periods have been described to range from year-round calving (Felix, 1994; Urian et al., 1996) to seasonal calving (Fruet et al., 2015; Kogi et al., 2004; Mann et al., 2000; Thayer et al., 2003; Urian et al., 1996; R. S. Wells et al., 1987). Seasonality of birth may reflect variations in water temperature (R. S. Wells et al., 1987), food availability (Urian et al., 1996), presence of predators (Mann et al., 1998, 2000), loss of a dependent calf, and duration of lactation (Barlow, 1984). With a narrow breeding season or loss of a calf late in the season, females would be forced to delay conception until the next breeding season, whereas a longer breeding season or early calf loss allows them to resume cycling quickly (Mann et al., 1999). Hormonal monitoring of captive dolphins indicates that females are spontaneous sporadic ovulates, repeatedly ovulating during a given season, while males may be active year-round with a prolonged elevation of testosterone concentrations over the period that different females may be ovulating (R. S. Wells & Scott, 2009). The maximum life span for females in Israel is unknown, but Sarasota females may live to their early 50s (Hohn, 1989; Sayigh et al., 1999).

Many other reproductive parameters interact with different biological, ecological, and social factors (Fruet et al., 2015; Stanton & Mann, 2012), resulting in variation between populations and individuals within the population (Henderson et al., 2014). While many studies of bottlenose dolphin reproductive parameters have been conducted worldwide, few have been conducted in the Mediterranean Sea, mainly in the western and central areas. As a coastal species, they are significantly impacted by anthropogenic activities (Crain et al., 2009), which can influence females' reproductive success and calf survival. Calves' survival rate of over 80% was measured in different populations (Fruet et al., 2015; Kogi et al., 2004; Mann et al., 2000; Robinson et al., 2017; R. S. Wells & Scot, 1990). In Doubtful Sound, New Zealand, a decline in first-year calf survival rates was observed from a mean of 82% between 1994-2001 to 37% between 2002-2008 (Currey et al., 2009). The decline was attributed to tourism impact and the freshwater inflow from a hydroelectric power plant (Rutger & Wing, 2006a). In the eastern Ligurian Sea, calf survival was 75% (Rossi et al., 2017a). The Gulf of Ambracia, Greece, a semi-enclosed shallow habitat with a progressively deteriorating coastal ecosystem, hosts one of the highest observed densities of bottlenose dolphins in the Mediterranean Sea (Borrell et al., 2021; Gonzalvo et al., 2016). Calf survival by age one in this region was 55% (Andres & Gonzalvo, 2023). Differences in maternal experience and behavior appear to be crucially important to calf survival in some populations (Fruet et al., 2015; Henderson et al., 2014). Calf survival might be lower in females with previous calves that had died (Robinson et al., 2017). Additionally, studies have shown that factors such as birth timing, maternal size and age, and birth order can influence variability in female dolphin reproductive success and calf survival rates (Brough et al., 2016; R. S. Wells et al., 2014). Research on bottlenose dolphins in Brazil has indicated an age-related decline in reproductive fitness, with older females reproducing at lower rates (Fruet et al., 2015). Numerous studies have demonstrated that reproductive rates in slow-growing populations tend to exhibit greater variability compared to survival rates (Gaillard et al., 2000; Mitchell et al., 2009;

Pfister, 1998). Moreover, this larger variability in reproductive rates can significantly impact population viability (Gaillard et al., 2000; Mitchell et al., 2009; Saether & Bakke, 2000). Thus, it is essential to establish baseline life history parameters for specific populations to explore species ecology and inform management. In long-term photo-identification studies, repeated sightings of marked females over multiple years allow researchers to build a comprehensive baseline of individual reproductive histories (Robinson et al., 2017). In addition, stranding data can provide useful information on reproductive parameters such as birth seasonality and mortality rate (Mcfee et al., 2006; Pitchford et al., 2013). Providing such data contributes to a deeper understanding of species' basic biology and how they interact with the environment.

1.6 Survival estimates

Capture-recapture methods provide a way of estimating population parameters and have been used extensively for estimating abundance, survival probability, population growth rates, and recruitment of several species of avians, amphibians, fish, and mammals (Reşit Akçakaya & Sjögren-Gulve, 2000; Schwarz & Seber, 1999). In the last few decades, the focus in capture-recapture models has increasingly focused on estimating survival rates rather than population size because survival estimators are substantially more robust to the partial failure of assumptions than are estimators of population size (Lebreton et al., 1992). For cetacean species, the most common sampling design to "capture" and "recapture" individuals is by using the photo-identification method (P. S. Hammond et al., 1990b). The basic principle of mark-recapture methods involves capturing, marking, and releasing an initial sample of individuals (*M*) (Figure 2). During a subsequent capture event, a second sample of individuals is captured (*S*), including some previously marked individuals (*R*). The proportion of marked individuals recaptured in the second sample represents the proportion of marked individuals in the population as a whole (S. Hammond et al., 2004). Equating these two proportions provides an estimate of population size (N) (Figure 3), also known as the Lincoln-Peterson Index.

$$\frac{R}{S} = \frac{M}{N} \rightarrow N = \frac{M \times S}{R}$$

M = animals marked and released
N = population size
R = animals recaptured on a second day
S = size of the sample on the second day

Figure 2: The Lincoln-Peterson Index: a statistical measure to estimate population size based on mark-recapture data

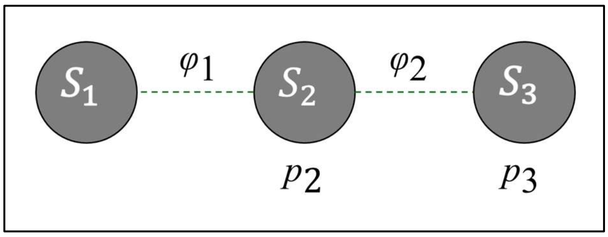


Figure 3: The basic 'structure' of mark-recapture sampling protocol

Such methods have been used for closed and open populations (Lebreton et al., 1992). Closed population models assume the population of interest is closed geographically (no immigration or emigration) and demographically (no births or deaths) during the sampling period (Schwarz & Seber, 1999). Open population models presume that all animals alive during a specific sampling occasion have an equal probability of surviving, staying in the population, and being captured, provided they are still alive and present in the population (Lebreton et al., 1992). Apparent permanent emigration in capture-recapture data occurs when transient individuals who are merely passing through the study area are sampled along with resident animals. These transient individuals leave the study area and thus have no chance of being recaptured (Silva et al., 2009). The basic open population capture-recapture model is the Cormack–Jolly–Seber (CJS) model, developed independently by Cormack (1964), Jolly (1965), and Seber (1965), and used to model populations subject to birth, death, emigration, and immigration. This model allows year-specific estimates of apparent survival (φ) and capture probability (p) (Figure 3). φ_i is the probability that a marked animal in the study population at sampling period i survives until period i+1 and remains in the population (does not permanently emigrate), and p_i is the probability that if alive and in the sampling period i, the individual will be encountered (Cooch & White, 2014; Lebreton et al., 1992; Schwarz, 2001). CJS estimates the survival rate by focusing on the probability of individuals remaining available for recapture over time. φ_i represents apparent survival, accounting for both true survival and the probability of emigration. Thus, $1 - \varphi$ represents both animals that died and animals that merely left the population (Pollock et al., 1990). There is a potential bias because of permanent emigration between emigration and mortality (Maria Fortuna, 2006; Williams et al., 1993). Such biases are considerable for capture probabilities but usually small for survival estimates (Kendall & Bjorkland, 2001). The basic assumptions of mark-recapture models as applied to cetaceans are: 1) Marked animals are not affected by being marked; 2) All samples are instantaneous, relative to the intervals between sampling occasions, and each release is made immediately after the sample; 3) every marked animal present in the population at time (i) has the same probability of recapture (p_i). If this assumption is violated, this is known as heterogeneity of capture probabilities; 4) every marked animal in the population in time (i) has the same probability of surviving to time (i+1) (P. S. Hammond et al., 1990a; S. Hammond et al., 2004). The assumption of a generally equal probability of capture among individuals is the most difficult to meet in mark-recapture studies with cetacean populations; failure to account for heterogeneity in capture probabilities can produce severe bias in population estimates (Pollock et al., 1990), although the effect on survival probability may be small (Carothers, 1973). Variations in capture probabilities can be caused by responses to capture (i.e. the boat), differences in age, sex, or behavior, social structure, individual ranging preferences, and temporary emigration (Arso Civil, 2014).

1.7 Stranding estimates

Stranded and by-caught cetaceans have been sampled as part of the stranding network activity that started in 2003 by the Israeli Marine Mammal Research & Assistance Center (IMMRAC) and the University of Haifa along the Mediterranean coast of Israel. A stranded marine mammal is defined as any deceased marine mammal found on a beach or floating nearshore or any live cetacean stranded on a beach or in water shallow enough to prevent it from freeing itself and resuming normal activity (Anthony & Worthy, 1999). Survival rates of live-stranded bottlenose dolphins are generally low (R. S. Wells et al., 2013), and none of the dolphins that have washed ashore alive have survived in the study area.

Along the Israeli Mediterranean coast, bottlenose dolphins account for 60% of all reported strandings (Kerem et al. 2012). The stranding rate has remained stable in recent decades, with a mean of eight individuals/year (Kerem et al., 2013). A previous study described the presence of *Toxoplasma gondii* infection in three individuals, including one case of coinfection with the herpesvirus. It was the first report of *T. gondii* infection of marine mammals in the Eastern Mediterranean Sea (Bigal et al., 2018).

Mortality in bottlenose dolphins in the Eastern Mediterranean Sea can be attributed to a variety of natural and anthropogenic factors. One significant cause is bycatch, where dolphins are inadvertently caught in fishing gear, leading to injury or death. Studies have shown that bycatch is a major threat to marine mammals globally, including in the Mediterranean region (Lewison et al., 2004). By-caught in gill net and trawler net are the most common in our region. Additionally, pollution, particularly from chemical contaminants like heavy metals and persistent organic pollutants, has been linked to increased mortality rates in dolphins due to its impact on their immune and reproductive systems (Tanabe et al., 1994). Furthermore, disease outbreaks, often exacerbated by environmental stressors, contribute to mortality. Viral infections such as morbillivirus have been documented to cause mass die-offs in dolphin populations (Van Bressem et al., 2009). Ship strikes and habitat degradation due to coastal development and human activities also pose significant risks to dolphin survival (Notarbartolo di Sciara, 2016).

The collection of stranding data over multiple years enables the analysis of trends, including yearly, monthly, and seasonal stranding rates, as well as gender, length, age class, and instances of human-induced mortality (Carmichael et al., 2022; Mcfee et al., 2006). Incorporating stranding data into this study provides valuable insights into mortality rates, enhancing the accuracy of the survival rate calculations. This approach enables a more robust understanding of the population's survival and mortality dynamics.

1.8 Research objectives

This research aims to examine female bottlenose dolphins' reproductive parameters and residency patterns along Israel's Mediterranean coast.

These objectives will be achieved through several aims:

1. Examine the population dynamics of female bottlenose dolphins along the Israeli coast, including habitat use and group dynamics
2. Estimate life history traits, including calving rate, fecundity, birth seasonality, interbirth intervals, weaning period, and mortality rates.

1.9 Hypothesis

Previous findings by (Mevorach, 2021) suggest a dynamic pattern of habitat use, with a small subset of dolphins sighted in the area more often than expected, while most dolphins were occasional or infrequent visitors. This pattern seems common in bottlenose dolphins, with some individuals presenting different degrees of residency. In many studies, females demonstrated smaller distributional ranges with longer presence within feeding areas (Gibson et al., 2013; Morteo et al., 2014). Therefore, we assume that females will have stronger residency patterns in the study area. Due to a very low predation risk (Bearzi et al., 2009), defensive behaviors are largely unnecessary in the area. Consequently, we assume that females with young calves will form larger groups, primarily for mutual support, whereas other individuals tend to create smaller, less cohesive groups. On the other hand, in an overfished area with limited resources (Golani et al., 2017), they tend to feed from trawling boats (Scheinin et al., 2014). Thus, we conclude that it will lead to the formation of smaller groups, as taking advantage of easy food sources improves the chances of raising a healthy calf as well as providing an adequate caloric intake for females (Fertl, 1997).

Reproductive parameters of female bottlenose dolphins are significantly influenced by the quality of their habitat (Mann et al., 2000). Nutrient-rich seas support higher fertility rates, shorter calving intervals, and better calf survival than oligotrophic seas. Environmental stressors further exacerbate these differences (Baker et al., 2018; Brough et al., 2016; Kellar et al., 2017; Rossi et al., 2017b). The Eastern Mediterranean Sea is characterized by its relatively warm, ultra-oligotrophic waters (Krom et al., 1992). Therefore, we assume that female bottlenose dolphins will have longer interbirth intervals (>3 years) and weaning age, as well as a lower calf survival rate than other populations. As with many aspects of their biology, bottlenose dolphins are flexible in the timing of their reproduction (Urian et al., 1996). In many populations, births tend to peak in the spring and summer months, possibly due to an increase in water temperature and food supply, but are documented year-round (Fruet et al., 2015; Steiner & Bossley, 2008; Tezanos-Pinto et al., 2015; Veneruso & Evans, 2012). Therefore, we predict that births occur year-round, with a slight seasonal peak in late spring and early summer.

2. Methods

2.1 Study area and surveys

The research study area encompasses the entire 196 km stretch of Israel's coastline along the Eastern Mediterranean Sea (Figure 4). The continental shelf in this region extends to a depth of 200 meters. It gradually widens from its narrowest point in the north, approximately 10 km from the shore to its widest point in the south, about 20 km from the shore. It is sandy in the south and sandy and rocky in the north. No deep-water surveys (further than 8 Km from shore) were conducted in this research. As part of MKMRS and Delphis NGO's long-term monitoring effort and IMMRAC's in the past, boat-based surveys were conducted throughout the year following the protocol outlined by Scheinin (2010). The surveys were opportunistic, primarily reliant on collaborations with private yacht and boat owners, and were conducted from one of eight coastal locations. In the South, these locations included Ashkelon and Ashdod. In the Center, Tel Aviv, Herzliya, and Sdot-Yam. In the North, the starting points were Haifa, Akko, and Nahariya. The greatest effort originated from the central and southern areas (on average 2-5 times a month), with less effort in the northern area. Sea conditions vary greatly during the year, and there are roughly 80 days suitable for surveying, with sea conditions of less than 3 on the Beaufort Scale (wind 7-10 knots, large wavelets, crests beginning to break, and scattered whitecaps). The survey route typically followed a transverse zigzag pattern between the 30-60 meter isobaths, running parallel to the coastline, at average searching speeds of 4-12 nautical miles per hour. Bottom trawlers, moving at speeds of 4-8 nautical miles per hour and typically operating between the longshore 40-60 meter isobaths, were opportunistically approached to observe dolphins foraging nearby.

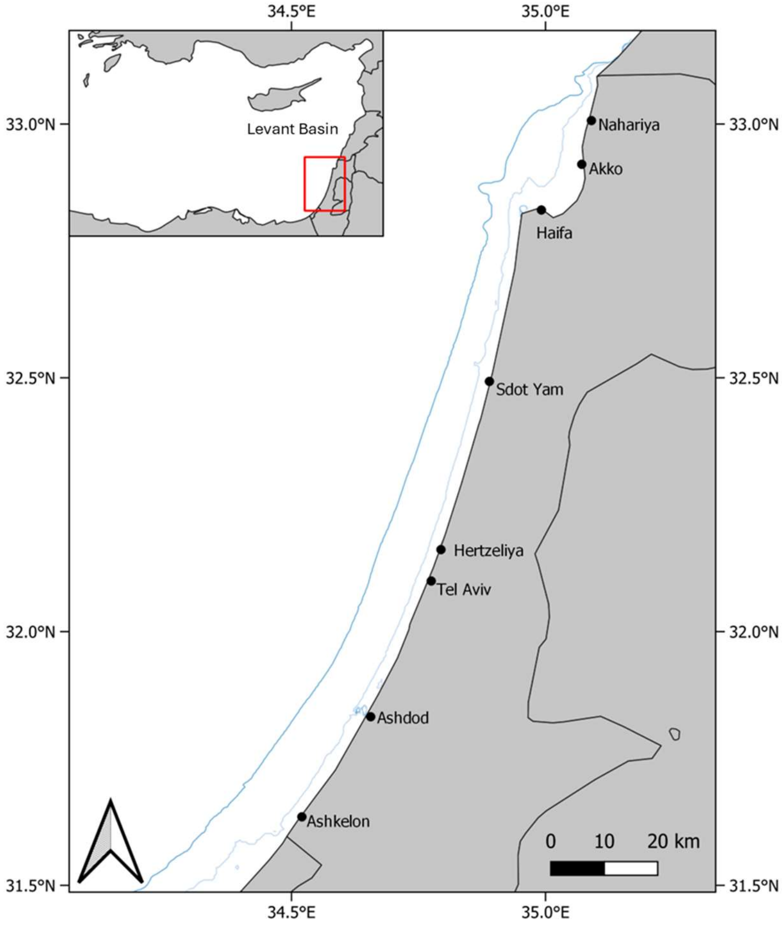


Figure 4: map of the study area
The Israeli coastline to the Eastern Mediterranean Sea. Each survey started from one of eight locations along the coast: Ashkelon, Ashdod, Tel Aviv, Herzliya, Sdot–Yam, Haifa, Akko, and Nahariya. Bathymetric contour lines indicate 30 and 60 meters depths, where most surveys were conducted.

During each survey, the boat's position was recorded along the route, while environmental parameters and all wildlife encounters were documented using 'Delphis'. A specialized data collection mobile application was created to allow easy data collection following the protocol (Marco, 2017). Upon sighting dolphins, the team approached to capture photographs and collect group focal follow data, which were also logged into the Delphis application. To minimize disturbances to the dolphins, the boat operated at a low speed and maintained about 10-30 meters, avoiding abrupt changes in direction or speed. Close approaches (less than 5-10 meters) were only made if the dolphins themselves initiated the interaction, either to bow ride or out of curiosity. Animals were kept in sight for as long as possible, continuously recording their behavior. Each individual was photographed using standard photo ID techniques (Würsig & Würsig, 1977b). High-quality photographs of the left and right sides of the dorsal fin were taken using a Canon EOS 7D 18MP camera with a 70-200mm f2.8 EF zoom lens and a Canon EOS R5 camera with a Canon RF 70-200mm f/2.8L IS USM zoom lens. This method ensured thorough documentation while minimizing the impact on the dolphins and preserving their natural behaviors.

A group was considered as all animals sighted together moving in the same general direction, engaged in similar activities, or interacting with each other within a radius of approximately 100 m (McHugh et al., 2011). "Feeding-related behavior" behind trawlers was considered when dolphins perform sequences of long dives (about 3-5 min) followed by a few ventilations within 300m of the stern of a working trawler and following its route (Bearzi et al., 1999; Fortuna et al., 1998).

2.2 Data classification

2.2.1 Sex determination

Gender was determined only when photographs of the genital area were available, during aerial behavior or bow-riding (Smolker et al., 1992). Furthermore, reproductive females were identified based on their close and lasting association with a calf, presumed to be their offspring. This assumption was made if the calf was observed in an infant position for most of the observation and appeared in at least two photographic frames from the same sighting (Blasi et al., 2020). This helps prevent false mother-calf pairings in bottlenose dolphins as a result of alloparental care (Hamilton, 1987; Bearzi, 1997).

2.2.2 Age determination

Individuals were assigned to one of four relative age classes based on observations of individual estimated size and body length, reproductive state, behavior, and/or previous knowledge of life history (Figure 5) (Smith et al., 2013). Classes were defined as: 1) adults: larger and darker in color, approximately 2.5 meters or more in length, sometimes with a dependant calf (Bearzi, 1997; Wilson et al., 1999); 2) juveniles: about two-thirds the size of adults, with relatively lighter coloration, usually with less distinctive nicks or without nicks in their dorsal fins; 3) calves: approximately half the size of an adult, usually without nicks in their dorsal fins. It is closely associated with an adult but not as strictly as a newborn; 4) newborns: less than half the size of a typical adult, constantly in close association with an adult, swimming in an infant position, with a typically surfacing behavior. Newborns are also identified according to the low and rounded dorsal fin and visible fetal folds (Baker et al., 2018; Bearzi, 1997; Henderson et al., 2014; Mann et al., 1999). It is acknowledged that visual observations may be subject to bias, as accurately assessing the size of a dolphin without measurement tools, particularly for large juveniles, is challenging. However, when there were uncertainties, the data were excluded from analyses (Tezanos-Pinto, 2009).

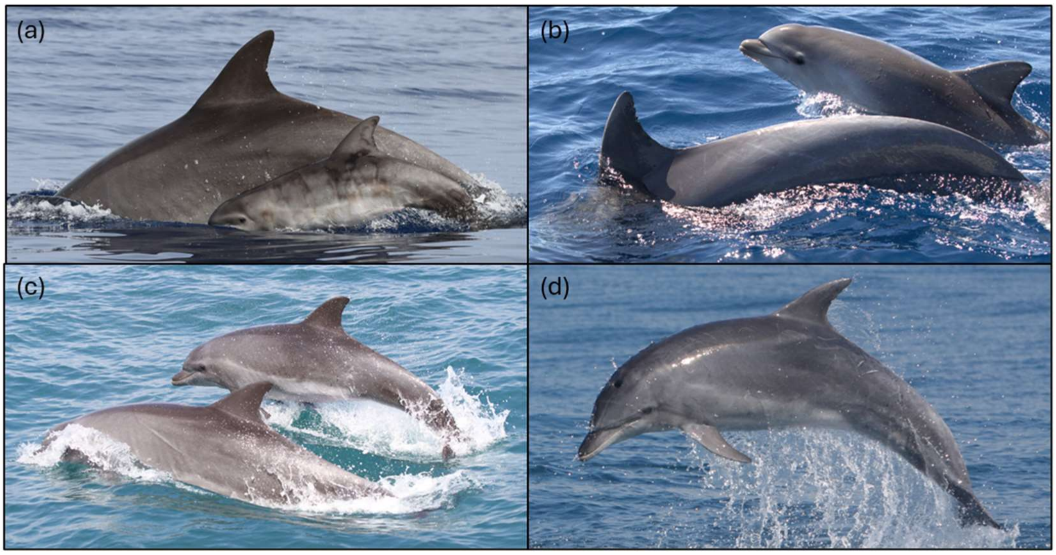


Figure 5: Age classification based on total body size: (a) newborns, (b) calf, (c) juvenile, and (d) adult. Photographs by Aviad Scheinin and Meytal Markovitch.

2.3 photograph processing

After each survey, the photographs were processed following a designated protocol (Appendix 1). Adobe Lightroom was utilized for photo analysis, as it allows for adding extracted information to the photograph's metadata, facilitating efficient sorting. Initially, the photographs were rated for picture quality (Q) based on Wilson et al. (1999), which range from 1 to 5. The picture quality is based on an evaluation focus/clarity, angle, and contrast (Würsig & Jefferson, 1990). A rating of 1 indicates photographs without dolphins or very poor quality, while a rating of 5 is assigned to images with straight-angle and sharply focused dorsal fins. Only photographs with a quality rating higher than 3 (Q > 3) were selected for further analysis. These selected photos were then assessed for the distinctiveness of the dorsal fin, providing an additional grading level (P. S. Hammond et al., 1990a; Wilson et al., 1999). The distinctiveness (Figure 6) related to how distinctive the markings on the individual's fin are and how easily the individual can be identified in varying levels of Q. Highly distinctive dorsal fins with visible and permanent notches on the dorsal fin's trailing edges were graded as 1, while smooth, mark-less fins were graded as 3. Features such as body and dorsal fin scars, lesions, and tooth raking were used as secondary characteristics (Wilson et al., 1999). However, since such characteristics are not necessarily permanent, individuals were not included in the catalog based on secondary features alone (Würsig & Würsig, 1977b). After grading, all extractable data from the photograph, including location, sex, age determination, and other essential information, were added as keywords to the metadata. Each individual was isolated for photographs containing multiple individuals by copying and cropping the images. Each dolphin was saved in a separate picture with its grading and metadata. All images featuring the same dorsal fin were grouped, with the highest quality left and right-side photographs receiving the ‘Best of’ tag (Feyrer et al., 2019). The ‘Best of’ photographs were then used to search for comparable matches within the catalog. Matches could be made using photographs of either side of the dorsal fin. When a match was found, all photographs of the identified individual were labeled with their identification number and name. If no match was found, the individual was assigned a new number and name and added to the catalog. Each photograph was re-examined to identify false positives (different individuals assigned the same catalog number) and false negatives (the same individual assigned multiple catalog numbers). An independent second observer then verified the final data (Berghan et al., 2008). Calves were given IDs in reference to their mothers to facilitate easier tracking.

All photographs with dorsal fins captured in Q > 3 taken between 2005 and 2023 were identified and cataloged across all observations. After processing, an Excel table was created to compile all observations of female dolphins throughout the study period. Each row of the table represents a female sighting with additional information such as date, presence of calf, calf’s number, and age determination.

