OCS Study
BOEMRE 2011-047

Determining the Potential Effects of Artificial Lighting From Pacific Outer Continental Shelf (POCS) Region Oil and Gas Facilities on Migrating Birds

September 2011

Bureau of Ocean Energy Management, Regulation and Enforcement

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Executive Summary

Beginning in the late 19th Century, scientists have reported deleterious effects of lighted man-made structures, especially coastal lighthouses, on birds (Rich and Longcore 2006; Montevecchi 2006). Recent investigations of offshore oil and gas platforms in the Gulf of Mexico Outer Continental Shelf (OCS) (Russell 2005), the Atlantic Ocean, offshore of Newfoundland (Baillie et al. 2005; Weise et al. 2001), the North Sea (Van de Laar 2007; Bruinzeel 2009), and offshore California (SES 2007, 2008) suggest that both resident and migratory bird species are regularly observed at offshore structures, and that nighttime lighting of oil and gas platforms can have adverse effects. These adverse effects include: 1) collision with the structures, resulting in injury or mortality (Rich and Longcore 2006); 2) disorientation and circling of the platforms—that is, entrapment by the illumination and a reluctance to leave its sphere of influence (Marquenie 2007; Rich and Longcore 2006; SES 2007), resulting in unnecessary energy expenditure, fatigue, and depletion of critical energy reserves; and 3) increased vulnerability to predation from platform-associated raptors (Russell 2005).

Because of limited scientific information on the migration pathways of birds over those regions of the Southern California Bight (SCB) where Pacific Outer Continental Shelf (POCS) production platforms are located, and due to concerns that these platforms might be posing similar risks to migrating and resident birds as reported in other regions of the world, the Department of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) commissioned this study to assess the interaction of migrating and resident birds with POCS platforms, with a special emphasis on night observations, when platform lighting might result in disorientation and entrapment of migrating birds.

Bird interactions with offshore petroleum production platforms in the San Pedro Basin, Santa Barbara Channel, and Santa Maria Basin were assessed during surveys conducted in spring (April/May/June) 2010 and 2011 and fall (September/October) 2010.

The objective of these surveys was to observe and characterize avian interactions with oil and gas production platforms in the POCS during fall and spring migrations, with particular focus on whether platform nighttime lighting had any effect on bird behaviors. Data were intended to help answer several general questions:

- Are bird/platform interactions occurring at platforms within the POCS?
- Are there any daytime/nighttime differences in bird/platform interactions?
- Do platform lights have deleterious effects on bird behavior?
- If interactions are occurring, are the same bird species or bird groups (i.e., marine, non-marine) similarly involved at the various platforms?
- What, if any, is the relationship of interactions with platform location relative to the mainland, the offshore Channel Islands, known flyways, geographic features known to affect migration routes, and proximity to nesting areas?
- Are there any physical factors (e.g., lunar cycle, weather, wind conditions) that seem to contribute to the occurrence of bird/platform interactions?

In support of the field study, a detailed literature review was conducted to gather information on bird migration flyways and pathways through the Santa Barbara, Point Arguello, and San Pedro regions of the SCB where POCS platforms are located. The literature review included an investigation into reported instances of bird attraction and possible entrapment by nighttime lighting from ships, lighthouses, oil and gas platforms, and coastal buildings. Finally, an assessment

of "off the shelf" remote imaging cameras was conducted to determine if the technology was capable of cost-effectively augmenting human observations during the study.

Avian surveys from POCS platforms were conducted over a 2-year period during two spring (April/May/June 2010 and 2011) and one fall (September/October of 2010) migration periods for the SCB. Six platforms (Edith, Gina, Gail, Habitat, Hermosa, and Irene) located throughout the study boundary were chosen as the primary locations for conducting bird observation, based on geographic location and on access and availability. In total, more than 678 hours of observations were conducted, with 154 hours of observations during daylight hours and 524 hours of observations during nighttime. During these observations, approximately 3,300 bird sightings were made of 75 different marine bird (seabird) and landbird species. Additionally, observations were made over all phases of the lunar cycle and during a range of meteorological conditions.

A variety of both landbirds and seabirds were observed in proximity to and occasionally perching on the platforms. Of the 3,300 sightings, less than 15 percent of the birds were observed interacting with the platforms. Birds were found on or observed landing on a platform 281 times, flying near a platform 172 times, and circling a platform (for a few passes) 12 times. A few seabird species, notably Brown Pelicans, Double-crested Cormorants, and Western Gulls, were observed habitually using the substructure of a platform for nighttime roosting. Occurrence of migratory landbirds on or near the structures was less frequent, as might be expected, and was somewhat episodic. Arrival of mixed flocks of passerines on platform Edith during early daylight hours in April 2010 and platforms Edith and Irene in October 2010 was noteworthy because of the number of individuals, i.e., approximately 150, 42, and 52, respectively. There were other examples of "minor fallouts" (mornings when large numbers of migrating birds arrived at the platforms likely as a result of stopping on the mainland overnight to roost) in spring 2011.

Of particular interest is the use of offshore platforms for roosting and hunting by Peregrine Falcons. It appears that use of offshore platforms by Peregrine Falcons is more than occasional, and has been reported on many platforms in the Gulf of Mexico (Russell 2005). Similar behavior appears to be occurring at POCS platforms where the combination of marine and terrestrial avian prey (the latter likely available on a less consistent basis) allows long-term exploitation and what might even be considered "seasonal residency" on some platforms. Hunting (including nighttime) by Peregrine Falcons, or evidence thereof, was observed during both spring and fall field efforts on multiple platforms within the study group. An examination of peregrine prey remains collected on platform Gina revealed a highly varied diet consisting of both landbirds and seabirds. Interestingly, peregrines on platform Gina were observed hunting at night, targeting migratory flocks of Red-necked Phalaropes. Nighttime hunting by Peregrine Falcons is an unusual adaptation that is rarely reported in the literature (DeCandido and Allen 2006). The behavior is likely facilitated by platform lights, which not only assist with prey detection, but may cause temporary disorientation of passing birds, thereby rendering them vulnerable to predation.

Based on the 524 hours of nighttime observations made during this study, no incidence of light disorientation or light entrapment by nocturnally migrating birds was observed. Based on both daytime and nighttime observations, there does not appear to be any differences in bird occurrence or interaction with the platforms relative to their proximity to geographic features such as the mainland, the Channel Islands, or a key geographic boundary such as Point Conception or Point Mugu. This may be in part the result of the more broadly dispersed migratory flyways in the Santa Barbara region that otherwise would result in more frequent bird encounters with offshore platforms and apparent random bird "fallout" occurrences at one platform versus another. Also, as suggested in the literature review of flyways through the Santa Barbara region, unlike in the Gulf of

Mexico and the North Sea and along the Atlantic Coast, the main migration pathway for landbirds is not over the water where encounters with offshore platforms would be expected to occur (SBCo 2008).

Based on field observations encompassing a broad range of temporal, geographic, astronomical, and meteorological parameters undertaken for the current study, there appears to be little or no adverse effects of POCS petroleum production platforms' lighting or structural features on local avifauna and their movements. Bird interactions with POCS platforms were observed to provide primarily a temporary and opportunistic refuge.

Differences in daytime versus nighttime interactions between platforms and migrating birds appear to be more a factor of the general patterns of migration than of platform location, design, or lighting. Birds were observed at the time of day or night that reflected migratory behavior reported in the literature and as supported by shore-based anecdotal accounts during the same period. The presence of passerines at the platforms where observations were made appears to be random and not influenced by physical characteristics of the structure or its location.

Attraction behaviors reported in the literature for phalaropes and various species of migratory landbirds observed on platform Irene in spring 2007 (SES 2007) were consistent with similar reports from the Gulf of Mexico (Russell 2005) and the North Sea (Marquenie et al. 2008; Marquenie 2007; Bruinzeel et al. 2009; Van de Laar 2007). These included both "entrapment" (continuous circling of the platform for a period of 3 hours) and apparent attraction to banks of lights illuminating structural components. Both behaviors resulted in consequent depletion of energy reserves. The fact that these observations were made on consecutive nights with only two nights of survey suggested that the phenomenon might be relatively common. Based on the more extensive set of observations collected during this study, it would appear that these phenomena occur far less frequently in the POCS than the one recorded occurrence at platform Irene and similar reported occurrences in the Gulf of Mexico and North Sea would indicate.

