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BEHAVIOR AND GROUP CHARACTERISTICS OF MARINE MAMMALS IN THE SOUTHERN CALIFORNIA BIGHT 2008-2010

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Introduction

The observed behavior of marine mammals in the Southern California Bight (SCB) has been little described and is limited to a few species and relatively small sample sizes. Since 2008, the U.S. Navy has been tasked by the National Marine Fisheries Service to monitor the distribution, occurrence and behavior of marine mammals within the Southern California Range Complex (SOCAL) off San Diego and San Clemente Island, California (DoN 2009). The initial primary goal has been to gather current baseline data that can be used comparatively to quantify potential effects of Navy major training events involving mid-frequency active sonar (MFAS) and underwater detonations. Numerous behavioral and group social parameters have been used to quantify and compare the reactions of various marine mammal species to anthropogenic and other stimuli such as underwater sound, vessels, predators, etc. (e.g., see review in Richardson et al. 1991). In such studies, baseline variables were compared to the same variables collected under stimulus-exposed conditions. Significant changes in a number of behavioral variables have been associated with such stimuli for whales. Examples include changes in dive and surface times, respiration rates, swim speeds, and headings among bowhead whales (*Balaena mysticetus*) (e.g., Richardson et al. 1985), gray whales (*Eschrichtius robustus*) (Malme et al. 1986), humpback whales (*Megaptera novaeangliae*)(Baker et al. 1985; Bauer 1986, Frankel and Clark 2002), and sperm whales (*Physeter macrocephalus*) (Madsen et al. 2002; Smultea et al. 2008). Among delphinids, reactions have included changes in dive and surface times, group size and cohesion, heading/orientation, swim speed, including bottlenose dolphins (*Tursiops truncatus*) (Smultea and Würsig 1992; Constantine et al. 2004), dusky dolphins (*Lagenorhynchus obscurus*) (Vaughn et al. 2010), and common dolphins (*Delphinus* spp.) (Stockin et al. 2009).

Of particular relevance to SOCAL are recent studies there and elsewhere focused on the behavioral responses of a number of cetacean species to playbacks of reduced sound levels of MFAS. The latter studies have been designed to facilitate collection of before, during and after behavioral, dive and vocalization data. Techniques have included vessel-based visual observations, passive acoustic recordings, photo-identification, and tagging of animals with satellite, time-depth-recorder, and acoustic sensors. However, vessels from which visual observations are made contribute to underwater noise and potential confounding disturbance to focal animals. In addition, the high expense of such studies, the difficulty in obtaining statistically sufficient sample sizes, and the general lack of baseline "undisturbed" regional behavioral data from SCB species limits the interpretation of the results. Despite the limitation, those studies currently represent the most integrated and comprehensive study focused on the behavioral responses to MFAS. Preliminary results indicate that responses or lack thereof appear to be related to the behavioral context when the noise exposure occurs, i.e., the level of individual response is related to what the individual is doing as has been shown for other cetaceans and stimuli (reviewed in Richardson et al. 1991). Although these studies have provided valuable insight, there is still a critical need for additional behavioral response studies, particularly with larger sample sizes and from other species (NRC 2003; Southall et al. 2008). Additionally, to interpret these results, it is also essential to understand what constitutes "normal" or "typical" behavior in the absence of the noise of interest which is difficult, if not impossible to obtain from vessel-based visual observations.

In this paper, we report selected results of aerial surveys conducted in the SCB on behalf of the Navy to gather baseline behavioral ecology parameters for marine mammals with which to provide a comparison database for animals exposed to MFAS. Variables of interest were selected based on results of other studies identifying certain quantifiable parameters shown to be demonstratively sensitive to underwater noise for some marine mammal species (e.g., Richardson et al. 1985, 1995; Malme et al 1986; Smultea and Würsig 1992; Gailey et al. 2007). The goal was to gather robust sample sizes of the selected behavioral and group characteristic variables to describe the typical behavior of Federally-listed and selected priority species as feasible. We also developed hypotheses linked with these variables to be used for future and ongoing identification and interpretation of potential reactions of marine mammals to MFAS and underwater detonations.

Methods

Eight aerial surveys were conducted from 2008-2010 in October and November 2008; June, July and November 2009; and May, July and September 2010 (Table 1). The observation platform was a high-wing, twin-engine, fixed-wing Partenavia P68 or Observer (OBS) aircraft. Survey methods were consistent with current accepted Distance Sampling theory (Buckland et al. 2001) and followed general protocol used for surveys SOCAL (e.g., Carretta et al. 2000). Survey lines consisted of generally E-W-oriented lines perpendicular to bathymetric contours (Figure 1). Surveys were flown at a speed of 100 knots from an altitude of approximately 357 m (1,000 ft). Previous studies indicate that bowhead whales (e.g., Richardson et al. 1985a,b; Patenaude et al. 2002), adult humpback whales (e.g., Smultea et al. 1995), and bottlenose dolphins (Smultea and Würsig 1995) show little or no detectable reaction to small fixed-wing aircraft circling at these altitudes and radial distances (also see review in Richardson et al. 1985 a,b; 1995). Preliminary data support these results (SES unpublished data). These parameters are well outside the Snell's Cone theoretical range of air-to-water sound transmission angle associated with over-flying aircraft (Urick 1972, 1983; Richardson et al. 1995). Thus, staying outside these parameters was anticipated to avoid the potential for the aircraft to affect the behavior of the observed animals.

The survey team consisted of a pilot and three marine mammal biologists experienced in line-transect survey methodology; identification of Pacific marine mammals; and marine mammal observations from aircraft. Two observers were in the back seats of the aircraft, while the third sat in the front right co-pilot seat, serving as the recorder and photographer.

The general survey approach was to: (1) follow survey lines until a sighting was made; (2) record basic sighting information per established protocol; and (3) circle the sighting to photo-document and confirm species and group size and take digital photographs as needed; or (4) increase altitude to ~365-455 m and radial distance ~0.5-1.0 km to conduct a detailed focal behavioral follow involving videography. Geographical Positioning System (GPS) locations were automatically recorded at 10-sec intervals on a handheld, WAAS-enabled Garmin 495 aviation

GPS as well as by the aircraft WAAS GPS. A Suunto handheld clinometer was used to measure declination angles to a sighting when it was perpendicular to the aircraft. Steiner 7 x 25 or Swarovski 10 x 32 binoculars were used as needed to identify species, group size, and behaviors.

Data were recorded using a Palm Pilot TX, Apple iTouch, or an Acer netbook laptop computer. Data recording software consisted of SpectatorGo or custom-designed Excel datasheets. Recorded variables included environmental data (Beaufort sea state, glare, visibility conditions); leg effort type (e.g., systematic line transect, connector (i.e., shorter) lines connecting systematic lines, random, transect, circling); species; estimated group size; and number of calves observed. Modified scan sampling and zero-one sampling approaches (Altmann 1974; Smultea 1994, 2008; Mann 2000) were used to record: (1) behavioral state; (2) minimum and maximum dispersal distance between nearest individuals within a subgroup (i.e., spacing estimated in body lengths [BL]); and (3) heading (in degrees magnetic) (see Table 2).

Photographs to confirm species identifications were taken using a digital camera with Image Stabilized (IS) zoom lenses (a Canon 40D with 100-400 mm ET-83C lens, a 20D with 70-200 mm 2.8 lens and 1.4x converter; or a D60 with 100-400mm lens). For focal follow behavioral sessions, a Canon Vixia HF10 or Sony HDR-XR550 12.0 megapixels high-definition (HD) digital video camera with a built-in optical image stabilizer and 12x optical zoom lens were used to record behaviors. Software vATS was used to convert video camera lapsed time to real-time. The microphone of the video camera was connected to the audio system of the aircraft so that all vocal input (i.e., behavioral verbal descriptions) was recorded into the video camera data stream.

Sighting rates (number of sightings per unit effort) were calculated for on-effort periods involving "point-to-point" effort (i.e., systematic, connector and transit leg types) (Smultea et al. 2009, Jefferson et al. 2011). Statistical analyses were conducted using Excel or SPSS software. Video analyses involved reviewing video and transcribing observed behaviors and recorded audio from the video onto a customized Excel spreadsheet (Smultea and Bacon 2011); the latter results are not includedhere.

Results

A total of 1,284 groups of marine mammals and an estimated 177, 770 individuals were sighted during approximately 37,798 km of all observation effort across eight aerial surveys from Fall 2008 through Fall 2010 (Table 1). Of these totals, 24,736 km consisted of point-to-point observation effort during which 924 sightings of approximately 85,502 individuals occurred. Sixteen marine mammal species were identified-- 13 cetacean and 3 pinniped (Table 1). Group size and initial behavioral state, heading, and minimum and maximum dispersal distance (within subgroups) data were recorded for most sightings when such information could be determined. Sighting rates, mean group sizes, and means and/or frequency distributions of headings, mean maximum dispersal distance, and behavior states are presented in Tables 2-4 and Figures 2-43; these parameters were also summarized by time of year and diurnal differences.

The following discussion is organized by species or species groups in descending order of group sighting frequency and is limited to the following seven most commonly sighted species each with a minimum of 20 sightings: common dolphin, California sea lion, Risso's dolphin, fin whale, blue whale, bottlenose dolphin, and Pacific white-sided dolphin. Sample sizes of the remaining species were considered too small to warrant summarization and interpretation of trends. Each subsection consists of a brief overview of natural history important to understanding the context of the study results. Results are then discussed in the context of what is known and of relevance for the species, and what those results may indicate relative to the animal's behavioral ecology. In general, the social behavior of the species discussed is not well documented and/or what is available has been collected outside the SCB with few exceptions.

Common Dolphin *Delphinus* spp.

Two species of common dolphin – short-beaked (*D. delphis*) and long-beaked (*D. capensis*) – occur in the SCB (Heyning and Perrin 1994; Chivers et al. 2010; Carretta et al. 2011). Common dolphins are the most abundant cetaceans off California (e.g., Dohl et al. 1981; Forney et al. 1995; Carretta et al. 2011; Jefferson et al. 2011). Historically, this abundance has changed both seasonally and inter-annually with varying oceanographic conditions, with abundance increasing off California during the warm-water months (Dohl et al. 1986; Barlow 1995; Forney et al. 1995; Forney and Barlow 1998; Forney 2000; Carretta et al. 2011). In response to oceanographic events, movements may be north-south and/or inshore-offshore (Barlow 1995; Forney and Barlow 1998). Short-beaked common dolphin abundance off California has increased dramatically since the late 1970s, suggesting a large-scale shift in distribution in the eastern North Pacific (Forney et al. 1995; Forney and Barlow 1998; Jefferson et al. 2011). The northward extent of this distribution appears to vary interannually and with changing oceanographic conditions (Forney and Barlow 1998).

Delphinus is often found associated with offshore bathymetric features, such as escarpments and submarine canyons (e.g., Dohl et al. 1986). However, common dolphins of both species have also frequently been found close to the SCB mainland (Smultea et al. 2009, 2010, 2011a). Perrin (2002) report that long-beaked common dolphins appear to be restricted to waters relatively close to shore, preferring shallower and warmer water than the short-beaked common dolphin (Perrin 2002). However, habitat partitioning among the two species is not clear-cut and is not typical for areas outside California and Baja California (Pinela et al. 2011). In fact, mixed aggregations of short- and long-beaked common dolphins have been reported within the SCB (G. Campbell and

T. Jefferson, pers. comm., 2011), and considerable geographical overlap has been observed in the SCB (Smultea et al. 2009, 2010, 2011a).

Common dolphins are typically sighted in schools of hundreds to over 1,000 individuals (Evans 1994; Jefferson et al. 2008). Nineteen species of fish and two species of cephalopods have been found within the stomachs of *Delphinus* from California waters, most of which are associated with the vertically migrating deep-scattering layer (Evans 1994). Off San Clemente Island, a distinct diurnal movement pattern has been recently reported, with common dolphins moving offshore into deeper waters in the late afternoon and evening, and returning inshore at dawn (Henderson 2010). This movement combined with the low rate of observed daytime foraging, analyses of vocalizations, and stomach content analyses suggest that common dolphins in this region are primarily engaged in night-time feeding (Henderson 2010).

We observed a total of 307 common dolphin groups consisting of an estimated 79,254 individuals (Table 2). Individuals were seen during all survey months from May-November. Consistent with past SCB studies, common dolphin sighting rates were relatively high in summer (11.4 groups/1,000 km) and fall (13.7 groups/1,000 km) (Figure 2). Sighting rate increased across the day from 8.8 in the morning to 15.9 groups/1,000 km in the late afternoon. Overall, mean group size was 258 ± 39.7 individuals. Although mean group size was higher in the morning (302 ± 119.0) vs. mid-afternoon (251 ± 50.4) and late afternoon (240 ± 64.6), this difference was not significant given the high degree of variability in group size. There was also no significant change observed in group size by season. We observed a mean maximum dispersal between individual common dolphins within subgroups of 5 ± 0.7 BL, with no significant changes by time of day or season.

Common dolphins were predominantly (37% of 110 groups) observed to "surface-active mill" followed by travel (34%) and surface-active travel (21%) based on initially observed behavior state. This species was the most surface-active of all marine mammal species observed, with 58% of all groups observed in a surface-active behavior state. Overall, mean heading of common dolphins groups was southerly (188º ± 15.8) as represented primarily by summer observations; no significant differences were found in headings by survey period or time of day (Figure 6). The latter result does not support observations reported by Henderson (2010) suggesting that common dolphins headed predominantly westward in the late afternoon and evening and predominantly eastward at dawn (based on 61 common dolphin groups observed on 97 days from a stationary vessel near San Clemente Island in 2006-2008).

In summary, common dolphins were observed in very social, large, relatively consistent group sizes of around 250 - 300 animals, with a trend for larger group sizes in fall vs. spring/summer. Despite large group aggregations, individuals appeared to be consistently very cohesive within subgroups based on a relatively small mean maximum dispersal distance and associated low variability around this distance. Overall, common dolphins were more likely to be headed in a southerly direction, although there were no significant diurnal differences in headings unlike reported for this species near San Clemente Island.

<u>California sea lion *Zalophus californianus*</u>

The California sea lion ranges along the west coast of Mexico to southern British Columbia, from about 19 degrees N latitude northward to 50 degrees N latitude. This is the most commonly observed pinniped in the SCB although its relative abundance is related to time of year. During the breeding season (May-July), nearly the entire population occurs south of 34 degrees N latitude. Breeding California sea lions occur in large numbers at and near colonies at the southern California Channel Islands (principally San Nicolas and San Miguel islands) from late May through August (Stewart et al. 1993). Most rookery sites in the Channel Islands are used as haul-out areas during the non-breeding season (Stewart and Yochem 2000). Sea lions seen near the mainland coast in southern California may be from the colony at the Coronado Islands in northern Baja California or perhaps even colonies farther south. Non-breeding sea lions from U.S. colonies occur farther north along the California coast throughout summer, and may remain there or move even farther north, during fall and winter. California sea lions are least abundant in the SCB during fall and winter when adult and subabdult males, many juveniles, and some adult females forage off northern and central California, Oregon, Washington, and British Columbia (Stewart et al. 1993). Adult females and pups generally remain year-round south of Monterey Bay, California, feeding in coastal waters in the summer and moving offshore in the winter (Melin and DeLong 2000; Melin et al. 2008).

The California sea lion is a coastal animal rarely venturing seaward off the continental slope (Antonelis and Fiscus 1980). Most individuals stay within 50 km of the rookery islands during the breeding season (Bonnell et al. 1978), primarily in productive upwelling areas around the islands or near Point Conception (Stewart et al. 1993). Bearzi et al. (2008) reported frequent sightings near canyons.

Life history of the California sea lion is strongly tied to the dynamics of the California Current System (CCS) (e.g., Block et al. 2010). During periods of strong negative upwelling in the CCS (e.g., El Nino-Southern Oscillation [ENSO] events), regional productivity declines and lactating female California sea lions travel farther from the colony, move farther offshore and dive deeper, presumably in response to movement of their prey deeper in the water column or to more productive areas (Melin et al. 2008). As a result, changes in distributions, pup production, female survivorship, and foraging behaviors of sea lions occur during El Niño years when there are substantial declines in their local abundance and distribution (e.g., Ono et al. 1987; DeLong et al. 1991). The unprecedented mortality of California sea lion pups born at San Miguel Island, California, and the record number of emaciated weaned pups that stranded along the central California coast in 2009 were associated with anomalous oceanographic conditions along the central California coast between May and August 2009 (Melin et al. 2010).

California sea lions are highly gregarious and often haul out in large numbers. Thus, most information on the occurrence and distribution of California sea lions in the SCB is based on observed densities at terrestrial haul -outs, though Bearzi et al. (2008) reported densities at sea nearshore off Santa Monica, California. General unquantified observations indicate that they are usually solitary while at sea, but tend to form large groups near food-rich areas (Antonelis and Fiscus 1980). California sea lions often “raft” at the water surface alone or in groups. They engage in cooperative foraging behavior with common dolphins (*Delphinus* spp.) along the ridges and canyons of the SCB per vessel-based observations of 140 sightings made at sea in Santa Monica Bay from 1997- 2001 (Bearzi 2006).

When in the SCB, this species forages mostly at depths of 150 to 300 feet, primarily in offshore upwelling areas, though they may also occasionally forage on demersal prey in nearshore kelp beds. During the breeding season, females are primarily coastal foragers and shallow divers

(Melin and DeLong 2000). During the non-breeding season, Melin and DeLong (2000) reported that tagged females forage over the slope or offshore.

The California sea lion diet is temporally dynamic, with animals feeding on seasonally abundant schooling or aggregating prey. Northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*), Pacific whiting (*Merluccius productus*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), shortbelly rockfish (*Sebastes jordani*), and market squid (*Loligo opalescens*) are their main prey in southern California (Lowry and Carretta 1999; Lowry et al. 1990, 1991). Diet of sea lions becomes more variable during El Niño oceanographic events due to decreased abundance and availability of their preferred prey. Migrating sea lions, especially subadult and adult males, may forage closer to the mainland coast, often associating with recreational and commercial fishing vessels, feeding on fish used for chum and depredating (i.e., taking) the fish (i.e., yellowtail, barracuda, or bonita) that have been caught (Hanan et al. 1989).

We observed a total of 298 California sea lion groups of an estimated 857 individuals (Table 2). Consistent with past SCB studies, they were seen during all survey months from May-November with highest at-sea sighting rates in fall (14.82 groups/1,000 km) vs. summer (9.37 groups/1,000 km) (Figure 8). Morning and mid-afternoon sighting rates (13.4 and 13.6 groups/1,000 km, respectively) were nearly double those observed in the late afternoon (6.9 groups/1,000 km) (Figure 8). This pattern could indicate that California sea lions tended to haul-out more in late afternoon and were thus not seen during line-transect surveys.

Consistent with other reports, California sea lions tended to occur alone or in small groups while at sea, with little variation in group size. Overall, mean group size was 3 ± 0.7 individuals. Although mean group size was somewhat lower in summer (2 ± 0.7) vs. fall (3 ± 0.9), this difference was not significant (X^2=1.42, df=1, p=0.23). Mean maximum dispersal distance between individuals within subgroups was 6 ± 3.8 BL, indicating that synchronized groups tended to remain close to one another while at sea, presumably socializing. Dispersal distance was not found to differ significantly by time of day or season.