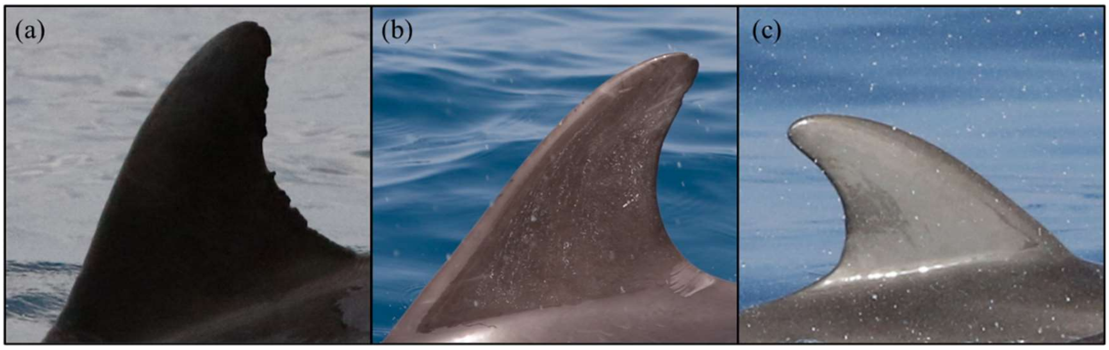


Figure 6: Categories of the distinctiveness of the dorsal fin: ***(a)*** highly distinctive (1) dorsal fin with visible and permanent notches.; ***(b)*** distinctive (2) dorsal fin with fewer cuts present; ***(c)*** non-distinctive (3) smooth and mark-less.

2.4 Site Fidelity

To investigate the presence of identified females in the study area over time, the mean seasonal and yearly sighting rates were calculated as (1) the number of seasons a dolphin was identified as a proportion of the total number of seasons surveyed (n = 38) and (2) the number of calendar years a dolphin was identified as a proportion of the total surveyed (n = 19) (Benmessaoud et al., 2013; Parra et al., 2006). The seasons were defined according to the annual temperature distribution (Ozer et al., 2022) as a cold season (December – May) and a warm season (June—November).

2.5 Group size and composition

The group size was visually determined *in situ* and later confirmed by photographs taken during each sighting (Hammond et al., 1990b). The mean group size was calculated separately for groups with and without calves to assess whether group size changed in the presence of calves. The mean group size while foraging from bottom trawlers was measured and compared. Interaction with bottom trawlers was characterized as dolphins following operating bottom trawlers while alternating long dives (3-5 minutes) at the location of the net, approximately 200–300 m from the stern (Genov et al., 2019).Additionally, based on water temperature, group size comparisons were made between the cold season (December – May) and the warm season (June—November). To assess changes in group size over time, the study period was divided into three distinct sampling intervals: 2005-2010, 2011-2016, and 2017-2023.

Group composition (or age class composition) were categorized as calf (and newborns), juvenile, adult, and reproductive female (Baker et al., 2018; Bearzi, 1997; Blasi et al., 2020; Henderson et al., 2014; Mann et al., 1999; Wilson et al., 1999). The proportion of dolphins in each age class was estimated based on visual observations and photographs.

2.6 Reproductive estimates

2.6.1 Annual calving rate

The annual calving rate was estimated as the total number of newborns divided by the total number of reproductive females sighted during that year (Scott Baker et al., 1987; Tezanos-Pinto et al., 2015). The mean annual calving rate was calculated using a weighted average, and the 95% confidence intervals for the calving rates across the years were determined using binomial variance. (Baker et al., 2018; Scott Baker et al., 1987; R. S. Wells & Scot, 1990). The annual calving rate was estimated using sightings of mother-calf pairs that were resighted over two consecutive encounters, and the calf's age was known (Tezanos-Pinto et al., 2015).

2.6.2 Fecundity

Fecundity was calculated as the ratio between the number of calves that survived to age one and the number of reproductive females in the population (R. S. Wells & Scot, 1990). Overall mean fecundity is a measure of the potential reproductive capacity of the population (Baker et al., 2018). Due to low sighting rates and the unknown fate of most calves, fecundity was calculated only for eight years.

2.6.3 Birth seasonality

Seasonal reproduction patterns were examined based on the estimated birth month of calves. The birth period is calculated as the midpoint between the last sighting of the mother before giving birth and the sighting of the mother with a new calf, and the proportional body length between mother and calf (adapted from Wells et al., 1987). If this period exceeded six months, the birth date was excluded from the analysis unless the calves exhibited distinct newborn characteristics (dark grey coloration, prominent fetal folds, floppy dorsal fin; Figure 5), with birth assigned to the month of their first sighting. Additionally, calving seasonality was supported using stranding data between 1994 and 2022. Fresh to moderately decomposed carcasses with a total length of ≤ 115 cm (neonates' total length as measured by Kerem et al., 2013 for this population) and having any characteristics of a newborn mentioned above were assigned as neonates (Fruet et al., 2015).

The mean monthly water temperature was calculated to investigate the potential linear correlation between mean water temperature and calving. Water temperature measurements were taken from the Israel Oceanographic and Limnological Research (IOLR) as part of the National Monitoring Program of Israel’s Mediterranean Waters (INMoP) framework. A continuous SBE16plusV2 Sea-Bird CTD located on the westernmost terminal sporting pole in the coal terminals in Ashkelon (south), 2.2 km offshore at a depth of 11-12 m, collected Continuous CTD Raw data at a high temporal sampling interval of 10min (Ozer et al., 2022). Spearman correlation coefficient was then calculated to investigate the potential linear correlation between average monthly water temperature and calving.

2.6.4 Interbirth intervals

The interbirth interval (IBI) was determined as the time elapsed between subsequent births for females observed with two or more calves during the study period (Blasi et al., 2020; Robinson et al., 2017). The IBI was calculated from the first sighting of a female with her initial calf to the first sighting of the same female with a subsequent calf. Two calculations were made. In order to reduce the probability that the birth of a new calf was missed for the less frequently sighted females, and the chance of the IBI being shorter if mothers lost unsighted calves, the first calculation includes only females that were sighted annually with a surviving calf of known birth within a year who did not disappear for more than a year from the study area (n = 11) (Blasi et al., 2020). Due to the limited sample size and sightings, the second calculation included calves with unknown fates (n = 3) to increase the sample size. If the date of birth (DOB) was known (see 2.5.3), it was used instead of the date of the first sighting of a female with her new calf to ensure more accurate calculations (Mann et al., 2000). The IBI was calculated by dividing the days between consecutive births by 365.25 (i.e., IBI in years). Six females were included in this analysis with 18 calves. DOB was known for six calves.

2.6.5 Weaning age

The weaning age was estimated for calves with a known birth date within six months. A calf was presumed to have weaned if it was > 1 year old and it and/or its mother had been observed independently in at least three subsequent dolphin group sightings (Baker et al., 2018). Additionally, when a new calf was born, the weaning period for the old calf was estimated based on the last sighting at which the calf stopped its exclusive association with the mother (but not necessarily in infant position) (Blasi et al., 2020).

2.7 Survival estimates

2.7.1 Mark-recapture modeling procedure

Cormack–Jolly–Seber (CJS) models (Cormack, 1964; Jolly, 1965; Lebreton et al., 1992; Seber, 1965) were fitted to the bottlenose dolphin dataset to estimate apparent survival probabilities based on 19 years of mark-recapture data (2005 – 2023). Only high-quality photographs of individuals with significant marks and calves born to mothers with conspicuous dorsal fin marks were considered in the analysis to avoid misidentifying individuals that can cause biased estimations (Boyd et al., 2010; Fruet et al., 2015). Sightings of individual dolphins made during the same year were pooled, and each year was treated as a sampling occasion (Silva et al., 2009). A capture history matrix was created for each individual dolphin. The matrix indicated whether an individual was sighted (1) or not sighted (0) during each year. Separate matrices were created for the following age classes: *1) Apparent adult survival*- all adult dolphins with well-marked dorsal fin (n=266); *2) Apparent calf survival*- all calves seen in the study area that were born to mothers with well-marked dorsal fin (n=112); *3) Apparent first-year calf survival*- only those calves identified as newborns (fetal folds and rounded dorsal fin, see 2.2.2) and born to known females observed in consecutive years were included to estimate the probability of a calf to survive to age one (n=14).

To assess the fit of the CJS model to the data, a goodness of fit (GOF) test was conducted using the 'R2ucare' package in R (Gimenez et al., 2018b). When the GOF component test is significant, correction is required for the fitted models to provide more accurate and reliable inference from the model (Silva et al., 2009). Overdispersion of the data was examined by calculating the variance inflation factor, ĉ. A value greater than 1 indicates overdispersion, requiring adjustments to the data. Standard errors and confidence intervals were also adjusted (Ludwig et al., 2021).

2.7.2 model selection

Analysis and model selection procedures were carried out using the 'Rmark' (Laake, 2013) package in R to construct models for the MARK program (G. C. White & Burnham, 1999). A set of candidate models was developed, running an exhaustive list of models based on the specified parameter definitions for survival probability (φ) and capture probability (p). For this purpose, the survival parameter and capture probability were defined as either staying constant over time (~1), varying by sampling occasions, varying by age class, or varying by effort. The sampling effort was determined by calculating the total km covered while searching for dolphins and the amount of time spent on observations each year. A total of 16 different models were fitted to the data to investigate the variation in capture and survival probabilities. Quasi-likelihood Akaike Information Criteria (QAICc) was used to select the best model (Akaike, 1985). It provides a convenient way to deal with overdispersed data (Seber, 1992) and also considers differences in effective sample size between models (Lebreton et al., 1992). The model with the lowest QAICc value was selected as the best-fitting model. The normalized QAICc weights were used to measure the strength of evidence for a given model relative to others (Silva et al., 2009). The evidence ratio (the ratio of weights between two models) was employed to evaluate how the model explains the data compared to others (Burnham & Anderson, 2002; Ludwig et al., 2021). To address the uncertainty associated with selecting models, survival estimates were averaged based on the weights of the candidate models (Burnham & Anderson, 2002).

2.7.3 Validation of model assumptions

(1) marks are not lost or missed. Only well-marked individuals and high-quality photographs were included, reducing the chances of missing or misidentifying marks; (2) individuals are immediately released after being sampled, and samples are instantaneous relative to the intervals between sampling occasions. The length of the photo-identification sessions was negligible compared to the interval between sampling occasions, and no individuals were removed from the population during the sampling process. (3 + 4) All marked individuals present on a given sampling occasion have the same probability of surviving and capturing. These assumptions were specifically assessed through goodness-of-fit (GOF) tests (Lebreton et al., 1992) using the R2ucare package in R.

2.8 Mortality estimates

2.8.1 Data collection

Data on stranded cetaceans have been collected by researchers from The Morris Kahn Research Station, University of Haifa, Delphis NGO, and in the past by The Israel Marine Mammal Research & Assistance Canter since 1993. The data contains individuals stranded on the beach, fisheries by-catches, and dead specimens known only from skeletal elements retrieved from the sea bottom. Strandings were reported by a variety of sources, including random beachgoers, researchers, fishermen, and social media publications. In most cases, when a stranding was reported, trained volunteers and/or researchers documented the event with GPS coordinates and photographic evidence. The recorded information included date, location, stage of decomposition, species, sex, weight, body length (measured from the tip of the rostrum to the tail fluke notch following Norris (1961)), any signs of entanglement, among other details. This data collection followed a protocol specifically adapted for work along the Israeli coast, which was based on several established protocols (Jsseldijk et al., 2019; Mazzariol, 2016; Rochelle et al., 2005) and has been refined and improved over the years through the experience gained in the field. Necropsies are also conducted wherever possible to relatively fresh carcasses, and tissue samples are taken to a tissue bank. Some mummified or disintegrated carcasses were incompatible with certain measurements.

These stranding datasets have provided useful information for managers on bottlenose dolphin stock structure and can be used to detect unusual mortality events and monitor living populations' health. Here, we examined annual, seasonal, and monthly trends and life-history parameters, such as sex ratio and age class composition.

2.8.2 Data classification and processing

Each stranded dolphin was divided into one of the following age classes: ≤1 year old, sub-adult, and adult. Age classes were defined based on two approaches. The first approach uses the counting of growth layer groups (GLGs) in their teeth, according to Hohn, 1980, 1989. The method involves analyzing the dentine layers within the teeth. Each GLG represents one year's growth, and age is estimated as the number of complete GLGs. Age was determined based on GLGs for 71 bottlenose dolphins between 1999 and 2010. If GLGs were not measured, the age class would be defined according to total body length based on the growth curve made by Kerem et. al. (2014): ≤1 year old were those males <194cm and females <225cm (the maximum length each sex is reached in their first year), sub-adult were males between 194-238cm and females between 225-250cm, and adults were all males >238cm and females >250cm. Only strandings of known length and sex were used in the age class analysis for the second approach. Seasons are defined as spring (March - May), summer (June – August), autumn (September – November), and winter (December – February).

A Generalized Linear Model (GLM) with a log link function and a Poisson error distribution was applied to analyze differences in expected stranding counts of bottlenose dolphins among years, seasons, and age classes between 1994 and 2022 (Mcfee et al., 2006). The GLM is an extension of the linear model that includes response variables that follow any probability distribution in the exponential family of distributions (Oppong & Asumadu, 2012). A GLM consists of three components:

1) *A random component-* specifies the conditional distribution of the response variable, Y_i, given the explanatory variables, x_{ij}.

2) *Linear predictor*- a linear function of the regression variables: $\eta = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k$ where βs are the coefficients to be estimated, and Xs are the predictor variables.
3) *Link function*- The link function connects the mean of the response variable to the linear predictor. It transforms the expected value of the response variable to the scale on which the linear predictor is expressed.

These components allow GLMs to model various data types and relationships between variables flexibly. The Poisson Regression is a GLM used to model count data (Nelder, 1974). It assumes the response variable follows a Poisson distribution, where the mean and variance are equal. The link function transforms the non-linear relationship into a linear form. In this case, a log link function was used to deal with the Poisson error distribution (Nelder, 1974; L. A. White & Buttrey, 2009). Overdispersion in Poisson regression occurs when the observed variance in the count data is greater than what the Poisson model predicts. In many real-world datasets, the assumption of equal mean and variance does not hold, leading to overdispersion (Hoef et al., 2007). The fit of the model was evaluated by comparing the residual deviance to the degrees of freedom or by calculating the ratio of the Pearson chi-square statistic to the degrees of freedom. A ratio significantly greater than one indicates overdispersion. When overdispersion was evident, a negative binomial error distribution was applied instead of the Poisson model as a corrective measure. All GLM analyses were conducted using the SAS program 9.4 version (Speedie et al., 2014).

2.9 Statistical tests

Student's unpaired t-test were used to test for significant differences when needed. The nonparametric Wilcoxon signed rank test was applied if the data was not normally distributed. The Spearman rank-order correlation coefficient was used to test for correlation between groups or parameters. The chi-squared Proportion Test is used to determine if there is a significant difference between the proportions of categorical variables in different groups. All statistical tests were performed using R software.

2.10 Ethic statement

No dolphins were harmed during this research. All observations were conducted from a safe distance, and the dolphins themselves initiated any interactions with the survey boat. Negative responses to the survey boat were rare and, when observed, prompted an immediate increase in distance. Collecting carcasses and data from stranding cetaceans is carried out under the permit of the Israel Nature and Parks Authority (Appendix 2).

3. Results

3.1 Sampling results

Between 2005 and 2023, 42,966.88 Km were covered in 1192 surveys. Bottlenose dolphins were recorded in 244 encounters in the study area (Table 1). Of the 244 surveys, 191 included females, and 129 included calves. 146 (62.39%) encounters were next to bottom trawler boats. The frequent encounters near bottom trawlers did not introduce a bias toward observing more groups containing calves. The presence of calves was not statistically different from groups without calves (χ^2 test of equal proportions; $\chi^2 = 1.16$, p = 0.28). In the absence of bottom trawlers, 58% of the encounters involved groups with calves, compared to 42% without calves. (Figure 7). Although groups with calves were slightly more frequently observed in all encounters, this difference was not statistically significant (χ^2 test of equal proportions; $\chi^2 = 0.803$, p = 0.37). A total of 65,561 photographs were taken; 13,585 of these were used for the photographic analysis of individually identifiable bottlenose dolphins. 301 bottlenose dolphins were photo-identified, excluding calves, and 276 had a significantly marked dorsal fin, which was categorized as 1 or 2 under the distinctiveness and quality gradings. No significant correlation existed between the annual survey effort and the number of individuals recorded (Pearson correlation, R = 0.11, t = 0.49, P = 0.62), meaning that increasing the number of surveys does not necessarily lead to identifying more dolphins.

Table 1: Survey effort estimated between 2005 and 2023

Year	Survey effort (KM)	Observations	No. of individuals captured	No. adult females recorded	No. newborn calves
2005	1434.79	16	54	15	1
2006	1880.99	18	45	12	1
2007	1254.55	10	25	10	1
2008	1248.89	11	35	9	4
2009	1936.21	10	22	11	4
2010	1962.31	20	71	21	2
2011	2702.98	18	75	27	4
2012	1821.19	13	50	20	5
2013	1386.49	11	26	14	2
2014	1206.59	12	33	19	2
2015	709.67	7	15	7	3
2016	1317.38	6	18	8	-
2017	5020.45	12	40	20	2
2018	4162.19	5	28	15	-
2019	8769.02	20	47	19	-
2020	6,022.94	18	26	16	5
2021	6,721.64	17	38	25	7
2022	5,533.76	9	26	17	5
2023	7,363.1	11	22	13	4

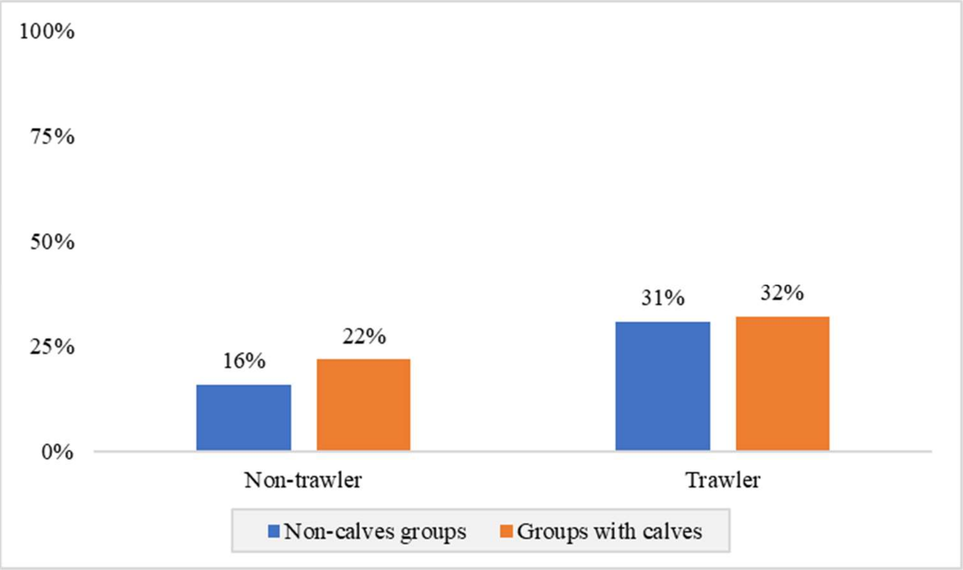


Figure 7: Comparison between the frequency of encounters with the presence or absence of bottom-trawl, divided by groups with and without calves (n = 244)

From 1994 to 2022, 248 bottlenose dolphin strandings and bycaught were reported along the coast. The number of strandings ranged from 4 in 1999 to 15 in 2006, with a mean of 8.6 ± 2.2 per year (Figure 8). The differences in the total number of strandings across years were insignificant (p = 0.49). The age class could be estimated for 195 stranded dolphins. 22.7% (n = 57) were ≤1 year old, ranging from 0 to 6 per year, with a mean of 1.97 ± 1.52. The total number of stranded dolphins with known sex was 165 (66%), and 86 were of unknown sex. The sex ratio was 1.00:0.77, males (n=93) to females (n=72). There was no significant difference in the proportion of stranded males and females (χ^2 test of equal proportions; $\chi^2 = 2.67$, p = 1). Of the ≤1-year-old dolphins, 43 were of known sex, presenting a 1:1 ratio as well between females (n = 22) and males (n = 21).

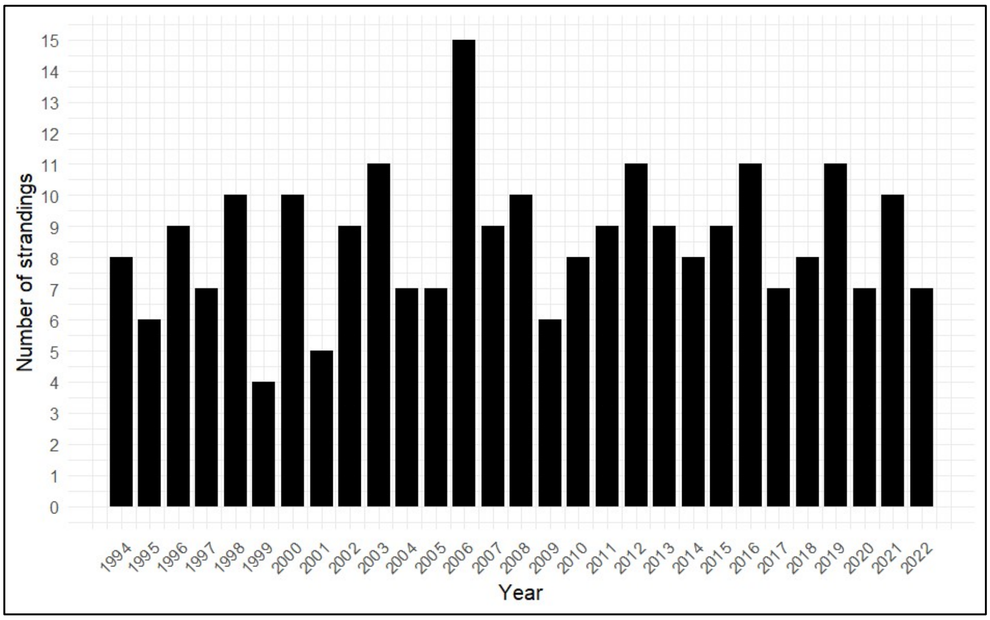


Figure 8: Number of bottlenose dolphin strandings per year between 1994 – 2022 (n = 248).

3.2 Occurrence and site fidelity

Based on stranding data shown in Figure 9, bottlenose dolphins are present year-round along the coast. The mean number of stranding was 0.71 ± 0.29 per month. The greatest number of strandings occurred in August (n = 35, 14%) and September (n = 32, 12.7%), while the lowest number of strandings occurred in December (n = 8, 3.2%). The discovery curve for this population indicates that new individuals join the population regularly, as shown in Figure 10. Of the 301 identified individuals, 152 (49%) were sighted only once (10 females, 142 unknown sex) (Figure 11). For individuals with unknown sex, the mean sighting rate was 2.27 ± 2.59 (range 1 – 13).

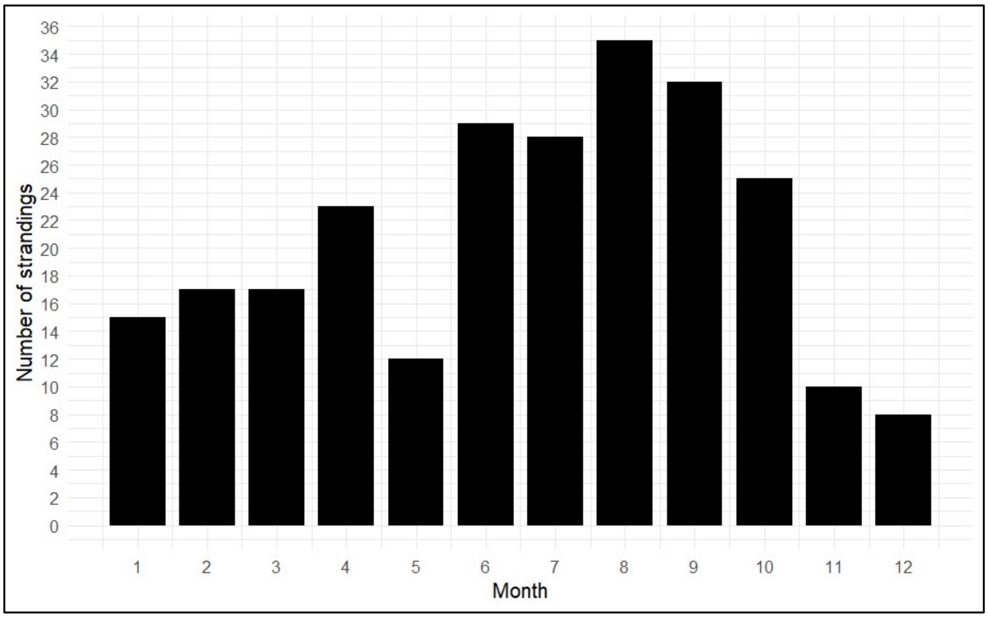


Figure 9: Number of bottlenose dolphin strandings per month between 1994 – 2022 (n = 248).