The apparent rarity of entrapment at POCS platforms would appear to be the result of significantly different environmental conditions and location of the migratory flyway than those that occur in the North Sea and Gulf of Mexico where entrapment has been documented. The migratory flyways for most seabirds are primarily located farther offshore than the relatively near-shore coastal region in which the POCS platforms are located; the passerines flyways are located farther inshore of the coast because of the need to transit the Santa Ynez and San Rafael mountains (Able 2004).

The occurrence of meteorological conditions, including high cloud cover and storm fronts, that obscure celestial and lunar light do not occur frequently in the active POCS region of California during the periods of fall and spring migration. Additionally, the topographic relief of the coastal ranges appears to force the majority of migrating birds that may be flying over the Santa Barbara Channel to fly at a higher altitude. This allows them to fly above the lower-altitude marine layer that predominates in this region of California, consequently limiting any blocking or obscuring of either celestial or lunar navigation clues and light. The geography of the Santa Barbara region is different than that of the North Sea or Gulf of Mexico where migrating birds are forced to move over large bodies of water from land mass to land mass without topographic relief mid-journey. Finally, the meteorological conditions necessary to support the attraction, disorientation, and entrapment of migrating birds, as observed in the North Sea and the Gulf of Mexico, appear to occur only rarely in the POCS during the fall and spring migration periods, based on our 2-year study. Therefore, the potential for platform light entrapment of migrating birds, as observed at platform Irene in 2007 (SES 2007), appears low and without discernable pattern.

1.0 Study Background

1.1 Status of Knowledge Concerning Bird Behavior in Response to Artificial Night Illumination of Oil & Gas Platforms

Beginning in the late 19th Century, scientists have reported deleterious effects of lighted man-made structures, especially coastal lighthouses, on birds (Rich and Longcore 2006; Montevecci 2006). These deleterious effects include direct habitat loss and fragmentation, displacement due to disturbance, death and injury due to collision, and disruption of migratory movements with a consequent increase in energy expenditures (Gauthreaux and Belser 2006; Montevecci 2006). Avian species characterized by nocturnal migration and other nighttime activities appear to be particularly affected by artificial illumination (Rich and Longcore 2006).

The presence of bright artificial lights from ships, lighthouses, shore-side buildings, and oil and gas platforms have been reported to result in altered natural behavior, collisions, and entrapment. "Entrapment" in this context is defined as repeated or continuous circling or hovering as a result of attraction and/or disorientation induced by artificial illumination.

Recent scientific investigations of offshore oil and gas platforms in the Gulf of Mexico Outer Continental Shelf (OCS) (Russell 2005), the Atlantic Ocean offshore of Newfoundland (Baillie et al. 2005; Weise et al. 2001), the North Sea (Van de Laar 2007; Bruinzeel et al. 2009), and offshore California (SES 2007, 2008) suggest that both resident and migratory bird species occur at offshore structures, and that lighting of oil and gas platforms at night can have adverse effects; these effects include: (1) collision with the structures, resulting in injury or mortality (Rich and Longcore 2006); (2) disorientation and circling of the platforms—i.e., entrapment by the illumination and a reluctance to leave its sphere of influence (Marquenie 2007; Rich and Longcore 2006; SES 2007), resulting in unnecessary energy expenditure, fatigue, and depletion of critical energy reserves; and (3) increased vulnerability to predation (Russell, 2005).

The attraction of birds to artificial light sources, and the subsequent adverse effects on them, appears to be influenced by visibility, ambient light, and lunar phase (Montevecci 2006). Visibility is perhaps most affected by weather, in particular fog, rain, and/or cloud cover. Dense cloud cover appears to obscure celestial clues and topographic features (e.g., coastline, mountain range, river valley), causing birds to fall off course. An illuminated platform may present an attractive refuge under such conditions, particularly for landbirds when flying over water. The flat, featureless ocean surface may add to the level of disorientation.

Most studies of the effects of artificially illuminated structures on birds have been conducted during periods of seasonal migration, when encounters are more frequent and migrating birds are less likely to be familiar with the encountered structures. Migration patterns (i.e., species, density, and timing) are primarily influenced by seasonality and ecological factors (available forage, nesting success, etc. on winter and nesting grounds), and their interactions are both complex and highly variable (Carlisle et al. 2009).

Weather conditions contribute greatly to interactions between migrating birds and lighted structures (Marquenie 2007; Rich and Longcore 2006). According to a study conducted on a Dutch platform in the North Sea, virtually all platform-bird interactions occurred during foggy nights with greater than 80 percent cloud cover (Marquenie 2007). Observations of migrating birds from offshore platforms in the Gulf of Mexico (Russell 2005) also reported that bird entrapment by

platform lights occurs most frequently at isolated platforms during stormy conditions with low-altitude cloud cover. The lunar cycle is also a consideration as lunar phase affects visibility.

Most seabirds migrate during daytime (with the notable exception of the phalaropes, which are known to migrate both during the day and at night), while most landbirds travel primarily at night, using celestial clues for navigation (Able 2004).

An annotated bibliography of published and unpublished scientific studies pertinent to bird interactions with lighted structures, in particular offshore oil and gas platforms, as well as bird migration in the Southern California Bight, is provided in Appendix A.

1.2 Migration Routes/Paths in the Santa Barbara Channel

Birds typically follow the same general geographic route, or migration route, between wintering and breeding grounds each year. Migration routes generally conform to major topographic features such as coastlines, mountain ranges, and rivers. Such heavily used topographic areas are often termed "flyways" within the United States (U.S.).

Platforms within the Pacific Outer Continental Shelf (POCS) complex fall within the coastal edge of the Pacific Flyway, one of four major North American flyways. The Pacific Flyway encompasses the western Arctic, including Alaska and the Aleutian Islands, and extends along the Rocky Mountain and Pacific coast regions of Canada, the U.S., and Mexico south to where it intergrades with other flyways in Central and South America. The longest and most important route within the Pacific Flyway originates in northeastern Alaska, passing for most if not all of its length through the interior of the U.S. The southward route of migratory landbirds that leave the U.S. in winter extends through the interior of California to the mouth of the Colorado River and then to winter quarters in western Mexico.

From any perspective, precise routes of migration are poorly defined. Migratory routes vary in terms of distance traveled, time of initiation, flight speed, geographical position, and latitude of breeding and wintering grounds. No two species of birds follow the exact same route, and different subpopulations within the same species may also travel different routes. Similarly, Carlisle et al. (2009) concluded, "On the basis of our present knowledge, we suggest that most species of landbirds migrate through the West on a relatively broad front but that, within species, routes may vary seasonally, and specific populations are likely restricted to narrower migration routes."

Studies of various North American migration routes indicate that the western migration system is unique in its evolutionary, ecologic, and geographic features. Kelly and Hutto (2003) even suggest that the western migratory system is possibly unique worldwide in that it is primarily an overland-based migration. Thus, the frequency or likelihood of migratory birds encountering and interacting with specific OCS platforms or groups of platforms as compared to others cannot be predicted based on our present knowledge.

Long-term studies of bird migration along the coastline of Southern California have not been conducted. Seasonal trends in species, timing, and weather effects are better understood than specific geographic patterns or migration routes for most bird species. Monitoring of spring seabird migration through the Santa Barbara Channel has been conducted on a limited basis (Lehman, 1994; Compton, 2008). Although data gathered through these efforts provide useful information on diurnal migration trends for several seabirds, these are fixed-point observations made from a local promontory (Goleta Point) and do not by themselves define migration routes.

Some insight into broad spatial patterns of migrating birds was gained using Weather Surveillance Radar, or NEXRAD (Next Generation Radar), to track nocturnal bird migration during the 2006 and 2007 spring and fall migration periods over the western transverse ranges (Santa Ynez and San Rafael Mountains) of northern Santa Barbara County. The study, which relied on archival radar data from nearby Vandenberg Air Force Base, was conducted in relation to a proposed wind turbine farm northwest of Lompoc, California (SBCo 2008). The highest densities of birds were recorded at high altitudes (2,000 to 5,000 feet) just west of the Santa Ynez and San Rafael Mountains, approximately 20 to 40 miles east of the project site. The migration directions observed were from the south-southeast (162 to 163 degrees) in the spring and from the north-northwest (332 to 333 degrees) in the fall. The study results indicate that most landbird migration in Santa Barbara County follows an inland route through the lower passes of the Coast Ranges, bypassing Point Conception and the Gaviota Coast. The observed peak migration periods were from mid-April to mid-May and from mid-August to the end of September. During periods of adverse weather, little or no migration occurred.

Due in large part to Santa Barbara's geographic orientation and moderate climate, migration periods can be protracted in both spring and fall. In contrast to the dramatic migratory pulses seen along the East Coast or the Gulf of Mexico where hundreds of thousands of neotropical migrants can be observed over a period of a couple of weeks, the largest numbers of migrating birds are found during the spring migration of seabirds along the Southern California coast.