California sea lions were most frequently (60% of 99 groups) observed "traveling" (swimming) in point-to-point movement based on initially observed behavior state, followed by milling (33%), with very little surface-active behavior seen (8%). Overall, mean heading of California sea lion groups was to the SSW (210º ± 25.3) as represented primarily by fall observations; no significant differences were found in headings by survey period or time of day (Figure 12).

Risso's dolphin *Grampus griseus*

Risso's dolphins in the SCB belong to the California/Oregon/Washington stock inhabiting shelf, slope and offshore waters within the SCB, and ranging into more northern slope and offshore waters into Washington (Carretta et al. 2011). Historical, year-round aerial surveys in the region indicate that this stock occurs most commonly off California during the colder water months then appears to generally shift northward primarily into Oregon and Washington waters during the warmer-water periods in late spring and summer (Green et al. 1992; Carretta et al. 2011). However, the abundance and distribution of this species appears vary with changes in seasonal and inter-annual oceanographic conditions (Forney and Barlow 1998).

Based on surveys between 1991 and 2008, Barlow and Forney (2007) and Barlow (2010) report abundance estimates ranging from approximately 4,000 to 11,000 animals in California waters, with no apparent consistent trend in abundance. However, In the SCB, Risso's dolphins appear to have been increasing in abundance over the last few decades (e.g., Leatherwood et al. 1980; Shane 1995; Forney et al. 1995; Carretta et al. 2000; Smultea et al. 2009, 2010, 2011 a,b; Jefferson et al. 2011), before which they were considered relatively rare. Their influx was correlated with the apparent near abandonment of SCB waters by short-finned pilot whales in the early 1980s in association with a severe ENSO and drop in squid abundance (Barlow 1995; Shane 1995). Within the SCB, Risso's dolphins have been consistently associated with shelf-edge habitats and other steep underwater topographical features from the mainland coast to waters west of San Clemete Island (SCI) (Carretta et al. 2000; Carretta et al. 2011; Forney and Barlow 1998; Smultea et al. 2009, 2010, 2011 a,b), usually over water depths of 400-1000 m (Baird 2008).

The social, feeding, and diving behavior of Risso's dolphins are little described. Reported typical group sizes for Risso's dolphins off California range from about 10-50 individuals (Forney and Barlow 1993, Baird 2008). In areas outside the SCB, stable groups of adults have been reported within larger aggregations. Limited data from a school killed in a drive fishery in Japan, it has been hypothesized that mature males travel between groups.

We observed 148 Risso's dolphin groups comprised of an estimated 2473 individuals during SCB aerial surveys from 2008-2010 (Table 2). Consistent with past SCB studies, Risso's dolphins were seen during all survey months from May-November. However, sighting rates (corrected for effort) were much higher in summer (9.96 groups/1000 km) vs. fall (2.33 groups/1000 km) (Figure 14). In contrast, Carretta et al. (2000) reported that Risso's dolphins were more abundant in fall than in summer. Risso's dolphin sighting rates tended to increase across the day: 4.46 groups/1,000 km in the morning, 6.31 groups/1,000 km in the mid-afternoon and 7.26 groups/1,000 km in the late afternoon (Figure 14). This could suggest diurnal inshore-offshore movement of the species such that they may have been farther offshore or out of our SCB study area in the morning periods. Overall, mean group size was 19 ± 3.3 individuals (n = 148) and was significantly lower in summer (16 ± 3.0, n = 118) than in fall (29 ± 10.3, n = 30) (Kruskal: X^2= 6.27, df=1, p=0.012). There was no significant difference in group size by time of day (Kruskal: X^2= 0.53, df=2, p=0.766). Overall, mean maximum dispersal distance between individuals was 6 ± 1.4 BL, n = 23). This dispersal distance decreased significantly across the day, with the largest maximum dispersal in the morning (10 ± 4.8 BL, n = 23) and the shortest maximum inter-individual distance during late afternoon (3 ± 0.77, n = 31) (Kruskal: X^2= 20.148, df=2, p<0.000).

Risso's dolphins were nearly always (80% of 114 groups) observed "traveling" in slow, point-to-point movement based on initially observed behavior state. Surface-active behavior was rarely observed (3% or 4 of 114 groups), unlike for common dolphins (Table 2). Similarly, Shane (1995) reported that 84% of 234 records of Risso's dolphin behavior off Santa Catalina Island consisted of a travel behavioral state (note however, that the latter data includes multiple recordings from the same group(s) followed from a small research vessel using instantaneous samples collected at 5-min intervals; the total number of separate groups was not indicated). Similarly, in Monterey Bay, California, Kruse (1989) reported that traveling was the most common behavioral state recorded for Risso's dolphins. Shane (1995) found that Risso's dolphins were engaged in feeding in only 1% of the 234 samples (diving repeatedly in the same location and surfacing facing in different directions); she hypothesized that feeding was rarely observed among Risso's dolphins because they were believed to feed primarily nocturnally, supported by tagging data from a single Risso's dolphin reported by Mate (1989).

However, the observed predominant slow travel behavior appears to contrast unquantified behavior observed among Risso's dolphins off Monterey Bay approximately 837 km north of the SCB (K. Forney and T. Jefferson, pers. comm., 2011). The latter dolphins are frequently surface-active such as porpoising, leaping, breaching, etc. Another interesting contrast for our recent Risso's dolphins observations compared to studies in the region from the 1980s and from Monterey Bay is that we rarely observed Risso's associated with other marine mammal species. Of our total 148 Risso's dolphin sightings, only 5 were associated with another species, most of which were California sea lions and common dolphins (3% of Risso's mixed species sightings); only 0.6% were with bottlenose dolphins. In contrast, Shane (1994) reported that Risso's commonly associated with bottlenose dolphins near Santa Catalina Island during 1983-1991. In Monterey Bay, Risso's dolphins appear to also associate more frequently with other marine mammals species than we observed in the SCB. Kruse (1989) reported that Risso's dolphins sightings from 1985 to 1987 were associated with another species, primarily northern right whale dolphins but also bottlenose dolphins. Extensive aerial surveys of the SCB conducted by the SWFSC during the 1980s and 1990s also may have had higher rates of mixed species associations for Risso's dolphins, particularly with bottlenose dolphins (Karin Forney, pers. comm., 2011). Interestingly, Risso's dolphins were associated with bottlenose dolphins during 1 of 66 Risso's sightings during approximately 24,854 km of aerial survey effort off the SCB from February-May 2011 (HDR, unpublished data).

Overall, mean heading of Risso's dolphin groups was to the SSW (195º ± 19.5) as represented primarily by summer observations. A slight temporal trend suggested more easterly movement in the morning vs. more westerly in the afternoon, but this difference was not significant (Figure 18). There were also no significant differences found in headings by survey period (Figure 18). Focal follows of this species for periods of up to one hour indicate that SCB Risso's dolphins are observable at or near the surface for extended periods of time engaged predominantly in very slow, synchronized travel in tight formations (SES, unpublished data). These observations suggest that during daylight periods, Risso's dolphins appear to rest/socialize, as suggested previously by Shane (1995) for Risso's dolphins observed near Santa Catalina Island in the 1980s during winter. The predominance of DSL prey species in stomach content analyses along with the diurnal resting behavior indicates that SCB Risso's dolphins are nocturnal feeders. Similar behavioral patterns have been documented for nocturnal-feeding/diurnal-resting Hawaiian spinner dolphins (e.g., Norris et al. 1994).

In summary, Risso's dolphins were most common during late spring/early summer, in contrast to SCB studies in 1998-1999 when they were most common during fall and winter (Carretta et al. 2000). Group size was consistently relatively small (about 20-30 individuals) compared to common dolphins, with largest group sizes during the fall cool-water season and during the morning. Group cohesiveness tended to be consistently tight based on dispersal distance of individuals within subgroups, with closer inter-individual spacing during the afternoon than the morning. Risso's dolphins predominantly traveled slowly and surface-active behavior was rarely observed, in contrast to behavior reported for this species to the north in Monterey Bay. Risso's dolphins were also less frequently associated with other species than reported for Monterey Bay. Differences in the behavior of Risso's dolphins in the SCB vs. farther north may be related to differences in prey abundance, distribution and behavior. Further examination of oceanographic and prey influences may reveal reasons for the observed geographical differences in behavior of Risso's dolphins.

Fin whale *Balaenoptera physalus*

Fin whales in the SCB belong to the California/Oregon/Washington stock within the eastern North Pacific population that ranges from Alaska to Mexico (Carretta et al. 2011). Historical surveys indicate that these whales occur year-round in southern/central California, with peak feeding numbers in summer and fall (Dohl et al. 1981; Forney et al. 1995; Barlow 1997; Carretta et al. 2000). They also feed during summer in Oregon (Green et al. 1992; McDonald 1994), and during summer/autumn in the Shelikof Strait/Gulf of Alaska (Brueggeman et al. 1990). Vocalizing fin whales have been recorded year-round off northern California, Oregon and Washington, principally between September and February (Moore et al. 1998). However, visually observed fin whale numbers appear to decline in winter/spring off California (Dohl et al. 1981; Forney et al. 1995; Smultea et al. 2009, 2010; Jefferson et al. 2011) and Oregon (Green et al. 1992), suggesting that they seasonally move outside these areas (Carretta et al. 2011). There are no reliable estimates on the current and historical abundance of fin whales in the entire northeast Pacific (NOAA 2011). The last estimate of 3,279 fin whales for the California/Oregon/Washington stock was based on ship surveys conducted in summer/autumn of 1996 (Barlow and Taylor 2001) and 2001 (Barlow 2003). Jefferson et al. (2011) recently estimated that 1.22 animals/100 km^2 inhabit the SCB during summer and fall using data from the same eight aerial surveys reported herein from 2008-2010.

Fin whales are typically associated with continental shelf waters (Jefferson et al. 2008). Within the SCB, recent studies indicate that fin whales concentrate primarily in waters west of SCI within the Navy's Southern California Anti-Submarine Warfare Range (SOAR), particularly along steep underwater ridges (Carretta et al. 2000; Smultea et al. 2009, 2010; Jefferson et al. 2011; Schorr et al. 2010). In particular, during June, we have commonly observed fin whales across San Nicolas Basin/SOAR between SCI and Tanner Bank (Smultea et al. 2009). However, they are also commonly found feeding within 10 km of San Diego, oftentimes with blue whales (Smultea et al. 2009, 2010, 2011b). Satellite-tagging of a few fin whales indicates that they travel between California, Oregon and Washington over periods of several days (Schorr et al. 2010). Schorr et al. (2010) suggested that fin whales may move relatively quickly between likely feeding areas, but remain more localized within those feeding areas for periods of time.

During the summer, fin whales lunge feed on krill, small schooling fish (e.g., herring, capelin, and sand lance), and squid but fast during the winter after migrating to warmer waters (NOAA 2011). We have observed and documented (with video) fin whales lunge feeding on swarms of red krill with frequent reddish –colored defecations within the SCB, including apparent inter-specific feeding competition with blue whales (SES and HDR unpublished data, Smultea et al. 2011b).

Specific breeding and calving areas of fin whales are unknown, but whaling data indicate that this activity occurs during mid-winter in more southern tropical and sub-tropical waters (Jefferson et al. 2008; NOAA 2011). Accordingly, the social and mating systems of fin whales are not well described or quantified. Available data indicate that long-term associations between individuals are rare, similar to most other baleen whales (NOAA 2011). Schorr et al. (2010) reported that fin whales off California to Washington are often observed in loose large aggregations; however, data from a small number of tagged individuals indicate that associations are ephemeral in nature. In the SCB, we have observed and documented (with video) socializing and touching among fin whales in what appear to be courting behaviors based on similarity with courting behaviors reported for humpback, gray, and bowhead whales (SES and HDR, unpublished data). We have also observed fin whale calves in the SCB (Smultea et al. 2009).

On the North Atlantic feeding grounds, fin whales typically occur in social groups of 2-7 individuals where they are frequently seen feeding in large groups or aggregations in association with humpback whales, minke whales, and Atlantic white-sided dolphins (Jefferson et al. 2008). In the SCB, we have commonly seen them interspersed with aggregations of blue whales but only rarely with other marine mammal species (SES and HDR unpublished data). One focal follow involved a mother-calf fin whale following and interacting (e.g., rolling, touching) with over 1,000 northern right whale dolphins documented for over 40 min with video in June 2009. The mother-calf pair remained at the tail end of the dolphin group. The dolphins appeared to interact with the fin whale mother and calf by swimming between and around them, while the fin calf often rolled on its mother's back/rostrum, meandering while slowly traveling.

During our 2008-2010 SCB aerial surveys, we observed a total of 51 fin whale groups comprised of an estimated 86 individuals (Table 2). Individuals were seen during all survey months with the highest sighting rate in May-June (Figure 20). The May-June sighting rate was 2-3 times higher than the July-September and October-November sightings rates; this difference was significant (X^2=13.73, df=2, p=0.001). Carretta et al. (2000) also reported seeing the fin whale year-round in our study area in 1998-1999, with highest abundance during warm-water (May-October) vs. cold-water (November-April) seasons. We did not find any significant diurnal differences in sighting rates (X^2=1.30, df=2, p=0.523).

Similar to blue whales, fin whales were nearly always (92% of 51 groups) observed "traveling", followed by milling (4%) and surface-active travel (4%). Like blue whales, this traveling probably involved feeding based on frequent reddish defecations and occasional lunge-feeding seen during the longer focal follow behavioral sessions (SES/HDR unpublished data). Overall, mean heading of fin whale groups was to the SSW (189 º ± 33) as represented primarily (36 of 51 groups) by summer observations. No significant differences were found in headings by survey period or time of day (Figure 24). Fin whales were headed more southwesterly in the mornings (212º ± 71.0) and more southeasterly in the afternoons (173º ± 43.9) though this trend was not significant (Kruskal:X^2=0.009, df=1, p=0.922). There were also no significant trends in heading by season (Kruskal: X2=0.550, df=1, p=0.458). Rather, headings were variable. Surprisingly few individuals headed south or north during the expected fall migration period (Figure 24).

Overall, mean group size of fin whales was 2 ± 0.2 individuals (n=51). This mean was nearly three times higher than that reported by Carretta et al. (2000) for fin whales in 1998-99 in the same region and season (warm-water season)(mean 1.3, n = 15). We observed smaller fin whale group sizes during late afternoon (mean 1 ± 0.3) than earlier in the day (2 ± 0.3), though this difference was not significant (Kruskal: X^2=5.308, df=2, p=0.070). No significant difference was found for group size in fall (mean 2 ± 0.6) vs. summer (mean 2 ± 0.2) (Kruskal: X^2=2.236, df=1, p=0.135). Carretta et al. (2000) reported a smaller mean group size of 1.0 fin whales (n=6) during the cool-water season; we did not survey the cool-water season. Tershy (1992) reported a median group size of 2.0 among traveling fin whales (n=197 sightings) in the central Gulf of California during year-round observations.

Mean maximum dispersal between individual fin whales within a group was 8 ± 4.6 BL, considerably less than the distance between blue whales in synchronized groups (16 ± 8.7 BL) (Table 2). Dispersal distance ranged from ~0.5 to 50 BL among fin whale groups, although socializing involving individuals touching was never observed during the May-November study period. Fin whales were occasionally (n = 2 events) seen in loose feeding aggregations with blue whales. In one focal behavioral session, video was taken of two fin whales suddenly increasing speed and turning sharply in front of several blue whales with one of the fin whales then gulping a reddish prey concentration of presumed krill.

Blue whale *Balaenoptera musculus*

Blues whales in the SCB belong to the Eastern North Pacific stock ranging from Alaska to the Costa Rica Dome. Southern and central California coastal waters are important feeding areas for this population in the summer and fall where their numbers appear to have increased from 1979-1996 (Carretta et al. 2011). Since 1996, blue whale numbers have fluctuated and declined off California, attributed to changes in the portion of the population feeding there in summer and fall (Calambokidis et al. 2009). In winter and spring, these whales migrate to biologically productive waters off Baja California, the Gulf of California, and the Costa Rica Dome, where at least small numbers are seen year-round (Reilly and Thayer 1990, Carretta et al. 2011). The population is believed to feed throughout the year. Breeding and calving areas are unknown but whaling data indicate this activity occurs during winter in more southern tropical and sub-tropical waters (Jefferson et al. 2008).

A total of 49 blue whale sightings of 84 individuals occurred (Table 2). Consistent with past DCB studies, blue whale sighting rates were highest in summer/fall. Individuals were seen during all survey months from May-November. However, sighting rates were significantly higher in summer (n=48 groups) vs. fall (1 group) (X^2=11.52, df = 3, p=0.001); (Figure 26). Overall, mean group size was 2 ± 0.4 individuals and was smaller in May-June (1.X whale per sighting) vs. July-December (2.X whales per sighting), although the difference was not significant (Kruskal: X2=0.859, df=1, p=0.354). Blue whale sighting rates were significantly lower in the morning than during the afternoon (X^2=9.94, p=0.007) (Figure 26).

Blue whales were nearly always (85% of 49 groups) observed "traveling" in point-to-point movement based on initially observed behavior (necessarily limited to a period within a surfacing bout), followed by milling (11%) and surface-active travel (4%) (Table 2). Overall, mean heading of blue whale groups was to the SSW (203º ± 35) as represented primarily by summer observations; no significant differences were found in headings by survey period or time of day (Figure 28). Travel also involved feeding on some occasions based on data from extended focal follows (SES/HDR unpublished data). Similar to fin whales, heading among blue whales was nearly always consistent and synchronized between individuals within a surfacing bout, but often changed between dives; the latter behavior combined with occasionally observed lunge feeding, reddish-colored defecation and swarms (presumed to be krill) indicate that blue whales are feeding in concentrated areas (SES/HDR unpublished data). Mean maximum dispersal between individuals was 16 ± 8.7 BL. We are not aware of other publications that systematically reported dispersal distances within groups of blue whales or any other baleen whales except mother-calf southern right whales (e.g., Tabor and Thomas 1982).

Common Bottlenose Dolphin *Tursiops truncatus*

Bottlenose dolphin distribution off California extends from at least Ensenada, Baja California, Mexico to as far north as 41 degrees N off California, ranging into Oregon and Washington waters during warm-water periods (Carretta et al. 2011). The bottlenose dolphin is a year-round resident to SCB waters. Three ecotypes are considered to occur in the SCB: coastal, island-associated, and oceanic (K. Forney, NMFS-SWFSC pers. comm. in DoN 2008).