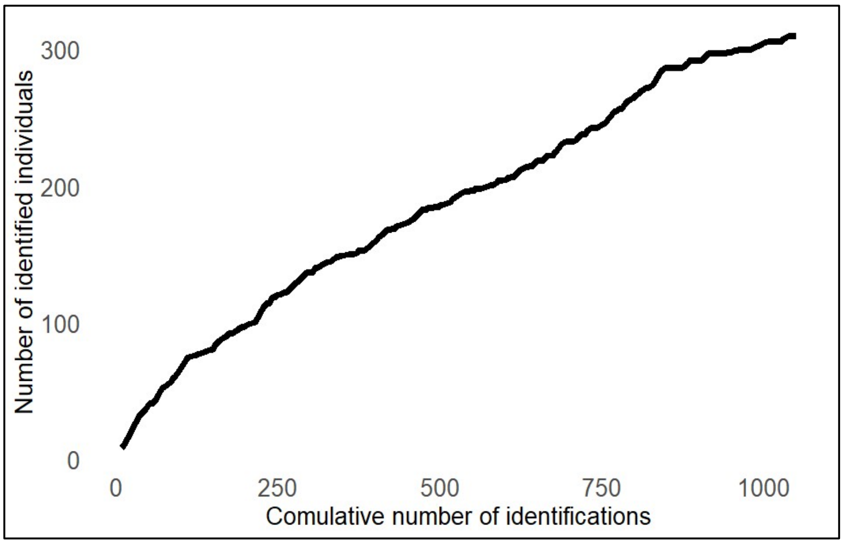


Figure 10: **Discovery curve for the bottlenose dolphins between 2005 – 2023 (n = 301)**

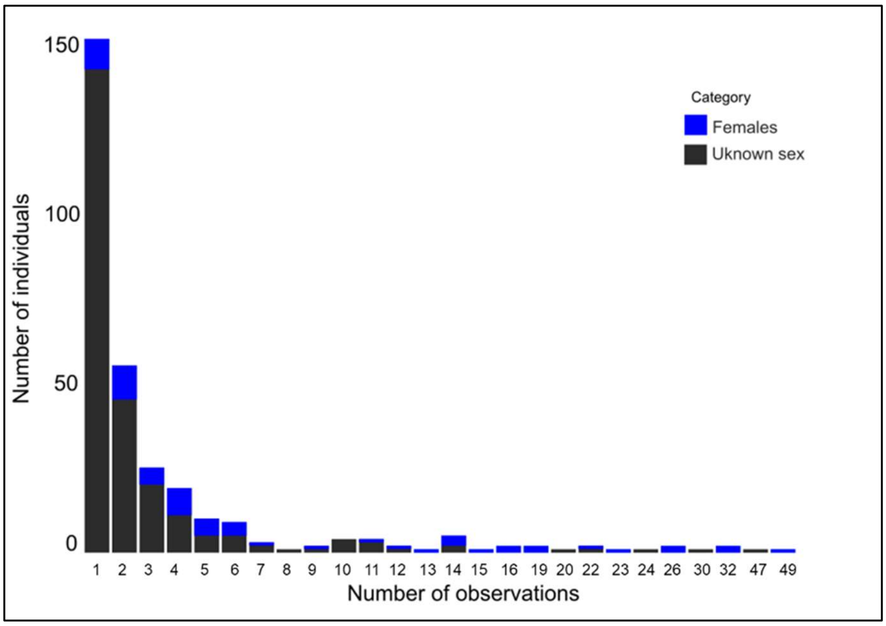


Figure 11: **Histogram of the frequency of observations of bottlenose dolphins between 2005 - 2023 (n = 301)**

61 individually identified dolphins were confirmed as females through their close associations with calves. One was presumed to be male based on observation of the genital slit, and the sex of the remaining dolphins could not be determined. The mean sighting rate for females was 8.4 ± 9.8 (range 1 – 49). The number of years a female was sighted ranged from 1 to 18, with a mean of 4.9 ± 4.16 (Figure 12), compared to individuals with unknown sex (1.64 ± 1.4, range 1 – 13). Ten females were observed during at least half the surveyed years (>9). This indicates that some individuals, particularly

females, used the Israeli coast regularly, while others were present less often. Both yearly and seasonal occurrence rates were low. The mean yearly occurrence rate for females was 0.26 ± 0.22 (range = 0.05 – 0.95). Relative to the total number of seasons surveyed, the mean seasonal occurrence rate was 0.16 ± 0.15 (range = 0.03 – 0.61). There was a significant difference in female sightings between the cold and warm seasons (χ^2 test of equal proportions; $\chi^2 = 4.53$, $p = 0.03$, df = 1), with more observations in the warm season. The frequently observed females (≥5 times, n = 29) presented a mean yearly sighting rate of 0.43 ± 0.2 (range = 0.16 - 0.95) and a mean seasonal rate of 0.28 ± 0.14 (range = 0.11 - 0.61). The mean yearly sighting rate for frequently observed individuals of unknown sex was calculated as a comparison and found to be 0.25 ± 0.13 (range = 0.1 – 0.68, n = 25).

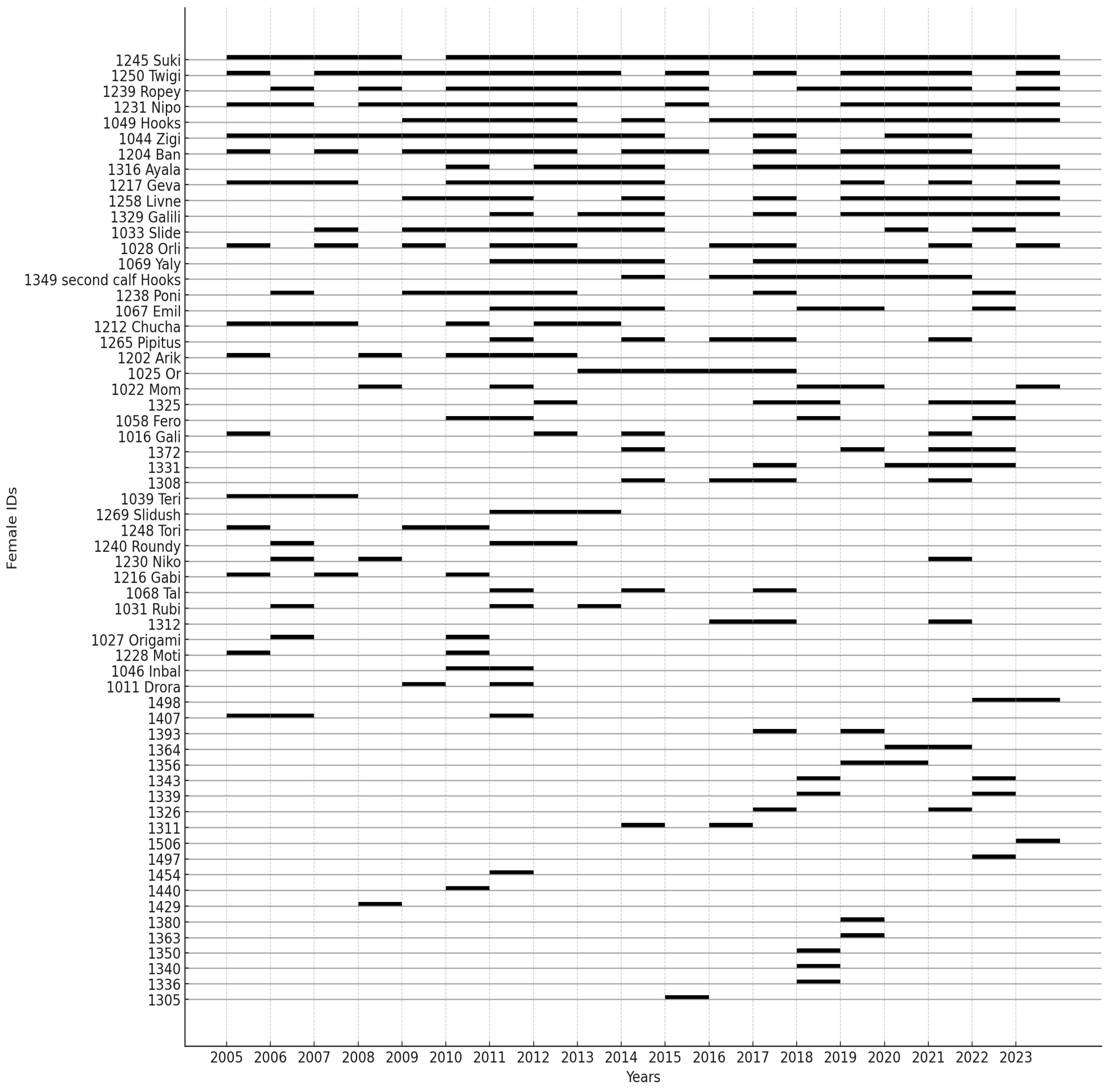


Figure 12: Summary of the yearly occurrence patterns of female dolphins during the study period. The x-axis represents the years, and the y-axis lists the female dolphin IDs, with the most frequently observed individuals placed at the top and the least frequent at the bottom. Black cells indicate the presence of a dolphin in a given year.

Table 3: All female bottlenose dolphins identified through photo ID between 2005 and 2023, including the ID name, number of years sightings, total number of sightings, number of calves, and occurrence (for years = number of calendar years a female was sightings/years of sightings, n = 19; for seasons = no. of seasons a female was sighting/total no. of seasons, n = 38)

Female ID	Years of sighting	Total sighting	No. of calves	Occurrence	
				For years	For seasons
1245 Suki	18	49	7	0.95	0.61
1250 Twigi	14	19	4	0.74	0.39
1044 Zigi	13	32	4	0.68	0.55
1049 Hooks	13	26	5	0.68	0.5
1231 Nipo	13	32	5	0.68	0.47
1239 Ropey	13	26	5	0.68	0.45
1204 Ban	12	22	3	0.63	0.37
1217 Geva	11	19	3	0.58	0.39
1316 Ayala	11	32	4	0.47	0.34
1258 Livne	10	14	1	0.53	0.29
1028 Orli	9	14	2	0.47	0.26
1033 Slide	9	12	5	0.47	0.32
1329 Galili	9	16	3	0.47	0.29
1069 Yaly	8	16	2	0.42	0.29
1067 Emil	7	9	3	0.37	0.21
1238 Poni	7	11	2	0.37	0.24
1349 second calf Hooks	7	11	2	0.37	0.24
1212 Chucha	6	13	2	0.32	0.21
1325	5	5	1	0.26	0.13
1022 Mom	5	5	3	0.37	0.24
1025 Or	5	7	1	0.26	0.16
1202 Arik	5	14	2	0.26	0.21
1265 Pipitus	5	5	3	0.26	0.13
1308	4	5	2	0.21	0.13
1331	4	5	1	0.21	0.13
1372	4	4	1	0.21	0.11
1016 Gali	4	4	2	0.21	0.11
1058 Fero	4	5	1	0.21	0.13
1312	3	3	1	0.16	0.08
1031 Rubi	3	3	1	0.16	0.08
1039 Teri	3	6	1	0.16	0.11
1068 Tal	3	4	1	0.16	0.11
1216 Gabi	3	3	2	0.16	0.08
1230 Niko	3	3	1	0.16	0.08
1240 Roundy	3	6	1	0.16	0.11
1248 Tori	3	5	1	0.16	0.08
1269 Slidush	3	4	1	0.16	0.11
1311	2	2	1	0.11	0.05
1326	2	2	1	0.11	0.05
1339	2	2	2	0.11	0.05
1343	2	2	1	0.11	0.05
1356	2	2	1	0.11	0.05
1364	2	4	1	0.11	0.08
1393	2	2	1	0.11	0.05
1407	2	3	1	0.11	0.05
1498	2	2	1	0.11	0.05
1011 Drora	2	4	1	0.11	0.08
1027 Origami	2	4	1	0.11	0.05
1046 Inbal	2	3	1	0.11	0.08
1228 Moti	2	2	1	0.11	0.05
1305	1	1	1	0.05	0.03
1336	1	1	1	0.05	0.03
1340	1	2	1	0.05	0.05
1350	1	1	1	0.05	0.03
1363	1	1	1	0.05	0.03
1380	1	1	1	0.05	0.03

3.3 Group dynamics

3.3.1 Group size

Group size for the entire population varied between 1 to 33, with a mean of 4.33 ± 3.9. Overall, the mean group size for groups with calves (5.2 ± 4.5, median = 4, n = 129) is significantly higher compared to groups without calves (3.4 ± 2.8, median = 2, n = 115) (Wilcoxon Two-Sample Test, P < 0.001) (Figure 13). The number of calves identified in each group varied from 1 to 8, with a mean of 1.82 ± 1.12. Across different periods, group size showed a significant difference between 2011 and 2016 (Wilcoxon Two-Sample Test, P <0.001, n = 67). The mean group size around bottom-trawler was significantly lower for both groups with calves (4.2 ± 3, median = 4, n = 74) and without calves (2.7 ± 2.1, median = 2, n = 72) compared to non-trawling observations (groups with calves: 6.6 ± 5.9, median = 5, n = 51; non-calves groups: 4.7 ± 3.5, median = 4, n = 37) (Wilcoxon Two-Sample Test, P = 0.002) (Figure 14). Still, while foraging behind the net, groups with calves were larger (Wilcoxon Two-Sample Test, P < 0.001). Furthermore, seasonal fluctuations were observed, with groups containing calves being larger during the cold season (6.4 ± 5.7, median = 5, n = 54) (Wilcoxon Two-Sample Test, P = 0.047), compared to the warm season (4.3 ± 3, median = 4, n = 75) (Figure 15). No differences were found between the seasons for adult-only groups (Wilcoxon Two-Sample Test, P = 0.861).

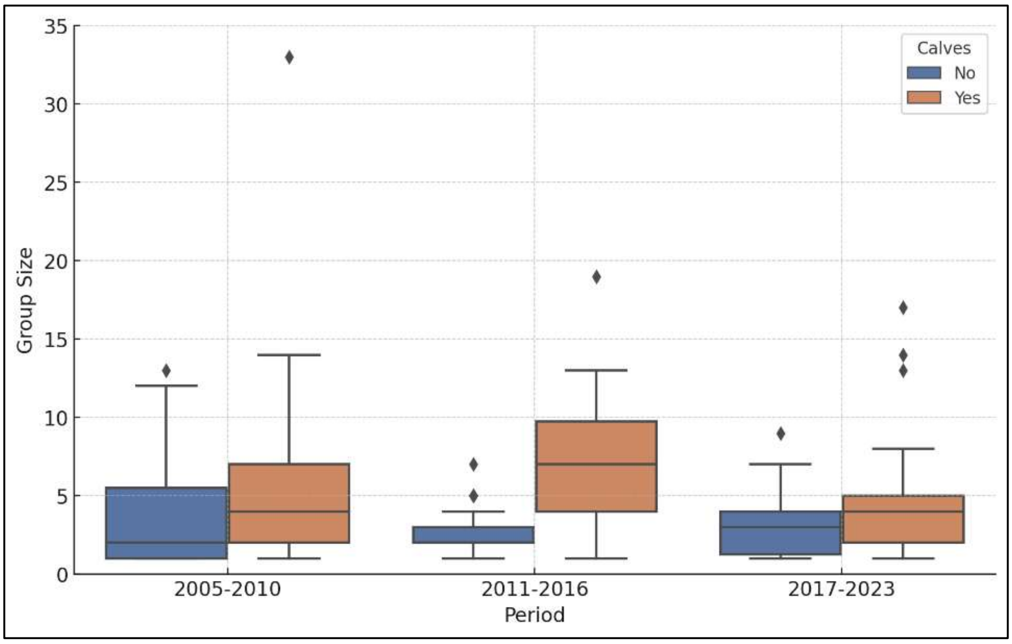


Figure 13: Trends in total group sizes by Presence of calves over time. The boxplot displays the interquartile range and median of total group sizes across three periods, with whiskers extending to data within 1.5 times the IQR and outliers marked by rhombuses.

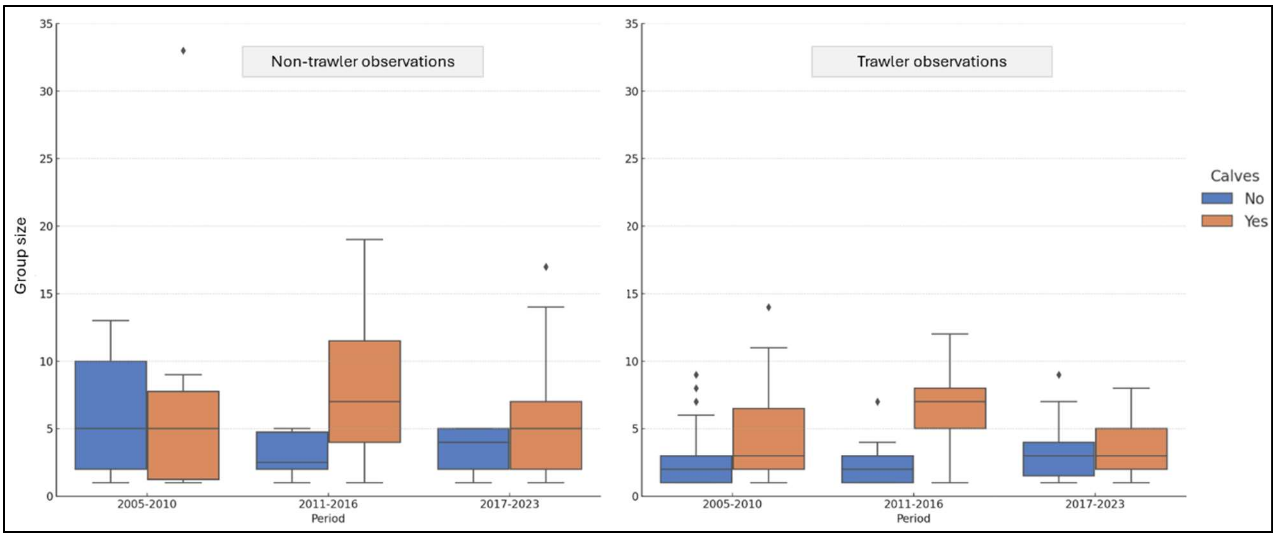


Figure 14: Distribution of Group Sizes by Presence of Calves and Trawler Activity across three periods, with whiskers extending to data within 1.5 times the IQR and outliers marked by rhombuses.

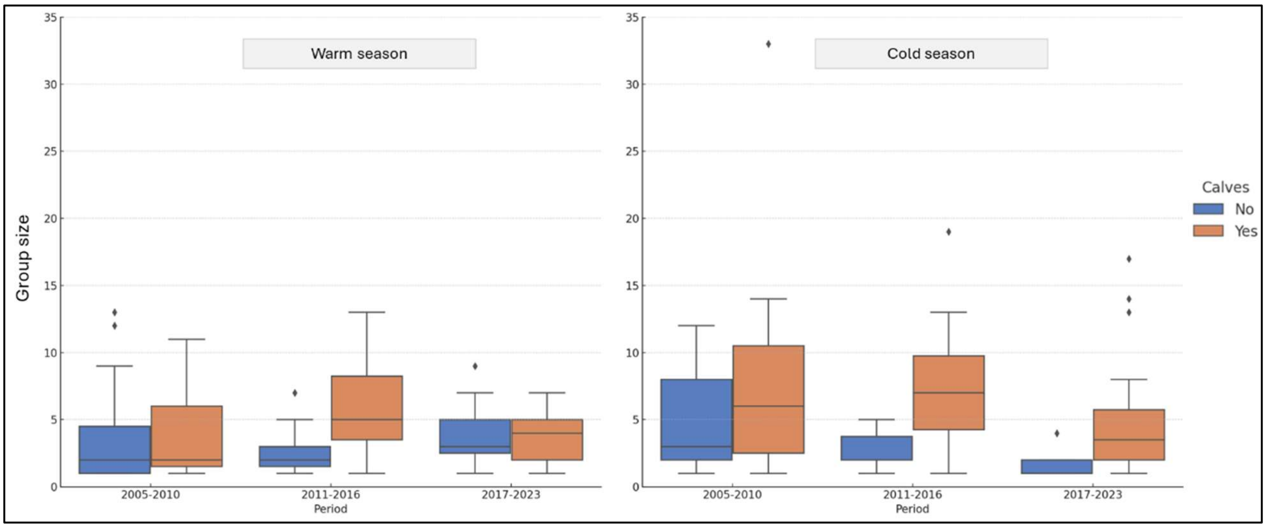
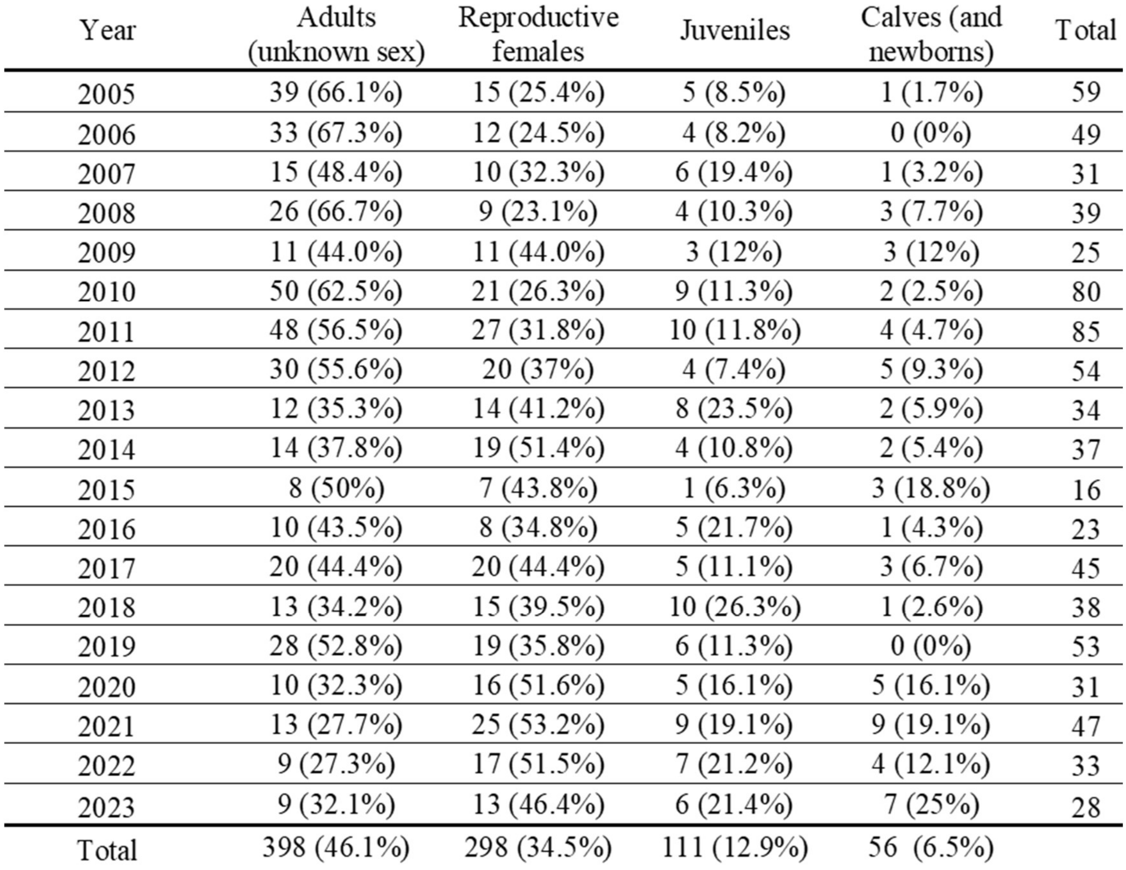


Figure 15: Seasonal Variation in Group Sizes by Presence of Calves across three periods, with whiskers extending to data within 1.5 times the IQR and outliers marked by rhombuses.

3.3.2 Group composition

The proportion of individuals in each age class was obtained based on data collected from 244 groups (Table 3). Reproductive females comprised 34.5% of the group composition, and almost 20% of the identified dolphins were young individuals (juveniles and calves). The proportion of calves (including newborns) was 6.5% and fluctuated throughout the study period, ranging from 0% in 2006 and 2019 to 25% in 2023.