Spring coastal seabird migration begins in late February, with peak movement occurring between late March and early May. Very large numbers of seabirds can be observed during this period, with loons, scoters, and Brandt's as the most conspicuous from shore. April and May are the peak months for spring migration for shorebirds and landbirds, with some association of increased pulses during periods of storm activity. Pelagic species (e.g., petrels, phalaropes, alcids, and jaegers) are most numerous from mid-April to early June.

Fall migration typically starts with the arrival of southbound shorebirds as early as late June through July. Fall landbird migrants begin to show up in early July, increasing through August and lasting until mid-November. If a peak occurs, it most likely occurs in late August through September. Southern California birders have noticed "fallouts" of fall migrants most frequently during the last two weeks of September and first week of October.

Fall migration of terrestrially associated species may differ from spring migration in several respects. Bird density during fall migration has been observed to be slightly higher than spring migration (SBCo 2008). Fall migration also includes larger numbers of juvenile birds (young-of-year) that are potentially more vulnerable to disorientation because of inexperience. Additionally, a southbound trajectory in fall, assuming it follows the coastline, might induce birds to overshoot land at or near Point Conception, particularly during nights with poor visibility. All of these factors can be expected to contribute to the increased likelihood of bird/platform interactions during fall migration.

Fall movements of pelagic species tend to be concentrated between mid-August and mid-October. Fall movements of coastal seabirds occur generally between October and December. Fewer seabirds are observed moving southward than are observed moving north in spring. This perception may be due to birds flying further offshore, and thus not as easily detected.

The potential effect of POCS platforms on resident seabirds was also considered in this study.

Xantus's Murrelets are most common from late February to July. Pigeon Guillemots are in the Santa Barbara Channel from March through early September. Rhinoceros Auklets are found from October to March. Cassin's Auklets are observed year-round, but are much more widespread (away from breeding locales on the Channel Islands) during fall and winter, when resident numbers are augmented by migrants and winter visitors. Common Murres, (a recently re-established resident breeder) are irregular in occurrence but most numerous in winter. Ashy storm petrels begin arriving in April, are common by May, and are present in the Santa Barbara Channel from May through October.

The migration pattern and behaviors of phalaropes during both the spring and fall migrations has particular relevance to the current study. During peak migration, nocturnal phalarope movements have thousands of birds moving through the region. One night, over 30,000 birds were estimated moving in a single hour after sunset on 3 May 1981 in Santa Barbara, California (Lehman 1994). The northward spring migration of both Red-necked Phalaropes (*Phalaropus lobatus*) and Red Phalaropes (*Phalaropus fulicarius*) to their near-arctic breeding grounds generally has more birds moving through the Santa Barbara Channel region within a short time window, creating increased densities of birds. Red Phalaropes tend to migrate farther offshore, while Red-necked Phalaropes are seen closer to shore (Lehman 1994; Dailey et al. 1993). Nocturnal spring migration of Red-necked Phalaropes on calm, clear nights have been documented over the Santa Barbara coastal plain west of Highway 101 in western Santa Barbara and eastern Goleta but not in western Goleta, indicating that the birds are likely moving up and over the San Marcos Pass (Lehman 1994). Presumably, low-visibility conditions could prohibit inland corridor movements, increasing the density of birds passing via the near-shore routes and the chance of encounter with offshore platforms. Wilson's Phalaropes are also observed during migration periods; however, due to their different breeding destination (western interior U.S.), they are primarily terrestrial migrants.

Coastally migrating phalaropes are highly dependent on areas of oceanographic convergence; the associated upwelling conditions provide concentrated biomass of their preferred prey items. Some studies documented large phalarope mortality events during spring migration periods when there are poor upwelling conditions in the Southern California Bight (Yen et al. 2006). Faced with poor foraging opportunities mid-migration, birds should move quickly through non-productive areas to reach the next better foraging locality.

The southward fall migration of the two dominant phalarope species occurs over a prolonged period of time compared to the northward migration. As males are responsible for parental care, females leave the breeding grounds upon completion of their last clutch. Males and juveniles initiate their southward migration after most of the females have already left the region. Red Phalaropes follow even farther offshore distribution patterns during southward migration than in their northward routes. Red-necked Phalaropes follow similar near-shore routes as in the spring migration.

1.3 Alternative Monitoring Technologies

The potential for alternative methods for monitoring the timing, frequency, character, and magnitude of bird/platform interactions was investigated in the literature and by the use of remote imaging equipment. The use of automated instrumentation could provide a more efficient and economical means of data collection compared to human observance. Remote technologies such as radar, acoustical recorders, and infrared cameras, have been used to document bird movement on and near offshore platforms (Delsholm et al. 2006). Remote technologies have the advantage of being able to collect information on a nearly continuous basis with minimal expenditure of labor;

some, like radar, can assess bird flock movements over a greater aerial region than can on-site human observers. Although each of these technologies provides additional information, each has inherent drawbacks.

1.3.1 Radar

Radar can provide information on flight altitude and trajectory data, as well as quantify the level of activity. Three types of radar systems (based on mode of operation) have application to monitoring bird movement: surveillance radar; Doppler radar; and tracking radar (Delsholm et al. 2006). Surveillance radar, such as that used for tracking ships and aircraft, can detect the trajectories of moving targets from a fixed position. The system can use either a fixed-beam antenna or parabolic disc; the former enables detection at greater distance over a pre-determined area of interest, while the latter has a wider spatial coverage. Doppler radar, commonly used in traffic control, is most useful in detecting the velocity of the target. Tracking radar is most widely used in military applications. Tracking radar can only track one object at a time, but renders more detailed information on the three-dimensional movements of the target. Surveillance radar has been used in studies designed to determine the effects of wind farms on resident and migratory birds. Marine surveillance radars can be used to collect data on both the spatial and vertical distribution of migrating birds if the equipment can be mounted in both vertical and horizontal operating modes.

1.3.2 Acoustic Recorders

Acoustical monitoring of flight calls using specialized microphones, recorders, and recognition software has been used to sample avian species composition during nocturnal migration as well as complement bird radar data collection (Evans and Rosenberg 1998; Farnsworth et al. 2004). This technique is limited in that it is only effective for tracking species that emit flight calls during migration and for species that fly at lower altitudes. Acoustical recording of flight calls has its limitations in industrial situations where noise from process equipment is a source of interference. Data analysis is also labor intensive.

1.3.3 Remote Monitoring Cameras

The use of low-light, infrared, and thermal imaging digital cameras to detect and monitor bird movements at night have been in use for many years, and will continue to be used as technology continues to improve and costs decline (Kunz et al. 2007). Thermal and infrared imaging systems have often been coupled with radar tracking to distinguish the number of birds in a flock detected in a radar image (Bruderer et al. 1999). With continued concerns about wind energy turbine effects on migrating birds, the use of internet-accessible digital “webcams” has also increased in recent years and has proven to be a valuable adjunct data source to traditional observer-gathered data (Kunz et al. 2007).

Moderately priced camera systems can provide information on the presence of species and their behavior within the focal range of the camera system. They can also be equipped with activity triggers that reduce the number of images being collected and thereby make the data analysis more manageable and less costly. One drawback of remote camera systems is that they may under-represent the number of birds and species present at a location because of the fixed positioning of the camera and its limited range of view. A component of this study included the utilization of an “off the shelf” remote imaging camera system with internet connectivity. Details of the system are provided in Appendix B and discussed briefly below.

1.4 Purpose of Study (study objectives and study questions)

Bird interactions with offshore petroleum production platforms in the San Pedro Basin, Santa Barbara Channel, and Santa Maria Basin were observed during focused surveys conducted in spring (April/May/June) 2010 and 2011 and fall (September/October) 2010.

The objective of these surveys was to observe and characterize any and all avian interactions with oil and gas production platforms during fall and spring migrations in the POCS, with particular focus on whether platform nighttime lighting had any effect on bird behaviors. Bird/platform interaction is defined as any normal or abnormal behavior by marine birds (seabirds) or landbirds that can be directly attributed to the presence of the platform. Study data were to help better understand the following general questions:

- Are bird/platform interactions occurring at all platforms within the POCS?
- Are there any daytime/nighttime differences in bird/platform interactions?
- Do platform lights have deleterious effects on bird behavior?
- If interactions are occurring, are the same bird species or bird groups (i.e., marine, non-marine) similarly involved at the various platforms?
- What, if any, is the relationship of interactions with platform location relative to the mainland, the offshore Channel Islands, known flyways, geographic features known to affect migration routes, and proximity to nesting areas?
- Are there any physical factors (e.g., lunar cycle, weather, wind conditions) that seem to contribute to bird/platform interactions?