Detailed long-term studies on bottlenose dolphins in the SCB have focused primarily on coastal communities along the San Diego coastline (within 1 km of coastline; Defran and Weller 1999). Pacific Coast bottlenose dolphins travel rapidly and extensively along the coastline in search of optimal feeding opportunities (e.g., Defran et al. 1999; Hwang 2011). Oceanographic events influence distribution; for example, there has been a change in residency patterns along Southern California and a northward range extension into central California after the 1982-83 El Niño (Hanson and Defran 1993; Wells et al. 1990). Since the 1982-83 El Niño, which increased water temperatures off California, bottlenose dolphins are sighted regularly in central California, as far north as San Francisco. Hwang (2011) suggested that irregular upwelling patterns off California might explain the apparent lack of a pattern in dolphin movements. In some parts of the SCB, such as Santa Monica Bay, the species occasionally aggregates offshore near areas of bottom relief, such as submarine canyons and escarpments (Bearzi 2005).

Bottlenose dolphins occur year-round offshore around the islands of San Clemente, Santa Catalina, and San Nicolas (Bonnell and Dailey 1993; Shane 1994; Carretta et al. 2000). The relatively large population of bottlenose dolphins occurring offshore, as noted by Bonnell and Dailey (1993), appears to center around Santa Catalina Island during most of the year. Most bottlenose dolphins were sighted during the winter months in the area. During the summer; the island-associated population is widely distributed through the Channel Islands (Bonnell and Dailey 1993). NMFS-conducted marine mammal aerial surveys off San Clemente Island during 1998-1999 determined that bottlenose dolphins were seen year-round, but were also the least abundant of marine mammal species seen in the area (Carretta et al. 2000). The species is ubiquitous in the SCB, found in waters close to shore and further offshore, across a wide range of bottom depths (e.g., Shane 1994). Stomach content analyses indicate that a large percentage of SCB bottlenose dolphin prey includes surf perches (*Embiotocidae*) or croakers (*Scianidae*) (e.g., Hanson and Defran 1993; Bearzi 2005).

Past studies reported that bottlenose dolphins in waters off California often associate with Risso's dolphins, short-finned pilot whales, both common dolphin species, California sea lions, and gray whales (Norris and Prescott 1961; Shane 1994; Bearzi 2005). However, only one of the 25 bottlenose dolphin sightings reported herein were associated with other species.

A total of 25 bottlenose dolphin sightings of 553 individuals occurred (Table 2). Consistent with past SCB studies, individuals were seen during all survey months from May-November. Sighting rates were slightly higher in summer vs. fall (1.27 and 0.78 groups/1,000 km), respectively), but this difference was not significant (Figure 32). Overall, mean group size was 22 ± 7.6 individuals and was slightly higher in summer (24 ± 8.3) vs. fall (19 ± 14.7) although the difference was not significant. Mean maximum dispersal between individuals within a subgroup was 5 ± 2.8, with no significant diurnal or season trends noted based on the limited sample size.

Bottlenose dolphins were mostly observed "traveling" (54% and group n = 13) in point-to-point movement based on initially observed behavior, followed by surface-active travel (21%). Overall, mean heading of bottlenose dolphin groups was to the SSW (198º ± 19.5) as represented primarily by summer observations (Figure 36), with no significant diurnal or season trends based on the limited sample size.

Pacific white-sided dolphin *Lagenorhynchus obliquidens*

The Pacific white-sided dolphin is found only in temperate waters (Leatherwood et al. 1984). Surveys suggest a seasonal north-south distributional shift of the species in the eastern North Pacific as water temperatures change. There is a year-round occurrence of the white-sided dolphin in California waters (Bonnell and Dailey 1993). This species occurs primarily off California during the cool-water months, shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Barlow 1995; Forney et al. 1995). Soldevilla et al. (2010) documented a fall–winter peak in seasonal occurrence in the SCB based on acoustic detections. Dohl et al. (1981) also noted a winter-spring shift in the population from offshore to inshore waters in the SCB. The Pacific white-sided dolphin is most common in waters over the continental shelf and slope.

Bonnell and Dailey (1993) reviewed white-sided dolphin occurrence based on aerial surveys conducted by Dohl et al. (1981) in the late 1970s in the SCB. Peak numbers, exceeding 10,000 animals, occurred from about September through November. During these months, abundance increases first in northern waters of the SCB, especially in the western Santa Barbara Channel, over the San Miguel Island shelf, and along the Santa Rosa-San Nicolas Ridge. By October and November, these dolphins are fairly widespread in the area at slightly lower densities. By November, sightings in central and eastern waters of the SCB begin to increase, indicating a general dispersal southward. By winter, numbers sharply decline in California waters. During January in the SCB, sightings were recorded only in offshore waters over the Santa Rosa Cortes Ridge, suggesting that the reduction in numbers in the area results from an offshore shift in the species distribution. In the spring, distribution in the SCB shifts to inshore waters, where Pacific white-sided dolphin sightings are typically clustered within 30 km of shore. A few sightings were recorded close inshore through June and July.

Two forms of the white-sided dolphin – northern and southern – occur along the U.S. West Coast; both forms occur in the SCB (Carretta et al. 2011). The NMFS has noted that it is not currently possible to distinguish animals without genetic or morphometric analyses (Carretta et al. 2011). Two types of white-sided dolphins in the SCB are distinguished by vocalizations (see Soldevilla et al. 2011). Predictive models (using acoustic data from both types) for the white-sided dolphins in the SCB suggest that habitat features important to the species include both the importance of ecological succession between abiotic variables and dolphin occurrence, as well as an association with prey-aggregating features, such as fronts and eddies (Soldevilla et al. 2011).

Pacific white-sided dolphins in the eastern North Pacific feed primarily on epipelagic fishes and cephalopods (e.g., Schwartz et al. 1992; Heise 1997).

A total of 20 Pacific white-sided dolphin sightings of approximately 602 individuals occurred (Table 2). Given this relatively small sample size, interpretation of results is limited and potential diurnal and seasonal patterns cannot be assessed. However, as little is known about the behavioral ecology and social behavior of this species, results discussed herein contribute to a rare data base for the species. Consistent with past SCB studies, individuals were seen during all survey months from May-November, with sighting rates notably higher in fall vs. summer (0.25 vs. 1.32 groups/1,000 km, respectively (Figure 38). Overall, mean group size was 30 ± 20.6 individuals. Mean maximum dispersal between individuals within a subgroup was 10 ± 5.3 BL.

Pacific white-sided dolphins were primarily observed traveling (54% of 13 groups) based on initially observed behavior, followed by milling (26%), and surface-active travel or milling (27%). Overall, mean heading of Pacific white-sided dolphin groups was southerly (175º ± 63.5), with considerable variation (Figure 42).

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TABLES

Table 1. Summary of Aerial Surveys conducted during 2008 – 2010 in the SOCAL Complex Range.

	Survey								
	October	**November**	**June**	**July**	**November**	**May**	**July**	**September**	**Total**
Survey Dates	17-21 Oct 2008	15-18 Nov 2008	5-11 June 2009	20-29 July 2009	18-23 Nov 2009	13-18 May	27 July-3 Aug	23-28 Sept 2010	**8 surveys: May, June, July, Sept, Oct, Nov**
No. Days Flown	5	4	6	9	6	6	7	6	**49**
Major Training Exercise (MTE) Before, During or After Survey?	Before/During	After	After	After	During/After	During	During/After	During/After	**During, before or after**
Total Flight Hr (Wheels up/down)	28	21	30	34	28	29	18	19	**207**
Total Observation Effort (km) *(excl. poor weather, over land)*	4563 km	3838 km	6140 km	6500 km	4823 km	4891 km	3125 km	3918 km	**37,798**
	(2464 nm)	(2072 nm)	(3315 nm)	(3510 nm)	(2604 nm)	(2641 nm)	(1688 nm)	(2116 nm)	**20,410**
No. Navy-directed Survey Changes (appox)	9	7	12	10	3	1	0	0	**42**
No. Coastline Surveys for Strandings (San Clemente Isld)	0	2	1	0	1	1	0	0	**5**
No. Groups Seen	115	185	161	240	93	152	86	252	**1,284**
Estim. No. Individuals	12,587	5732	9489	22,719	12,826	5,453	11,090	37,874	**117,770**

Survey									
	October	**November**	**June**	**July**	**November**	**May**	**July**	**September**	**Total**
Mean Group Size	109.4	31	58.9	94.7	137.9	35.9	131.3	150.3	**85.6**
No. Dead Sightings	0	3 *(2 CA sea lions, 1 blue whale)*	0	2 *(2 prob. CA sea lions)*	0	0	0	0	**5**
No. Species	9	9	11	10	10	9	5	9	**16***
No. Focal Groups Circled 5-9 min	22	20	24	37	14	10	6	6	**139**
No. Extended Focal Groups Circled >10 min	5	7	7	8	10	20	13	10	**83**
Longest Focal Follow Duration	29 min (*Fin whale*)	60 min (*Fin whale*)	48 min (*Fin whale*)	38 min (*Long-beaked common dolphin*)	40 min (*Killer whale*)	144 min (*Fin whale*)	59 min (*Blue whale*)	45 min (*Bryde's Whale*)	**144 min. total of longest focal**
No. Photos Taken	1050	1280	1099	2301	2203	1350	2900	741	**12,183**
Estimated Usable Video (min)	53	41	83	50	90	334	373	142.41	**1024**

*Note: Sixteen species were seen during the eight surveys. Not all species were seen during each survey.

Table 2. Overall Group Characteristics of Marine Mammals from 2008-2010 in the SOCAL Complex Range

Species	Scientific Name	No. of Groups	No. of Individuals	Mean of Greatest Group Size	Sighting Rate Indiv/1000 km	Mean Group Heading	Initial Group Behavior States	Mean of Greatest Group Dispersal
Common dolphin sp.	*Delphinus* sp.	307	79,254	258 ± 39.7	12	188º ± 15.8	37% SA Mill, 34% Travel, 21% SA travel, 8% Mill	5 ± 0.7
California sea lion	*Zalophus californianus*	298	857	6 ± 5.9	12	210º ± 25.3	60% Travel, 33% Mill, 4% SA mill, 4% SA travel	6 ± 3.8
Risso's dolphin	*Grampus griseus*	148	2743	37 ± 37.5	6	195º ± 19.5	80% Travel, 17% Mill, 2% SA Mill, 1% SA travel	6 ± 1.4
Fin whale	*Balaenoptera physalus*	51	86	3 ± 3.3	2.1	189º ± 33	92% Travel, 4% Mill, 4% SA travel	8 ± 4.6
Blue whale	*Balaenoptera musculus*	49	84	2 ± 0.4	2	203º ± 35	85% Travel, 11% Mill, 4% SA travel	16 ± 8.7
Bottlenose dolphin	*Tursiops truncatus*	25	553	22 ± 7.6	1	198º ± 52.1	54% Travel, 21% SA travel, 13% Mill, 13% SA mill	5 ± 2.8
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	20	602	30 ± 20.6	0.8	175º ± 63.4	47% Travel, 26% Mill, 16% SA travel, 11% SA Mill	10 ± 5.3
Humpback whale	*Megaptera novaeangliae*	5	9	2 ± 0.8	0.2	198º ± 52.1	100 % Travel	1 ± 0
Northern elephant seal	*Mirounga angustirostris*	5	24	8 ± 7.2	0.2	130 ± 184.1	75% Travel, 25% Mill	2 ± 1
Minke whale	*Balaenoptera acutorostrata*	4	6	2 ± 1.0	0.2	31º ± 60.3	75% Travel, 25% SA travel	10 ± 0

Species	Scientific Name	No. of Groups	No. of Individuals	Mean of Greatest Group Size	Sighting Rate Indiv/1000 km	Mean Group Heading	Initial Group Behavior States	Mean of Greatest Group Dispersal
Cuvier's beaked whale	*Ziphius cavirostris*	4	12	3 ± 1.9	0.2	145º ± 132.9	100 % Travel	2 ± 0.7
Northern right whale dolphin	*Lissodelphis borealis*	3	1,200	400 ± 312.4	0.1	223º ± 136.9	100% SA Travel	8 ± 4.1
Bryde's whale	*Balaenoptera edeni/brydei*	2	2	1 ± 0	0.1	145º ± 112.9	100 % Travel	0
Killer whale	*Orcinus orca*	2	67	34 ± 44	0.1	235º ± 194.3	100 % Travel	22 ± 36.9
Sei/Bryde's whale	*Balaenoptera borealis/edeni/brydei*	1	3	3 ± 0	0.04	120º ± 0	100 % Travel	8 ± 0
	Total:	**924**	**85,502**					

Table 3. Sighings of marine mammals from 2008-2010 in the SOCAL Complex Range in desecening order. Note: Sightings did not occur during January-March.

Species	Total Sightings	No. Summer Sightings	Summer Sighting Rate (Indiv/1000 km)	No. Fall Sightings	Fall Sighting Rate (Indiv/1000 km)	No. Apr-June Sightings	Apr-June Sighting Rate (Indiv/1000 km)	No. July-Sept Sightings	July-Sept Sighting Rate Indiv/1000 km	No. Oct-Dec Sightings	Oct-Dec Sighting Rate Indiv/1000 km
Common dolphin sp.	307	131	7	176	32	35	6	220	27	52	6
California sea lion	298	108	6	190	35	85	14	95	12	118	13
Risso's dolphin	148	118	6.1	30	1.1	75	12	49	6	24	2.7
Fin whale	51	36	1.8	17	2.9	25	4	10	1.2	16	1.8
Blue whale	49	48	2.5	1	0.2	12	1.9	36	4.4	1	0.1
Bottlenose dolphin	25	15	0.8	10	1.8	12	1.9	7	0.9	6	0.7
Pacific white-sided dolphin	20	3	0.2	17	3.1	2	0.3	1	0.1	17	1.9
Humpback whale	5	2	0.1	3	0.6	2	0.3	0	0	3	0.3
Northern elephant seal	5	1	0.1	6	0.7	1	0.2	3	0.4	1	0.1
Minke whale	4	2	0.1	2	0.4	1	0.2	2	0.2	1	0.1
Cuvier's beaked whale	4	1	0.1	3	0.6	0	0	2	0.2	2	0.2
Northern right whale dolphin	3	3	0	0	0	3	0.5	0	0	0	0
Bryde's whale	2	0	0	2	0.4	0	0	1	0	1	0.1
Killer whale	2	0	0	2	0.4	0	0	0	0	2	0.2
Sei/Bryde's whale	1	0	0	1	0.2	0	0	1	0.1	0	0
Total	**924**	**468**		**460**		**253**		**427**		**244**	

Table 4. Marine Mammal Sightings from 2008-2010 during each period of the day.

Species	Overall Number of Sightings	Sightings during the morning (6-12)	Morning Sighting Rate Indiv/1000 km	Sightings during the early afternoon (12-16)	Early Afternoon Sighting Rate Indiv/1000 km	Sightings during the late afternoon (16-20)	Late Afternoon Sighting Rate Indiv/1000 km
Common dolphin sp.	307	60	9	168	13	79	16
California sea lion	298	92	13	173	13	33	7
Risso's dolphin	148	31	4.5	81	6.3	36	7.3
Fin whale	51	15	2.2	29	2.3	7	1.4
Blue whale	49	4	0.6	31	2.4	14	2.8
Bottlenose dolphin	25	6	0.9	16	1.3	3	0.6
Pacific white-sided dolphin	20	3	0.4	16	1.3	1	0.2
Humpback whale	5	0	0	5	0.4	0	0
Northern elephant seal	5	1	0.1	3	0.2	1	0.2
Minke whale	4	2	0.3	2	0.2	0	0
Cuvier's beaked whale	4	2	0.3	2	0.2	0	0
Northern right whale dolphin	3	0	0	2	0.2	1	0.2
Bryde's whale	2	0	0	2	0.2	0	0
Killer whale	2	1	0.1	1	0.1	0	0
Sei/Bryde's whale	1	1	0.1	0	0	0	0
Total	**924**	**218**		**531**		**175**	

FIGURES

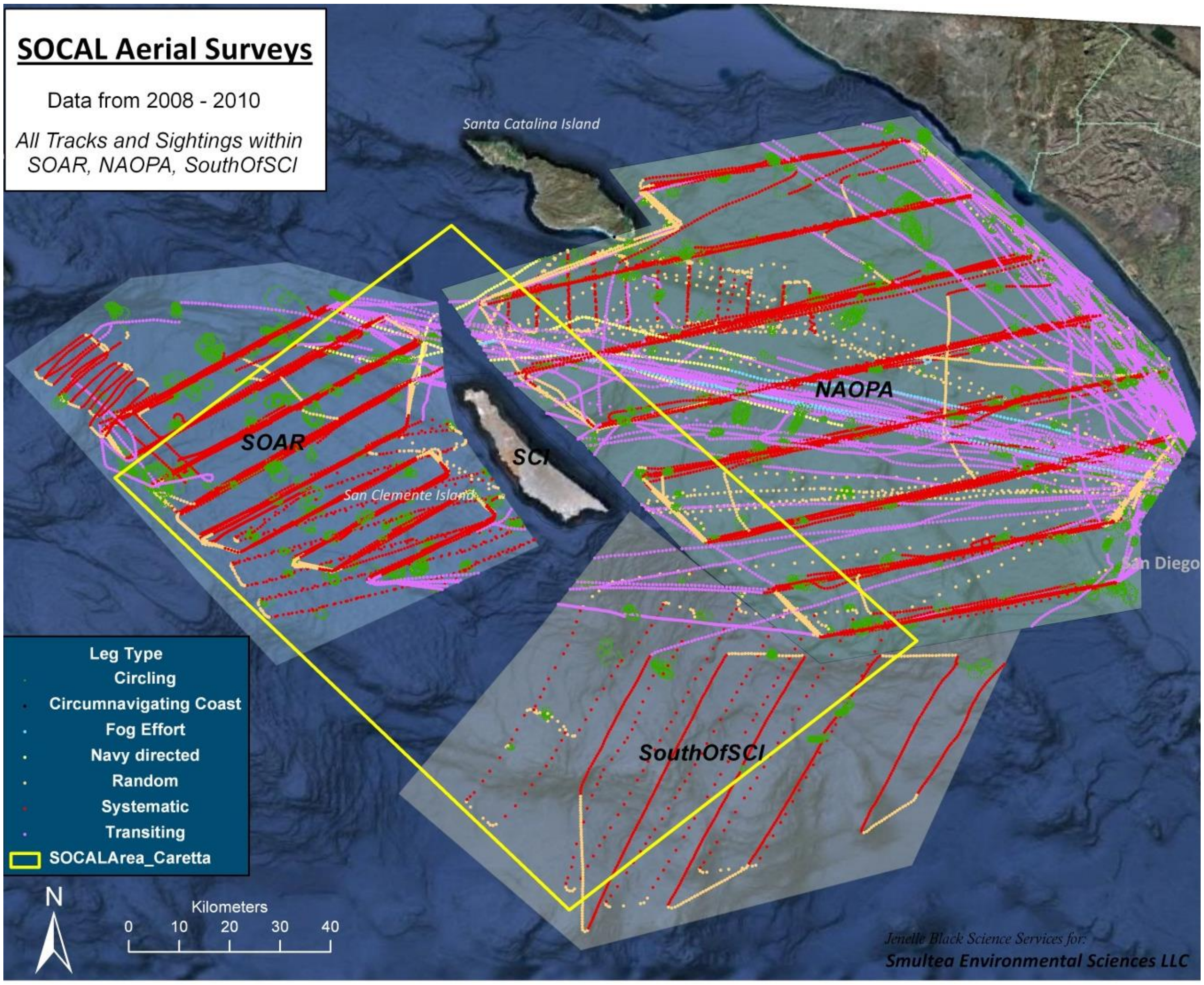

Figure 1. Survey tracks of all effort during 2008-2010 aerial surveys conducted during 2008-2010 in the SOCAL Complex Range.