Table 5: Proportion of individuals in each age-class as judged by bode size between 2005 and 2023. Number of individuals observed (and percentage)



Year	Adults (unknown sex)	Reproductive females	Juveniles	Calves (and newborns)	Total
2005	39 (66.1%)	15 (25.4%)	5 (8.5%)	1 (1.7%)	59
2006	33 (67.3%)	12 (24.5%)	4 (8.2%)	0 (0%)	49
2007	15 (48.4%)	10 (32.3%)	6 (19.4%)	1 (3.2%)	31
2008	26 (66.7%)	9 (23.1%)	4 (10.3%)	3 (7.7%)	39
2009	11 (44.0%)	11 (44.0%)	3 (12%)	3 (12%)	25
2010	50 (62.5%)	21 (26.3%)	9 (11.3%)	2 (2.5%)	80
2011	48 (56.5%)	27 (31.8%)	10 (11.8%)	4 (4.7%)	85
2012	30 (55.6%)	20 (37%)	4 (7.4%)	5 (9.3%)	54
2013	12 (35.3%)	14 (41.2%)	8 (23.5%)	2 (5.9%)	34
2014	14 (37.8%)	19 (51.4%)	4 (10.8%)	2 (5.4%)	37
2015	8 (50%)	7 (43.8%)	1 (6.3%)	3 (18.8%)	16
2016	10 (43.5%)	8 (34.8%)	5 (21.7%)	1 (4.3%)	23
2017	20 (44.4%)	20 (44.4%)	5 (11.1%)	3 (6.7%)	45
2018	13 (34.2%)	15 (39.5%)	10 (26.3%)	1 (2.6%)	38
2019	28 (52.8%)	19 (35.8%)	6 (11.3%)	0 (0%)	53
2020	10 (32.3%)	16 (51.6%)	5 (16.1%)	5 (16.1%)	31
2021	13 (27.7%)	25 (53.2%)	9 (19.1%)	9 (19.1%)	47
2022	9 (27.3%)	17 (51.5%)	7 (21.2%)	4 (12.1%)	33
2023	9 (32.1%)	13 (46.4%)	6 (21.4%)	7 (25%)	28
Total	398 (46.1%)	298 (34.5%)	111 (12.9%)	56 (6.5%)	

The Poisson GLM was applied to examine the differences in stranding rates between age classes and seasons. The data were divided into three age classes representing ≤1 year old, sub-adults, and adults. The goodness-of-fit test for this data set showed overdispersion within the model (deviance/df= 1.44). Therefore, the negative binomial model was used to adjust for overdispersion in the data. The reference age class was adults, and no significant difference was found between the age classes (≤1-year-old: $p = 0.1$; sub-adult: $p = 0.15$). Data were then divided into seasons, and the negative binomial model was applied here, too, due to overdispersion in the data (deviance/df= 1.08). When compared to the reference season (e.g., Summer), the expected log count of dead animals was significantly lower compared to all seasons (Winter: $p < 0.001$; Spring: $p = 0.002$ and Autumn $p = 0.003$). The highest number of strandings occurred in summer (June-August) ($n = 92$, 36.7%) for all age classes, and the lowest was in winter (December-February) ($n = 40$, 15.9%).

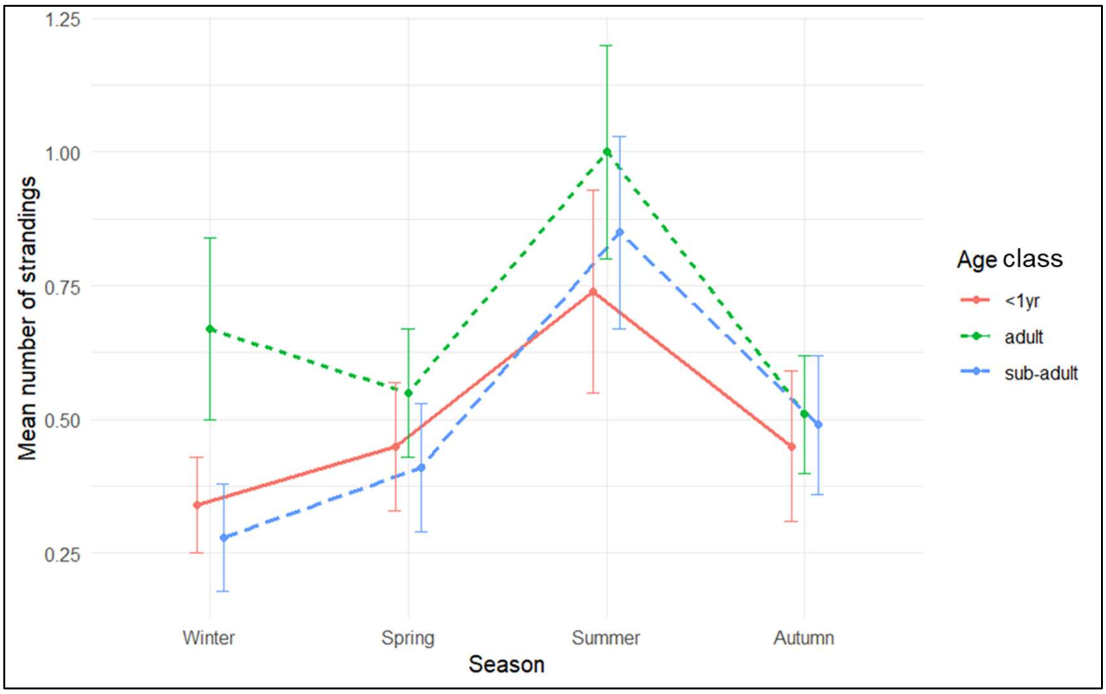


Figure 16: The mean number of bottlenose dolphin strandings by season, divided by age class. Whiskers represent standard error.

3.4 Reproductive parameters

3.4.1 Mothers and calves

Between 2005 and 2023, 517 individual identifications of 61 reproductive females were made. Of these, 48.3% (n = 250) were identified with a calf. The number of reproductive females observed each year ranged from 7 in 2015 to 27 in 2011, with a mean of 15.8 ± 5.6. 61% (n = 37) were sighted with only one calf, 16% (n = 10) with two successive calves, and 23% (n = 14) with three successive calves or more. The maximum number of calves produced by any known female was seven (ID 1245 Suki) (table 2). A total of 114 dependent calves were recorded during the study period, with an average of 2.12 ± 1.86 sightings per calf (range 1 – 14). Hooks's (ID 1049) daughter (ID 1349) was first sighted in 2014 and has been observed for eight years (besides 2015) in the study area with two calves, allowing examination of age at first reproduction, which was ~5 years.

3.4.2 Births

19 newborns were recorded during the study period with an average of 2.7 ± 1.97 each year (range 0 – 7). No newborns were observed in 2016, 2018, and 2019, possibly because they were missed. There were only six observations in 2016 and five in 2018. However, in 2019, there were 20 observations. Once these three years are removed from the calculation, the mean rises to 3.3 ± 1.7 per year (range 1 – 7). There was no correlation between the survey effort and the number of births recorded annually (Pearson correlation, R = 0.084, t = 0.34, p = 0.73). Thus, the variation in the number of births per year could not be explained by the variation in survey effort.

3.4.3 Calving rate and fecundity

To prevent bias, the years 2016, 2018, and 2019 were excluded from the subsequent calculations. Annual calving rates ranged from 0.07 to 0.44, with a mean of 0.2 newborn/reproductive females/year (95% binominal CL 0.02 – 0.42). The estimated fecundity for the population ranged from 0.04 and 0.33 and was 0.11 ± 0.1 (n = 8) (table 4).

Table 4: Annual calving rate and Fecundity between 2005 and 2023

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
calving rate	0.07	0.08	0.10	0.44	0.36	0.10	0.15	0.25	0.14	0.10	0.43	-	0.10	-	-	0.31	0.28	0.29	0.31
Fecundity	0.07	-	-	0.33	0.09		0.11	0.05	-	-	-	-	-	-	-	0.13	0.04	0.06	-

3.4.4 Birth seasonality

The month of birth was assigned through phothoID data for 15 calves from 12 known females. The estimates were accurate to within one month for three calves (20%), within two months for two calves (13.3%), within three and four months with one calf each (6.7%), within five months for six calves (40%), and six months for two calves (13.3%). New-born calves were sighted from April to October, and two newborns were recorded in January. Most births (64.29%) were recorded from June to August (n = 9), with a pick in July (35.71%), coinciding with the annual peak in sea surface temperatures. All stranding records (n = 7) occurred between April and September, with three-stranded newborns in June (42.86%). There is a moderate positive correlation between sea surface temperature and the number of births, but this correlation did not reach significance. (Spearman correlation, r = 0.55, P = 0.06, n = 22) (Figure 17).

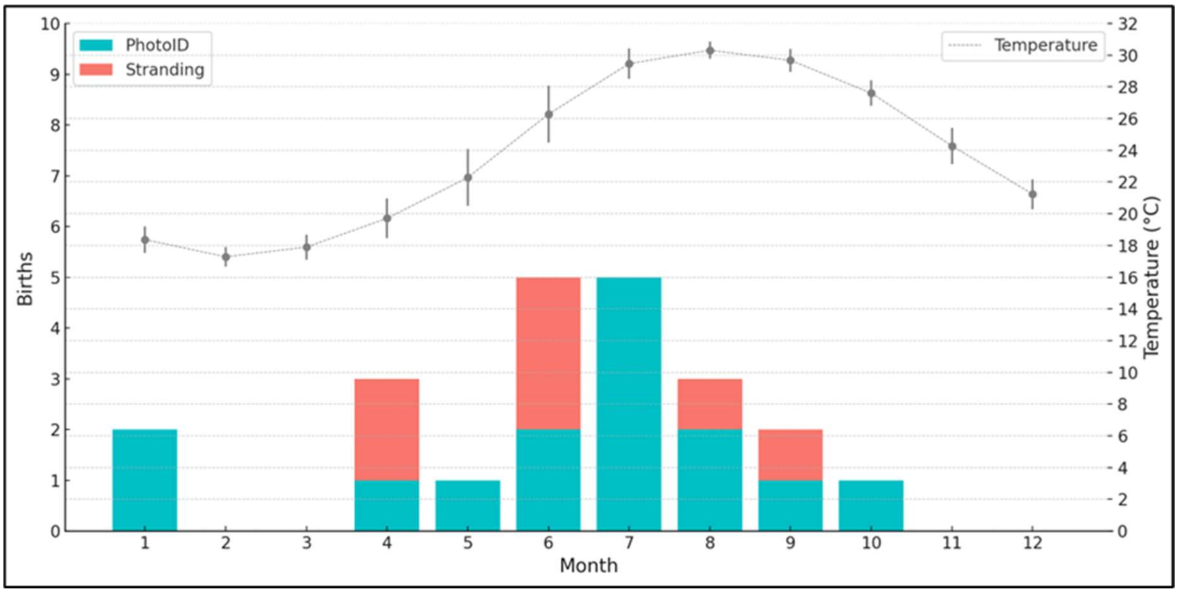


Figure 17: Birth seasonality based on photo ID (2005 – 2023) and stranding data (1994 – 2022) aligned with mean monthly temperature (dashed line). Whiskers represent standard error.

3.4.5 Interbirth intervals (IBI) and weaning age

The mean IBI was calculated for six females and was 2.84 ± 0.87 years (median = 2.6, n = 11), ranging from 1.89 (ID 1245 Suki) to 4.4 years (ID 1250 Twigi) (Figure 18). DOB was known for six calves. Excluding the three intervals of calves whose fate was unknown, the mean IBI was 2.97 ± 0.96 years (median = 2.59, n = 8). Notably, female 1329 (Galili) lost her calf less than six months after birth due to an incidental catch in a gill-net. This is the only instance where a calf's date of birth and death are known, enabling the calculation of IBI following calf loss, which was 1.5 years until the appearance of a new calf.

Figure 18: Interbirth interval of 6 female bottlenose dolphins
For calves that survived to age one (n = 8) and calves with unknown fate (n = 3).

The weaning period was calculated for four calves with known birth dates. The mean weaning age was 2.61 ± 0.48 years, ranging from 2.13 to 3.4 (Table 5). One calf born to a provisioned female (Suki's fifth calf) maintained a strong association with its mother for more than seven years, even after the birth of her new calf (4.1 years after the first sighting of the fifth calf). However, the calf was also observed occasionally independent of its mother.

Table 5: **weaning age for Israel's bottlenose dolphins** Between 2005 and 2023, including female ID, calf's number, years of occurrence, and weaning age in years.

ID	No. of calf	Years of occurrence (n)	Weaning age (yrs)
1245 Suki	5	2017-2024 (7)	3.4
	6	2021-2023 (3)	2.13
1316 Ayala	2	2018-2021 (4)	2.52
1044 Zigi	2	2008-2010 (3)	2.42

3.4.6 Survival estimates

In total, 16 CJS capture-recapture models were run to investigate survival and capture probability for 276 adults and 112 calves. Test for goodness-of-fit for this data set showed a significant lack of fit ($\chi^2 = 147.84$, p = 0, df = 69) with overdispersion occurring within the model ($\hat{c} = 2.14$). Therefore, the variance inflation factor was used to adjust for overdispersion in the data. The most parsimonious model for survival suggests that survival varied in response to age class, while capture probability varied in response to time (table 6). The evidence ratio between the first and second models was 25, indicating that the first model is effectively the only one that fits the data well and supports the first model as the best fit. The preferred model estimated an adult's apparent survival of 0.80 (95 % CI 0.77–0.82). The model accounting for calves estimated survival probabilities of 0.52 (95 % CI 0.43–0.60) and 0.73 (95 % CI 0.55–0.86) for first-year calf survival. The estimate for capture probability showed variation with time, with the lowest estimate in 2015 (= 0.16, 95% CI: 0.09-0.23) and the highest in 2010 (= 0.81, 95% CI: 0.67-0.90) for adult dolphins. The capture probability of calves was not considered because their abundance depends on their mothers. The median capture probability across all sample occasions was 0.41, meaning that in 50% of the study period, 41% or less of the marked population was recorded.

Table 6: CJS models applied from mark-recapture data
Summary of all CJS models for survival (Phi) and recapture (p) probabilities applied to the dataset. Models are ranked according to the lowest QAICc and ΔQAICc, and the highest Akaike weight. QDeviance is the measure of the GOF of the model, and npar refers to the number of parameters.

Model	npar	QAICc	ΔQAICc	Weight	QDeviance
Phi (~group) p (~time)	21	954.25	0	0.933	464.92
Phi (~group) p (~group)	6	960.68	6.43	0.037	502.43
Phi (~group) p (~effort)	5	961.76	7.51	0.022	505.55
Phi (~group) p (~1)	4	964.01	9.77	0.007	509.83
Phi (~1) p (~time)	19	971.86	17.61	0	486.75
Phi (~effort) p (~time)	20	973.41	19.16	0	486.20
Phi (~1) p (~effort)	3	979.70	25.45	0	527.53
Phi (~1) p (~group)	4	979.72	25.47	0	525.53
Phi (~effort) p (~effort)	4	981.14	26.89	0	526.95
Phi (~1) p (~1)	2	981.52	27.28	0	531.37
Phi (~effort) p (~group)	5	981.56	27.31	0	525.35
Phi (~effort) p (~1)	3	983.19	28.94	0	531.02
Phi (~time) p (~time)	36	991.07	36.82	0	469.44
Phi (~time) p (~group)	21	991.39	37.14	0	502.06
Phi (~time) p (~1)	19	993.93	39.69	0	508.82
Phi (~time) p (~effort)	20	994.70	40.45	0	507.49

4. Discussion

4.1 Population dynamics

4.1.1 Pattern of habitat use

Bottlenose dolphins have been observed along the Israeli coast year-round throughout the study period, as confirmed by photo ID and stranding data. The distribution of stranding estimates and the annual number of individuals identified through photo ID suggest a stable population with no significant trends observed, supported by previous studies conducted in the area (Galili et al., 2023; Mevorach, 2021; Scheinin et al., 2010; Zuriel et al., 2023). However, there were slight variations in observation frequency throughout the study period. Some known dolphins were observed repeatedly along the coast, while others disappeared completely, and new individuals joined the cataloged population regularly. Throughout the study period, 49% of the identified individuals were observed only once (n = 151, 9 females and 142 unknown sex). The discovery curve (Figure 10) showed a steady accumulation of new individuals over the years, suggesting a stable yet open population structure. The absence of a plateau in the curve indicates that new individuals continue to join the population, either through birth or immigration, while others may die, leave the study area or go undetected due to limited sightings. Studies on bottlenose dolphin populations in semi-enclosed bays have observed that discovery curves for identifying new individuals can reach an asymptote after a few surveys. In the Kvarneric, North Adriatic Sea, the asymptote reached after 75 surveys (Bearzi, 1997). In the Gulf of Ambracia, Greece, the discovery curve exhibited an asymptotic pattern after a year of surveys (Gonzalvo et al., 2016). In Moray Firth, Scotland, the discovery curve suggested a population close to permanent immigration. The slight increase in the curve over time represented an addition of ~4 new individuals/yr. On average, six neonate calves were observed each year; this can readily be explained by the recruitment of surviving calves into the marked population (Wilson et al., 1999). When examining populations from open coastal waters, such as in the Strait of Sicily (Papale et al., 2017) and in Madeira, Portugal (Dinis et al., 2018), discovery curves show steady slopes similar to those in the present study. This slope does not necessarily indicate an increase in population size but rather highlights the dynamic nature of the population, with new dolphins being captured in the dataset and some previously identified dolphins not being resighted.

In the current study, 244 sightings of bottlenose dolphins were recorded. 79% (n = 192) of the sightings included females, and 53% (n = 129) included calves. Most sightings occurred near bottom trawlers (62.39%, n = 146), which was found to be the predominant behavior among the Israeli population of bottlenose dolphins (Scheinin et al., 2014). Given that trawlers provide an essential source of available energy, particularly for mothers with calves (Fertl, 1997), it was expected that encounters with groups containing calves would be more frequent near trawlers, potentially introducing a bias toward calf observations. However, this was not the case. Although calves were more frequently observed near trawlers, the difference was insignificant (Figure 7). The trend remained consistent even without trawlers, indicating that most observations in the study area throughout the year included females with calves. Furthermore, as a population residing in ultra-oligotrophic waters, these dolphins exhibit a notable dependence on the local bottom-trawl fleet (Scheinin et al., 2010). Foraging around trawler nets was observed across the entire population, highlighting their reliance on this food source (Mevorach, 2021).

Although bottlenose dolphins were never absent from the study area, site fidelity and residence patterns of identified individuals suggest different degrees of residency among the dolphins using the study area. The mean sighting rate was low throughout the study period, but females showed higher sighting rates than individuals of unknown sex. When comparing site fidelity and residency estimates among bottlenose dolphin populations, caution is necessary due to variations in population sizes and habitat characteristics (such as prey and predator availability) and the diverse sampling and analytical techniques employed to estimate these parameters. Worldwide, bottlenose dolphin populations display variation in their occurrence patterns, distribution, and site fidelity. Within a population, individuals have been observed showing varying levels of residency, from exclusively resident (Wilson et al., 1999) to seasonal residents (Lodi et al., 2014) or transients (Silva et al., 2008). High site fidelity and residency are typical of bottlenose dolphins in protected coastal areas with high prey availability and low predation risk (Bearzi, 1997; Zanardo et al., 2016). Conversely, low levels of site fidelity are typical of dolphins that exhibit large-ranging patterns in areas of lower productivity, where prey availability is highly variable in space and time (Ballance, 1992; Defran et al., 1999). In Israel, most dolphins exhibited low yearly and seasonal sighting rates, with only a core group frequently observed and remaining in the area for extended periods. The observed population is probably a part of a larger, wide-ranging population, with some individuals displaying a higher level of residency. Based on sightings distribution and occurrence rates, females showed a higher site fidelity than other individuals, consistent with findings reported in the Strait of Sicily (Papale et al., 2017) and the Southern Gulf of Mexico (Morteo et al., 2014). The most common pattern observed in terrestrial mammals is male-biased dispersal with female philopatry (Flanders et al., 2016), which has also been observed in some cetacean populations (Connor et al., 2000; Morteo et al., 2014), where differences in dispersal have been associated with different reproductive strategies and competition for resources (Scott et al., 1990). Sex-related dispersal patterns in bottlenose dolphins are often attributed to differences in reproductive requirements and as a strategy to prevent inbreeding (Krützen et al., 2004; Parsons et al., 2003; Rogers et al., 2004). These differing movement patterns between males and females can influence the number and availability of group partners and potential mates, reinforcing sexual segregation. Moreover, this suggests that males may play a primary role in gene flow among adjacent locations, as observed in some other dolphin communities (Morteo et al., 2014; Natoli et al., 2004; Smolker et al., 1992). The high variability of resident patterns among identified females in this study suggested a dynamic pattern of habitat use; some were not observed in several subsequent years, then returned; others had oscillating resighting patterns over many years. Of the 61 females, 50 (82%) were sighted in multiple years, most of them (36 of 50) in consecutive years (range 2 – 13 years). Of the 61 identified females, the core group (≥5 sightings) includes 28 females that resighted in 3 or more years. Within this core group, some females demonstrated strong site fidelity. Two females from the core group, Arik (ID 1202) and Chucha (ID 1212), have not been observed in the past eight years. Five females were observed from the beginning of the study (2005) through the end of the study period (2023), with a mean yearly occurrence rate of 0.68 ± 0.16 (range 0.47 – 0.95). Four of these females were observed for several consecutive years (range 2 – 7 years) but were also absent in some years. Suki (ID 1245), the most observed individual, sighted 49 times over 18 years (all study years except 2016). This suggests that some females may prefer this region as their main habitat and may temporarily leave the area over a larger range (Papale et al., 2017). The observed variation in female occurrence rates may also be attributed to methodological factors. Resident females might have been present year-round in the study area but were not encountered during surveys, not photographed, inadequately photographed (preventing identification), or photographed well but not subsequently recognized during photo identification analyses. Moreover, the large study area and varying sea conditions could impact the ability to detect individuals. Any of these factors could contribute to the variation in sighting rates of resident females. Similarly, these factors might also lead to misidentifying resident dolphins as transient due to their low sighting rates. Differences in habitat use among mature females may be explained by their need to balance the priorities of energy demands and calf protection, likely driven by the varying socio-ecological strategies of individual females (Gibson et al., 2013). The energetic demands of lactation are high for female odontocetes; caloric intake is more than 40% higher during lactation than during pregnancy and estrous (Rendell et al., 2019). If meeting these energy requirements is the higher priority, females with calves may require larger core areas to ensure sufficient energy intake. Conversely, if protecting their offspring is the higher priority, females with calves may confine themselves to smaller core areas in shallow, sheltered parts of their home range (Gibson et al., 2013).

In Israel, there are limited food resources (Sharir et al., 2011), and it is possible that trawling has an important effect on dolphin distribution, as documented in the Adriatic Sea (Bonizzoni et al., 2023). Despite the physical risks, feeding on bycatch offers dolphins an easy meal, enabling them to conserve energy that would otherwise be used for foraging while still providing a high caloric intake benefit (Fleming, 2004). A female who knows how to exploit this resource has an advantage, as she gains the necessary caloric intake and improves her chances of raising a healthy calf (Bernard & Hohn, 1989). As intelligent animals with an opportunistic approach (Greenman et al., 2012), some dolphins appear to have learned to exploit human fishing activities to their advantage. Mothers are believed to teach these behaviors to their calves, passing on these foraging skills to the next generation (Fertl, 1997). This resource likely constitutes a primary food resource for the local females and may be the reason for this residency pattern. Moreover, it is possible that only the individuals who learned how to feed from the trawlers could stay, while the others had to periodically or permanently move on to forage elsewhere.

Several studies have described nursing areas as a specific region within their habitat when females with calves are observed more frequently (Barco et al., 1999; Gibson et al., 2013). These areas are typically characterized by shallow, protected waters that provide safety from predators, stable environmental conditions, and an abundant food supply (Gibson et al., 2013). For example, Scott et al. (1990) found that females with neonates spent more time in particular geographic areas than other dolphins in Sarasota Bay. These nursery areas were protected and shallow and offered high prey availability for the energy demands of lactating females. Depending on environmental conditions and resource availability, nursing areas can be utilized year-round or seasonally. In the southern end of Port Phillip Bay, Australia, adult-calf groups were present in the study area throughout the year, suggesting that the area may serve as a nursery ground for bottlenose dolphins (Scarpaci et al., 2003). A study in the Mississippi Sound found that dolphins utilize coastal areas more during the summer, potentially as nursery grounds, with a higher presence of calves during this season, suggesting seasonal use of these areas due to favorable conditions (Miller et al., 2013). A study in the Indian River Lagoon, an estuary on the east coast of Florida, was the first that quantitatively assessed female ranging patterns with respect to their reproductive status (Gibson et al., 2013). The study found that females continued to use a large proportion of their overall range, but concentrated in different areas depending on their reproductive status. Although it was not significant, most females had smaller home ranges and core areas when observed with a dependent calf, particularly during autumn. In Israel, calves were present throughout the year (as documented through photo identification and stranding data), with seasonal fluctuation and more observations during the warm season. Given that most surveys in the study area were conducted in relatively shallow areas of 30-60 meters, this area may serve as an essential calving and nursery ground, and summer may provide favorable conditions for rearing calves. Numerous studies have shown that female bottlenose dolphins play a vital role in shaping and maintaining the community's social arrangement and in the conservation of the population (Blasi & Boitani, 2014; Mann et al., 2000). However, a more detailed investigation of this issue was not possible due to limited observations, large intervals between sightings, and a small sample size. Further research is needed to gain a deeper understanding of their habitat use.