2.0 Methodologies

2.1 Field Observations

Avian surveys from POCS platforms were conducted over a 2-year period during two spring (April/May/June 2010 and 2011) and one fall (September/October 2010) migration periods for the Southern California Bight. Six platforms located throughout the POCS study region were chosen as the primary locations for conducting bird observation based on geographic location (i.e., intent to sample over a broad geographic range within the study area), access, and availability. These six platforms (Edith, Gina, Gail, Habitat, Hermosa, and Irene) were located in four geographically separated areas of the POCS: San Pedro (Edith); the eastern Santa Barbara Channel adjacent to the Channel Islands (Gina and Gail); Central Santa Barbara Channel inshore (Habitat); and offshore Point Arguello (Hermosa and Irene) (Figure 2-1). A seventh platform (Henry) was visited only during the spring 2010 survey for part of one day while another observer was located on an adjacent platform.

The initial field survey in spring 2010 was conducted at only four platforms (Edith, Gina, Hermosa, and Irene) with continuous observations over 2 days and nights at each location by two observers, for a total of nine nights and all or part of 12 days. The fall 2010 survey effort was adjusted to facilitate more days and nights of observations at more locations in an attempt to capture both the period of peak migration and a range of environmental conditions (e.g., lunar cycle and weather). The fall 2010 effort consisted of twenty (20) observation periods in which one observer focused on nighttime hours with select daylight periods on one of five platforms (Edith, Gina, Gail, Hermosa, and Irene) over a 24-hour time period. On several dates, observers were on different platforms concurrently. The spring 2011 survey effort was performed similarly to the fall 2010 effort with individual observers visiting different platforms (Edith, Gina, Hermosa, and Irene) for 24- to 48-hour periods, focusing primarily on night observations and having observers present on POCS

platforms in an almost continuous basis over an eight-week period. A total of 22 visits to four platforms were made between 20 April and 2 June 2011.

Table 2.1 lists the dates and locations of all platform observations. In total, more than 678 hours of observations were made during the study. Copies of all bird sighting and weather data sheets are contained in Appendix C.

2.1.1 Human Bird Observations

Spring 2010 observations were made on a near-continuous basis (daytime and nighttime) by two biologists working in shifts (or occasionally in tandem). Fall 2010 and spring 2011 surveys were focused primarily on nighttime observations by one observer with random daytime observations. The key periods of dawn and dusk were observed during all platform visits.

Observations were recorded on standardized data forms. Data included survey interval, location, weather conditions, species, and type of behavior. Each bird observation was categorized by level of interaction with platform structures or nearby water. Birds seen circling the platform with no signs of artificial light entrapment (i.e., one or two circles) or those that flew nearby without stopping were considered to have no direct platform interaction. Those birds that landed either in the water directly underneath or that landed on any portion of the platform structure were marked as interacting with the platform, and further details regarding their location, type of activity, and general condition were noted. Observers also collected photographic records of many of the birds observed.

Observers were equipped with 10-power binoculars and digital cameras. Most observations were made from a stationary position from one of the decks of the platform. Observation stations were selected based on which afforded the most unobstructed views and contained the highest elevation lighting on the platform. Additionally, meandering pedestrian transects to other parts of the structure were made.

Species identification was based on both visual and auditory characters. Because the majority of observations were recorded at night, visual detection was dependent on ambient, artificial light emanating from the platform. Although there are differences between platforms, the illumination from various light sources typically extends about 100 yards from the structures with enough intensity to identify birds. Birds identified solely by auditory characters were estimated by number of calling individuals that likely under-represents the true number of these birds moving past a platform.

Other observational data recorded includes time and duration, direction of flight, specific structural component of the platform utilized (in the case of direct interactions), and behavior. General behaviors such as roosting, resting, foraging, and flying were noted. Behavioral responses to artificial lighting were characterized as indifference, attraction, repulsion, or disorientation. Possible consequences of these behaviors, including fatigue, injury, and mortality, were also recorded if observed.

In addition to direct bird observations, platform workers were queried informally about their experiences observing birds while stationed offshore. These accounts were recorded in the field notes.

2.1.2 Remote Camera Observations

The efficacy of remote camera technology as an adjunct means of data collection was initially investigated during the fall 2010 survey period. During the spring 2011 survey period, a prototype demonstration system (consisting of low-light and infrared video cameras, digital storage, and internet access, along with batteries and solar panel recharging capability) was deployed. This remote imaging package was referred to by the project team as the "BirdCam." Appendix B provides a detailed description of the technology employed and its potential for future application.

Table 2-1: Summary of field observations.

PLATFORM	LOCATION	DATES
Spring 2010		
Platform Gina	East SB Channel	19-21 April 2010
Platform Edith	San Pedro	23-25 April 2010
Platform Habitat	Point Arguello	2-3 May 2010
Platform Hermosa	Point Arguello	6-8 May 2010
Fall 2010		
Platform Gina	East SB Channel	15-16 September 2010
Platform Irene	Point Arguello	
Platform Edith	San Pedro	16-17 September 2010
Platform Edith	San Pedro	20-21 September 2010
Platform Gina	East SB Channel	21-22 September 2010
Platform Hermosa	Point Arguello	20-21 September 2010 21-22 September 2010
Platform Gail	East SB Channel	27-28 September 2010
Platform Edith	San Pedro	28-29 September 2010
Platform Irene	Point Arguello	29-30 September 2010
Platform Gina	East SB Channel	5-7 October 2010
Platform Hermosa	Point Arguello	6-9 October 2010
Platform Edith	San Pedro	
Platform Edith	San Pedro	12-13 October 2010
Platform Irene	Point Arguello	15-16 October 2010
Spring 2011		
Platform Gina	East SB Channel	20-21 April 2011
Platform Irene	Point Arguello	25-27 April 2011
Platform Edith	San Pedro	27-28 April 2011
Platform Hermosa	Point Arguello	30 April - 2 May 2011
Platform Irene	Point Arguello	2-4 May 2011
Platform Edith	San Pedro	3-5 May 2011
Platform Gina	East SB Channel	5-7 May 2011
Platform Edith	San Pedro	10-11 May 2011
Platform Irene	Point Arguello	11-12 May 2011
Platform Hermosa	Point Arguello	12-13 May 2011
Platform Irene	Point Arguello	17-18 May 2011
Platform Hermosa	Point Arguello	24-25 May 2011
Platform Edith	San Pedro	26-27 May 2011
Platform Gina	East SB Channel	30-31 May 2011
Platform Irene	Point Arguello	31May - 1 June 2011
Platform Hermosa	Point Arguello	1-2 June 2011