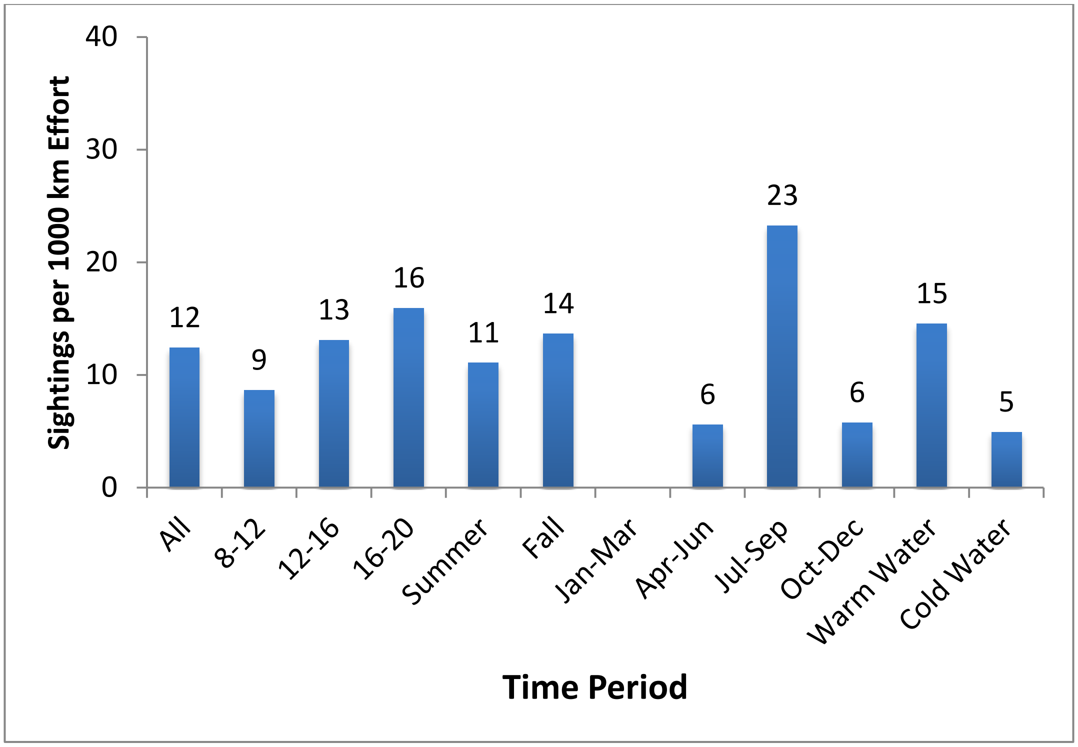

Figure 2. Common Dolphin Delphinus species sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

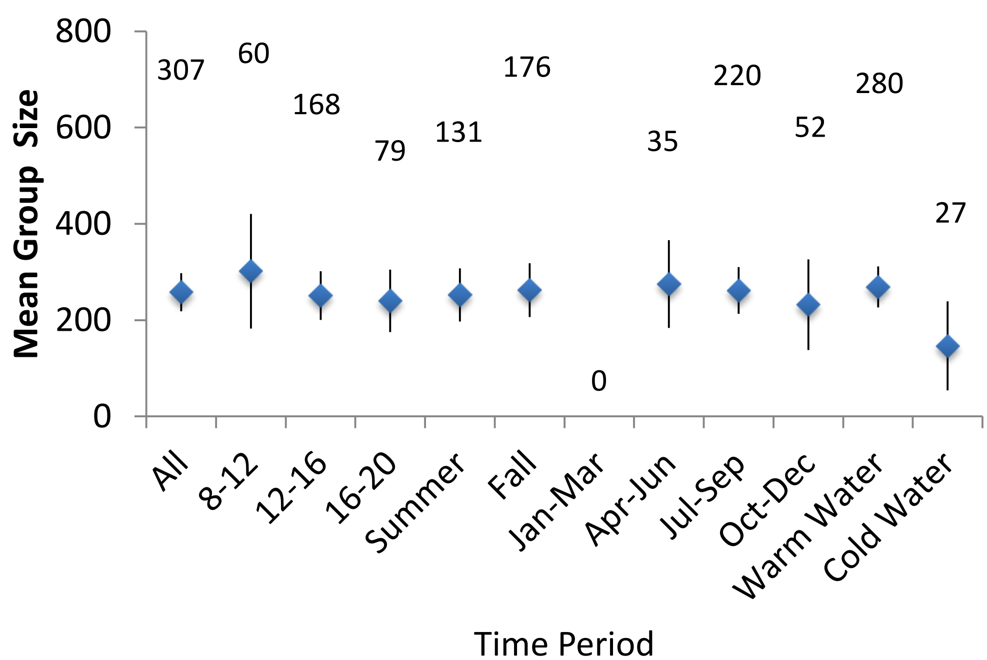

Figure 3. Common Dolphin Delphinus species mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

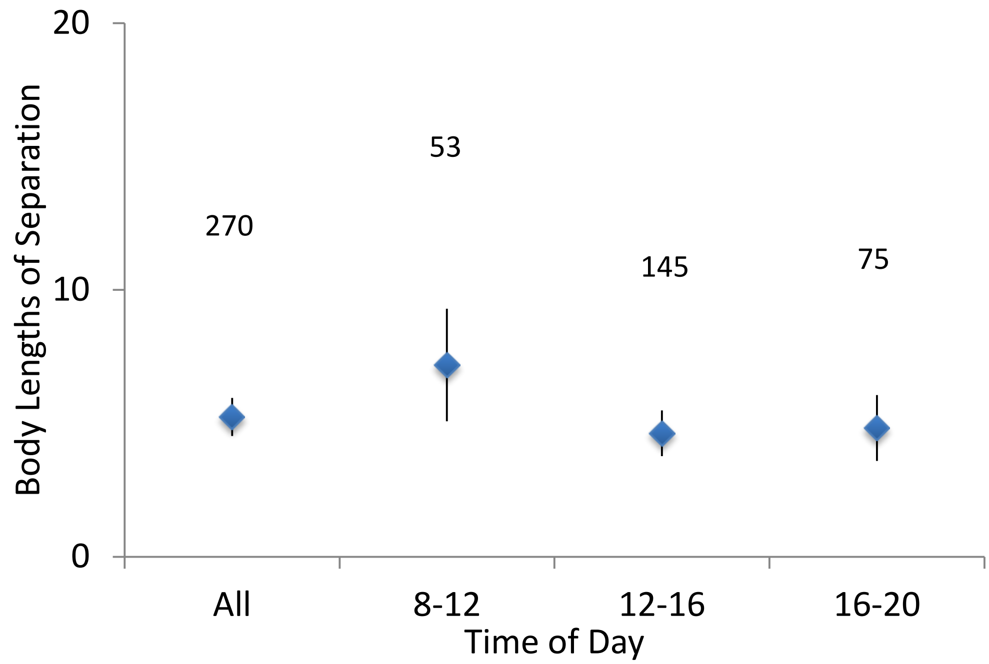

Figure 4. Common Dolphin Delphinus species mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

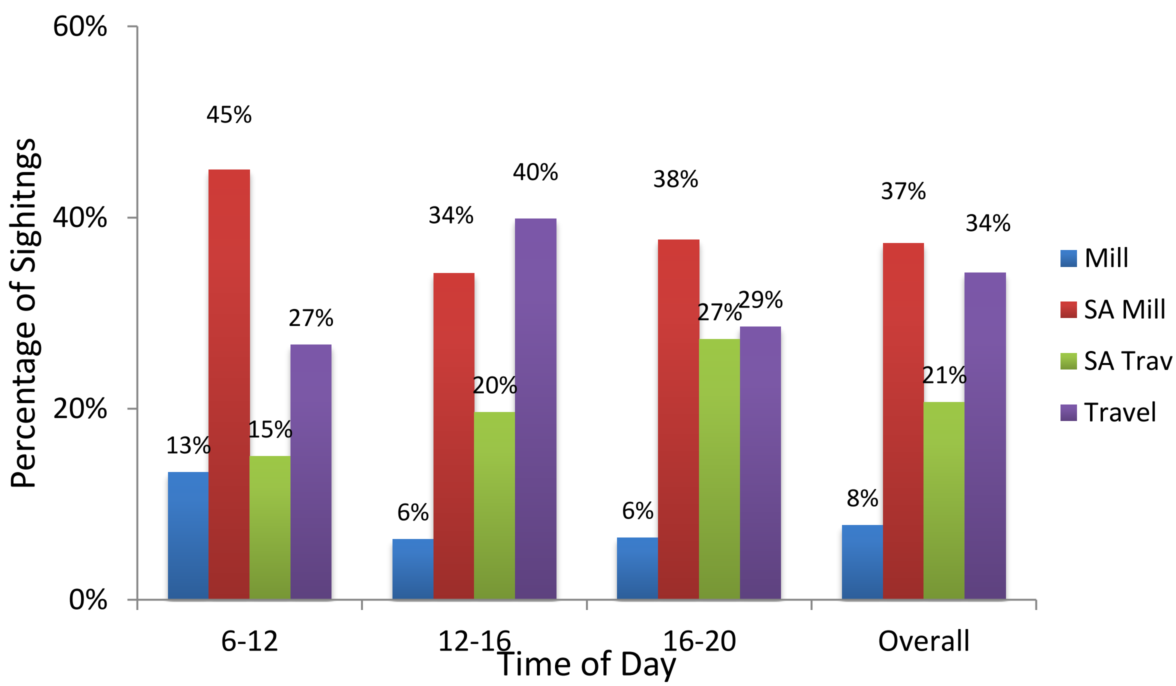

Figure 5. Common Dolphin Delphinus species initial behavior observed by time of day.

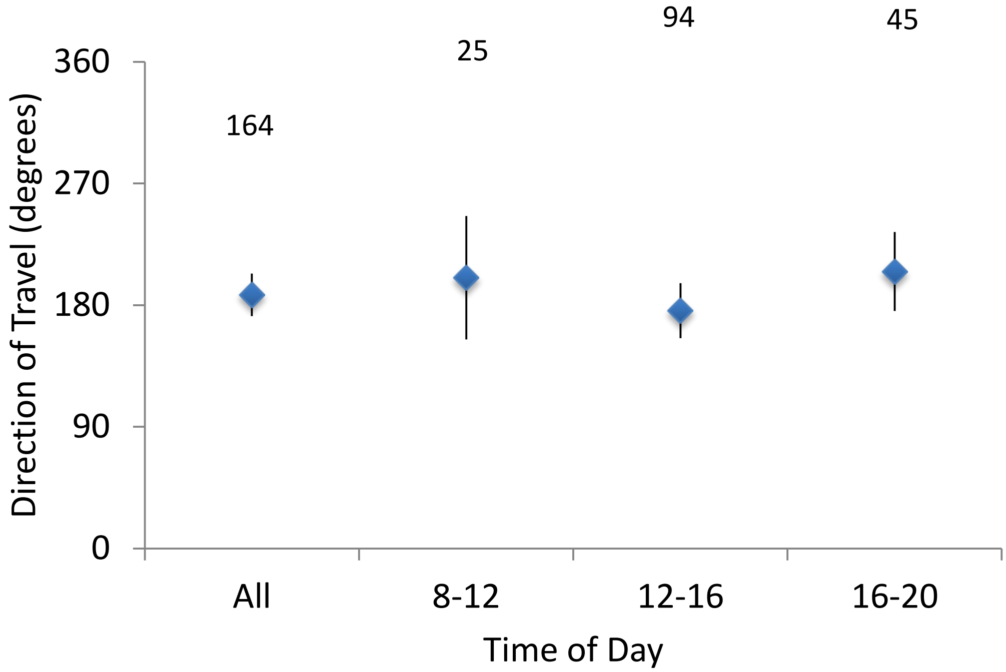

Figure 6. Common Dolphin Delphinus species mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

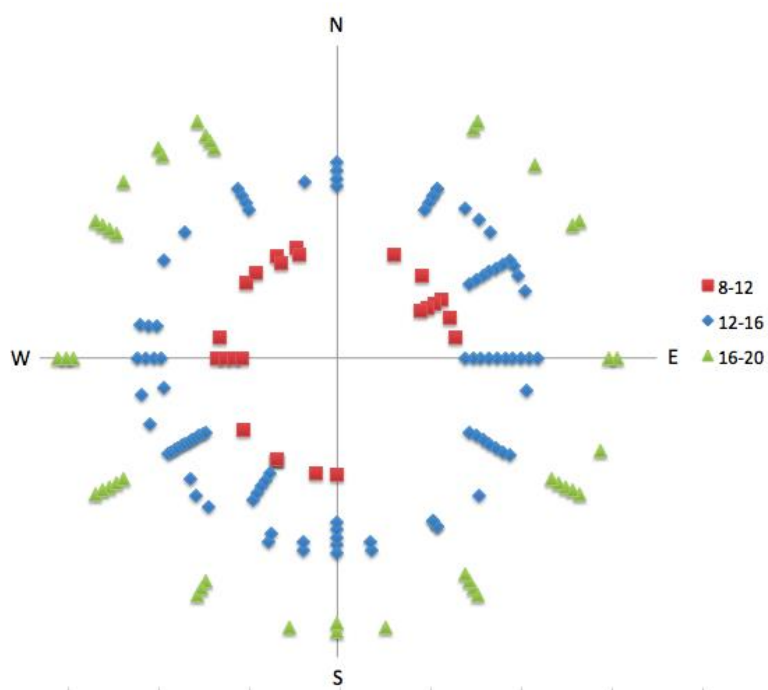

Figure 7. Common Dolphin Delphinus species mean group heading (degrees magnetic) by time of day.

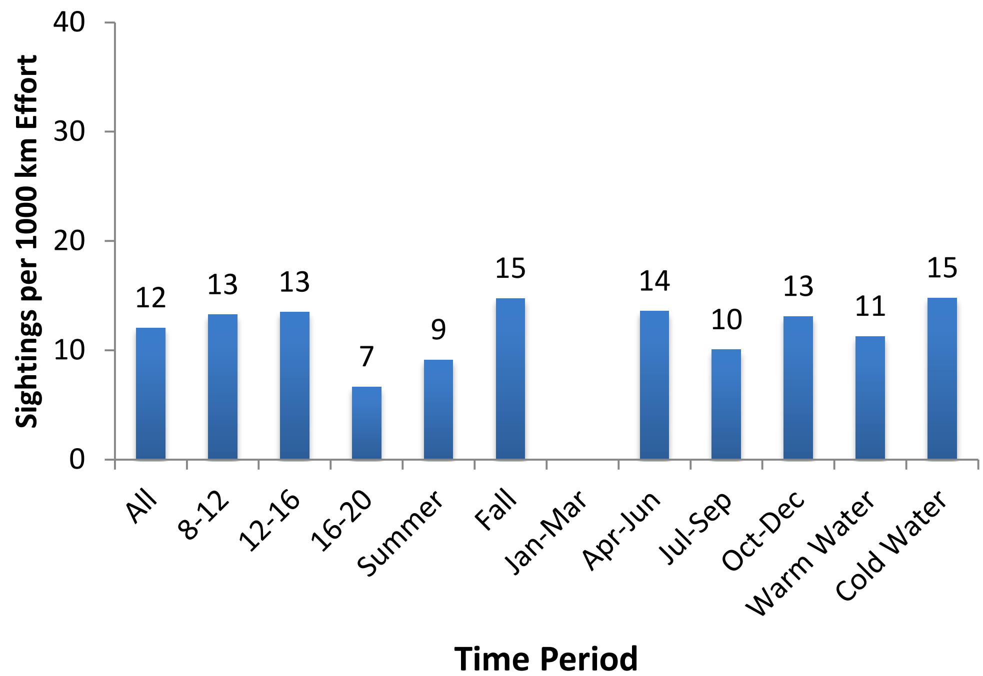

Figure 8. California Sea Lion Zalophus californianus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

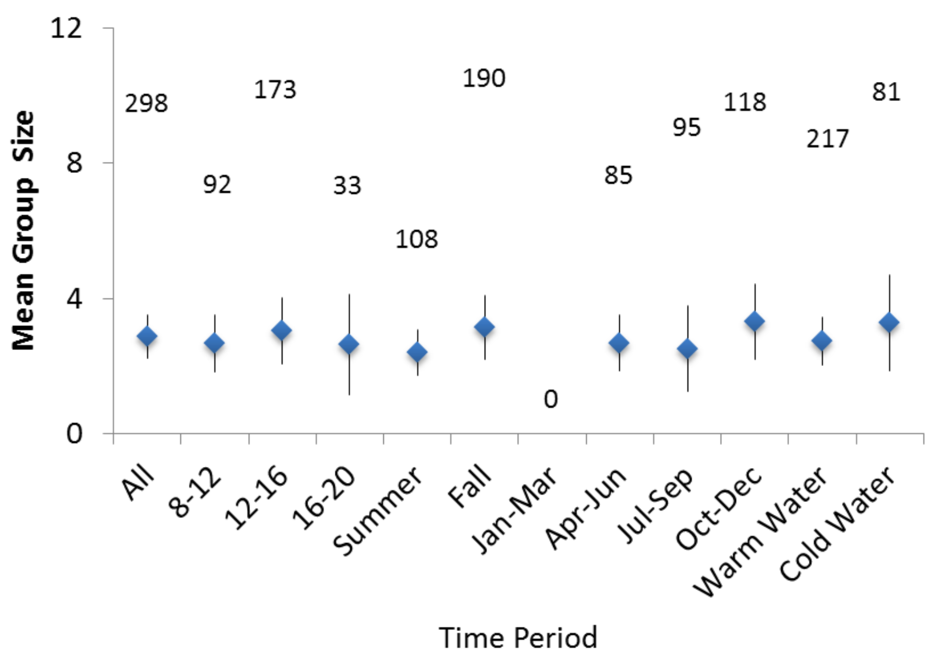

Figure 9. California Sea Lion Zalophus californianus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