Bottlenose dolphins in the Eastern Mediterranean Sea, including the Levantine Basin, exhibit clear genetic differentiation from other regions (Bearzi et al., 2009). Evidence of limited gene flow between the Eastern Mediterranean and other regions suggests that the population in this area may experience a certain degree of isolation. (Natoli et al., 2005). Although the population boundaries are unknown, it is estimated to extend northward to Lebanon and southward to Gaza. Considering the likelihood that the study area serves as a nursery ground and that males predominantly facilitate gene flow (Morteo et al., 2014), it is plausible that this area plays a role in connecting gene flow between the northern and southern regions. Furthermore, evidence suggests gene flow occurs between pelagic and coastal populations within this region (Gaspari et al., 2015). Future investigations of population structure are needed to fully comprehend the complex population dynamics and the influence of local environmental factors on population structure. Moreover, future deep-water surveys and collaboration with neighboring countries should provide better insight into their home range.

4.1.2 Group Dynamics

The mean group size for identified dolphins in the study was 4.33 ± 3.9, smaller but compatible with other populations in Mediterranean coastal waters (Bearzi, 1997). This group size is typical for coastal populations living in areas with limited and dispersed food resources (Rogers et al., 2004) and is probably related to foraging behavior (Semeráková, 2022). Moreover, a smaller group size would be expected when the predation risk is low (Rogers et al., 2004). In the coastal waters of the Mediterranean, the average group size is typically around seven individuals (Bearzi, 1997; Maria Fortuna, 2006), as found in the Eastern Ionian Sea (6.8 ± 4.2) (Bearzi et al., 2005) and in Lampedusa Island, Italy (6.09 ± 3.37) (Pace et al., 2012), while in the Aeolian Islands, the mean group size was 12 ± 7 (Bearzi et al., 2009). Groups that included calves were larger than adult-only groups (Figure 13) and have been related to the potential advantages, including enhanced calf assistance and protection, reduced maternal investment, and the benefits of learning for its young members (Norris & Dohl, 1980). The group size near the bottom trawl was smaller, and groups with calves followed a similar pattern as larger groups (Figure 14). This smaller group size can be attributed to the high competition and the limited space and resources within the trawl net (Bezamat et al., 2020). Similar findings were observed in other studies (Bearzi et al., 1999; Rogers et al., 2004), usually when feeding on patchy prey concentrated in limited areas. Forming larger groups allows mothers to spend a greater proportion of time foraging by being assisted by other females in caring for young calves (Methion et al., 2023). Moreover, groups containing calves were larger during the cold season (Figure 15). The seasonal variation in group size is likely influenced by the number of observations between trawler-associated groups (n = 119) and non-trawler groups (n = 217) during the cold season, compared to the warm season (trawler: 194; non-trawler: 120). Another explanation could be a spatial variation in local conditions during winter that may affect group size (Tezanos-Pinto, 2009). The addition of new individuals into the population and the leaving of others affected the general social structure (Mevorach, 2021) and may explain the variations in group size between the periods. Additionally, dolphin group size fluctuations may reflect human activities' impact on coastal ecosystems (Methion et al., 2023). In Israel, these changes could be associated with the implementation of trawler activity restrictions starting in 2017 and shifts in targeted fish species that occurred multiple times during the study period (Galili et al., 2023; Scheinin et al., 2010). There was not enough data to explain how the changes in trawler activities affect population dynamics, and further investigation is needed.

The proportion of age-class groups in the study area over comparative periods was similar, despite some fluctuations in the proportion of calves and newborns observed throughout the years (Table 3). These variations may be due to differences in the number of individuals utilizing the Israeli coast each year and captured during the study. Additionally, changes in age class composition between periods could be attributed to birth pulses occurring in certain years (Haase & Schneider, 2001). A similar finding was reported in Doubtful Sound, New Zealand, where periodic fluctuations in calving were attributed to a group of females synchronizing their births and being more successful at rearing calves than other groups (Henderson et al., 2014). Moreover, An increased proportion of newborns or calves in a particular year may be due to several females simultaneously reaching sexual maturity and giving birth around the same time (Tezanos-Pinto, 2009). It may also explain the variations in calving rates and fecundity (see 4.2.1). Overall, 6.5% of the dolphins sighted were calves (including newborns), while in other studies, the proportion of calves was ~10% (Tezanos-Pinto, 2009; Weigle, 1990; Wursig, 1978).

The division of the stranding data into age classes did not show significant differences. When data were pooled into seasons, more strandings were recorded during the summer for all age classes (Figure 16). Seasonal differences in the frequency of strandings could result from variations in oceanographic and climate conditions, indicate local changes in distribution and/or abundance, or result from the combination of both factors (Silva & Sequeira, 2003). The sea conditions experienced during summer not only tend to push carcasses to shore but also could contribute to the death of weak, injured, or young animals. Fermentation processes in their stomachs occur much faster in warmer water, causing rapid positive buoyancy, which may drift the carcass toward the shore. In winter, they may sink and be consumed before the fermentation process occurs (Moore et al., 2020; Noren & Wells, 2009). Moreover, as endothermic animals, dolphins depend on blubber and internal metabolic processes to maintain a stable body temperature (Mintzer & Fazioli, 2021). Bottlenose dolphins perform unique thermoregulatory responses to avoid hyperthermia (Heath & Ridgway, 1998), and it is possible that the energetic costs of this mechanism increased their vulnerability. However, it is well-studied that bottlenose dolphins migrate to warmer water due to a combination of ecological and environmental factors (Miller et al., 2013; Mintzer & Fazioli, 2021). These results coincide with the higher sighting rates and the number of births observed in the summer, suggesting seasonal migration into the study area during the warm months. The sex ratio of stranded dolphins was almost equal, minimizing the probability of sex segregation in the study area (Morteo et al., 2014). Although sex and body size remained unknown for some of the individuals recorded in this study, there is no reason to believe this would consistently affect a single gender or age class. In addition, beach attendance is higher in the summer, which can increase the number of carcasses found and reported. Mortality causes were mostly unknown, and further investigation is crucial to better understand factors influencing the population dynamics and mortality causes.

4.2 Females' reproductive parameters

4.2.1 Calving rate and fecundity

The annual calving rates were slightly lower but remained comparable to findings from other studies on bottlenose dolphins (Baker et al., 2018; Tezanos-Pinto, 2009). Some years have wide confidence intervals, indicating high uncertainty in the estimates. This can be due to small sample sizes or high variability in the data. The population's fecundity, which accounts for births surviving beyond one year, aligns with the fecundity rates reported for bottlenose dolphins in other regions (Baker et al., 2018; Fruet et al., 2015; R. S. Wells & Scot, 1990). Since their wider habitat range, some females may have given birth elsewhere. Still, both calving rates and fecundity were likely underestimated. First, some calves could have been born and died before being recorded (Steiner & Bossley, 2008). Additionally, although the number of calves observed each year was higher, the absence of detailed records on the approximate age of calves and/or their birth dates, coupled with the lack of information on the calves' fates and large intervals between observations, resulted in the exclusion of most calves from the analysis. Consequently, the actual calving rates and fecundity are likely higher than reported. This underscores the need for more precise data collection to reduce uncertainty. Expanding survey efforts and incorporating new technologies, such as tag attachment devices (TADpole) (Moore et al., 2024), can help address these knowledge gaps. Despite the limited sample size, the results suggest that the reproductive capacity of the Israeli bottlenose dolphin population is potentially relatively good.

4.2.2 Birth seasonality

Birth seasonality was first documented in the study area by Scheinin et al. (2010), who found that most births occur during the warm months, but it was not statistically tested due to a small sample size. The study found a moderate positive correlation, indicating that higher sea temperatures may be associated with increased births (Figure 17). However, this correlation did not reach statistical significance, likely due to the limitations of the small sample size, which reduces the power to detect true relationships and increases the risk of Type II errors, where a true effect is present but not detected (Bishara & Hittner, 2012). This rise in births during the warmer months, coinciding with higher water temperatures, reflects a general breeding pattern observed in other regions globally, including the Mediterranean Sea (Bearzi, 1997; Blasi et al., 2020; Fruet et al., 2015; Kogi et al., 2004; Mann et al., 2000; Thayer et al., 2003; Urian et al., 1996; R. S. Wells et al., 1987). However, bottlenose dolphins are flexible in the timing of their reproduction. Although births are diffusely seasonal, individual females can give birth throughout the year (Dos Santos & Lacerda, 1987). Warm water might influence birth seasonality since it is known to be thermally efficient for both the mother and the calf (Mann et al., 2000). During the warmest months, the energy demand on lactating females is reduced, and newborns require less energy to regulate body temperature (Wells et al., 1987).

4.2.3 IBI and weaning age

While the interbirth intervals of 3 years calculated in the study area fall in the range of some areas (Figure 18), such as New Zealand and Southern Brazil (Fruet et al., 2015; Haase & Schneider, 2001), intervals greater than three years were found to be more common among bottlenose dolphins, as reported in other studies (Robinson et al., 2017; Rutland, 2018). In most studies, shorter IBIs (1-2 years) are often attributed to the loss of calves within their first year of life (Fruet et al., 2015). This may explain the longer IBIs observed after excluding calves with unknown fates from the calculation. It is possible we missed longer IBIs due to low sighting rates. However, two years between successive births have been observed for three females (1245 Suki, 1316 Ayala, and 1231 Nipo) with surviving calves. Even though the sample size is small, it is an unusual pattern for bottlenose dolphins. Shorter IBIs are typically common in areas with optimal conditions for bottlenose dolphins (Fruet et al., 2015). Longer periods of parental care may be explained by differences in nutrition levels, age, body size, and the time it takes a calf to become proficient at catching prey (Tezanos-Pinto, 2009). Alternatively, the IBI might be extended following a fetal loss, leading to the weaning of the previous calf for an additional year (Mann et al., 2000). Moreover, higher IBIs were observed between surviving first and second-born calves in young mothers, presumably reflecting the high energetic cost incurred in first-calf production (Robinson et al., 2017). Due to limited observations, we could measure the IBI between the first and second calves for only two females, Nipo (ID 1231) and Ban

(ID 1204). The IBI for these individuals was 2.61 years and 2.7 years, respectively. It is expected that in less productive areas with limited food resources, IBI would be longer. Although our sample size was small, the results appear to be on the lower end of the spectrum. There are several possible reasons for shorter IBI. Due to the environmental conditions in the Levantine basin, female individuals in this area exhibit accelerated early growth compared to other sub-populations, reaching their final length 5–8 years earlier than their counterparts in the western North Atlantic (Kerem et al., 2013). This rapid early growth may also suggest earlier physical maturation (Perrin & Reilly, 1984). During the study, the age at first reproduction was recorded only once, representing the minimum observed age of sexual maturity for females (Peddemors, 1989). Given these factors, it is suggested that female calves grow faster and may spend less time with their mothers in the study area, potentially contributing to a shorter IBI. Additionally, the variations in IBI may contribute to differences in maternal condition (Hill et al., 2007). On the other hand, there is a possibility that calves survived to age one but did not survive until weaning. In three cases out of eight included in this analysis, the calves were no longer seen with their mother after two years, which may bias the estimation downward if the calves died. The minimum IBI observed in the study area following calf loss was 1.5 years.

The mean IBI (2.97) and the mean weaning age (2.61) may indicate that dolphins in the study area tended to wean their current calf at about mid-pregnancy, as reported for other bottlenose dolphin populations (Mann et al., 2000). Due to low sighting rates, gaps between observations, and the short periods most females remain in the study area, we could only determine the weaning age for four calves (table 5). However, our findings align with previous estimates in other populations (Blasi et al., 2020; Fruet et al., 2015).

4.2.4 Survival estimates

Overall, bottlenose dolphins in the study area exhibited lower apparent survival rates across all age classes than those reported in other studies (Baker et al., 2018; Currey et al., 2009; Fruet et al., 2015; Ludwig et al., 2021; Tezanos-Pinto et al., 2015; R. S. Wells & Scott, 1990). The annual adult survival rate was estimated at 0.80 (95% CI: 0.77–0.82), remaining relatively constant throughout the study period. A slight decline in the survival rate was observed compared to previous findings from the same area using the same method (0.83 ± 0.01, 0.80 – 0.86) (Mevorach, 2021). However, no increase in stranding rates was detected over the years (Figure 8). The reduction in survival rates may be attributed to the low capture probabilities recorded during the two additional years included in the current analysis (2022: 0.38 ± 0.06, 95% CI: 0.25–0.52; 2023: 0.5 ± 0.08, 95% CI: 0.34–0.66). Several studies have indicated that in slow-growing populations, adult survival typically has a greater influence on population growth than reproductive rates (Brault & Caswell, 1993; Heppell et al., 2000). However, when survival rates remain relatively constant while reproductive rates fluctuate, as observed in the current study, variations in reproduction may have a greater impact on population viability (Manlik et al., 2016).

This study was the first to calculate the annual calf survival rate for the Israeli bottlenose dolphin population. The annual survival rate for first-year calves was estimated at 0.73 (95% CI: 0.55–0.86), higher than the overall calf survival rate, estimated at 0.52 (95% CI: 0.43–0.60), similar to the finding reported for the Doubtful Sound population in New Zealand and it was mainly attributed to the freshwater inflow from a hydroelectric power plant (Henderson et al., 2014). The freshwater inflow forms a low-salinity layer up to 10 meters deep, colder than the underlying seawater from June to November (Gibbs, 2001). It has been associated with higher rates of epidermal lesions in dolphins (Henderson et al., 2014) and was found to impact food-web dynamics (Rutger & Wing, 2006b). Our result contradicts expectations, as calves are typically most vulnerable during their first year of life (Mann et al., 2000). As in other mark-recapture studies, the first-year survival rate may be overestimated (Henderson et al., 2014). The narrow time intervals and sampling limitations increase the likelihood of missing early deaths, leading to overestimating the first-year survival rate. Still, it was lower than reported in other populations, such as Brazil (0.84, 95 % CI: 0.72–0.90) (Fruet et al., 2015) and Florida (0.8 ± 0.07) (R. S. Wells & Scott, 1990). A lower first-year survival rate was also found in the Gulf of Ambracia, Greece, a semi-enclosed shallow habitat with a progressively deteriorating coastal ecosystem, and was 0.55 (Andres & Gonzalvo, 2023).

We used a Cormack-Jolly-Seber (CJS) model to estimate apparent survival rates, while the methods used in previous studies differed and may not be entirely comparable. Moreover, survival rates may be biased downward, as CJS models cannot discriminate between emigration and mortality. As previously mentioned, many observed individuals are assumed to be transient dolphins in the study area, which may negatively bias survival estimates, as transient individuals have lower capture probabilities than residential individuals (Ludwig et al., 2021). This variability in survival estimates may also be related to varying degrees of natural and human-induced impacts (Silva et al., 2009) or ecological differences between study sites (Currey et al., 2009). The Israeli coastal environment faces both direct and indirect anthropogenic pressures that may impact mortality rates, including chemical and noise pollution (Spanier & Zviely, 2023), entanglement in fishing gear (particularly bottom-trawls and gill-nets) (Israel's stranding network database –unpublished data, Kerem et al., 2013), and depletion of food sources (Spanier & Zviely, 2023). These factors, combined with the natural conditions of the basin, may contribute to the relatively low survival rates observed. In addition, the causes of high calf mortalities are uncertain, with several factors potentially influencing the mortality rate. According to Mann & Watson (2005), calf condition is likely the primary factor, which can be influenced by environmental conditions and maternal care. The maternal condition may be affected by factors such as age, experience, and early growth patterns, with foraging success being the most significant contributor (Hill et al., 2007). It is possible that females in the study area do not feed as successfully as females in other places (Steiner & Bossley, 2008; Tezanos-Pinto et al., 2015). Moreover, the timing of birth may also play an essential role in calf survival, with those born during the birth pulse showing higher survival rates (Robinson et al., 2017). According to Bezamat et al. (2020), calves born closer to the peak of the mullet season in Brazil have a higher survival rate. They also suggested cooperative foraging with fishermen may positively influence calf survival and female reproductive success._However, in Moray Firth, calf length was identified as a better predictor of first-year survival than birth month (Cheney et al., 2015), as smaller calves may be more susceptible to thermoregulatory stress (Model & Shine, 1988). The smaller body size observed for bottlenose dolphins in this region (Sharir et al., 2011) possibly influences survival rates as well.

Another factor that may influence calf mortality is whether the calf is the firstborn. Generally, the survival rate for firstborn calves is lower (Mann et al., 2000). A primiparous female may lack the experience to care for her offspring properly (Von Streit & Ganslosser, 2013). Additionally, contaminants such as PCBs, which bioaccumulate in dolphins, are transferred to calves through the mother, with the first calf receiving a higher load of these toxins (Schwacke et al., 2002), potentially leading to increased morbidity or mortality. Data on tissue pollutant levels in cetaceans from the Levantine Basin are scarce, with only seven individuals sampled in the area (Shoham-Frider et al., 2009). The effect of contaminants on calf mortality has yet to be studied for these populations, but it could be a potential contributing cause of death.

4.3 Conclusion

This study aimed to assess female bottlenose dolphins' reproductive traits and residency patterns along the Israeli Mediterranean coast, providing valuable insights into the species' life history and its relationship with the region's ecological conditions. As discussed before, most individuals were transient, and the study area is probably just a portion of a broader range used by this population. However, reproductive females exhibited stronger site fidelity and were observed with calves throughout the year. This suggests the importance of these coastal habitats for calf rearing and the potential vulnerability of these areas to further environmental degradation. Despite the low survival rates, the population appears stable, potentially compensating through increased reproductive rates. The regional resource limitation in the eastern Levantine Basin may have prompted females to Accelerate growth and reach early sexual maturity. Additionally, the high number of interactions between dolphins and bottom-trawler fisheries highlights the reliance on this food source, particularly for females with calves, and may contribute to increased reproductive success in an area with scarce food resources. While beneficial in the short term, this strategy may pose long-term risks to the population due to bycatch and reduced prey availability, and further research is needed to assess their influence on population dynamics and survival rates. We suggest that variations in reproductive success play a more crucial role in influencing population viability than survival rates in our region. Overall, the findings of this study underscore the importance of long-term monitoring of bottlenose dolphin populations in the eastern Mediterranean. The reproductive and survival parameters observed provide essential baseline data for conservation efforts. With ongoing pressures from habitat degradation, overfishing, and climate change, it is crucial to implement effective management strategies that address this population's direct and indirect threats.

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5. Supplementals

5.1 Appendix 1: Photo ID protocol

Israel Dolphin photo ID protocol
Version 2.0
Updated January 2021
Yaly Mevorach
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Introduction to Photo ID

This guide focuses on using Adobe Lightroom to facilitate the photo identification of the dolphin populations in Israel. It was developed in the process of integrating photos from a long-term photo identification dataset of Bottlenose dolphins between 2005-2020 and common dolphins between 2009-2020. The target of this procedure is to establish a complete presence absence data sheet which include the variant observations and the individuals encountered in them. This data will be later used for abundance, movement, social structure analysis and more.

Part 1 details the photograph organization and data management of the row data itself, as in the photographs taken during observations.
Part 2 details the keywording and process each of the photographs that contains individuals should go through.
Part 3 describes the matching process of the individuals to the catalog.
Part 4 describes how the data is being organize for each of the analysis.
The software needed for this procedure are: Lightroom and ‘Advanced Renamer’, make sure they are installed on your computer.

<u>Part 1 – Data management</u>

<u>Organizing the pictures:</u>
Once back from a survey, download all the pictures from the survey to the computer and save them in a folder named after the date, location of the survey port of operation and the name of the photographer: 2017-02-04_Her_Aviad

Go through the photographs in the folder itself and delete the ones that shows only sea or people (no animals at all). Before you delete any files make sure there is a backup of the folder that should remain untouched.

Open Advanced Renamer and rename all the pictures from the survey (after you deleted the only sea ones), in the following format: year-month-day_location-photographer_serial number. See appendix A for further explanations. For example: 2017-06-03_Her-Yaly_001

If there is more then one observation in the survey, separate the photographs to different folders before you import them to lightroom. Add Ob1 / Ob2 to the name of the folder.

Using Lightroom:

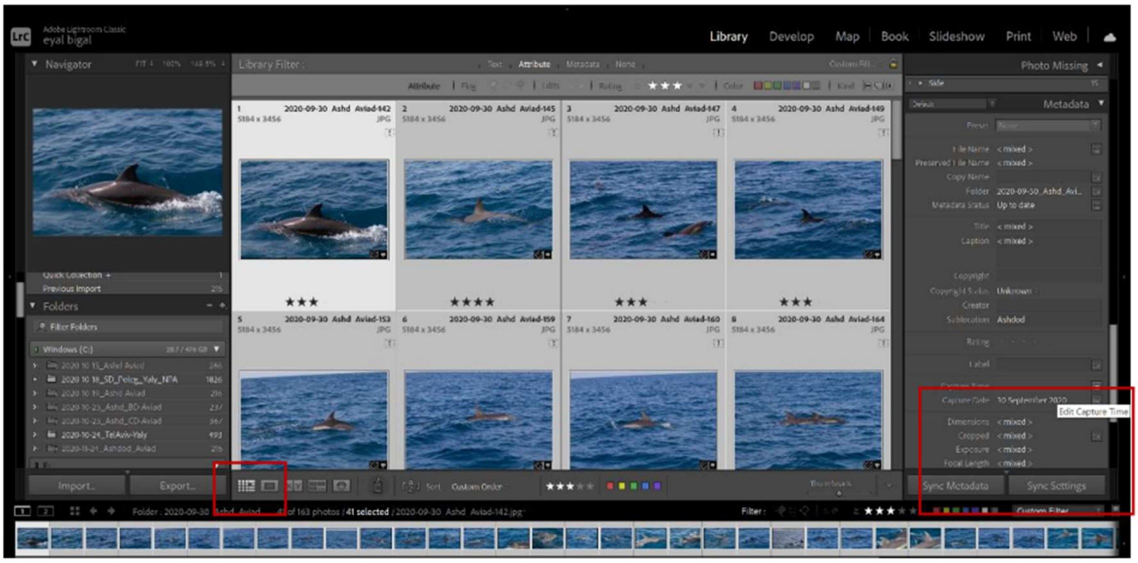
We use the photo management program Adobe Lightroom to create digital catalogues to organize, edit, and match the photos of dolphins taken since 2005. Lightroom is a database that does not store the photos, but instead keeps the metadata about each photo. If the photos are moved on the computer, the photos in Lightroom will be greyed out and/or have an exclamation mark on their thumbnails. The location will need to be updated in Lightroom by right-clicking on the parent folder and selecting “Find the missing folder”. To find all missing photos in the catalogue, go to Library > Find All Missing Photos. The photos will be placed in a collection (under Catalog) for easy access until their location is found. Lightroom allows the metadata of photos to be edited (filename, GPS, keywords, quality ratings, date, etc.). The metadata can be saved to the photos through Lightroom BUT be careful, as metadata can be overwritten if saving from an outdated catalogue.

Part 2 – photograph processing

Once the photographed are named, they can be imported to the lightroom:

Open Lightroom > go to File > Import Photos and video > Select the folder from the survey > press check all and then import.

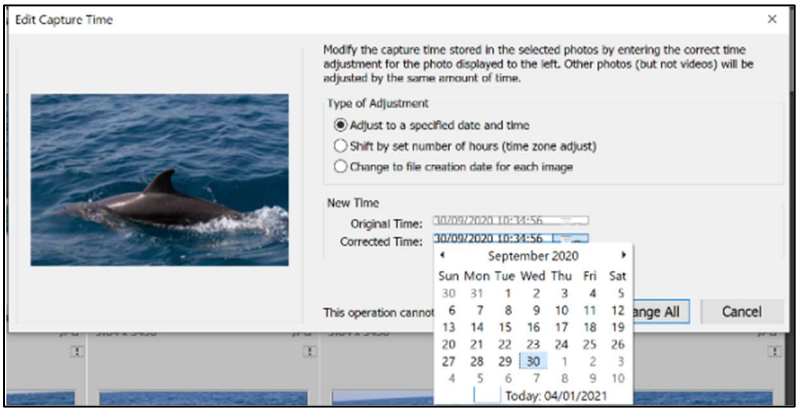
Before we start with the grading, make sure the date of the photographs is true and add a location to them all. You can select and change the metadata of multiple photographs using ctrl + A while in the grid view, as shown in Figure 1.



File Name < mixed >
Preserved File Name < mixed >
Folder 2020-09-30_Ashd_Avi...
Metadata Status Up to date
Title < mixed >
Caption < mixed >
Copyright Status Unknown
Sublocation Ashdod
Capture Date 30 September 2020
Dimensions < mixed >
Cropped < mixed >
Exposure < mixed >
Focal Length < mixed >

Figure 1: The lightroom library window

On the left corner, you can find the view you are in. on the right of the screen appear the metadata of the chosen photographs. All of them should have the same capture date. If not, press on the little symbol next to it to 'Edit capture time'. A new window will appear that allows you to edit the capture time, as seen in Figure 2. In addition, add the location of the survey under the sublocation field in the metadata, as shown in Figure 1. Once this is done, move on to the grading procedure.



Modify the capture time stored in the selected photos by entering the correct time adjustment for the photo displayed to the left. Other photos (but not videos) will be adjusted by the same amount of time.