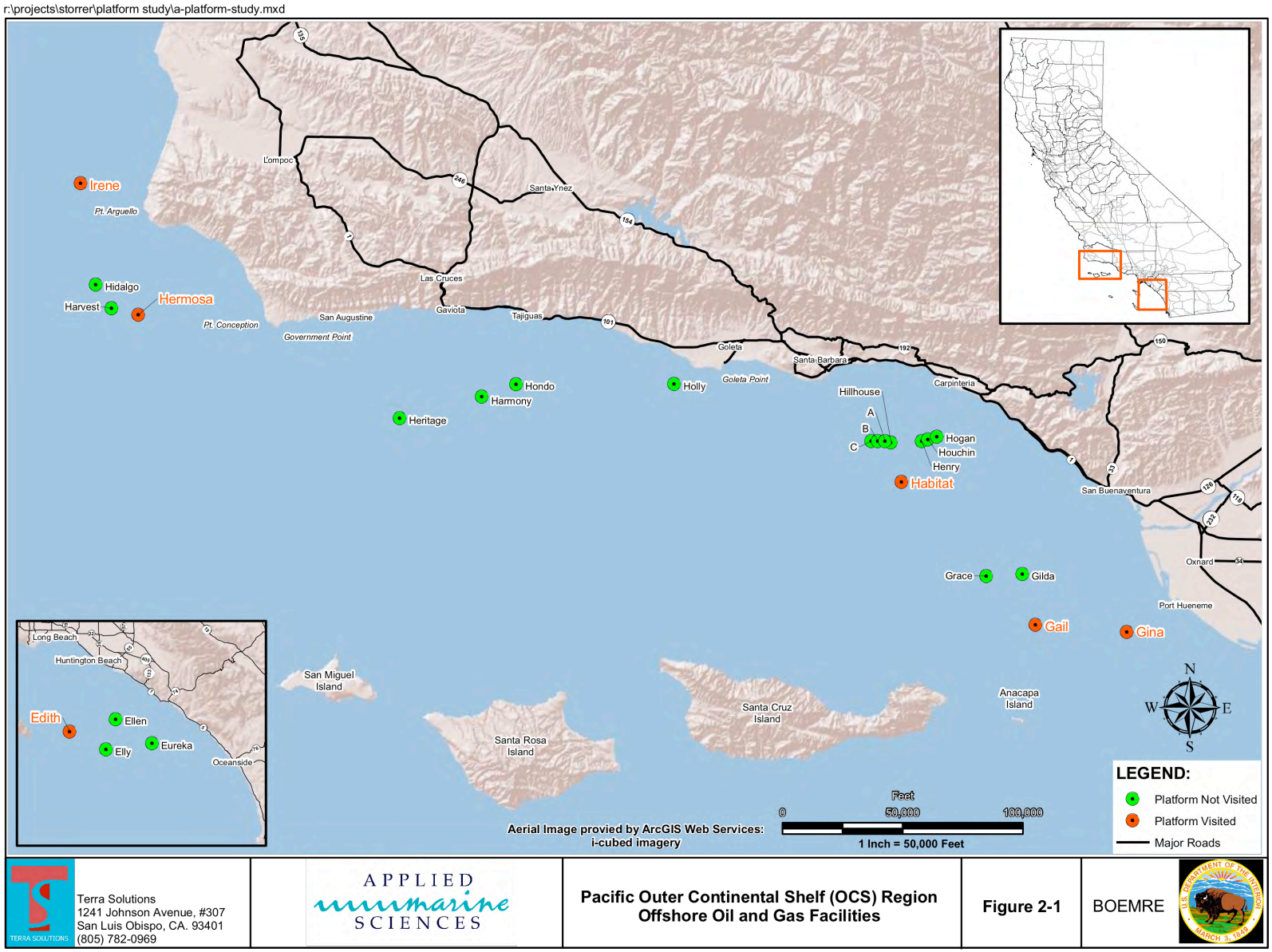

Figure 2-1. Pacific Outer Continental Shelf Oil and Gas Platforms.

3.0 Study Results

3.1 Platform Bird Observations

3.1.1 Observation Effort

The results of the study reflect nearly 680 observer-hours conducted over the 2-year study period (Table 3-1). During the fall 2010 and spring 2011 efforts, observer time was concentrated on single-observer surveys, with an emphasis on capturing various phases of the lunar cycle and weather conditions, with nighttime observations taking precedence over daytime observations. As illustrated in Table 2-1, during the fall 2010 and spring 2011 survey periods, observers were placed on individual or multiple platforms throughout the POCS during the expected peak migration periods identified during the literature review. Table 3-2 details the hours of nighttime observation gathered at each platform. Based on previous research indicating that the highest potential for bird/platform lighting interactions occurs during new moon phases and period of poor visibility, 37 percent of the nocturnal surveys were scheduled during new moon periods. In terms of weather variability, 50 percent of surveys experienced 100-percent cloud cover and 16 percent experienced heavy obscuring fog. Table 3-3 provides information on key meteorological conditions during field observations conducted during the new moon phase.

Table 3-1: Observer hours by platform between spring migration season 2010 through spring 2011. Daytime observations were not emphasized after spring 2010.

	SPRING 2010 (hours)		FALL 2010 (hours)		SPRING 2011 (hours)		Total (hours)
Platform	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**	
Edith	19.25	13.75	5.25	58.5	6.5	57.25	160.5
Gail			4.5	11.75			16.25
Gina	35	33	0.75	50.75	4.75	45.75	170.0
Habitat	11.5	4				4.5	20.0
Henry[1]	2.75						2.75
Hermosa	14	20.25	6.5	63.5	22.0	48.0	174.25
Irene			8.75	34.75	12.75	78.25	134.5
Total	***82.5***	***71***	***25.75***	***219.25***	***46.0***	***233.75***	***678.25***

[1] Observations at Platform Henry were for a partial day during daylight hours and only during the spring 2010 field effort. Because the observations from Henry were extremely limited, they were not used in any of the report analysis and are included only for completeness.

Table 3-2. Nighttime observer hours by moon phase.

Platform	MOON PHASE (hours)					
	New	Crescent	Half	Gibbous[1]	Full	Total
Edith	38.25	29.75	13.5	35	13.0	129.5
Gail				11.75		11.75
Gina	48.25	45.0	12.75		23.5	129.5
Habitat				8.5		8.5
Henry						0
Hermosa	72.25	15.25	14.75	8.0	21.5	131.75
Irene	35.75	21.0	23.75	24.0	8.5	113.0
Total	***194.5***	***111.0***	***64.75***	***87.25***	***66.5***	***524.0***

[1] The Gibbous moon phase includes the moon phase both immediately before (waxing moon) and after (waning moon) a full moon.

Table 3-3: Meteorological conditions during surveys conducted under new moon conditions.

Survey Date	Platform	Weather Conditions					
		Precipitation[1]	Cloud Cover	Visibility	Avg. Wind Speed	Direction	Temp (°F)
5-Oct-10	Gina	NONE	100%	>10km	16	SE	62
5-Oct-10	Hermosa	SP	75%	>10km	3	N	59
6-Oct-10	Gina	CP	75-100%	>10km	9	E	60
6-Oct-10	Hermosa	SP	75-100%	>10km	7	SE	60
7-Oct-10	Edith	NONE	Clear	>10km	15	NW	64
7-Oct-10	Gina	NONE	75%	>10km	10	NE	60
7-Oct-10	Hermosa	NONE	100%	>10km	7	NW	60
8-Oct-10	Edith	NONE	Clear	>10km	6	NW	60
8-Oct-10	Hermosa	NONE	Clear	>10km	20	NW	60
30-Apr-11	Hermosa	NONE	Clear	>10km	20	NW	66
1-May-11	Hermosa	NONE	Clear	>10km	20	NW	62
2-May-11	Hermosa	NONE	Clear	>10km	15	NE	54
2-May-11	Irene	NONE	Clear	>10km	15	W	68
3-May-11	Edith	NONE	Clear	>10km	10	NW	69
5-May-11	Edith	FOG	100%	>10km	5	SE	68
5-May-11	Gina	FOG	100%	<1km	10	NW	62
30-May-11	Gina	NONE	Clear	>10km	17	W	64
31-May-11	Gina	NONE	Clear	>10km	10	NW	54
31-May-11	Irene	NONE	75%	>10km	2	NW	56
1-Jun-11	Hermosa	NONE	Clear	>10km	15	NW	56

[1] CP= convective precipitation; SP= stratiform precipitation

Table 3-4: Individual observations of birds flying in proximity to or landing on selected platforms during both spring and fall migration periods during 2010 and 2011.

		Edith	Gail	Gina	Habitat	Henry	Hermosa	Irene	Total
2010	Spring	101	0	46	6	3	55	0	211
	Fall	45	6	25	0	0	46	51	173
2011	Spring	20	0	52	0	0	12	6	90
	Total	***166***	***6***	***123***	***6***	***3***	***113***	***57***	***474***

3.1.2 Bird Observations

Observations by Season, Location, and Time of Day

The 2-years and 3-seasons of combined survey efforts resulted in 474 instances of birds appearing near or on a part of the various platforms surveyed (Table 3-4). Each observation period included portions of dusk and dawn, and for the first season, daytime observations. Each observation was categorized to period depending on whether the duration of the observation fell within the calendar sunset and sunrise times. Clearly, there are times of day and seasonal effects observed between the platforms (Table 3-5).

Relative to all of the platforms used as observation locations during this study, platforms Edith, Gina, and Hermosa had the most observed bird activity (Table 3-6). During spring 2010, a single large pulse of morning migrants was observed at platform Edith. Similar large pulses were observed at other platforms.

Nocturnal bird observations were highest at Gina (spring 2011) and Hermosa (spring 2010). This likely reflects the large proportion of seabirds migrating past the platform (Red-necked Phalaropes) as well as those utilizing the platform for nighttime roosting habitat (gulls, cormorants, and pelicans). Table 3-6 reflects the proportion of marine versus terrestrial guilds observed on or near the platforms seasonally as well as by time of day.