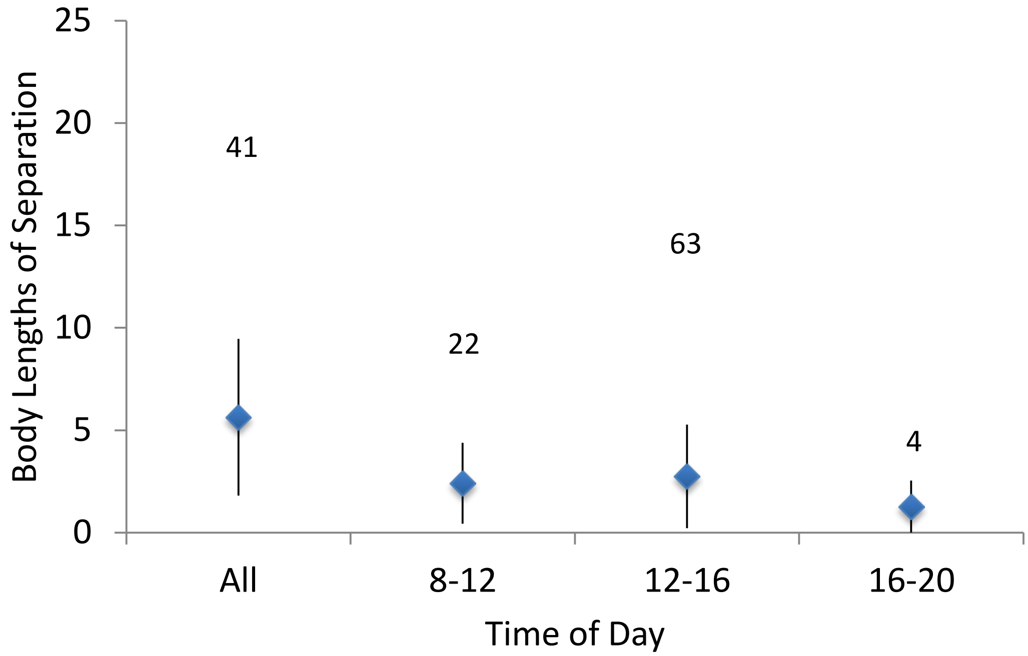

Figure 10. California Sea Lion Zalophus californianus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

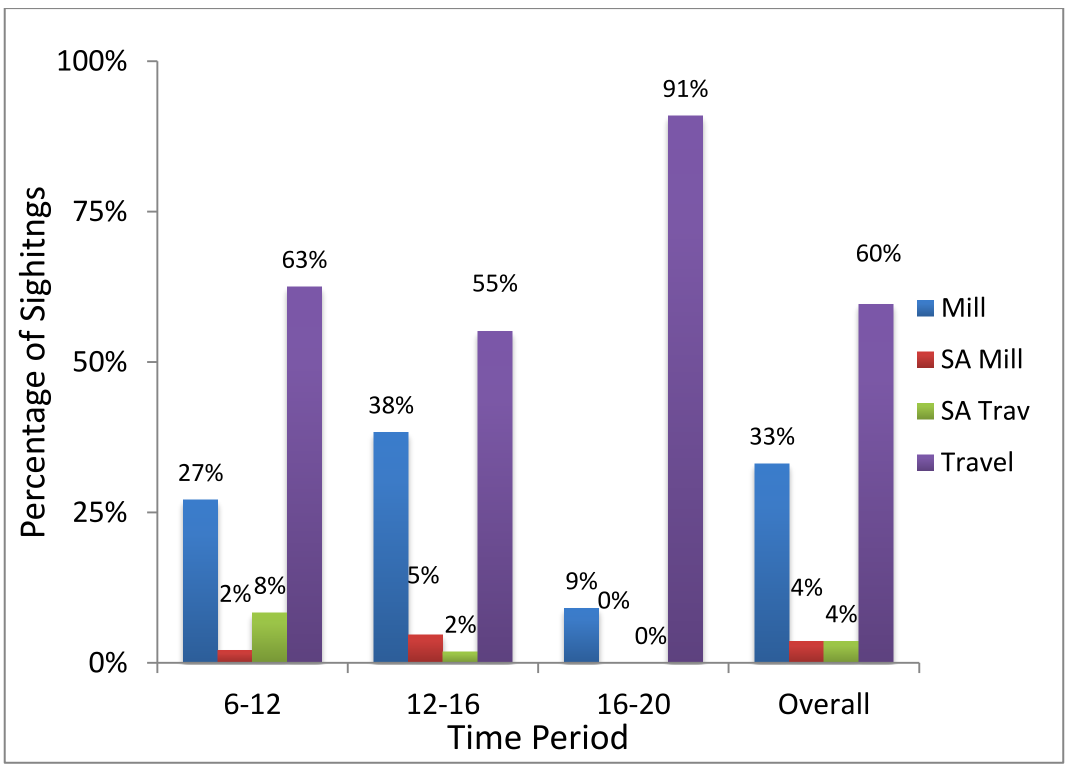

Figure 11. California Sea Lion Zalophus californianus initial behavior observed by time of day. Note: SA=surface active.

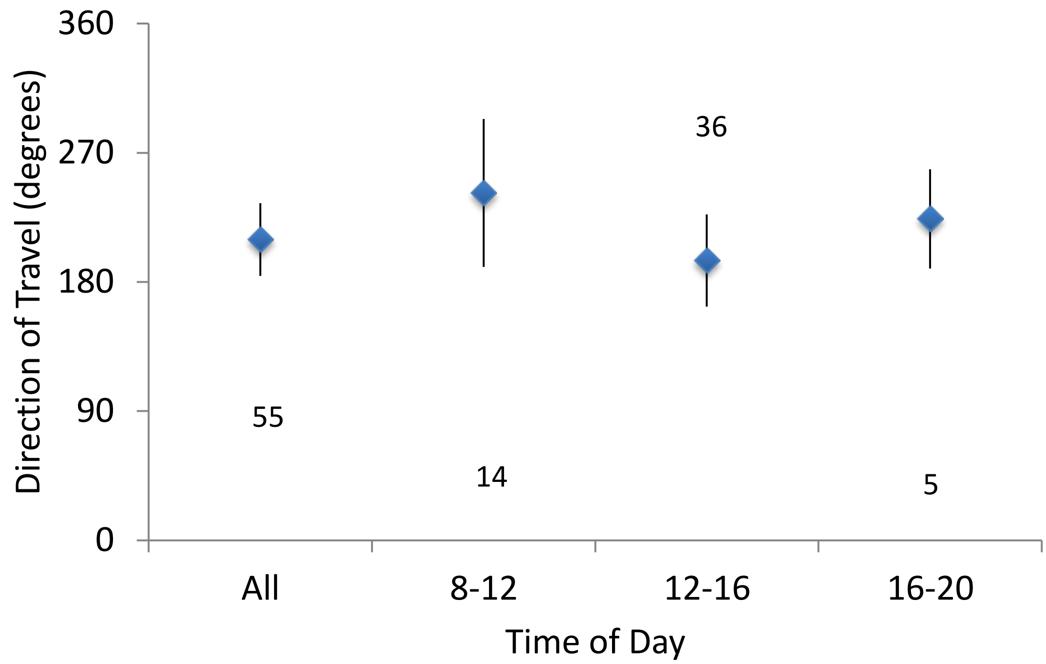

Figure 12. California Sea Lion Zalophus californianus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

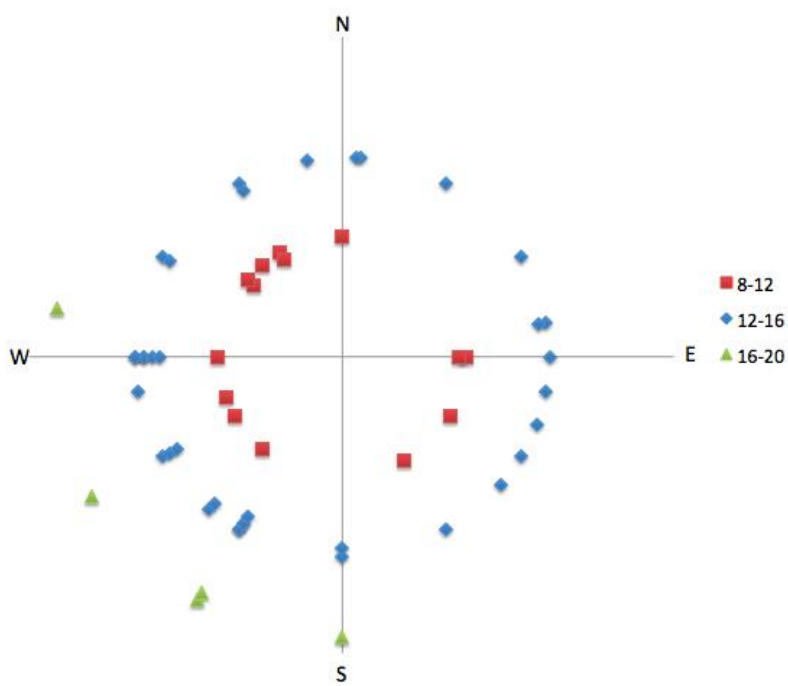

Figure 13. California Sea Lion Zalophus californianus mean group heading (degrees magnetic) by time of day.

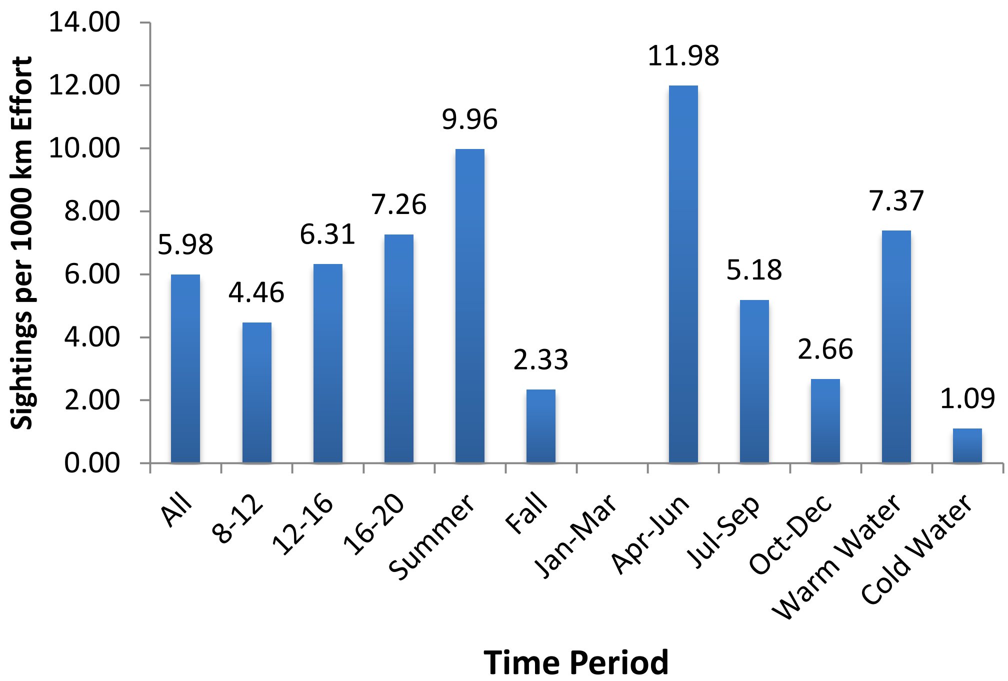

Figure 14. Risso's Dolphin Grampus griseus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

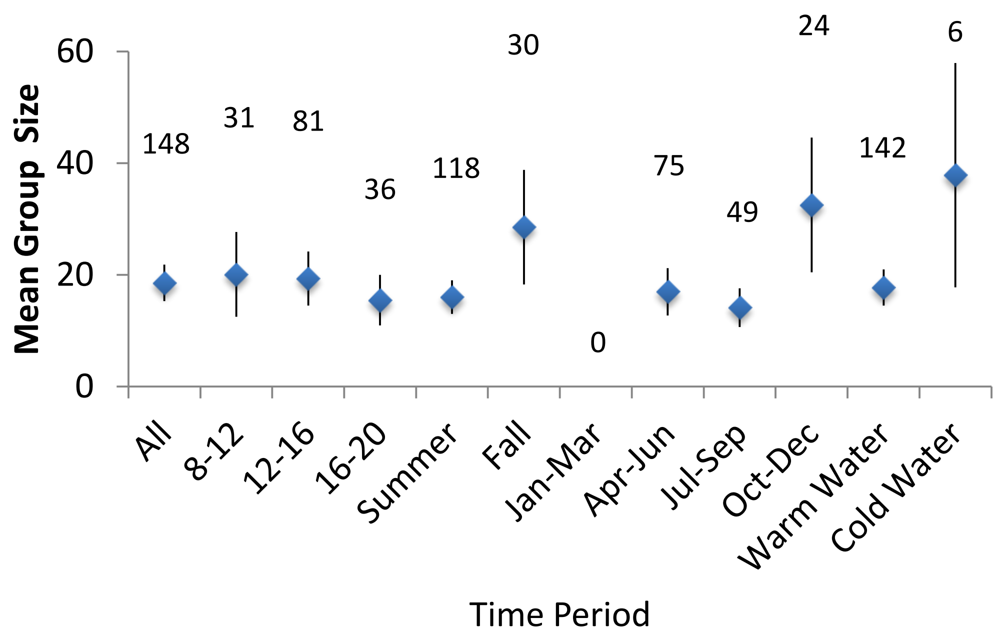

Figure 15. Risso's Dolphin Grampus griseus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

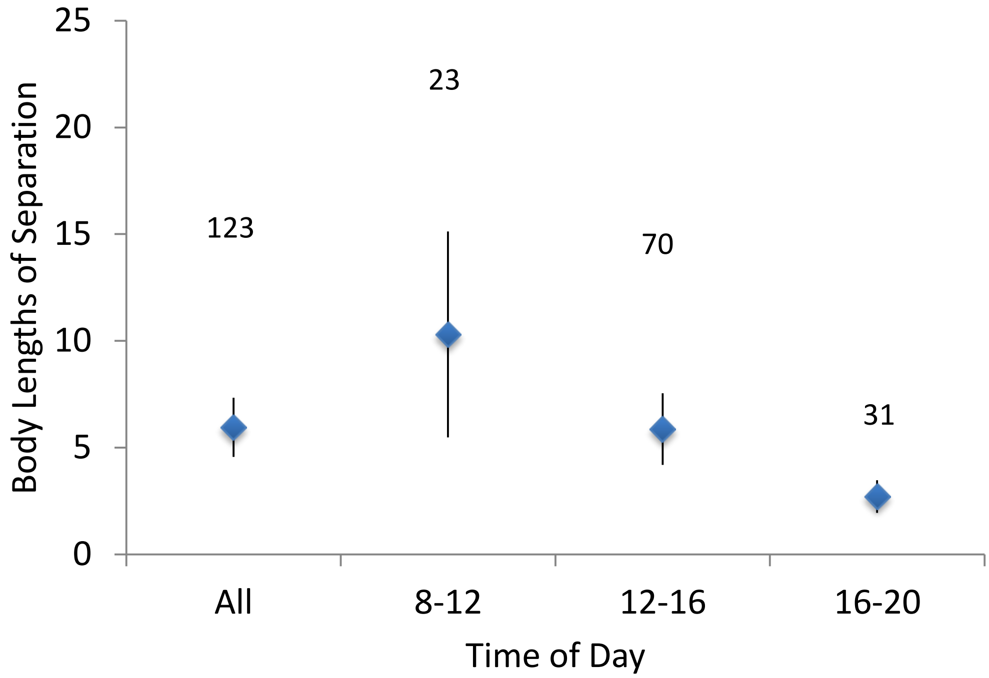

Figure 16. Risso's Dolphin Grampus griseus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

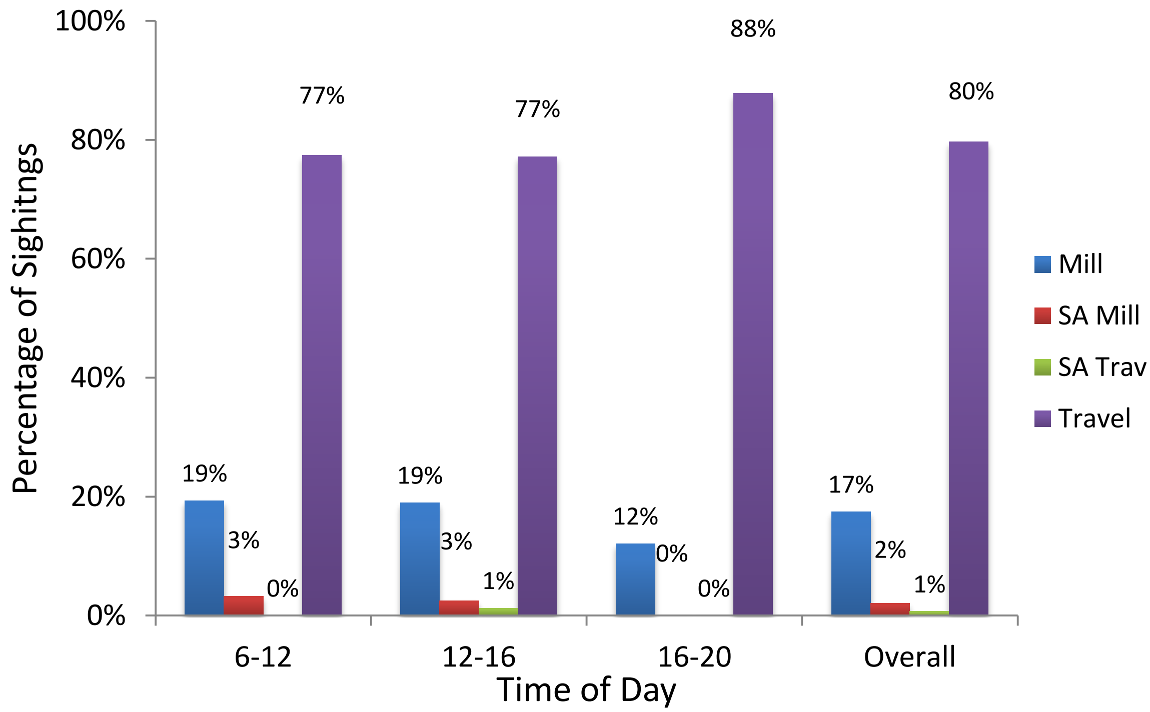

Figure 17. Risso's Dolphin Grampus griseus initial behavior observed by time of day. Note: SA=surface active.