Type of Adjustment

● Adjust to a specified date and time
○ Shift by set number of hours (time zone adjust)
○ Change to file creation date for each image

New Time

Original Time: 30/09/2020 10:34:56
Corrected Time: 30/09/2020 10:34:56

September 2020

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3
4	5	6	7	8	9	10

Today: 04/01/2021

This operation cannot

Figure 2: Edit capture time window

If there is more than one observation in the same survey, the photographs should be already separated into different folders, as seen in Figure 3. In addition, choose all the photographs in the folder and label each of the observations with its number (Figure 3).

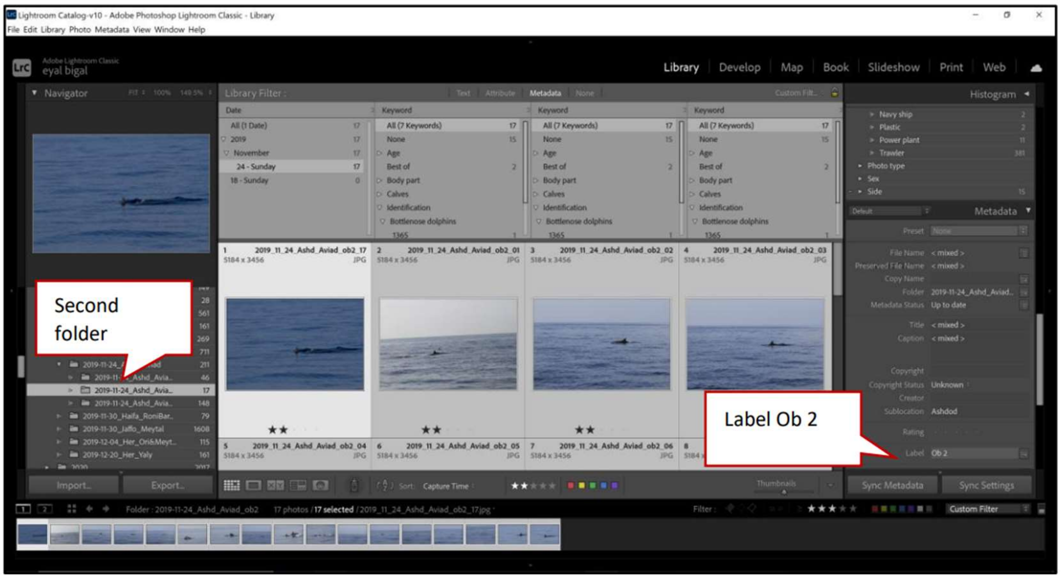


Figure 3: Dividing the photographs to several

Grading the pictures:

Each photograph should be evaluated for photographic quality and grade of the distinctiveness of the dorsal fin (Berrow et al., 2012; Ingram & Rogan, 2003; Whitehead et al., 1997; Wilson et al., 1999)

Quality rating

All photographs should be graded from 1 to 5 when 1-2 are non-relevant photographs and 3-5 are following criteria published by Ingram & Rogan, 2003. The grading of the photograph is made by marking the number of stars the photograph should receive according to the grading, as seen in Figure 4. By simply pressing on the right number on the keyboard, the grade is added to the photograph.

Photo Grade 5 - Well-lit and focused shots taken perpendicular to the dorsal fin at close range.

Photo Grade 4 - More distant, less well-lit, or slightly angled shots of dorsal fins.

Photo Grade 3 - Poorly lit or out-of-focus shots taken at acute angles to the dorsal fin.

Photo Grade 2 – Pictures with dolphins with absolutely no option for Identification, bad angle or no dorsal fin.

Photo Grade 1 – No dolphins at all, other animals or boats.

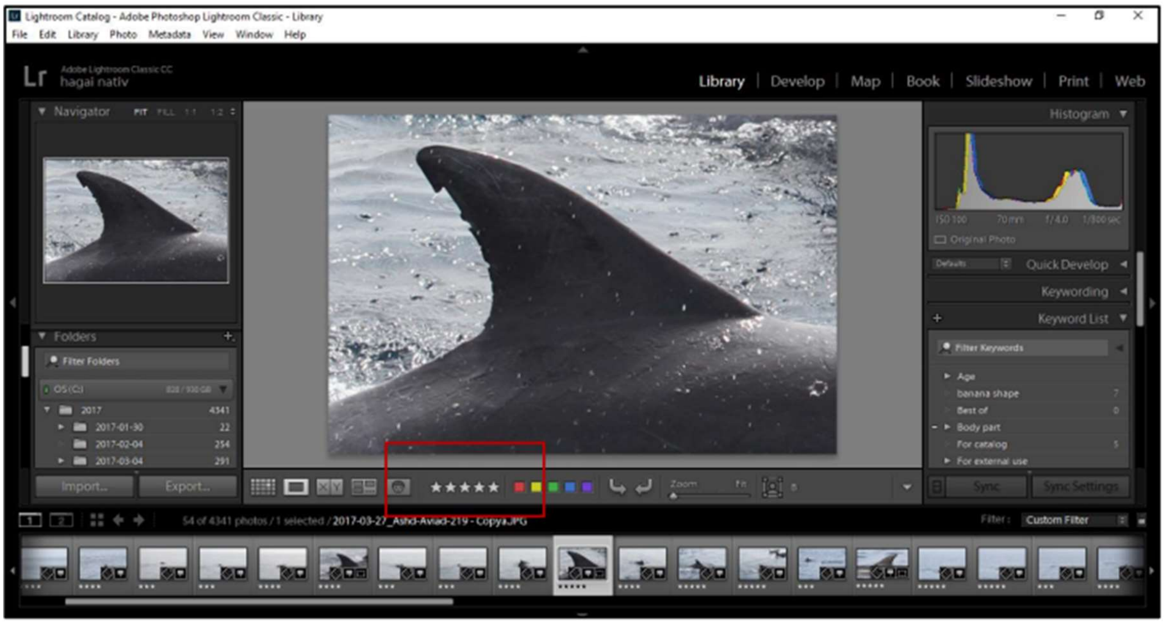


Figure 4: The grading process of a photograph

Once the quality grading of the entire folder is finished, a filter is needed to consider only the photographs graded 3 and higher for further processing. You can filter the photographs by pressing on the number of stars you want to filter to. Make sure the sign ≥ appears before the stars, as seen in Figure 5.

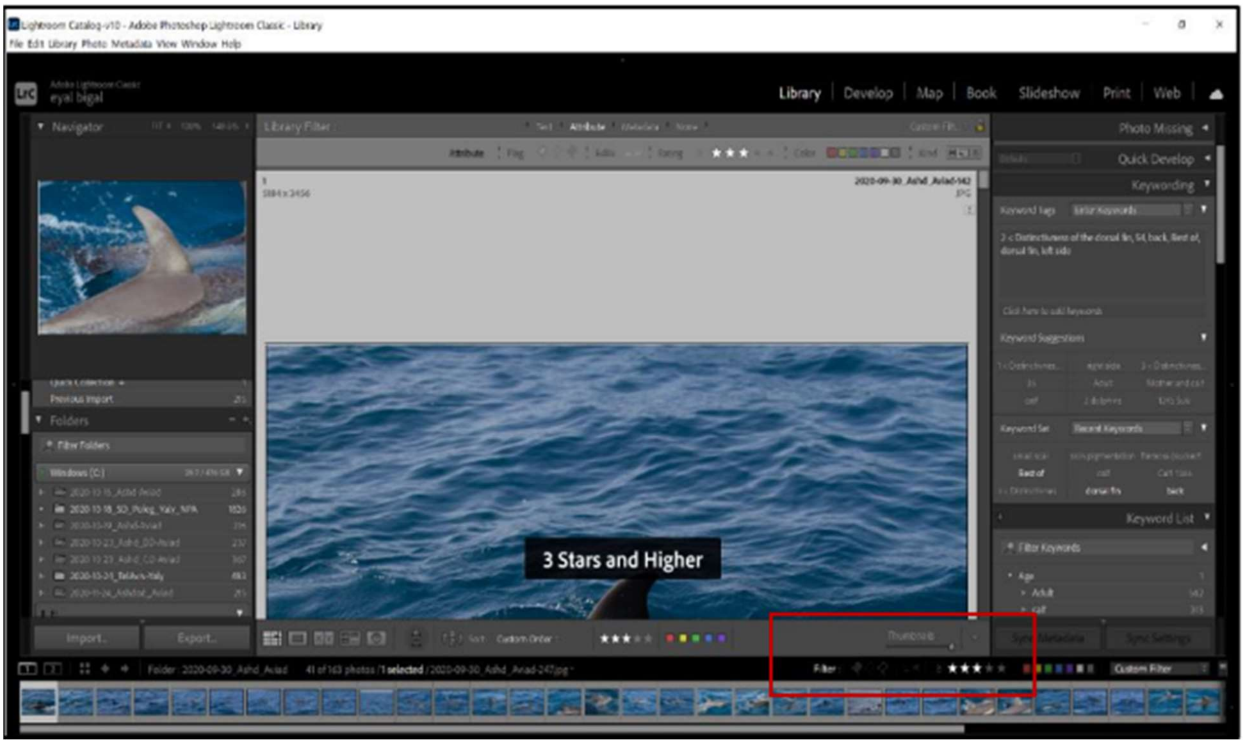


Figure 5: Filtering only the high-quality photographs

Once you have filtered the photographs, you remain with the ones that contain dorsal fins. Go through each of these photographs and follow the following steps:

1. Distinctness rating

In the keywords list, under marking, there are three categories of the distinctiveness of the dorsal fin. Examine the dorsal fin carefully and check the appropriate category. This is the

time to have a second examination of the quality grading. If the dorsal fin is not focused and you cannot be sure what category to assign in, change the quality grade to 2.

The photographs of dorsal fin should be graded from 1 to 3 following criteria published by Ingram (Ingram & Rogan, 2003).

Distinctiveness Grade 1 - marks are consisting of significant fin damage or deep scarring that were considered permanent.

Distinctiveness Grade 2 - marks are consisting of deep tooth rakes and lesions with only minor cuts present.

Distinctiveness Grade 3 - marks are consisting of superficial rakes and lesions.

2. Adding keywords

This is the step when we add any interesting detail from the photograph to its metadata to be viewed and analyzed easily in the future. You want to put all the information from the picture in keywords to have them saved to the metadata of the picture. Put only the ones you are sure about, the ones you are not sure about can always be added later. (Whitehead lab, Dalhousie university, 2018)

<u>List of keywords:</u>

- Age (decide the age according to the body size of the dolphin, if it's a calf, it's usually swimming next to his mother) (Berrow et al., 2012)
    - Adult (full-size animal, relatively dark)
    - Juvenile (two-thirds the size of an adult, paler, usually no scars, clean look)
    - Calf (less than 1-year old, without neonatal folds)
    - Newborn (1-2 months old, neonatal folds)
- Behaviour (If unique behavior appears in the photograph)
    - Feeding
- Best of
- Body part
    - Back
    - Belly
    - Dorsal fin
    - Face
    - Fluke
    - Genitals
    - Whole body

- Calves (identification of the calf in the picture, few examples as following)
  - Calves Bottlenose
    - Calf 1365
    - Calf 1305
    - Calf 1308
    - Calf 1309
  - Calves Common
    - Calf 1
    - Calf 10
    - Calf 15
    - Calf 16
  - Temporal ID (when the identification is not decided yet)
    - Calf A
    - Calf B
- For external use (when the photograph has unique features that might be of use in the future)
  - For catalog
  - For protocol – distinguish marks to be used as examples
  - For publishing – jumping dolphins, for example
- Identification (identification of the individual in the photograph)
  - Bottlenose dolphins
    - 1001 Adi
    - 1002 Affi
    - 1003 Ali
    - 1004 Alon
  - Common dolphins
    - 1
    - 2
    - 3
    - 4
  - Temporal ID
    - A
    - C
- Marking
  - Distinctiveness of the dorsal fin
    - 1

        - 2
        - 3
    - Entanglement
    - Fetal folds
    - Identifying marks on other body parts (if there are unique markings on other areas except for the dorsal fin that can be used for identification)
    - Large scar
    - Small scar
    - Miscellaneous (anything that worth mentioning but does not appear in the list)
    - Open wand
    - Propeller (gash or series of scars appearing to be caused by a boat propeller)
    - Remora (suckerfish)
    - Showing ribs
    - Skin pigmentation
    - Sloughed skin
    - Tooth rake
- Multiple dolphins (when the photograph contains more than one individual or a pair of mother and calf) should be marked here. If the number of dolphins in the photograph is not among the keywords, add it.
    - 2 dolphins
    - 3 dolphins
    - Mother and calf
- Other objects
    - Birds
    - Boat
    - Navy ship
    - Plastic
    - Power plant
    - trawler
- photo type
    - Copied for cropping
    - cropped
    - need cropping
- Sex (Figure 6)
    - Female

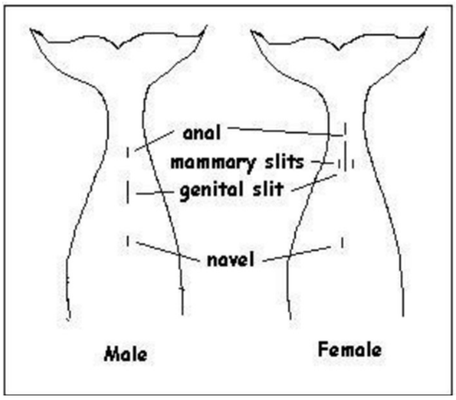


Figure 6: How to recognize the sex of the dolphin

  - Male
- Side – what side of the dorsal fin is viewed in the photograph
  - Front
  - Left side
  - Right side
  - Underwater picture

<u>Examples of Marks</u>

All photographs were taken from the photo ID catalog created by Scheinin (Scheinin, 2010)

- Open wounds (wounds with red tissue):

- Remora (suckerfish)

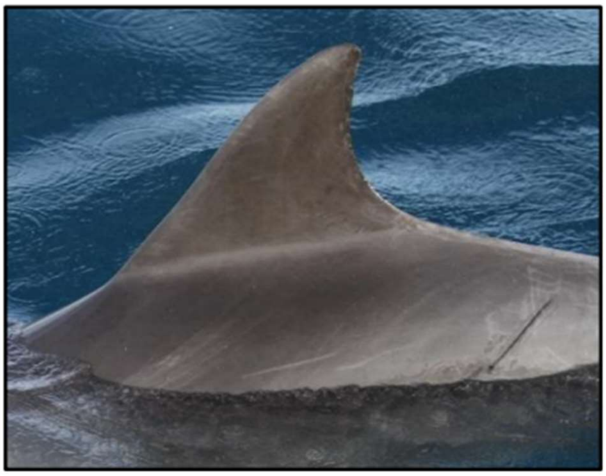
- skin pigmentation (any weird pigmentation on the body that is not normal)

- Showing ribs - Skinny (any dolphin that appears very thin, usually with prominent ribs)

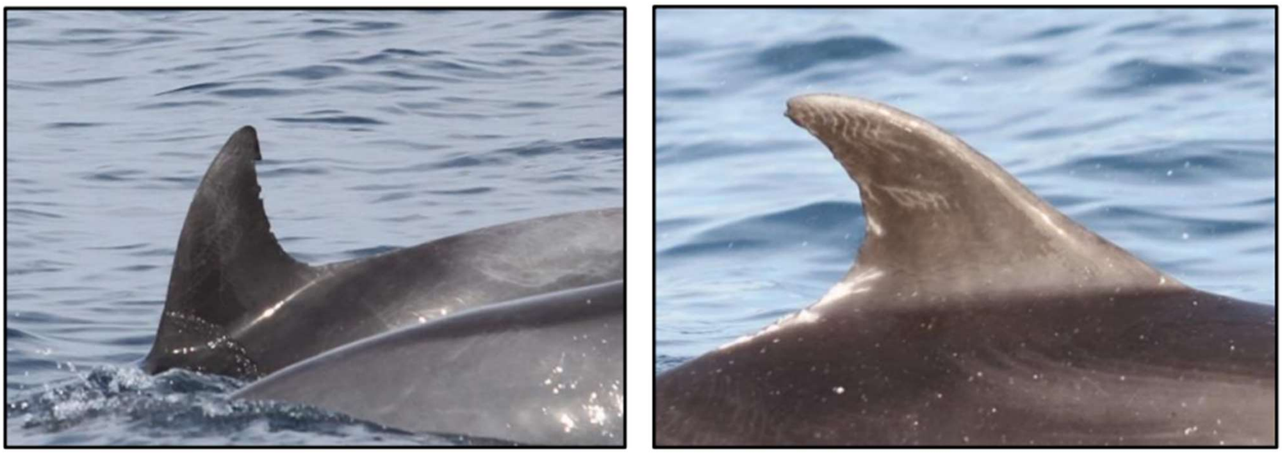
- Tooth rake (two or more parallel linear scars caused by the teeth of other animals)

- Fetal folds of a newborn

- Scars (small on the left and big on the right)



- Distinctiveness of the dorsal fin category 1 (big notches and missing chunks)



- Distinctiveness of the dorsal fin category 2 (small notches or scars on the dorsal fin)

- Distinctiveness of the dorsal fin category 3 (usually calves or juveniles, scratches on the dorsal fin might be used for a short-term identification but they will heal and therefore considered under the third category)

3. Individual identification

Temporary ID

The last and most crucial step of the processing is the individual identification. Each dorsal fin that appears in a photograph should receive a temporary ID letter – A, B, C, and so on. Using ‘Draw face region’, a small human face button as seen in Figure 7, surround the dorsal fin and name it with a letter. The letter you added will appear in the keywords list under ‘temporal ID’. Once you named a dorsal with its temporal ID, you should tag it with the same letter every time it appears in a photograph. In order to remember the shape of the dorsal fin, I recommend drawing it in your notebook or writing down its significant features. If there are multiple individuals in the photograph, name them all, there is no need to separate them for now. If a dorsal is not completely shown in the picture, and there is no way to be sure about its identity, leave it unnamed. A calf should be named after its mother letter – Calf A, Calf B, and so on.

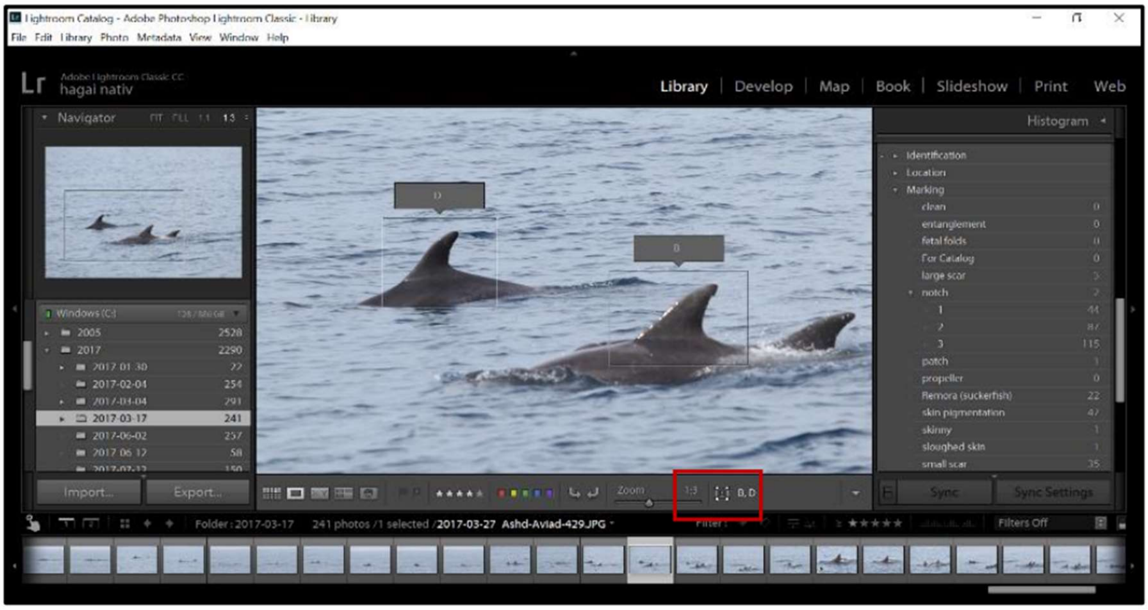


Figure 7: Naming the individuals using ‘draw face region’

Best of

Once you have recognized all the different dorsal fins in the observation, it is time to choose the best photographs of each dolphin to use for the matching process. In order to examine and choose the best photograph of each individual, press metadata on the upper side of the Lightroom window. Now you can filter the photographs according to the keywords you added. You can choose how many fields and which ones will be used to filter by pressing on the small icon next to each field (circled in a red box in Figure 8). Choose the date of the observation and go through all the temporary IDs you have. For each dolphin, choose a left and right photograph and mark them as best of. The order of your actions is listed in Figure 8. This is the time to double-check your identifications, make sure there aren't different dolphins with the same letter or different letters for the same dolphins.

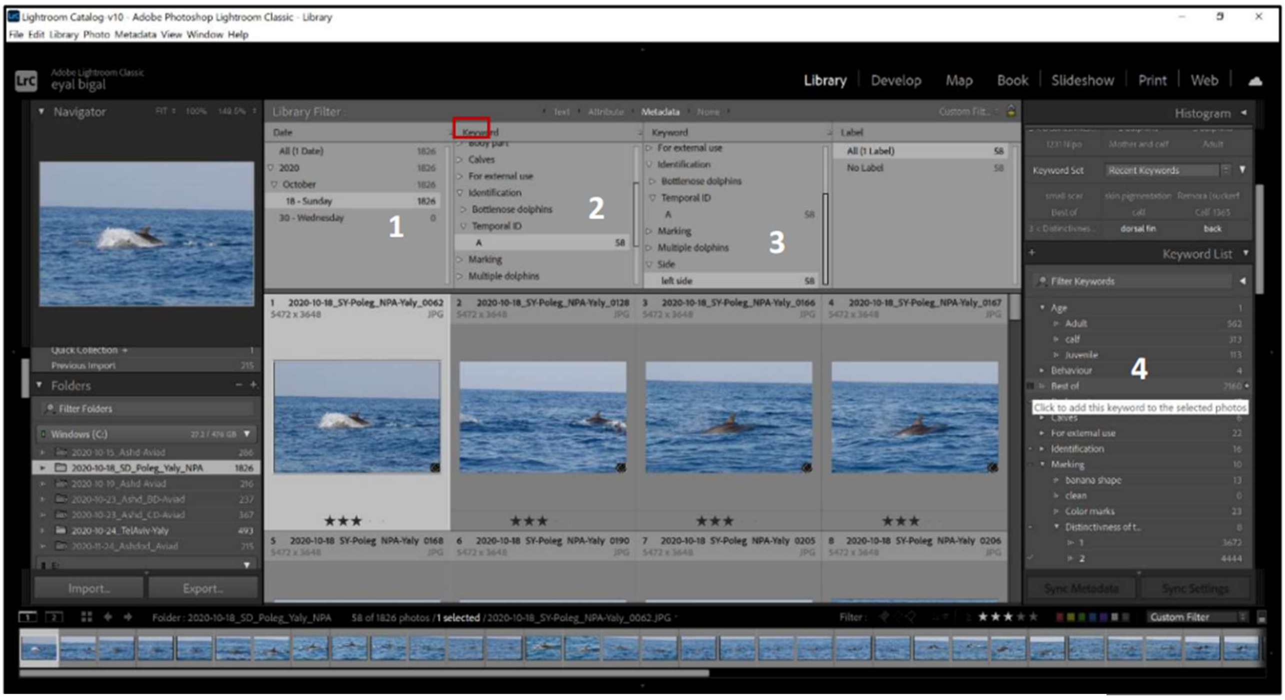


Figure 8: The needed steps to add the 'best of' tag

Photos with multiple dolphins

If the best photograph of a dolphin is one with multiple individuals, you will have to copy and crop it. Follow these instructions:

1. Right-click on the picture > show in explorer. This will lead you to the folder where the picture is located.
2. Copy the picture as many times as there are dorsal fins and add a letter starting from 'a' to the photograph's name. for example, if there are 3 dolphins, you will have one original picture and 3 copies, a b and c. example – 2020-03-14_Her-Aviiad_15copya.
3. Crop each copy in Explorer, where copy a is for the most left dorsal, and b is for the second most left, and so on. Crop the entire dolphin (not just its dorsal fin) as long as there aren't any other fins in the frame.
4. Go back to Lightroom > right click on the folder name on the left side of the screen > synchronize folder > synchronize > wait until the syncing is complete.
5. The copies will now show on Lr with the names you gave them.
6. Go over the cropped photographs and fix their temporal ID and keywords to match the present details.
7. Mark the cropped photograph with 'Best of'.

Once all these steps are finished, open the people view to see all the individuals you assigned. If you are confident with your work, move on to the next part. If not, double-check your work.

Part 3

After we named each of the individuals with a temporary ID, it is time to look for matches from the catalog. Open the catalog on a second screen for comparison and the best of left and right photographs on the first screen. Open the best of photograph using the metadata filter as shown in Figure 9, choose the left and right photograph, and press 'compare view' at the bottom of the screen as seen in Figure 9.