Observations by Species

A variety of bird species were observed in the study. Over 75 different species were documented from among the 3,300 individual bird sightings. Some sightings were only classified to bird group where limited visibility did not permit positive identification to species observed. Of the species observed, 13 were classified as marine species (16 percent), while the remaining 66 (84 percent) were terrestrial species. Of the 75 bird species observed, 60 percent were represented by only 1 or 2 individuals, and 75 percent by fewer than 5 individuals. More than half (55 percent) of the 3,300 birds observed during the study were gulls, cormorants, or pelicans, which are year-round inhabitants of the region, and which accounted for less than 1 percent of the total bird species observed at the platforms during the study. Three bird species, Western Gulls, Red-necked Phalaropes, and California Gulls, accounted for 81 percent if all birds observed, and of those, only Red-necked Phalaropes are migratory.

Table 3-7 presents the bird species observed and the number of individuals observed. The most common terrestrial species observed were Wilson's Warblers, followed by flyover groups of Lesser Goldfinches, and pulses of Cassin's Kingbirds; in addition, nearly every platform had Black Phoebes

present for the duration of most observations. A variety of small moths (e.g., Corn Earworm, *Helicoverpa zea*) were observed aggregating at a number of platforms, perhaps because they were attracted to the lights.

Table 3-5: Proportions of bird observations by platform and time of day.

	OBSERVATIONS [1]													
	Edith		Gail		Gina		Habitat		Henry	Hermosa		Irene		Total
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Day	Night	Day	Night	
Spring 2010	0.20	0.02	0.00	0.00	0.03	0.07	0.00	0.01	0.01	0.00	0.11	0.00	0.00	**0.45**
Fall 2010	0.04	0.05	0.00	0.01	0.01	0.04	0.00	0.00	0.00	0.03	0.07	0.02	0.08	**0.36**
Spring 2011	0.02	0.02	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.01	0.01	0.00	0.01	**0.19**
Total	*0.26*	*0.09*	*0.00*	*0.01*	*0.04*	*0.22*	*0.00*	*0.01*	*0.01*	*0.04*	*0.20*	*0.03*	*0.09*	***1.00***

[1] Note: As discussed in the methods section, the amount of time spent on day and night observations varies between the spring 2010 and the fall 2010 and spring 2011 surveys.

Table 3-6: Proportions of all bird observations by platform divided into marine (Mar) and terrestrial (Terr) Guilds. Marine species include gulls, cormorants, pelicans, and phalaropes.

Season/Year		OBSERVATIONS BY ECOSYSTEM GUILD													Total
		Edith		Gail		Gina		Habitat		Henry	Hermosa		Irene		
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Day	Night	Day	Night	
Spring 2010	**Mar**	0.01	0.00	0.00	0.00	0.02	0.07	0.00	0.01	0.00	0.00	0.11	0.00	0.00	**0.24**
	Terr	0.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.20**
Fall 2010	**Mar**	0.01	0.03	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.02	**0.11**
	Terr	0.03	0.03	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.02	0.05	0.02	0.06	**0.26**
Spring 2011	**Mar**	0.00	0.02	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.01	0.01	0.00	0.01	**0.14**
	Terr	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.05**
Total		*0.26*	*0.09*	*0.00*	*0.01*	*0.04*	*0.22*	*0.00*	*0.01*	*0.01*	*0.04*	*0.20*	*0.03*	*0.09*	***1.0***

Table 3-7: Types of bird species and number of individuals seen during the study duration. Species are abbreviated using the standardized American Ornithological Union 4-letter code system.

BIRD SPECIES AND NUMBERS OBSERVED					
Common Name	**AOU Code**	**# Ind.**	**Common Name**	**AOU Code**	**# Ind.**
Western Gull	WEGU	1246	Lincoln's Sparrow	LISP	2
Red-necked Phalarope	RNPH	975	Pelagic Cormorant	PECO	2
California Gull	CAGU	451	Pacific-slope Flycatcher	PSFL	2
Brandt's Cormorant	BRCO	82	Ruby-crowned Kinglet	RCKI	2
Double-crested Cormorant	DCCO	57	Snowy Egret	SNEG	2
Brown Pelican	BRPE	55	Spotted Towhee	SPTO	2
Wilson's Warbler	WIWA	51	Warbling Vireo	WAVI	2
Passerine species (undet.)	-	50	Western Grebe	WEGR	2
Lesser Goldfinch	LEGO	31	Western Wood-Pewee	WWPE	2
Cassin's Kingbird	CAKI	30	American Bittern	AMBI	1
Black Phoebe	BLPH	25	American Pipit	AMPI	1
Eurasian Collared-Dove	ECDO	22	American Redstart	AMRE	1
Ring-billed Gull	RBGU	22	Ash-throated Flycatcher	ATFC	1
Mourning Dove	MODO	19	Black-bellied Plover	BBPL	1
Peregrine Falcon	PEFA	19	Belted Kingfisher	BEKI	1
Yellow-rumped Warbler	YRWA	15	Black-headed Grosbeak	BHGR	1
White-crowned Sparrow	WCSP	12	Blackpoll Warbler	BLPW	1
Orange-crowned Warbler	OCWA	9	Black-throated Gray Warbler	BTYW	1
Brewer's Blackbird	BRBL	8	Black-and-white Warbler	BAWW	1
Phalarope species (undet.)	-	8	Dove species (undet.)	-	1
Townsends Warbler	TOWA	8	Dusky Flycatcher	DUFL	1
Warbler species (undet.)	-	8	Fox Sparrow	FOSP	1
Common Yellowthroat	COYE	6	Golden-crowned Sparrow	GCSP	1
Heermann's Gull	HEEG	6	Lazuli Bunting	LAZB	1
Savannah Sparrow	SAVS	5	Least Bittern	LEBI	1
Brown-headed Cowbird	BHCO	4	Merlin	MERL	1
House Wren	HOWR	4	Nashville Warbler	NAWA	1
Magnolia Warbler	MGWA	4	Northern Mockingbird	NOMO	1
Red-breasted Nuthatch	RBNU	4	Orchard Oriole	OROR	1
Vaux's Swift	VASW	4	Olive-sided Flycatcher	OSFC	1
Great Egret	GREG	3	Osprey	OSPR	1
Hermit Warbler	HEWA	3	Pine Siskin	PISI	1
Western Tanager	WETA	3	Ruddy Duck	RUDU	1
American Goldfinch	AMGO	2	Say's Phoebe	SAPH	1
Brown Booby	BRBO	2	Western Scrub Jay	SCJA	1
Bullock's Oriole	BUOR	2	Snowy Plover	SNPL	1
Burrowing Owl	BUOW	2	Tennessee Warbler	TEWA	1
Chipping Sparrow	CHSP	2	Yellow Warbler	YWAR	1
Green Heron	GRHE	2		Total	3310
Hummingbird sp. (undet.)	-	2		75 Species	

Bird Interactions with POCS Platforms

As noted in the methodologies, each bird observation was categorized by level of interaction with platform structures or nearby water. Birds seen circling the platform with no signs of artificial light entrapment (i.e., one or two circles) or those that flew nearby without stopping are considered to have no direct platform interaction. Birds that landed either in the water directly underneath or that landed on any portion of the platform structure were marked as interacting with the platform, and further details on their location, type of activity and general condition were noted. Of the 474 birds observed in close proximity to a platform, 61 percent either landed briefly, landed for some duration, or landed in the water directly underneath the platform (Table 3-8).

Table 3-8: Occurrence of bird interactions with POCS platforms observed.

BIRD INTERACTIONS		NO INTERACTION		DIRECT INTERACTION		Total
		Circle	Flying Near	Lands Platform	Lands Water	
Day	Marine	0	0	36	0	36
	Terrestrial	4	27	106	1	138
Night	Marine	2	125	63	8	198
	Terrestrial	6	19	74	0	99
Total		***12***	***172***	***281***	***9***	***474***

Nocturnal platform observations were nearly equally divided between species with no platform interaction (51 percent) and those directly landing on the platform or on the water adjacent to the platform structure (49 percent). Of these nocturnal observations, 67 percent were of marine species. Of the seabird observations, 64 percent had no platform interaction. This proportion of seabirds with no interactions is primarily composed of phalaropes, which are the predominant marine migrant in the Santa Barbara Channel. While flocks of phalaropes have been known to become entrapped by platform lights (SES 2007), no single instance of this phenomenon was observed during the 2-year study period. The remaining proportion of seabirds that did interact with the platforms were Western Gulls, Brandt's Cormorants, and Brown Pelicans, which were most often found using the sub-decks as nighttime roosts.