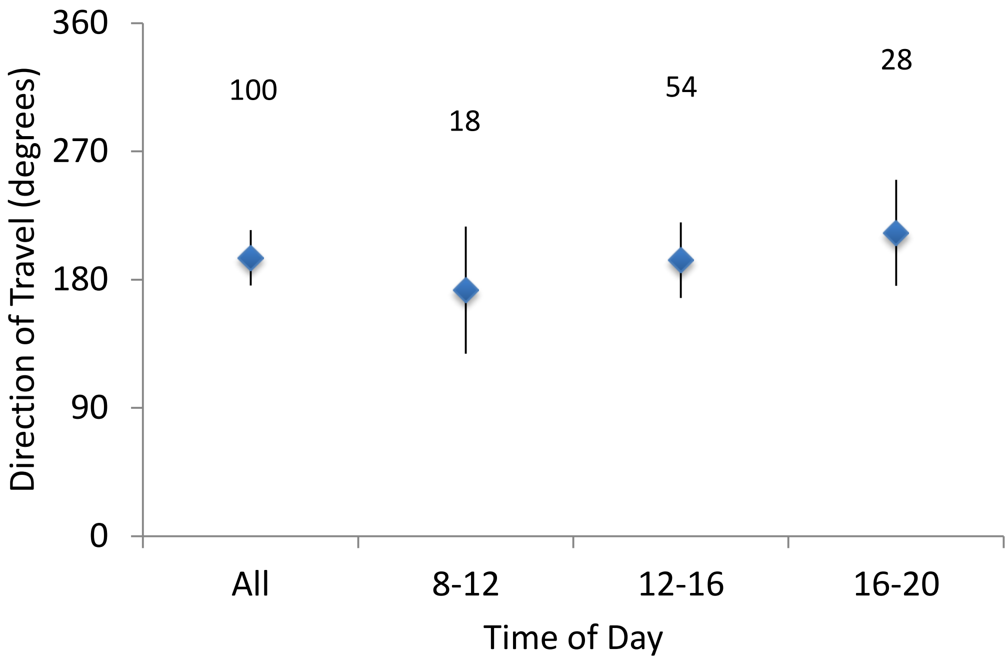

Figure 18. Risso's Dolphin Grampus griseus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

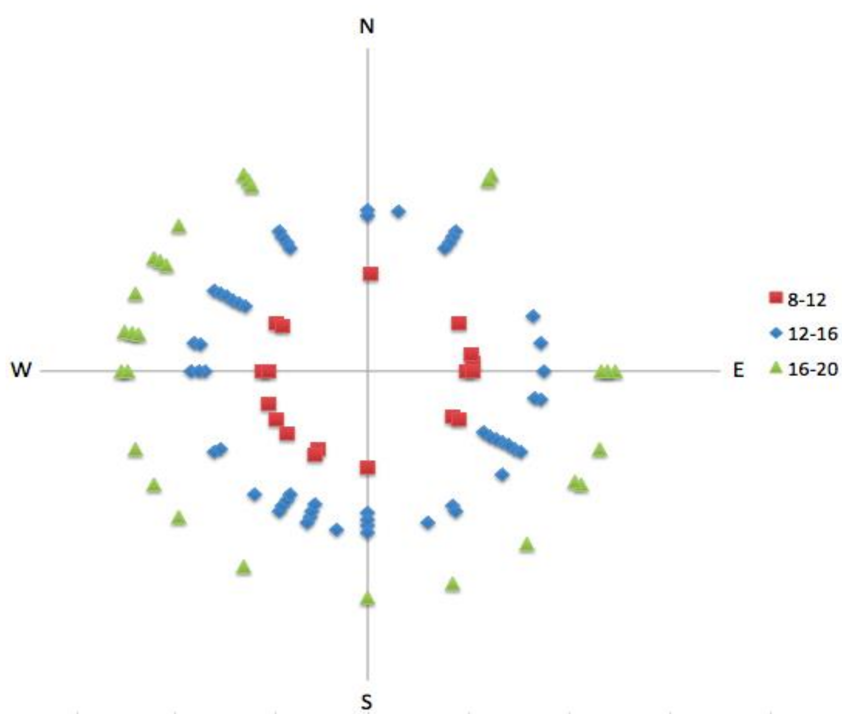

Figure 19. Risso's Dolphin Grampus griseus mean group heading (degrees magnetic) by time of day.

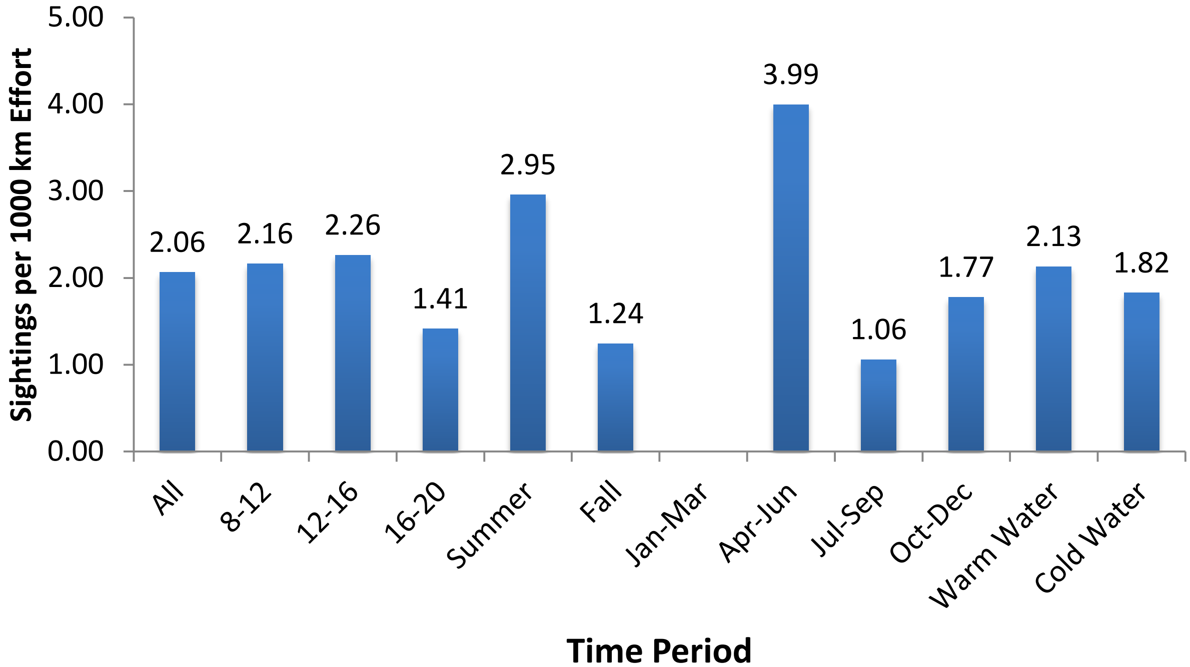

Figure 20. Fin Whale Balaenoptera physalus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

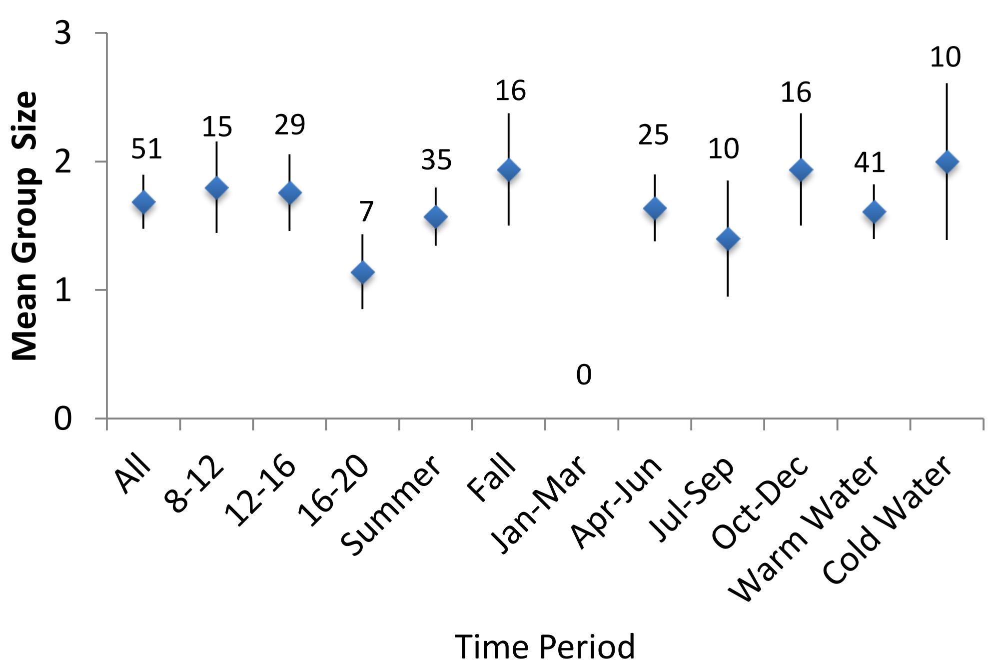

Figure 21. Fin Whale Balaenoptera physalus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

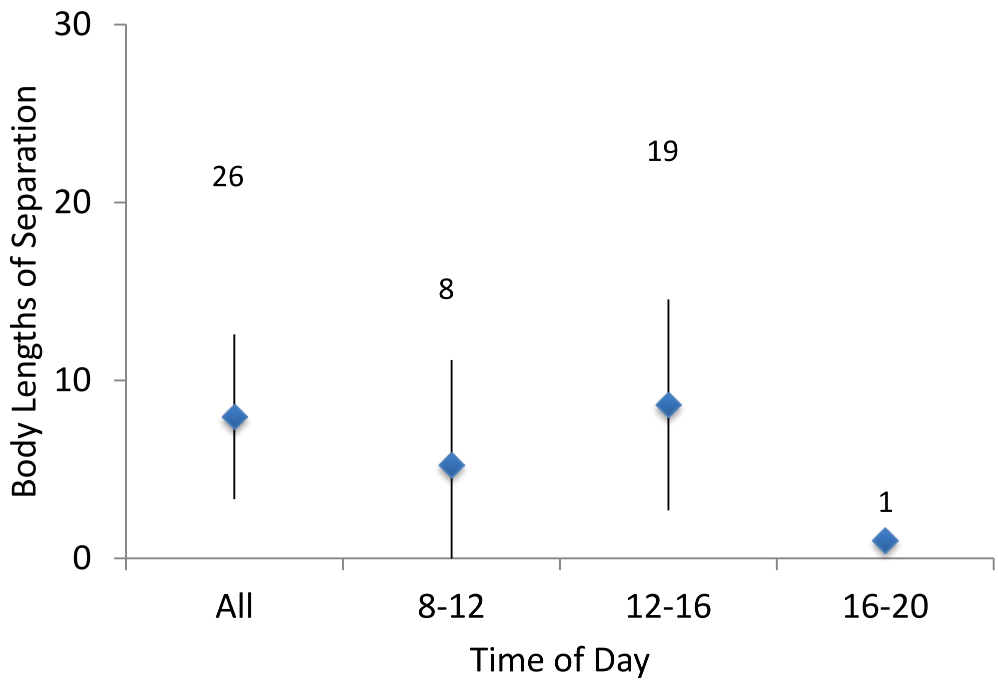

Figure 22. Fin Whale Balaenoptera physalus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

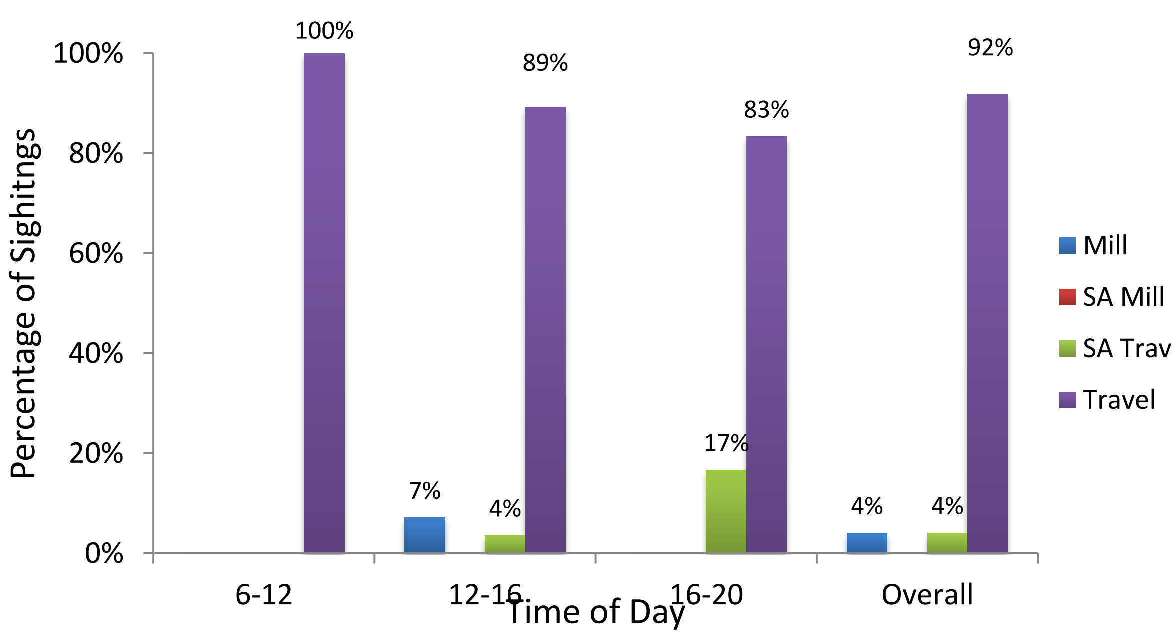

Figure 23. Fin Whale Balaenoptera physalus initial behavior observed by time of day. Note: SA=surface active.

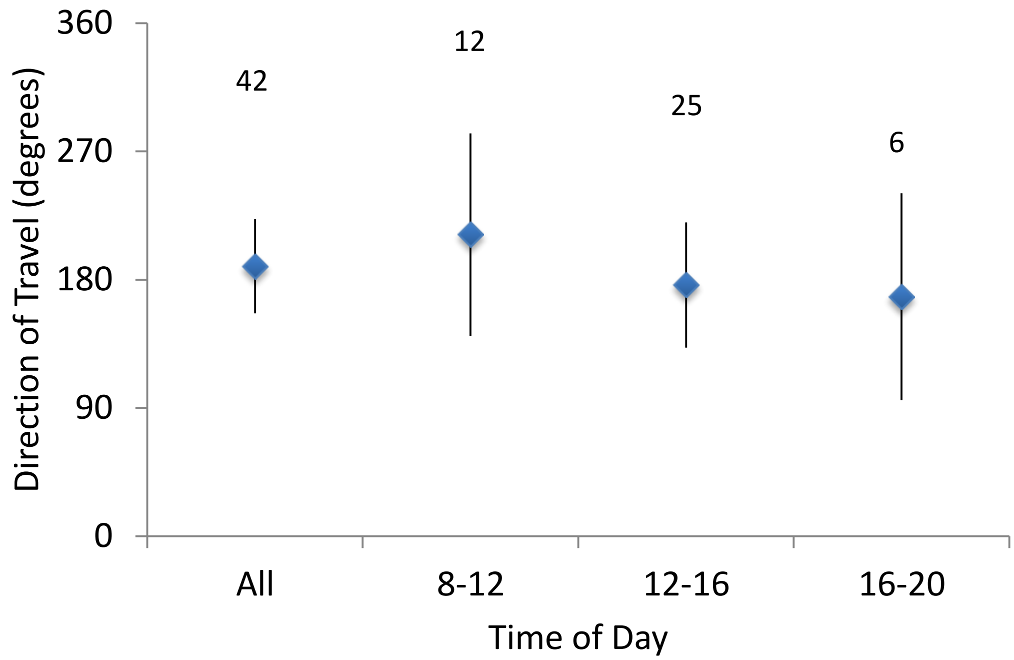

Figure 24. Fin Whale Balaenoptera physalus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

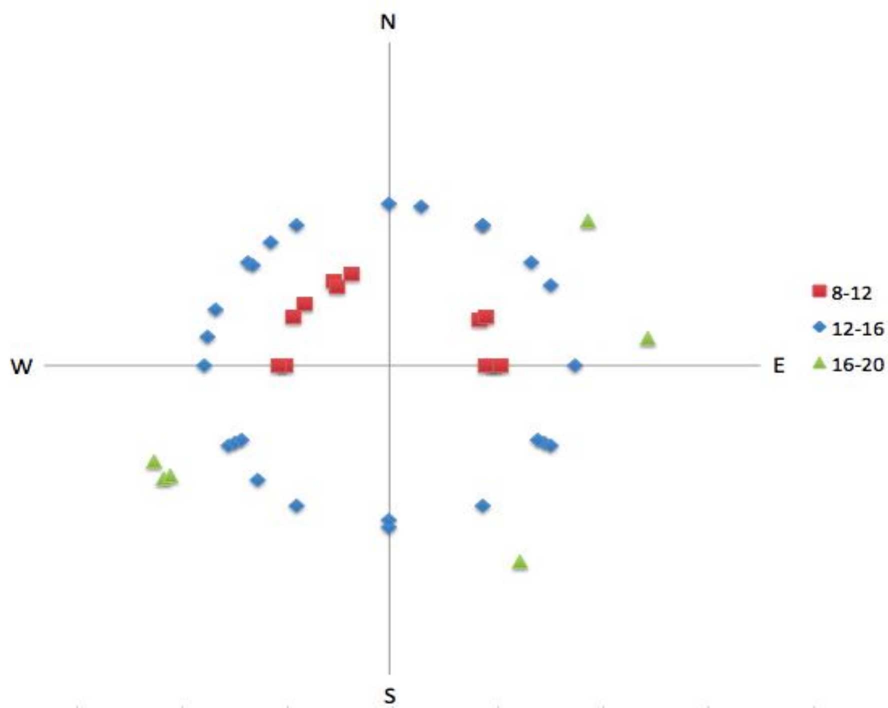

Figure 25. Fin Whale Balaenoptera physalus mean group heading (degrees magnetic) by time of day.