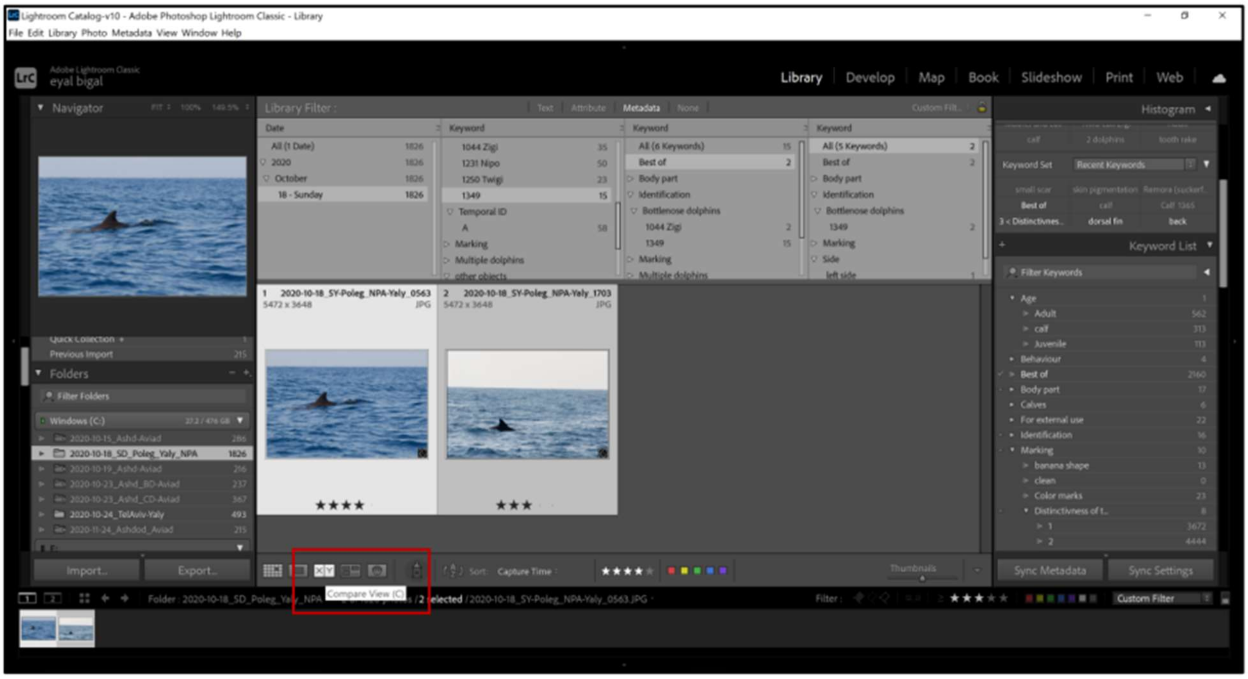


Figure 9: Comparing right to left to find a match

Once you opened the photograph on the share screen, zoom in on the dorsal fin for better view. make sure the little lock symbol is in an open position so you can zoom in separately for each photograph, as seen in Figure 10.

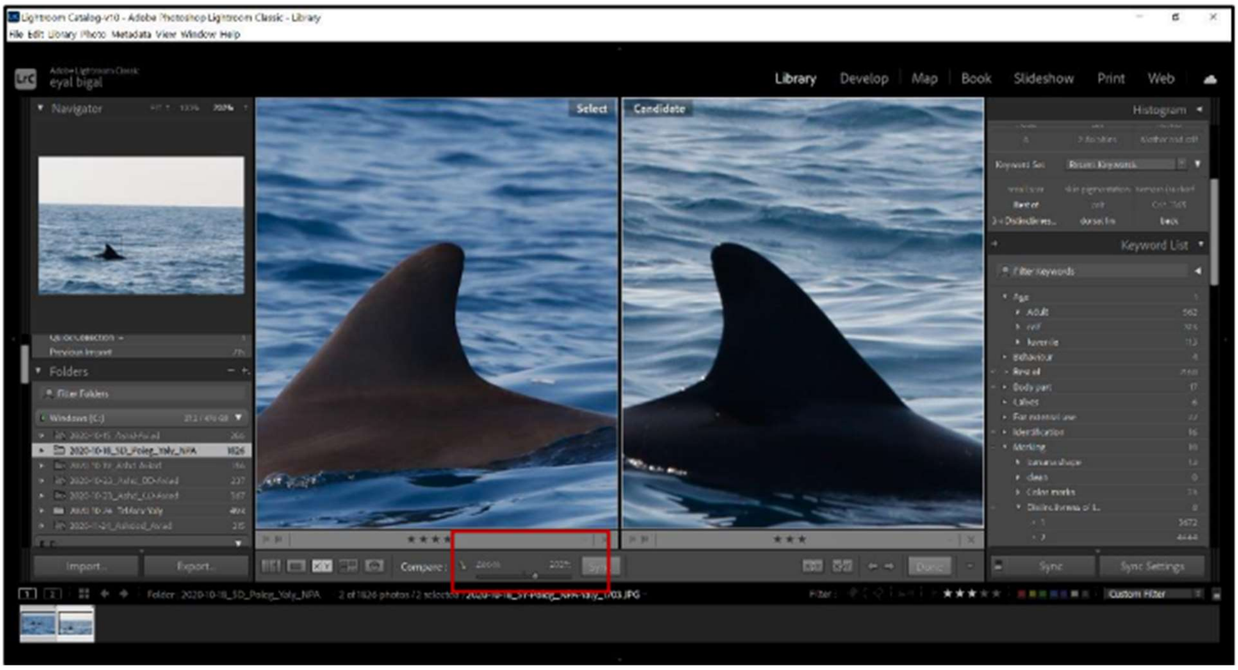


Figure 10: Zooming in on each side of the dorsal fin to better examine the markings

Now you are in ideal conditions for the matching process. Go through the catalog on the second screen and examine the dorsal fins for a match. Observe the dorsal in detail and look for every mark or sign that can be used to ensure the match. If the photograph is shaded or needed colouring corrections to better see the fin. Press 'Develop' on the upper right side of the screen and correct the colours using the scales on the right side for a better view. If a match to the catalog is found, change the temporary ID of the dolphin to its permanent ID. Do it on the people view screen to make sure the change is contained on all the photographs of the specific individual, as seen in Figure 11.

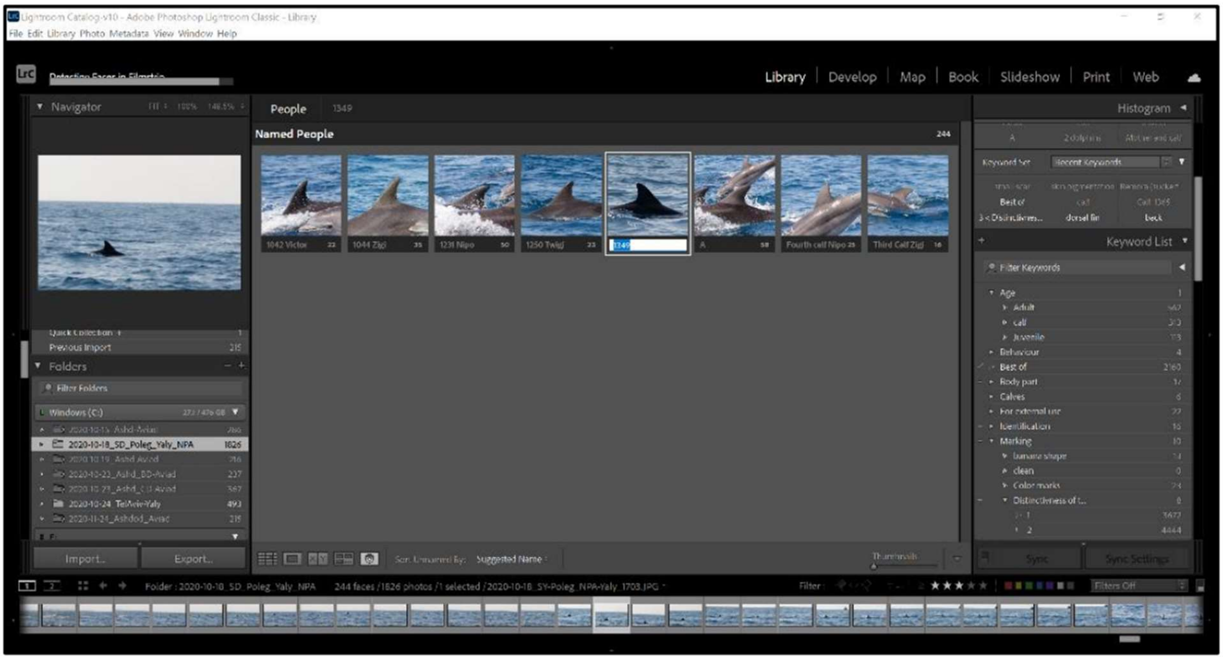


Figure 11: Changing ID's to all the photographs of the same individual

A calf should be named with reference to its mother, for example, Calf Zigi. If you did not find a match to the catalog, create a new individual. Name it with the next available serial number from the catalog (if the last dolphin in the catalog is 1488 then the new individual will be named 1489). Use the best of photographs of the individual for the catalog slide.

Once the identification process is done, and all the individuals are matched to the catalog or given a new serial number, and there are no temporal IDs left, the best of photographs should be titled after the individual in them. Follow the steps in Figure 12 (make sure you choose both left and right photographs):*final matching of the individuals to the catalog must be approved by two researchers at least. (Stevick et al., 2011)

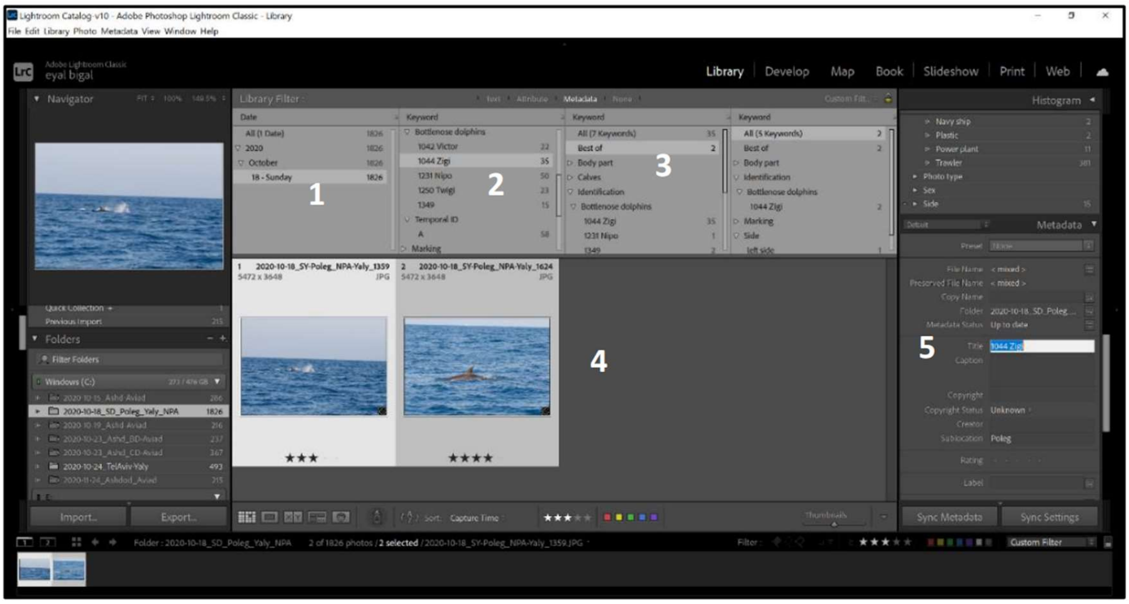


Figure 12: the five steps taken to title all the individuals photograph with their ID

Before you export the photograph to an excel sheet, add a caption to the left and right photographs. Choose all the left or right photographs in the folder and change the ‘Caption’ field to Left or Right, respectively, as seen in Figure 13.

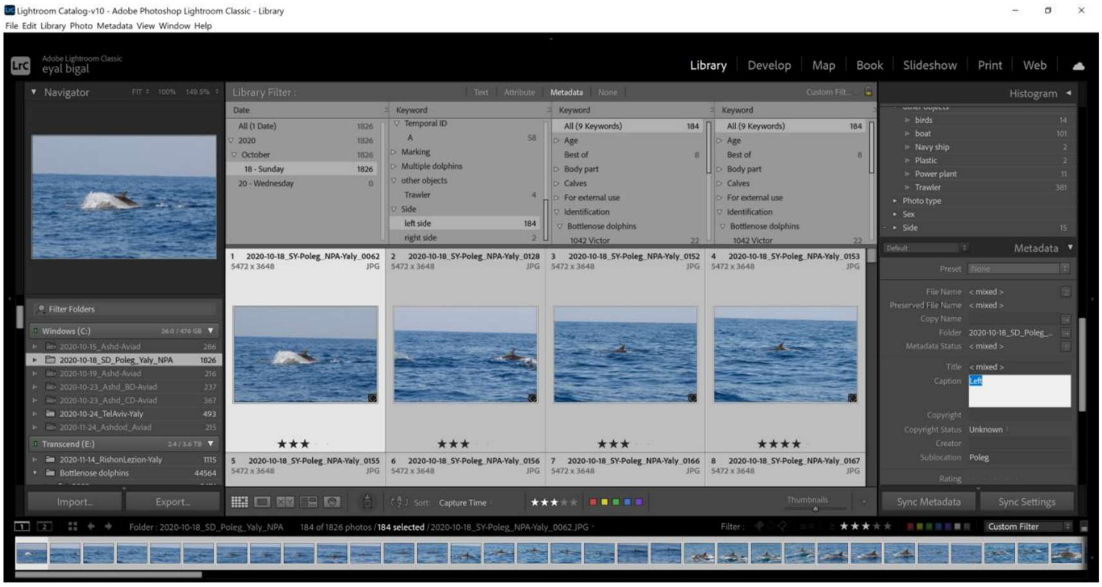


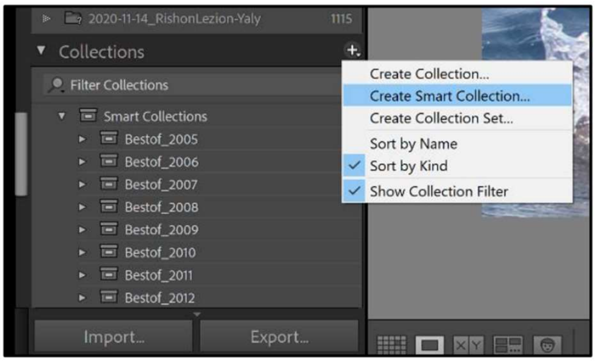
Figure 13: Adding ‘left’ and ‘right’ to the caption field

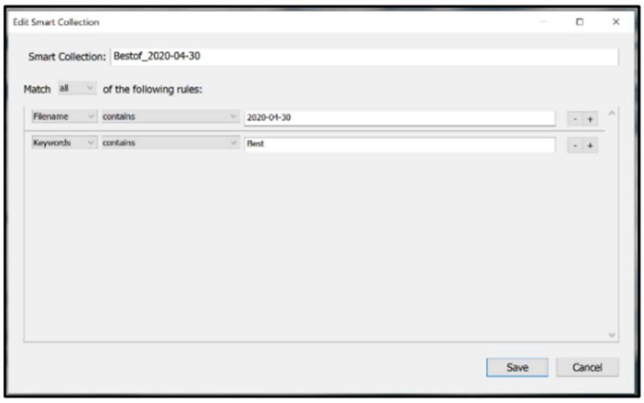
Part 4

Best of smart collections

Only the best of photographs is used for the analysis, and therefore a ‘best of’ smart collection must be created before we export the data. Create a smart collection for every survey and a collection set for every year. On the left side of the screen, under the list of folders, you will find your collection. Press on the small plus sign to create a new smart collection.

The following screen will appear, name the collection after the name of the folder, and define the conditions which select the photographs that will be included in the collection. In this example, the name of the photograph must contain the date of the survey (as we named it in the beginning), and the keywords must contain Best. You can also exclude photographs you don’t want by defining ‘doesn’t contain’ instead of ‘contains’ under the condition.





Smart Collection: Bestof_2020-04-30

Match all of the following rules:

Filename contains 2020-04-30

Keywords contains Best

Lightroom Plug-Ins

We use the ***List view*** plug-in to bulk export metadata from Lightroom and Excel. follow these steps for installation:

1. Download from these links:

https://www.photographers-toolbox.com/products/jbeardsworth/listview/

2. Move the downloaded plug-in(s) to a folder of your choosing (but don't delete them even after enabling the plug-ins in Lightroom).
3. In Lightroom, go to File > Plug-in Manager
4. Click "Add" and find the plug-in download.
5. Enter the registration code (ask your supervisor for this), then click "Enable"

Select desired photos or set a filter, in our case, the best of collection.

1. In Lightroom, go to file > Plug-in Extras > Standard View (this may take a few seconds to load, depending on how many photos you choose).
2. Choose desired metadata to export by clicking on the triangle of each column (Figure 14). Make sure you choose the date original and no other date formats.
3. Click the green icon at the top of the screen. This will open an Excel document with your metadata (it may take a few seconds).
4. Save as an excel document and name accordingly.

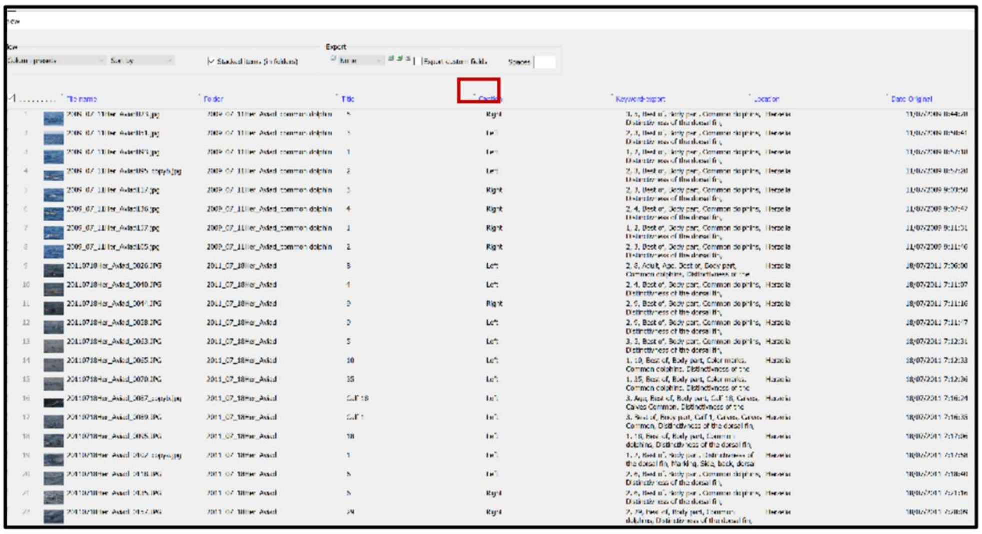


Figure 14: how to change the metadata field being exported

List of fields to export:

- File name

- Folder

- Title

- Rating

- Caption

- Label

- Keywords

- Location

- Date original

- Longitude and latitude (if the photographs contain them)

Before you export, make sure all the data is correct and every field is filled with the right information

<u>Processing the excel sheet</u>

Before we move on to the analysis in R, we need to prepare the excel sheet in the right format. Choose everything > add borders to the table > color in black (sometimes it exports in white, and it seems like some data is missing) > delete the empty columns (country, state, city).Change the title column to ID and the caption column to SIDE.

Name this tab as the original tab and copy the table to a new tab for further processing.

1. Separate the date from the hour: Insert a new column next to the existing date column. Data > text to column > delimited > check space under delimiters > general > finish
2. Change the date format to short date under 'home', number.

Copy the entire table to a new tab and name it 'no duplicates'

1. Move the date column next to the ID column
2. Remove duplicates in order to have only one line for each individual in each observation
   Select all > Data > remove duplicates > unselect all > check the date and ID boxes > OK

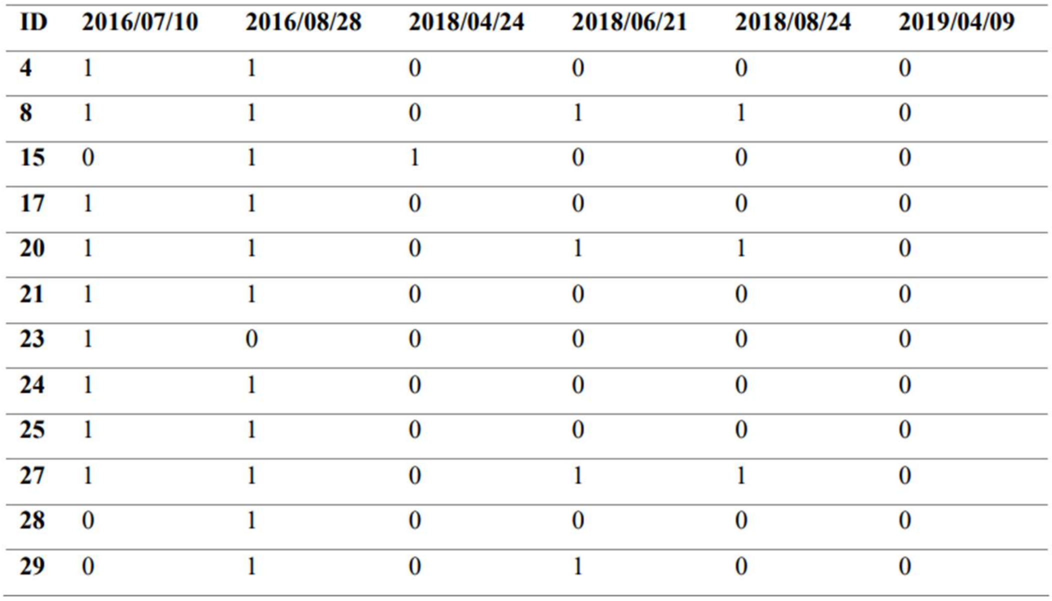
Check to see that only the extra data was removed.

Copy the ID and Title columns to a new tab and name it 'Presence table'.

1. Change the order of the dates to have the year at the beginning: at the column next to the existing date enter the function {=TEXT(B2, "yyyy/mm/dd")} where B2 is the original date. Apply to the entire column.
2. Copy the entire column of new dates to another new column but this time as independent data (paste 1,2,3) and name it - 'Date'
3. Delete the original date column and the one you created using the function.
4. Create a new column next to the date column and name it 'presence'. Put the number 1 in every cell in this column.

Create a ‘Pivot table’ with the presence-absence data of the dolphins. The date would be the columns; ID would be the rows, and the presence data will be the values in the table. Name the tab – ‘Pivot table’. Copy the data from the pivot table to a new tab (you can’t manipulate the pivot table) and name it ‘PA table’. Fill in the empty cells of the new table with 0’s: Select 98 all > Ctrl+H > find what -leave empty > write 0 under replace > replace all. check that the process was done correctly. Copy the table to a new tab and name it ‘Confidant PA table’. This is the time to delete individuals that you don’t want in the analysis. In addition, delete the ‘Grand total’ and ‘blank’ columns and rows.