The remaining 33 percent of nocturnal observations were terrestrial birds. Of the terrestrial species observed at night, 75 percent landed on the platforms and 25 percent passed over or near a platform without landing. Of the 74 observations of terrestrial species landing on platforms, 70 of these birds were determined to be vigorous in condition. Only 3 individual birds (Warbling Vireo, Chipping Sparrow, and an unidentified passerine species) were noted by the observer as exhibiting behaviors suggestive of being tired; and one bird (a Least Bittern) arrived at the platform exhausted. The Least Bittern subsequently died and was archived at the Santa Barbara Museum of Natural History (SBMNH) vertebrate collections. Behaviorally, when these birds were occupying the platform, 34 percent were actively foraging and the remaining 66 percent were quietly resting until their departure.

A variety of seabirds were observed in proximity to and occasionally perching on the platforms. A few seabird species, notably Brown Pelicans, Double-crested Cormorants, and Western Gulls, were observed habitually using the substructure of the platforms for nighttime roosting. Occurrence of migratory landbirds on or near the structures was less frequent, as might be expected, and was

somewhat episodic. Arrival of mixed flocks of passerines on platform Edith during early daylight hours in April and platforms Edith and Irene in October was noteworthy because of the number of individuals, approximately 150, 42, and 52, respectively. There were some occurrences of "minor fallouts" in spring of 2011.

Prolonged periods of behavior that might be characterized as unnatural attraction to or disorientation as a result of platform lights were not observed.

A few observations were recorded of bird behavior that could be characterized as having been influenced by the platforms. Opportunistic foraging on insects by migrant passerines was observed during daytime hours in both spring and fall. The closest correlation between behavior and nighttime lighting was momentary, and "temporary disorientation" by Red-necked Phalaropes observed on platforms Gina and Hermosa. The phalaropes' apparent disorientation occurred as they approached the platform at night and were immediately preyed upon by Peregrine Falcons.

3.2 Summary of Platform Operator Interviews

Anecdotal accounts of birds on POCS platforms provided by industry workers are limited in both accuracy and level of detail. Nonetheless, they offer a longer-term perspective and may shed some light on how frequently and under what conditions such interactions occur.

Platform workers reported occasional observations of "little yellow birds," usually during summer foggy conditions. They also reported rare incidents of finding dead or dying birds on the decks of the structure.

One platform worker offered an account of bird activity from a week previous with "hundreds flying around" from 0200 to 0300 hours. He reported conditions as light to moderate north winds. The same individual reported seeing birds most often during foggy conditions, and his description suggests passerines, doves, and owls. He reported seeing small birds that were "tame and approachable"—i.e., presumably tired. He has also occasionally observed small plump birds (presumably alcids) landing on the platform.

Platform workers described seeing more landbirds during May and June, possibly coinciding with Santa Ana wind conditions. Crews also reported a Peregrine Falcon nesting attempt on platform Gina, resulting in one egg being laid in a previous year.

3.3 Remote Camera Technology

Between 5 May and 10 June 2011, a 34-day period, the BirdCam continuously recorded 9,844 images. Of these, 5,235 were captured at night (between the hours of 6:00 p.m. and 6:00 a.m.); the remaining 4,609 images were shot during the day when platform lighting was not operational. All images collected by BirdCam on platform Gina (1.84 GB of data) are contained on the DVD that accompanies Appendix B.

Of the 5,235 nighttime images, 110 shots (2 percent) revealed the presence of a bird on or near the platform. Some of these images record the presence of a single bird that had not moved in the interval between shots. Adjusting for these duplications, the imagery documents only four separate events when individual birds flew, landed, or perched on the platform or flew within the BirdCam's view. During a period of operation spanning more than 400 hours of nighttime operation (34 days times 12 hours per night), the BirdCam recorded birds on the platform for a total of 6 hours, 38 minutes. Only one species of bird, Western Gull (*Larus occidentalis*), was recorded in these images, and in all cases, the pictured birds were shown roosting casually on top of platform equipment or

on a handrail within a few feet of bright lights. Although the cameras were capable of recording birds flying close to the platform or landing on the platform within the focal depth of the camera, the specific cameras used in the BirdCam cannot see birds flying at a distance as far from the platform as can the human eye.

4.0 Discussion of Results

4.1 Study Findings

This study has provided new data and valuable information to inform an overall understanding of the presence and interactions of birds with the oil and gas platforms in the POCS during fall and spring migrations. As suspected, both seabirds and landbirds interact with these man-made offshore islands in what appears to primarily be an opportunistic manner. Observed behaviors included resting (temporary harborage) and opportunistic foraging by landbirds. Successful foraging on insects was observed on a number of occasions. It seems unlikely, however, that invertebrate densities could be sustained by the platforms, given the lack of natural substrate (e.g., plants). This transient food resource is probably not a factor that would attract birds to platforms on a regular or prolonged basis.

Of the 23 production platforms in the POCS, one or more platforms in each of the three major geographic regions (San Pedro Basin, Santa Barbara Channel, and Santa Maria Basin) were used as points of observation over two spring and one fall migration periods. Likewise, surveys were conducted from platforms located close to shore, close to the Channel Islands, in the eastern and western Santa Barbara Channels, and offshore San Pedro. An original premise of this study was that there might be variability in how birds interacted with the various platforms (how frequently and in what manner), based on their specific geographic location within the study area and proximity to established migratory flyways. Variability in platform design was also considered a possible factor by the field observers. Size of the platform (e.g., the smaller Edith vs. the much larger Hermosa), configuration, and lighting aspects were found to vary considerably among POCS platforms. Furthermore, the issue of operational noise on platform Habitat was identified as both a possible deterrent to bird interactions and an impediment to effective data collection. Although continuous observations were not gathered during each migration period at all platforms sufficient to support an exhaustive detailed statistical analysis, the approximately 680 hours of observations, at multiple platform locations distributed over the entire geographic range of the active POCS oil and gas production area, and over multiple days and nights, clearly suggests that there are no differences in general utilization or behavior by either seabirds or landbirds with POCS platforms based on their general geographic location. Similar species of birds were observed at all locations, and although slight differences in the number of birds observed at different platforms at different times or seasons did occur, these occurrences appear to be random rather than the result of the geographic location of the platform.

The majority of birds observed in close proximity to the platforms were seabirds, predominantly gulls, cormorants, and pelicans. Western Gulls, Brandt's Cormorants, and Brown Pelicans were most often found using the sub-decks as nighttime roosts. Their association with the platforms likely has little to do with the platforms' lighting effects, but rather the availability of appropriate structure to facilitate roosting.

There appear to be no substantive differences in nocturnal bird occurrence or interaction with the platforms relative to their proximity to geographic features such as the mainland, the Channel Islands, a key geographic boundary such as Point Conception or Point Mugu, or to other platforms.

This may be in part the result of more broadly dispersed migratory flyways (on a narrow geographic scale) in the Santa Barbara region that otherwise would result in more frequent bird encounters with offshore platforms. Also, as suggested in the literature review of flyways through the Santa Barbara region, unlike in the Gulf of Mexico, North Sea, and along the Atlantic Coast, the main migration pathway for landbirds is not over the water where encounters with offshore platforms would be expected to occur (SBCo 2008).

One of the study's initial premises was that variability in platform design might be a factor in determining the extent of bird/platform interactions. Size of the platform (e.g., the smaller Edith vs. the much larger Hermosa), configuration (e.g., the small Gulf of Mexico style vs. the North Sea style of architecture), and lighting aspects were found to vary considerably. As stated above, although insufficient data to support detailed statistical analysis were obtained, the fact that no detectable repetitious differences in bird presence or interaction with individual platforms appeared to occur suggests that individual platform design is not a key variable influencing the potential for bird interactions.

The remoteness or isolation of a platform from other platforms was suggested as one of the factors that might contribute to observed bird entrapment by night lighting on platforms in the Gulf of Mexico (Russell 2005). Platform Irene is the most remote platform in the POCS. Although SES (2007) reported observing bird entrapment at Irene, based on the 135 hours of observations at Irene conducted during the current study with no observable entrapment occurring, the remoteness of a platform as an important physical factor in bird interactions in the POCS remains unknown. The observations made during the current study were made under variable meteorological conditions and lunar cycles as well as similar conditions that were present during the 2007 entrapment report by Storrer (SES 2007).

The literature suggests that three factors may have an important effect on the frequency of bird/platform interactions: seasonal timing, weather, and lunar cycle. Study surveys were timed to coincide as much as possible with peak periods of spring and fall migration, with the assumption that this would maximize the chances of observing any interactions between birds and the platforms. A second spring migration period was added to the study to enable observations over an 8-week period to match a comparable series of observations made over the previous fall migration period.