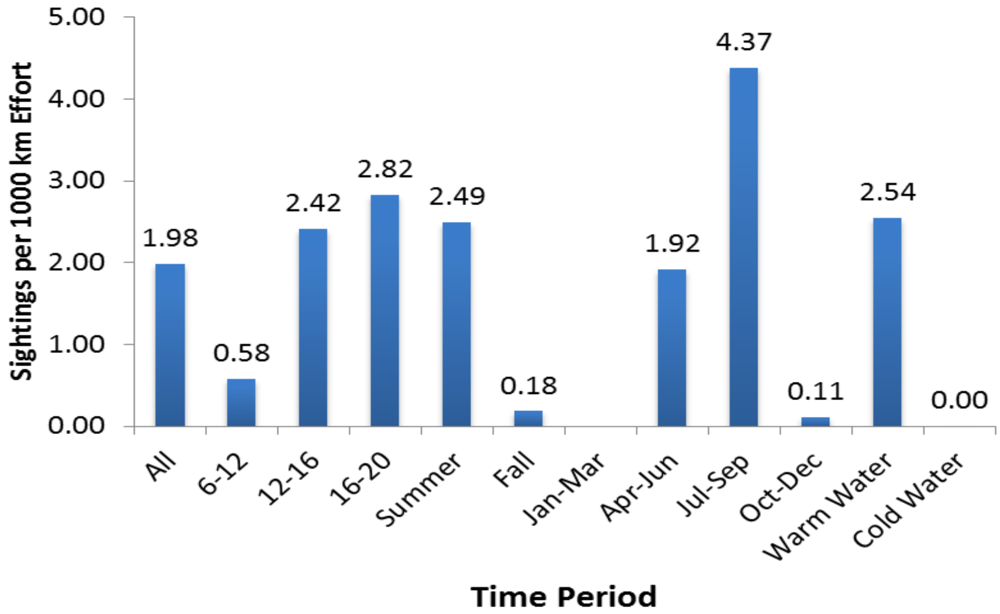

Figure 26. Blue Whale Balaeanoptera musculus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

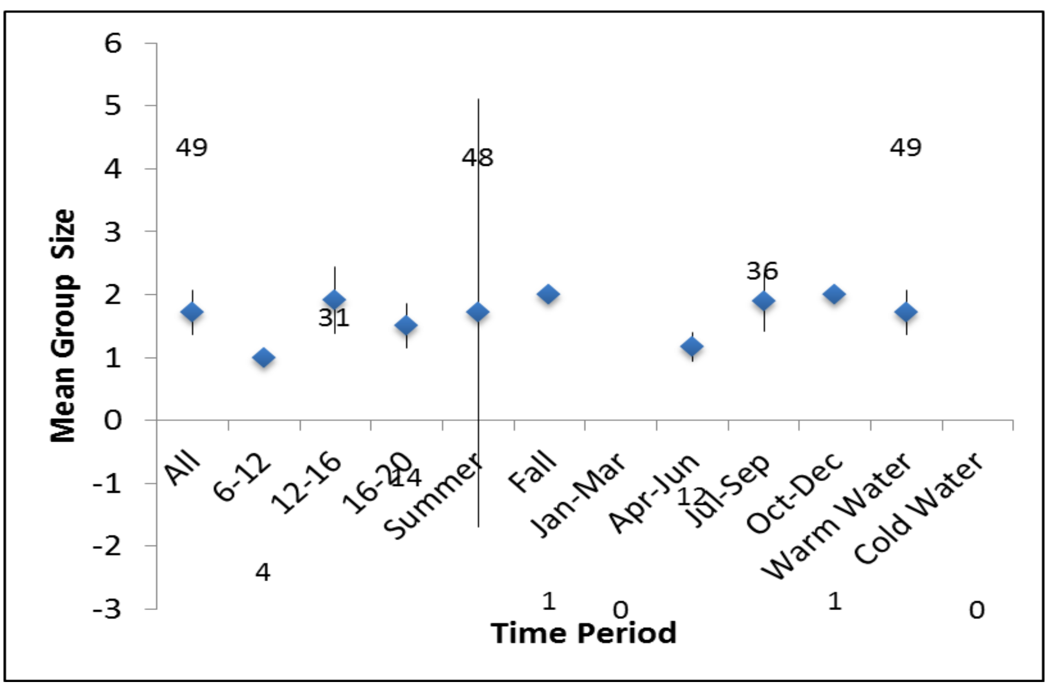

Figure 27. Blue Whale Baleanoptera musculus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

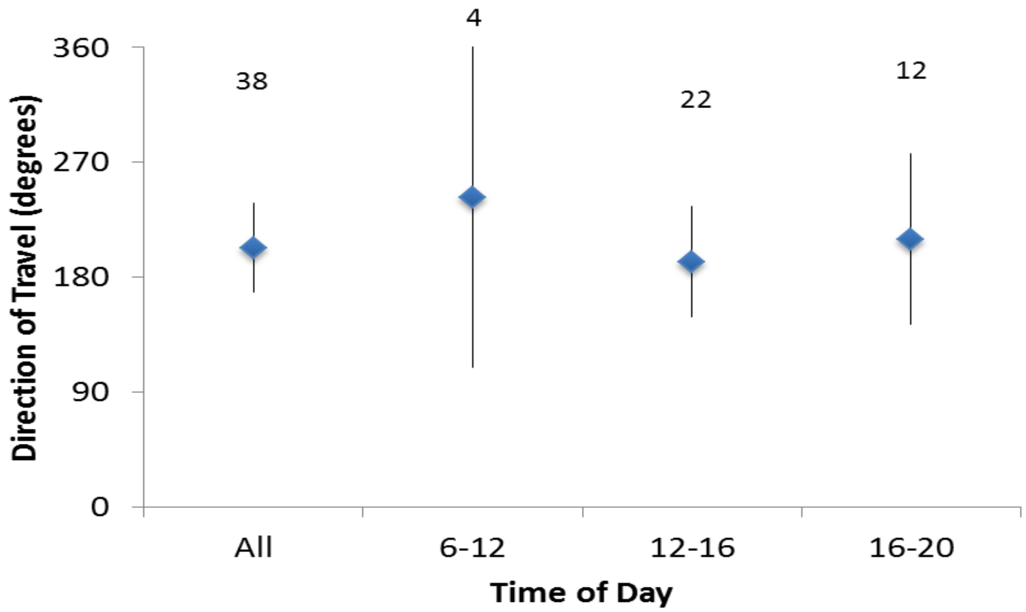

Figure 28. Blue Whale Baleanoptera musculus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

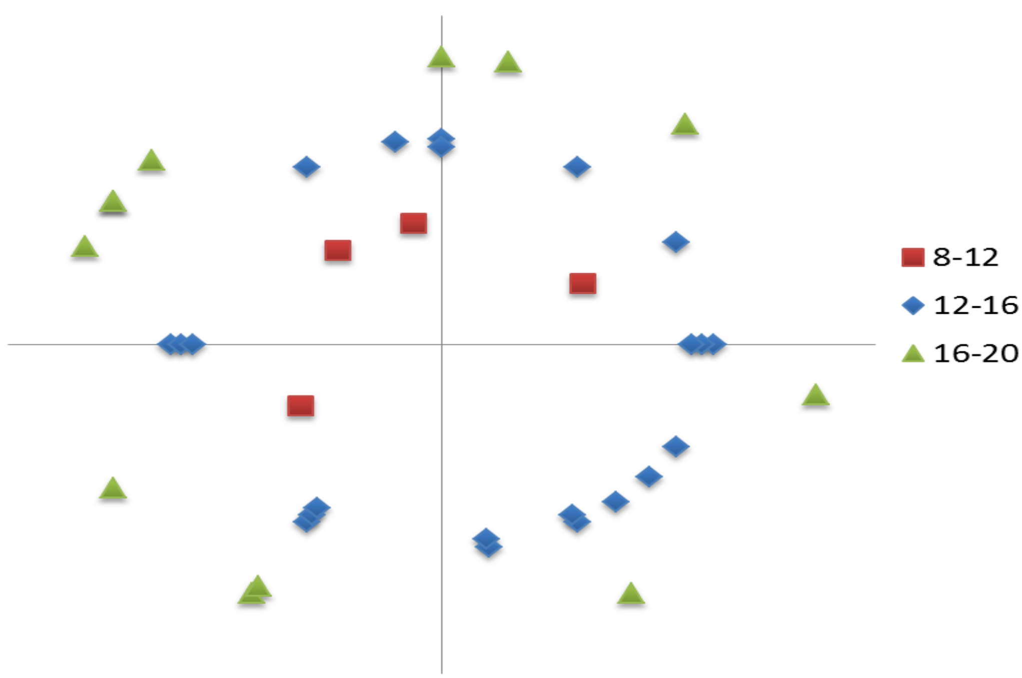

Figure 29. Blue Whale Baleanoptera musculus mean group heading (degrees magnetic) by time of day.

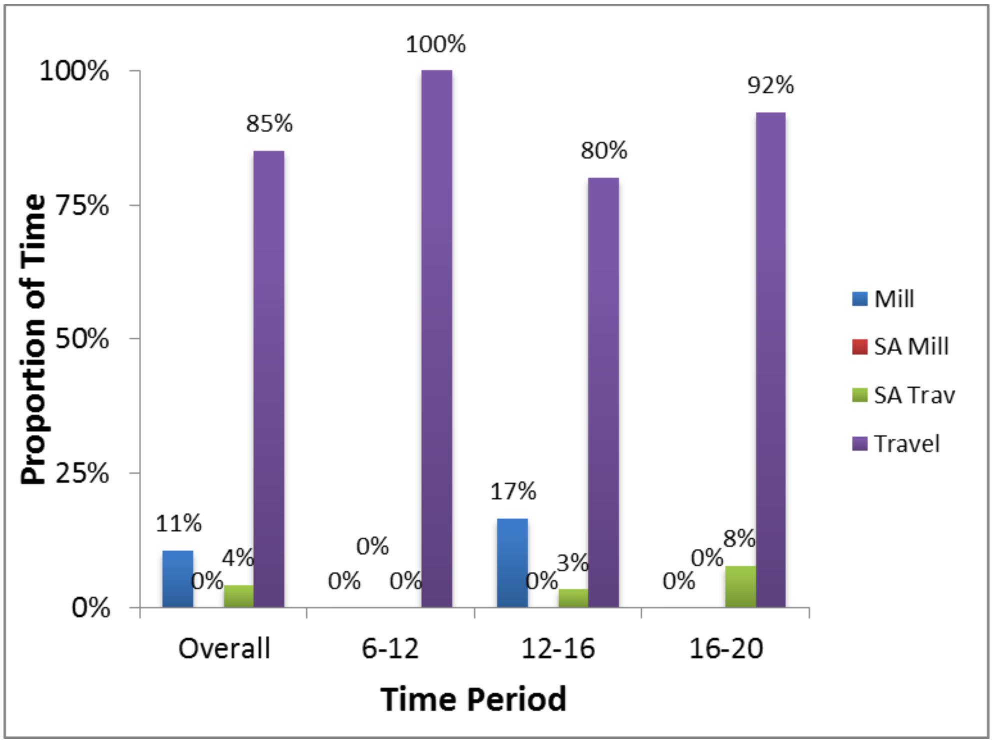

Figure 30. Blue Whale Baleanoptera musculus initial behavior observed by time of day. Note: SA=surface active.

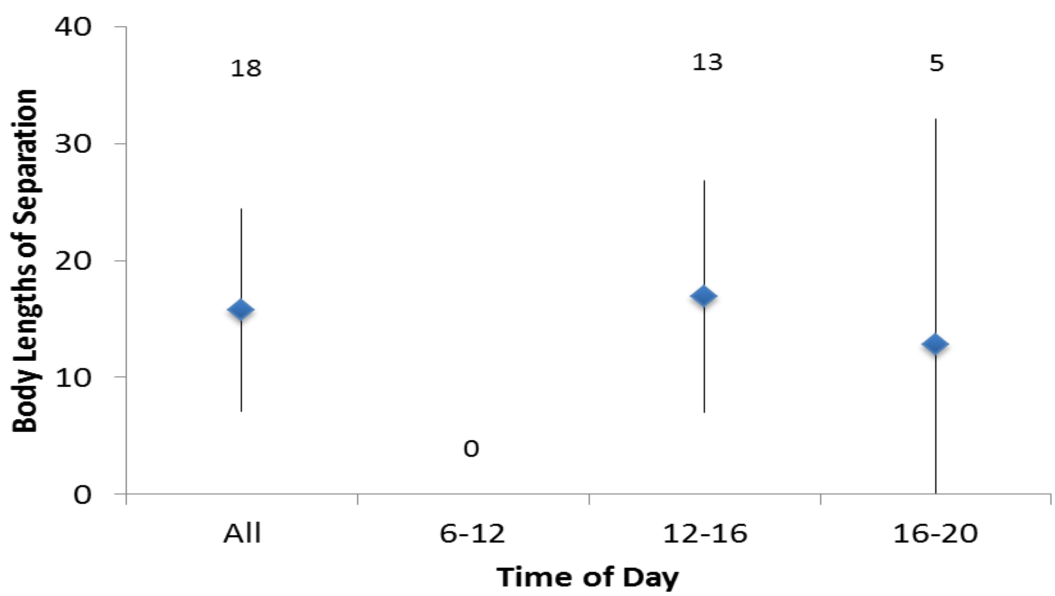

Figure 31. Blue Whale Baleanoptera musculus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

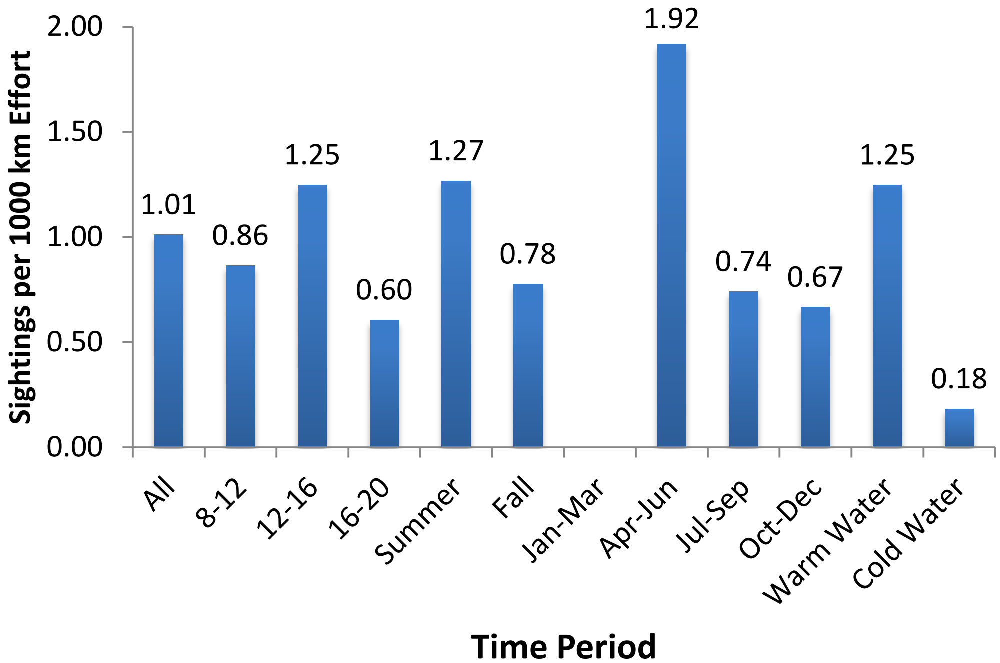

Figure 32. Bottlenose Dolphin Tursiops truncatus sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

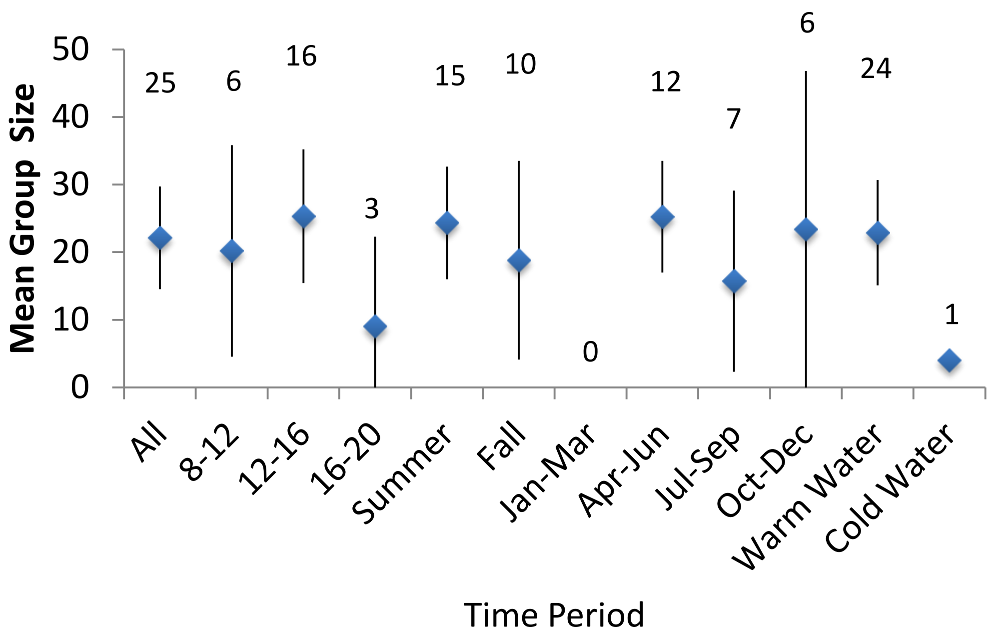

Figure 33. Bottlenose Dolphin Tursiops truncatus mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

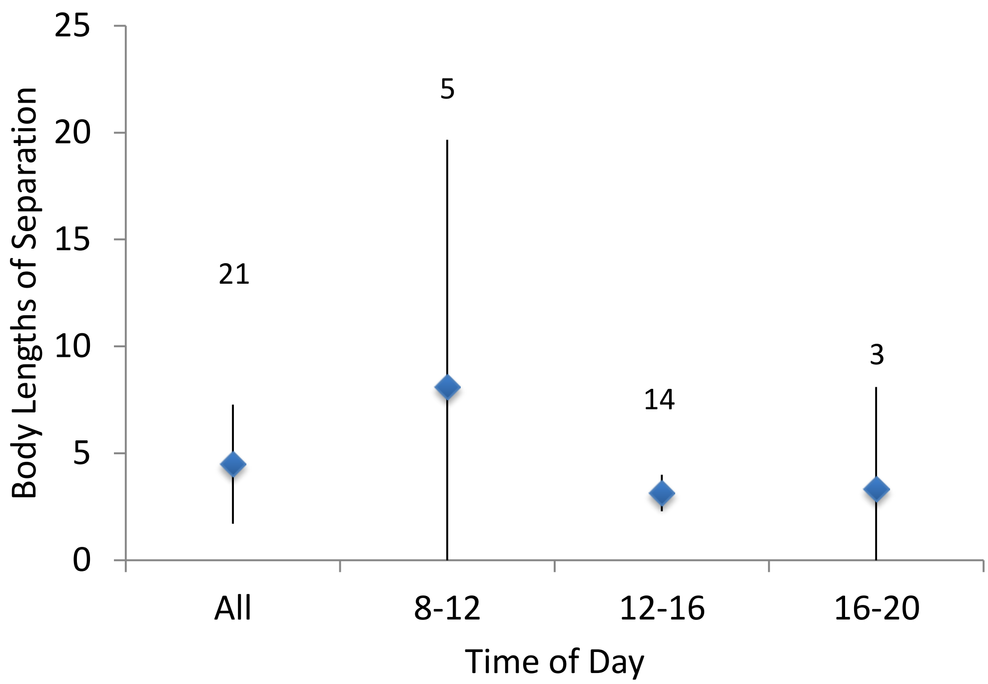

Figure 34. Bottlenose Dolphin Tursiops truncatus mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

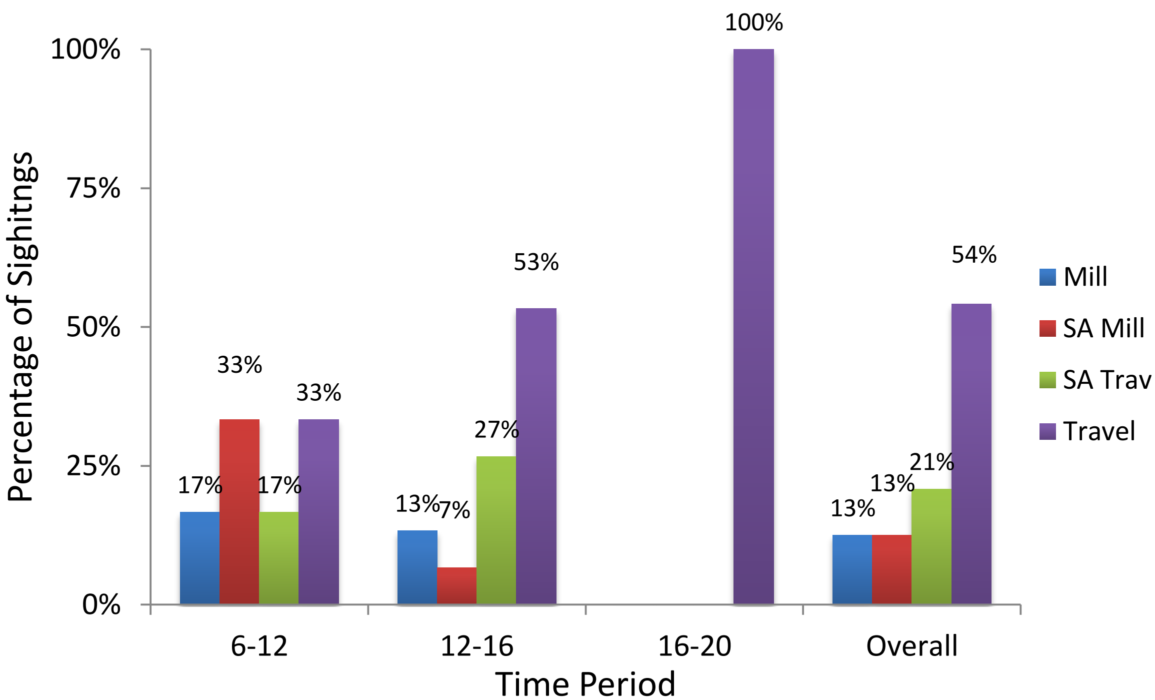

Figure 35. Bottlenose Dolphin Tursiops truncatus initial behavior observed by time of day. Note: SA=surface active.