Table 1: the right format that will be imported to R for further analysis

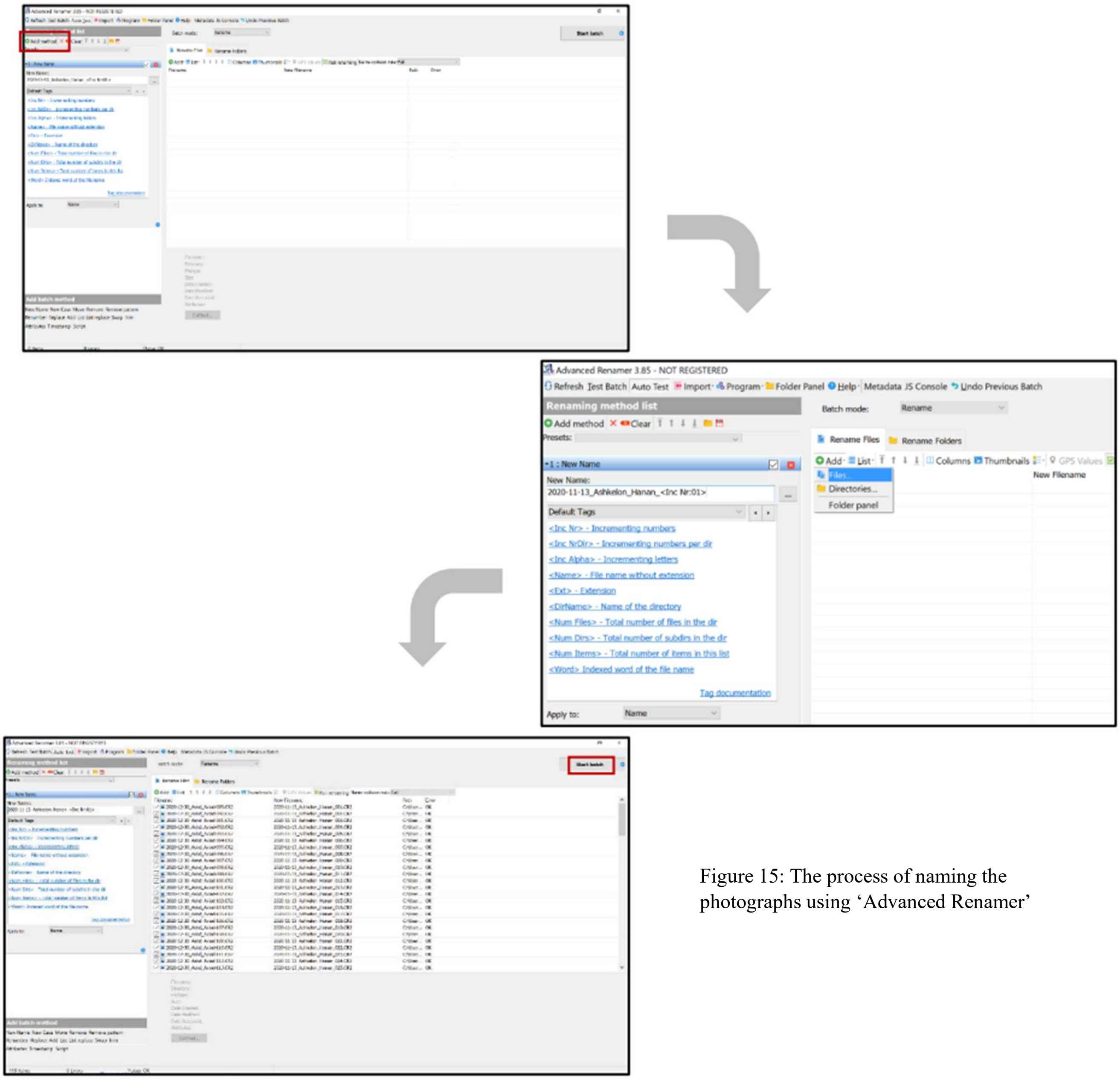


ID	2016/07/10	2016/08/28	2018/04/24	2018/06/21	2018/08/24	2019/04/09
4	1	1	0	0	0	0
8	1	1	0	1	1	0
15	0	1	1	0	0	0
17	1	1	0	0	0	0
20	1	1	0	1	1	0
21	1	1	0	0	0	0
23	1	0	0	0	0	0
24	1	1	0	0	0	0
25	1	1	0	0	0	0
27	1	1	0	1	1	0
28	0	1	0	0	0	0
29	0	1	0	1	0	0

Appendix A – naming the photographs:

Open the main window of ‘Advanced renamer’ > Press add method to add the naming format needed. Press on the method <Inc Nr> - incrementing numbers and add the correct format before the number. It should look like that - YYYY-MM-DD_locations_photographer_<Inc Nr:01>

Press add and then files to choose the folder of the photographed that need name changing. Select all the photographs within the folder. The list of the files will appear in the main window. On the left will appear the original name of each photograph, and on the right the new name. Check that the names are correct, and then press ‘start batch’. The names of the photographs are now changed in the folder. The process is shown in Figure 15.



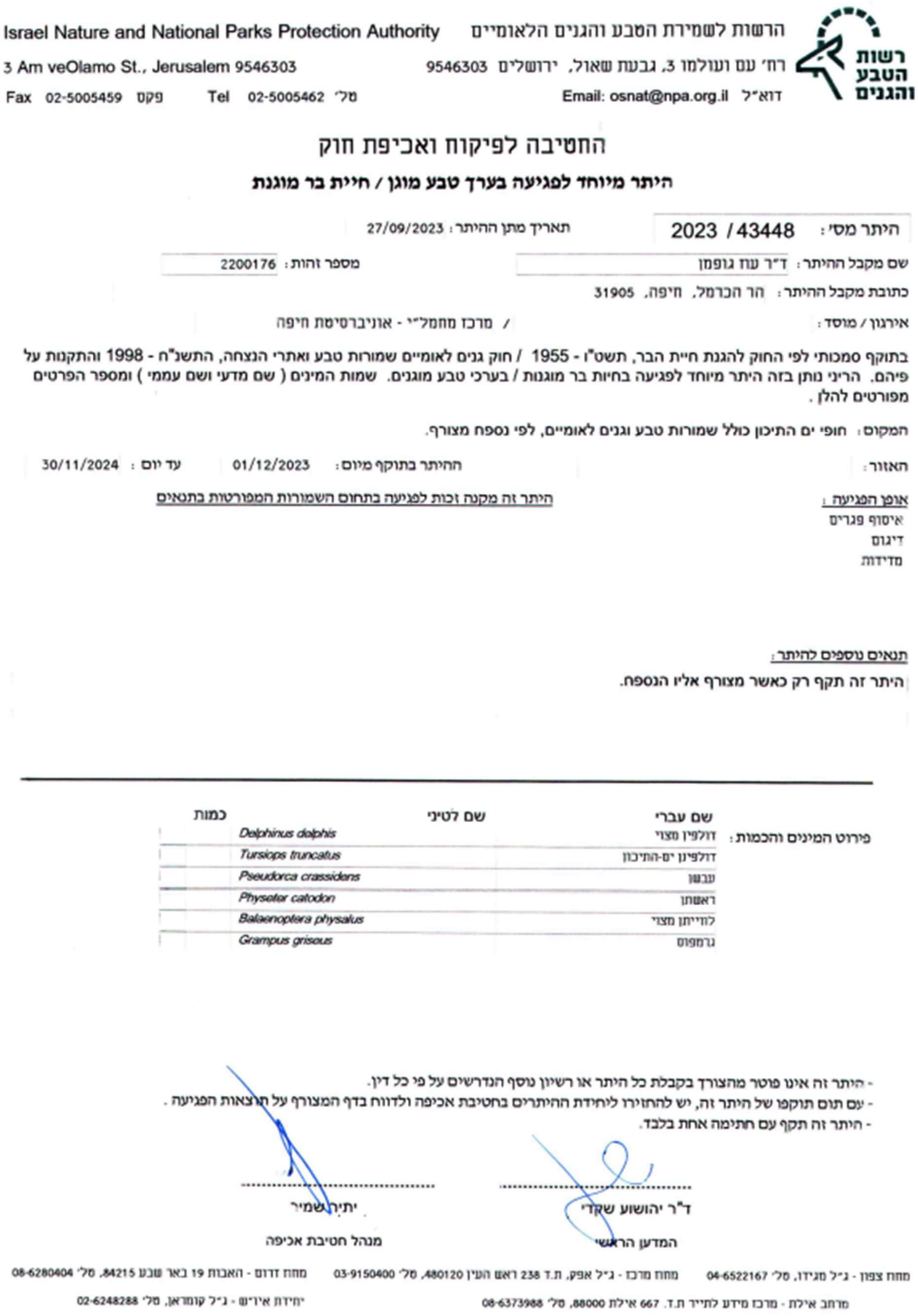
New Name: 2020-11-13_Ashkelon_Hanan_<Inc Nr:01>

Batch mode: Rename

Apply to: Name

Figure 15: The process of naming the photographs using ‘Advanced Renamer’

5.2 Appendix 2: Special Permit for Impacting Protected Natural Resources or Protected Wildlife



Israel Nature and National Parks Protection Authority
3 Am veOlamo St., Jerusalem 9546303
Fax 02-5005459 פקס Tel 02-5005462 טל'

הרשות לשמירת הטבע והגנים הלאומיים
רח' עם ועולמו 3, גבעת שאול, ירושלים 9546303
Email: osnat@npa.org.il דוא"ל

רשות הטבע והגנים

החטיבה לפיקוח ואכיפת חוק

היתר מיוחד לפגיעה בערך טבע מוגן / חיית בר מוגנת

היתר מס' : 2023 / 43448 **תאריך מתן ההיתר :** 27/09/2023

שם מקבל ההיתר : ד"ר עוז גופמן **מספר זהות :** 2200176

כתובת מקבל ההיתר : הר הכרמל, חיפה, 31905

אירגון / מוסד : / מרכז מחמל"י - אוניברסיטת חיפה

בתוקף סמכותי לפי החוק להגנת חיית הבר, תשט"ו - 1955 / חוק גנים לאומיים שמורות טבע ואתרי הנצחה, התשנ"ח - 1998 והתקנות על פיהם. הריני נותן בזה היתר מיוחד לפגיעה בחיות בר מוגנות / בערכי טבע מוגנים. שמות המינים (שם מדעי ושם עממי) ומספר הפרטים מפורטים להלן .

המקום : חופי ים התיכון כולל שמורות טבע וגנים לאומיים, לפי נספח מצורף.

האזור : **ההיתר בתוקף מיום :** 01/12/2023 **עד יום :** 30/11/2024

אופן הפגיעה : **היתר זה מקנה זכות לפגיעה בתחום השמורות המפורטות בתנאים**

איסוף פגרים
דיגום
מדידות

תנאים נוספים להיתר :

היתר זה תקף רק כאשר מצורף אליו הנספח.

פירוט המינים והכמות :

שם עברי	שם לטיני	כמות
דולפין מצוי	*Delphinus delphis*	
דולפינן ים-התיכון	*Tursiops truncatus*	
עבשן	*Pseudorca crassidens*	
ראשתן	*Physeter catodon*	
לווייתן מצוי	*Balaenoptera physalus*	
גרמפוס	*Grampus griseus*	

- היתר זה אינו פוטר מהצורך בקבלת כל היתר או רשיון נוסף הנדרשים על פי כל דין.
- עם תום תוקפו של היתר זה, יש להחזירו ליחידת ההיתרים בחטיבת אכיפה ולדווח בדף המצורף על תוצאות הפגיעה .
- היתר זה תקף עם חתימה אחת בלבד.

ד"ר יהושוע שקדי
המדען הראשי

יתירה שמיר
מנהל חטיבת אכיפה

מחוז צפון - ג"ל מגידו, טל' 04-6522167 מחוז מרכז - ג"ל אפק, ת.ד 238 ראש העין 480120, טל' 03-9150400 מחוז דרום - האבות 19 באר שבע 84215, טל' 08-6280404
מרחב אילת - מרכז מידע לתייר ת.ד. 667 אילת 88000, טל' 08-6373988 יחידת איו"ש - ג"ל קומראן, טל' 02-6248288

רשות
הטבע
והגנים
מחלקת היתרים

נספח להיתר מיוחד לפגיעה בערך טבע מוגן

היתר מס. 2023/43448

מקבל ההיתר: ד״ר עוז גופמן ת.ז. 2200176

נספח זה תקף רק כאשר הוא מצורף להיתר 2023/43448

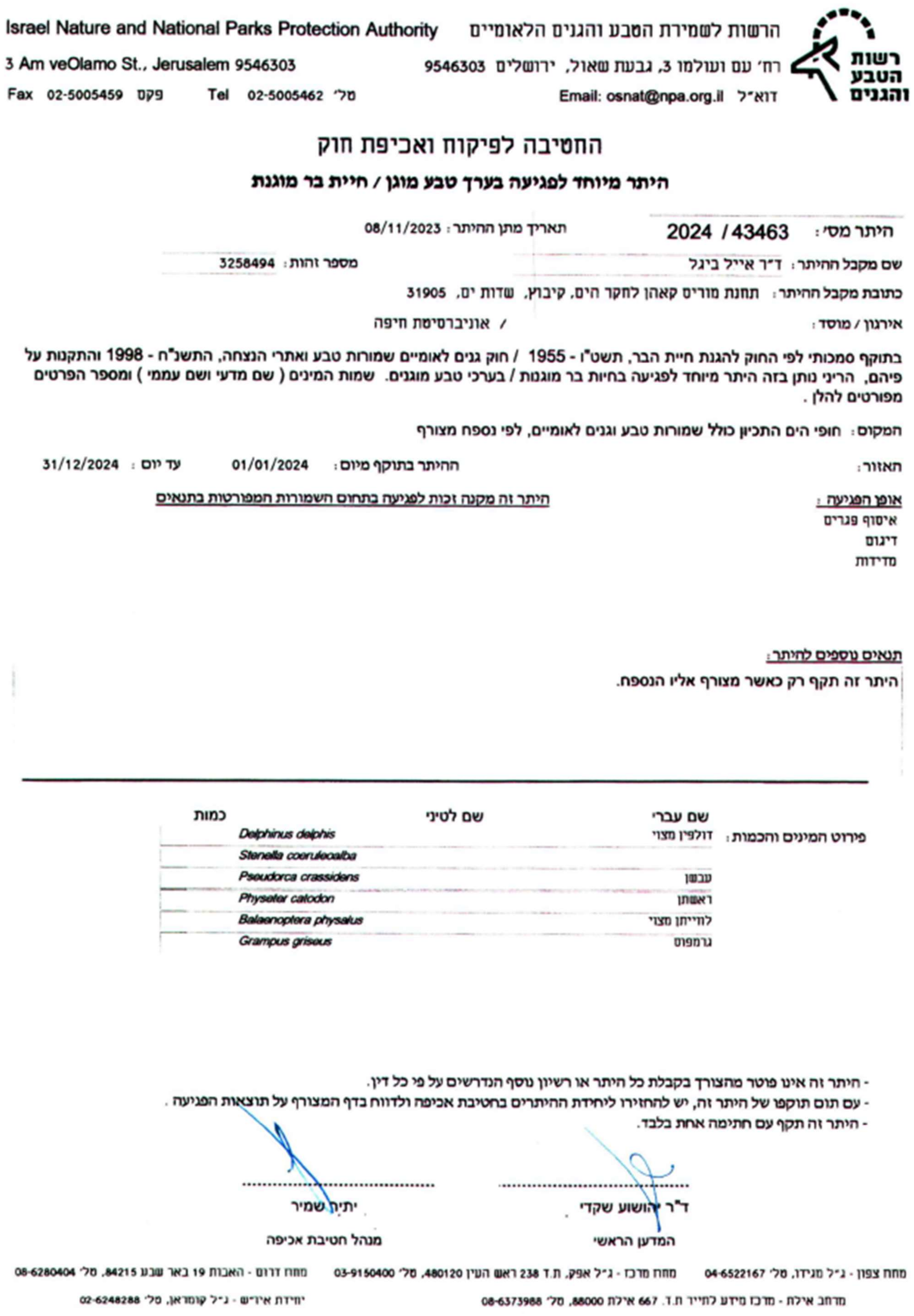
היתר זה בתוקף החל מ- 01/12/2023 ועד 30/11/2024

תנאים נוספים להיתר:

1. יש לתאם את הפעילות מראש עם פקחי הרשות הרלוונטיים לפי רשימה מצ״ב.
2. בעל ההיתר יתאם מראש כל פעולה של דיגום הפגר בשטח עם ד״ר תומר ניסימיאן וטרינר הרשות, נייד: 050-5479959, וד״ר יניב לוי, נייד: 053-7512220, מרכז הצלה לצבי ים.
3. ההיתר ניתן לאיסוף, דיגום פיזי, או מדידות של יונקים ימיים מתים בלבד.
4. ניתוח לאחר המוות יתבצע רק במתקן המאושר ע״י וטרינר רט״ג.
5. שימור דגימות שונות יתבצע לפי הנחיות וטרינר רט״ג.
6. אין לסחור, להעביר, לתת או לחלק דגימות, חלקי גופה, פסדים ושלדים שלמים של יונקים ימיים ללא אישור רט״ג.
7. יש לדווח לרשות **דיווח מלא** כולל פרטים מלאים על ארועי החפה, דיגום ונתיחה: נ.צ. מדויק של מקום ההחפה, מין, גיל וזוויג, מדדי גודל גוף, סיבת המוות-אם ידועה. פרטי הנתיחה (דיווח מיד בסיום הנתיחה), והטיפול בפגר - כולל קבורה בשטח לצורך הרכבת השלד לתערוכה/מחקר/למוסד.
8. החלטה על אופן הטיפול בפגר בשטח תתקבל ע״י רט״ג לאחר התייעצות משותפת ותכלול בחינה של הטבעת גופות יונקים ימיים גדולים בים במקום קבורה על היבשה.
9. בהיתר זה ייקחו חלק גם: ד״ר שלומי עמיאל, ד״ר אלון לוי, ד״ר דני מוריק, ד״ר גלעד ימין, ד״ר דני כרם, ד״ר אביעד שיינין, ד״ר מיה אלסר, פרופ׳ יוסי יובל, יפית ברנר, ניר הדר, יותם צוריאל, רוני הורוביץ, אייל ביגל, קים קובו, רותם תעסה, גיא שונק ויאלי מבורך.

ד״ר יהושע שקדי
מדען הרשות

יתיר שמיר
מנהל חטיבת אכיפה



רשות הטבע והגנים
הרשות לשמירת הטבע והגנים הלאומיים
Israel Nature and National Parks Protection Authority
רח' עם ועולמו 3, גבעת שאול, ירושלים 9546303
3 Am veOlamo St., Jerusalem 9546303
דוא"ל Email: osnat@npa.org.il
טל' Tel 02-5005462
פקס Fax 02-5005459

החטיבה לפיקוח ואכיפת חוק

היתר מיוחד לפגיעה בערך טבע מוגן / חיית בר מוגנת

היתר מס' : 43463/ 2024
תאריך מתן ההיתר : 08/11/2023
שם מקבל ההיתר : ד"ר אייל ביגל
מספר זהות : 3258494
כתובת מקבל ההיתר : תחנת מוריס קאהן לחקר הים, קיבוץ, שדות ים, 31905
אירגון / מוסד : / אוניברסיטת חיפה

בתוקף סמכותי לפי החוק להגנת חיית הבר, תשט"ו - 1955 / חוק גנים לאומיים שמורות טבע ואתרי הנצחה, התשנ"ח - 1998 והתקנות על פיהם, הריני נותן בזה היתר מיוחד לפגיעה בחיות בר מוגנות / בערכי טבע מוגנים. שמות המינים (שם מדעי ושם עממי) ומספר הפרטים מפורטים להלן .

המקום : חופי הים התיכון כולל שמורות טבע וגנים לאומיים, לפי נספח מצורף

תאזור :
ההיתר בתוקף מיום : 01/01/2024
עד יום : 31/12/2024

היתר זה מקנה זכות לפגיעה בתחום השמורות המפורטות בתנאים

אופן הפגיעה :
איסוף פגרים
דיגום
מדידות

תנאים נוספים להיתר:
היתר זה תקף רק כאשר מצורף אליו הנספח.

פירוט המינים והכמות :

שם עברי	שם לטיני	כמות
דולפין מצוי	*Delphinus delphis*	
	Stenella coeruleoalba	
עבשן	*Pseudorca crassidens*	
ראשתן	*Physeter catodon*	
לווייתן מצוי	*Balaenoptera physalus*	
גרמפוס	*Grampus griseus*	

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- עם תום תוקפו של היתר זה, יש להחזירו ליחידת ההיתרים בחטיבת אכיפה ולדווח בדף המצורף על תוצאות הפגיעה .
- היתר זה תקף עם חתימה אחת בלבד.

ד"ר יהושוע שקדי
המדען הראשי

יתיה שמיר
מנהל חטיבת אכיפה

מחוז צפון - ג"ל מגידו, טל' 04-6522167 מחוז מרכז - ג"ל אפק, ת.ד 238 ראש העין 480120, טל' 03-9150400 מחוז דרום - האבות 19 באר שבע 84215, טל' 08-6280404

רשות
הטבע
והגנים
מחלקת היתרים

נספח להיתר מיוחד לפגיעה בערך טבע מוגן

היתר מס. 2024/43463

מקבל ההיתר: ד״ר אייל ביגל ת.ז. 32584948

נספח זה תקף רק כאשר הוא מצורף להיתר 2024/43463

היתר זה בתוקף החל מ- 01/01/2024 ועד 31/12/2024

תנאים נוספים להיתר:

1. יש לתאם את הפעילות מראש עם פקחי הרשות הרלוונטיים לפי רשימה מצ״ב.
2. בעל ההיתר יתאם מראש כל פעולה של דיגום הפגר בשטח עם ד״ר תומר ניסימיאן וטרינר הרשות, נייד: 050-5479959, וד״ר יניב לוי, נייד: 053-7512220, מרכז הצלה לצבי ים.
3. ההיתר ניתן לאיסוף, דיגום פיזי, או מדידות של יונקים ימיים מתים בלבד.
4. ניתוח לאחר המוות יתבצע רק במתקן המאושר ע״י וטרינר רט״ג.
5. שימור דגימות שונות יתבצע לפי הנחיות וטרינר רט״ג.
6. אין לסחור, להעביר, לתת או לחלק דגימות, חלקי גופה, פסדים ושלדים שלמים של יונקים ימיים ללא אישור רט״ג.
7. יש לדווח לרשות **דיווח מלא** כולל פרטים מלאים על ארועי החפה, דיגום ונתיחה: נ.צ. מדויק של מקום ההחפה, מין, גיל וזוויג, מדדי גודל גוף, סיבת המוות-אם ידועה, פרטי הנתיחה (דיווח מיד בסיום הנתיחה), והטיפול בפגר - כולל קבורה בשטח לצורך הרכבת השלד לתערוכה/מחקר/למוסד.
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9. בהיתר זה ייקחו חלק גם: פרופ׳ דני צ׳רנוב, ד״ר אביעד שיינין, ד״ר דני מוריק, יאלי מבורך, ד״ר מיה אלסר, יותם צוריאל,, יפית ברנר, ענת בהר,

ד״ר יהושע שקדי
מדען הרשות

יתיר שמיר
מנהל חטיבת אכיפה

מאפייני רביה של נקבות דולפינן מצוי לאורך רצועת החוף הישראלי

קים קובו

תקציר

מאפייני רביה של נקבות מהמין דולפינן מצוי (*Tursiops truncatus*) נחקרו רבות ברחבי העולם, אך כמעט ולא נחקרו בים התיכון. אוכלוסיית הדולפינן המצוי בים התיכון מהווה תת-אוכלוסייה השונה גנטית מאוכלוסית המקור באוקינוס האטלנטי. כמין חופי, הם מושפעים באופן משמעותי מפעילות אנושית כגון זיהום, דיג יתר והריסה ודילול של בתי גידול, אשר עלולות להשפיע ישירות על שרידות גורים ועל הצלחת הרבייה של נקבות, במיוחד באזור עם אתגרים סביבתיים ייחודיים כמו במזרח הים התיכון. במחקר זה נעשה שימוש בנתוני התנהגות ותמונות סנפירים שנאספו לאורך השנים, כמו כן בנתוני החפה לאורך חופי ישראל. הנתונים נאספו בין ינואר 2005 לדצמבר 2023 באמצעות 1,192 סקרי שייט. במהלך 244 תצפיות תועדו 301 דולפינים, למעט גורים, בהתבסס על ניתוח של 13,585 תמונות סנפירים באיכות גבוהה. בין השנים 1994 ל-2022 דווחו 248 מקרים של דולפיננים מצויים שנסחפו לחוף או נלכדו ברשתות דיג לאורך חופי ישראל. מחקר זה בחן את שיעור ההמלטות, פוריות, עונת רבייה, מרווחים בין הלידות, גיל גמילה מינקות, שיעורי שרידות ומגמות הקשורות לתמותה. בין השנים 2005 ל-2023 בוצעו 517 זיהויים פרטניים של 61 נקבות פוריות ו-114 גורים. 79% (n = 192) מהתצפיות כללו נקבות ו-53% (n = 129) כללו גורים. בסך הכל, 61% (n = 37) מהנקבות הללו נצפו עם גור אחד, 16% (n = 10) עם שני גורים ו-23% (n = 14) עם שלושה גורים או יותר. המספר המרבי של גורים שנולדו לנקבה ידועה היה שבעה. בנוכחות גורים, להקות נוטות להיות גדולות יותר, אך קטנות במהלך חיפוש מזון בקרבת מכמורתנים. למרות גודל המדגם הקטן, התוצאות מצביעות על עונתיות, כאשר רוב הלידות מתרחשות באביב ובקיץ, במקביל לעלייה בטמפרטורת המים. שיעור ההמלטות היה 0.2 ושיעור הפוריות היה 0.1. ממוצע המרווחים בין הלידות היה 2.97, והוא נכלל בטווח הנמוך של הערכים שנמצאו באוכלוסיות דולפינים דומות. גור יונק בממוצע 2.61 שנים, מה שמרמז כי דולפינים באזור המחקר נוטים לגמול את צאצאיהם הנוכחיים בערך באמצע ההריון. שיעורי ההישרדות של דולפינים בוגרים (0.80) ושל גורים (כלל הגורים: 0.52 ; שרידות בשנה הראשונה: 0.73) , היו נמוכים מאלה שדווחו במחקרים אחרים, מה שמעיד כי הצלחת הרבייה עשויה להשפיע יותר על מצב האוכלוסייה מאשר שיעורי ההישרדות באוכלוסייה זו. על פי נתוני ההחפה, שיעורי התמותה נותרו יציבים במהלך 30 השנים האחרונות, עם ממוצע של שמונה פרטים בשנה. ישנה עלייה משמעותית בשיעורי תמותה בכל קבוצות הגיל במהלך הקיץ. ממצאים אלה מדגישים את החשיבות במחקר זה לחיזוי מגמות באוכלוסייה ותגובותיהן ללחצים סביבתיים. התוצאות מדגישות את הצורך הקריטי במחקרים ארוכי-טווח של מינים מאריכי-חיים ברמת הפרט והאוכלוסייה לצורך שימור וניהול.

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