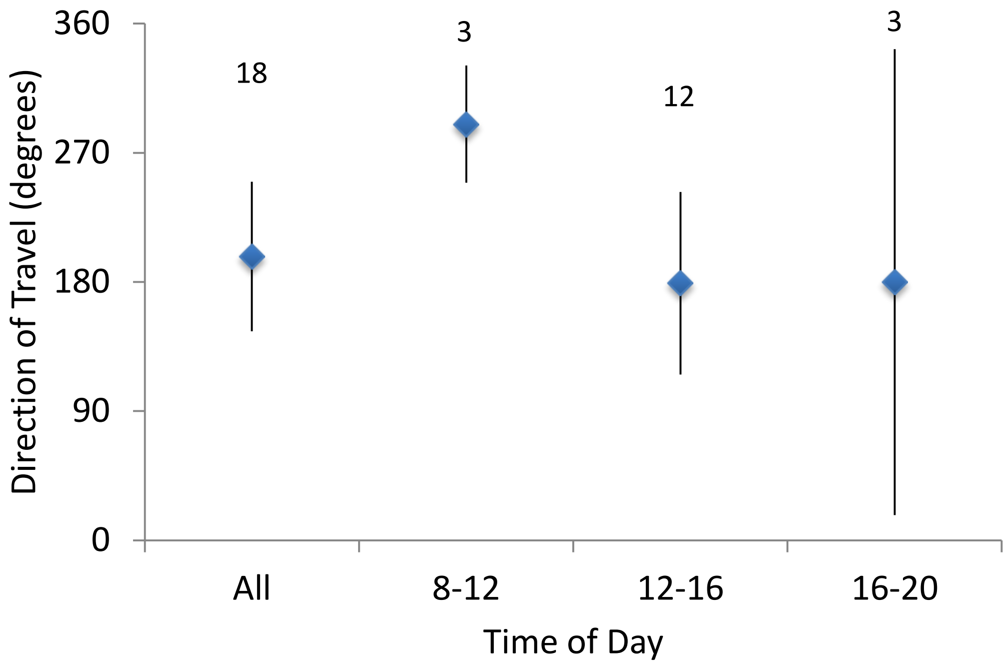

Figure 36. Bottlenose Dolphin Tursiops truncatus mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

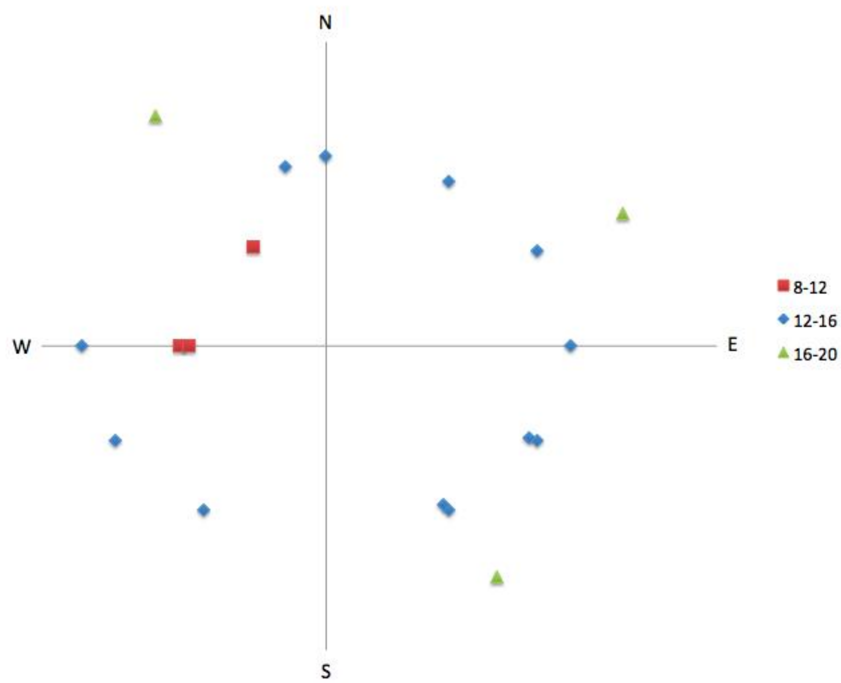

Figure 37. Bottlenose Dolphin Tursiops truncatus mean group heading (degrees magnetic) by time of day.

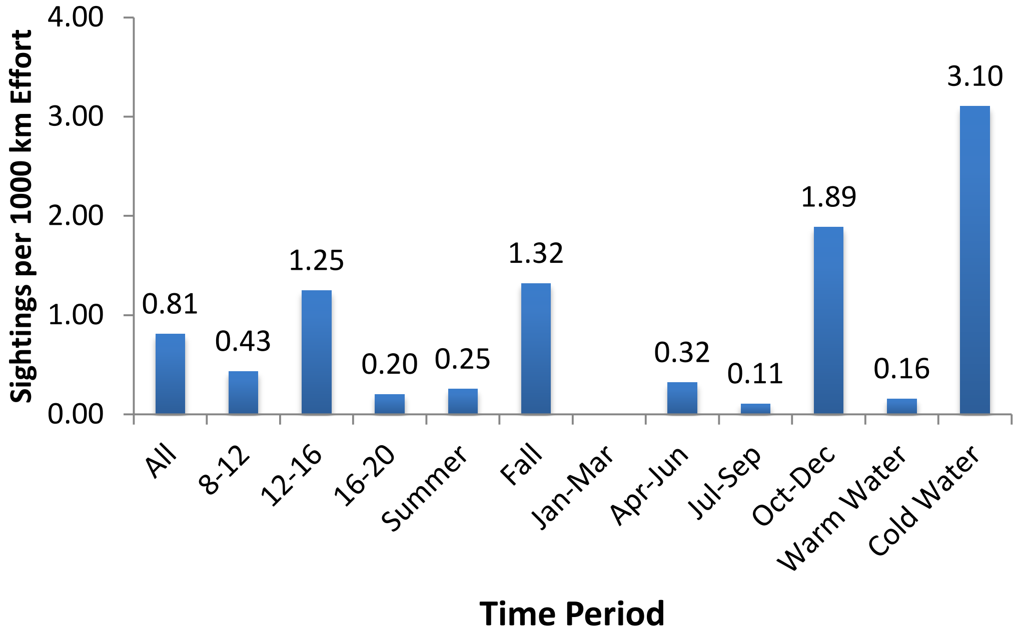

Figure 38. Pacific White Sided Dolphin Lagenorhynchus obliquidens sightings per 1,000 km of effort based on time of day, season, quarter, and water temperature.

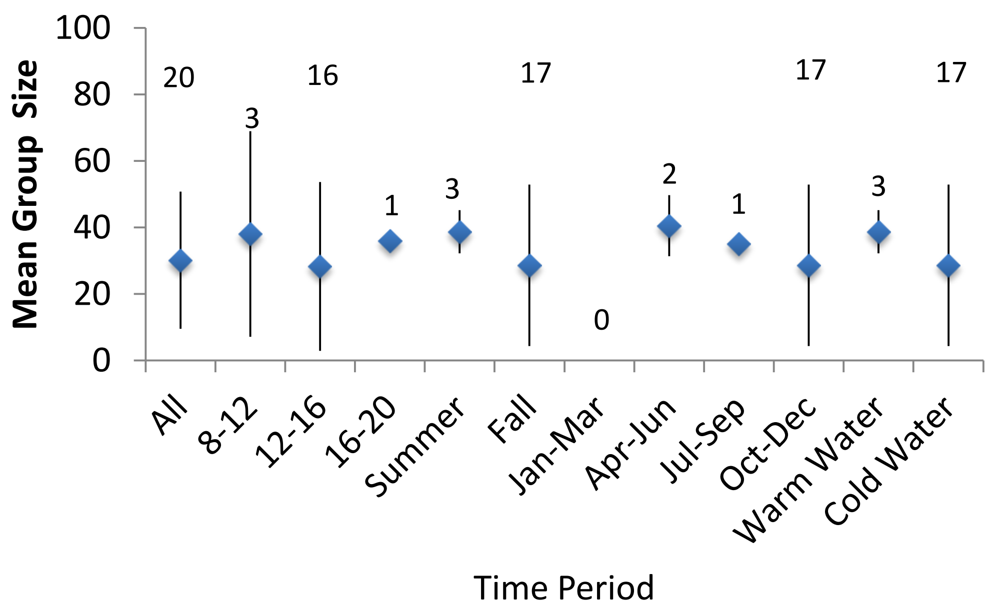

Figure 39. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean group size by time of day, season, quarter, and by water temperature. Numbers refer to the total sightings for which data was collected.

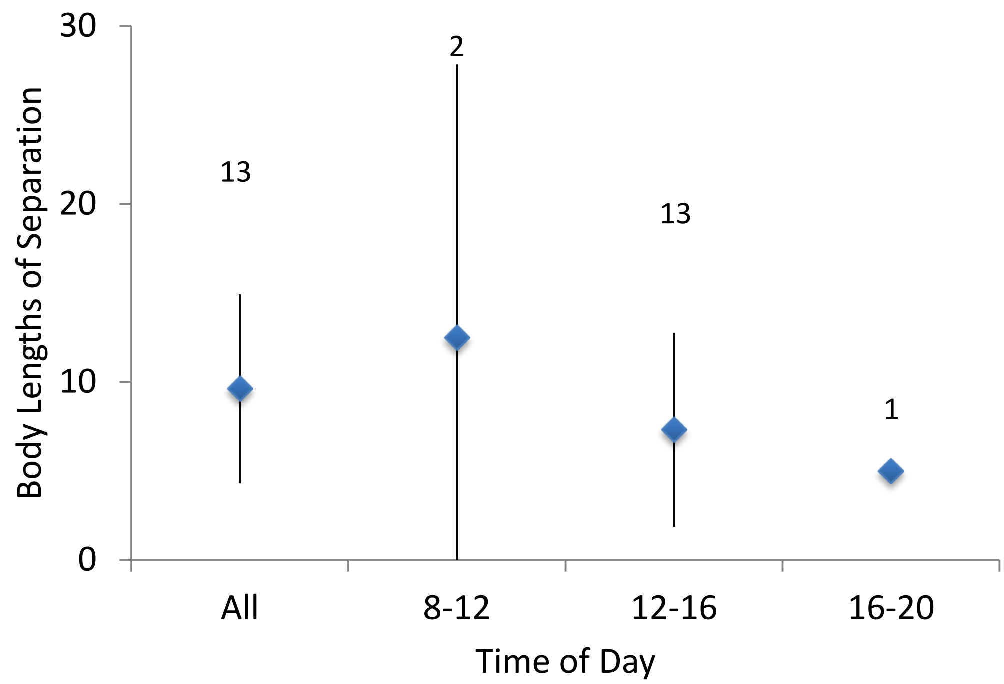

Figure 40. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean of all maximum dispersions recorded for a sighting by time of day. Numbers refer to the total sightings for which data was collected.

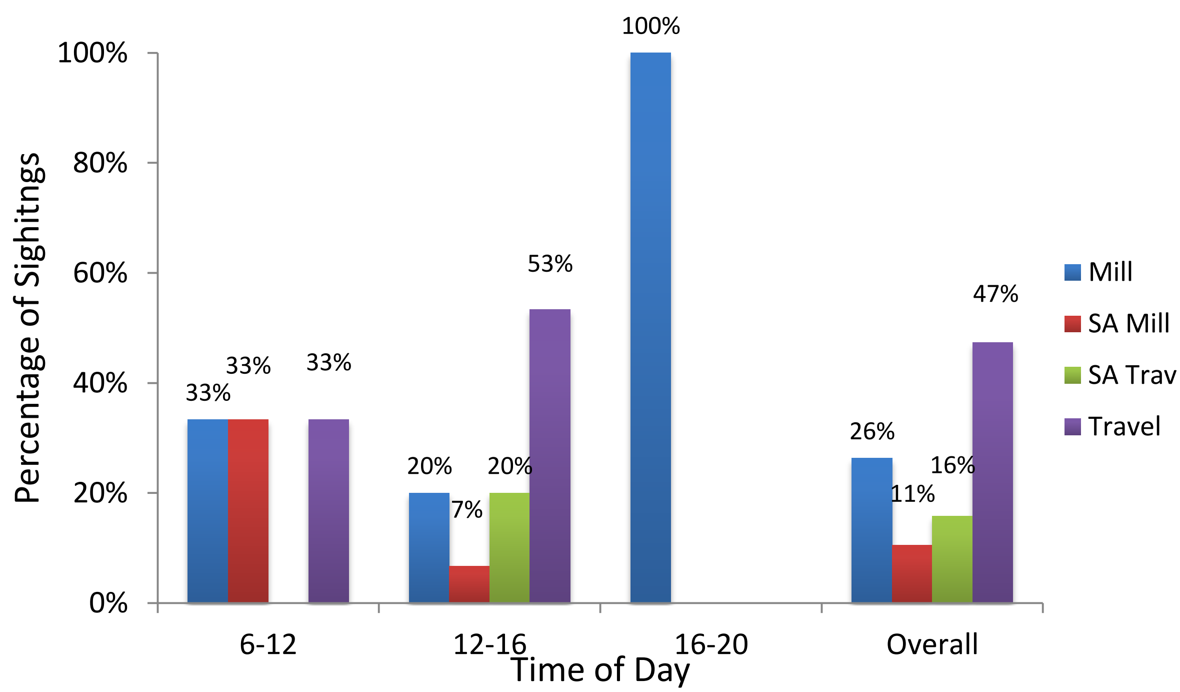

Figure 41. Pacific White Sided Dolphin Lagenorhynchus obliquidens initial behavior observed by time of day. Note: SA=surface active.

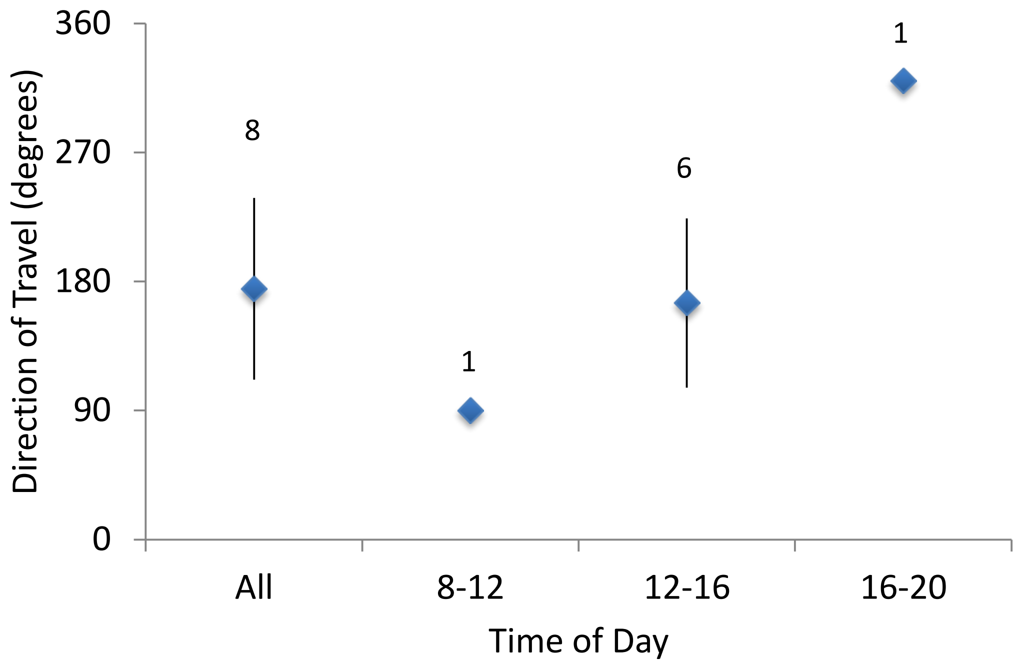

Figure 42. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean group heading by time of day. Numbers refer to the total sightings for which data was collected.

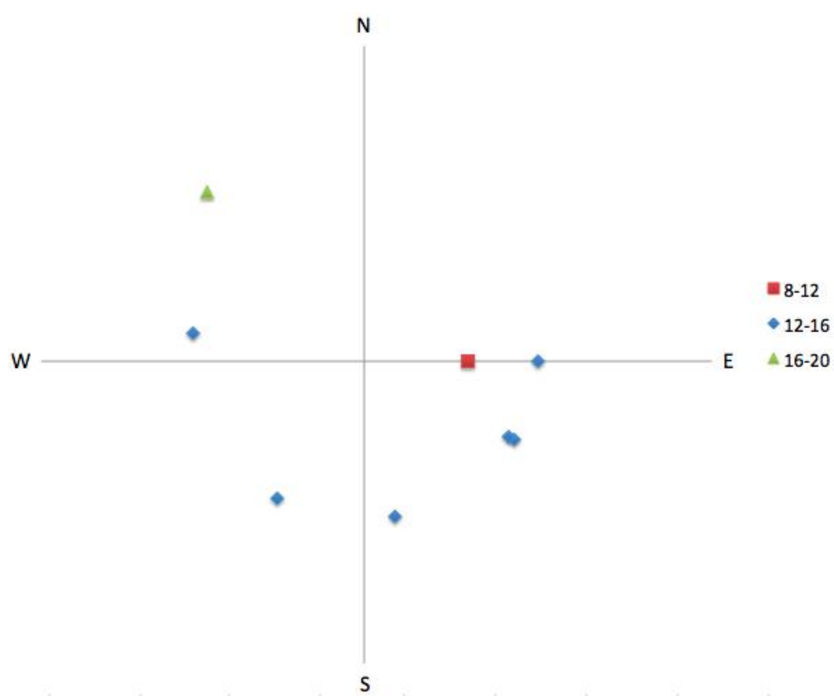

Figure 43. Pacific White Sided Dolphin Lagenorhynchus obliquidens mean group heading (degrees magnetic) by time of day.

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