Seasonal timing may not be as important a factor as time of day or weather, particularly with landbirds. During the spring 2010 survey, continuous day and night observations were made over a 48-hour period at multiple platforms. Observations from these surveys indicated that the peak periods of bird migration near or over the platforms appeared to occur in the early hours of the morning and just after dusk. These observations were consistent with reported migration behavior of night-migrating bird species (Abel 2004). The fall 2010 and spring 2011 surveys were adjusted to capture these anticipated periods of peak migratory activity, in addition to the additional nighttime hours.

Additionally, with prevailing northwest winds and clear skies, landbirds appear to migrate more inshore and over land, and therefore may be less likely to encounter platforms on their spring northbound migration routes. Flying over land and following the coastline northwards, most landbirds likely encounter platforms primarily when inclement weather conditions cause them to shift offshore. In these circumstances, platform lights may have a greater effect on migrating birds. During the spring 2010 surveys, northwest winds, clear skies, and lack of fog (typical spring offshore conditions in California) were the prevailing conditions during each of the platform surveys, with the exception of platform Edith. Birds migrating southward in fall may have a greater

potential to encounter platforms because of the orientation of the coastline and assumed trajectory of southbound birds. Given the abrupt east-west coastline shift from north-south at Point Conception, birds traveling south may overshoot land if following the coastline. Although as mentioned above, it appears that most landbirds migrate more inshore and over land in order to fly through one of the passes through the Santa Ynez and San Rafael Mountains.

Past migration research also indicates that most nocturnal migrating passerines will ground themselves on the mainland during nights with thick, dense fog or high cloud ceilings. Upon first light, they take flight in search of food and continue on their migration route. It is conceivable that lingering fog can act to disorientate these birds in low-altitude flight, veering their flight path offshore. Once the birds drop below the low fog, the platforms are the first structures they encounter; often, they will land and linger until visibility permits re-orientation with the coastline. Although the literature does not provide any clarification of this occurrence, on several occasions during this study, large flocks of passerines were observed to descend on platforms in the early morning (as at Edith in spring 2010).

Finally, lunar cycle was considered an important physical factor because birds that utilize lunar light for navigation might be more susceptible to disorientation when the moon is not visible but a brightly lit offshore platform is visible. The literature suggests that a combination of a new moon and inclement weather in which lunar light and celestial cues are obscured contributes to bird entrapment by night lighting at offshore platforms (Russell 2005; Van de Laar 2007; Bruinzeel et al. 2009).

The fall 2010 and spring 2011 surveys encompassed a range of environmental conditions, including moon phase, dense fog, patchy fog, rain, overcast skies, clear skies, and wind of varying speed and direction. These were the factors identified in the literature as most likely contributing to or influencing bird-lighting interactions, and an effort was made to capture each variable in scheduling the field surveys. During the two spring and one fall migration periods in which observations were made, a wide variety of meteorological conditions were encountered that would have been expected to support light entrapment; however, none was observed.

It appears that the use of offshore platforms by Peregrine Falcons is more than opportunistic or occasional. It has become relatively common on platforms off the coast of Southern California as well as platforms in the Gulf of Mexico (Russell, 2005). The combination of marine and terrestrial avian prey (the latter likely available on a less consistent basis) allows long-term exploitation and what might even be considered "seasonal residency" on some platforms. Hunting (including nighttime) by Peregrine Falcons, or evidence thereof, was observed during both spring and fall on all platforms within the study group. Examination of Peregrine Falcon prey remains collected on platform Gina revealed a highly varied diet consisting of both landbirds and seabirds. Interestingly, Peregrine Falcons on platform Gina were observed hunting at night, targeting migratory flocks of Red-necked Phalaropes. Nighttime hunting is an unusual adaptation that has been reported only rarely in the literature (DeCandido and Allen 2006). This behavior is likely facilitated by platform lights that not only assist with prey detection, but may cause temporary disorientation of prey, thereby rendering birds vulnerable to predation.

Perhaps not coincidentally, captive-bred Peregrine Falcons or those removed from perilously located eyries in urban locations have been released from Vandenberg Air Force Base (VAFB) in association with recovery efforts. VAFB is located north of Point Concepcion, a few miles from the Point Arguello/Point Pedernales platform complex. Furthermore, there is an account by a platform worker of an unsuccessful nesting attempt on platform Gina.

4.2 Remote Camera Technology Test

Periodic remote examination of the BirdCam imagery recorded on platform Gina during the spring 2011 field season indicated that a 5-minute interval provided a good balance between temporal detail (i.e., how often an image was captured) and the project staffing resources required to examine and evaluate the resulting data. The BirdCam's photo interval could have been modified remotely during the field season to shoot still images or videos more frequently, had such modification been deemed desirable. The detail and resolution of BirdCam images allowed species identification and gross characterization of behavior in most cases when birds were present.

Because of operator placement requirements, BirdCam imagery recorded on platform Gina captured only one corner of one of the structure's upper decks, and therefore presented only a limited picture of events that might have otherwise been observable by the BirdCam. Moreover, in its present configuration, which employs the supplied IR camera, the BirdCam is capable of "seeing" to only a limited distance (less than 100 feet) out into the dark beyond the reach of platform lighting. The addition of more camera units, and the addition of true night-vision, heat-sensing cameras to each unit would improve the scope of captured imagery and increase its interpretive power.

Even operating within the limitations of its current design iteration, BirdCam images provided a pool of continuous, remote observations that corroborated the intermittent observations of human investigators collected on this and other platforms during this study: that few birds are observed attracted to or using the platforms at night.

BirdCam's intended use in the study was two-fold. To 1) test BirdCam's Proof of Concept and 2) could BirdCam detect birds exhibiting light entrapment behavior (i.e., circling the platform continuously for a prolonged period of time and/or striking platform lights and structures) as reported by SES (2007). The images gathered by BirdCam over the 34-days of its deployment showed no evidence of birds exhibiting light entrapment behavior.

BirdCam's placement on platform Gina, although not ideal, provided an effective view from one corner of the platform that would have been expected to be able to capture birds flying in close proximity to the platform or colliding with the deck lights. Even though images were collected every 5-minutes, it can be assumed that if any birds had been entrapped by platform lights that BidCam's placement and focal length (100 feet) would have recorded it. Review of the 5,235 low light and IR nighttime images revealed no evidence of birds flying past the platform or behaving in an erratic manner. This fact may be the result of limitations in BirdCam to detect and record birds flying past the platform, that very few birds flew past the platform at night, or that birds flew past the platform during the 5-minute interval when BirdCam was not recording an image. Additional deployment of BirdCam will be necessary to fully evaluate its capabilities for nighttime observations along with side-by-side human/camera observations to validate its effectiveness and accuracy.

5.0 Study Conclusions

5.1 General Conclusions

Based on the extensive field observations encompassing a broad range of temporal, geographic, astronomical, and meteorological parameters undertaken for the current study, adverse effects of night lighting on POCS petroleum production platforms in the San Pedro Basin, Santa Barbara Channel, and Santa Maria Basin appears to be an infrequent phenomenon. POCS platforms may

provide temporary refuge and opportunistic foraging opportunities for both resident and migratory birds, as well as habitual roosting sites. This observation is consistent with observations made in the Gulf of Mexico where migrating birds fly regularly over offshore platforms (Russell 2005). With the exception of the Peregrine Falcons, the platforms are unlikely to provide a sustainable foraging resource.

Differences in daytime versus nighttime interactions between platforms and migrating birds appear to be due more to the general patterns of migration rather than platform location or design. Birds were observed at the time of day or night that reflected migratory behavior reported in the literature and as supported by shore-based anecdotal accounts during the same period. The presence of passerines at the platforms from which observations were made appears to be highly variable and possibly opportunistic. The data collected during this study do not appear to support any influence by physical characteristics of the structure or its location, although no statistical analyses were carried out to explicitly test this conclusion. Considering that both fall and spring observations were made during peak migrating periods, very few passerines were observed at the platforms corroborating information contained in the literature, which indicates that their flyways are predominantly located farther onshore. The majority of birds observed were local marine birds.

Behaviors by phalaropes and various species of migratory landbirds observed on platform Irene in spring 2007 (SES 2007) were consistent with similar reports from the Gulf of Mexico (Russell 2005) and the North Sea (Marquenie et al. 2008; Marquenie 2007; Bruinzeel et al. 2009; Van de Laar 2007). The observation of platform Irene included both "entrapment" (continuous circling of the platform for a period of 3 hours) and birds swarming in proximity to and in some instances coming in contact with banks of lights illuminating structural components of the platform. Both behaviors resulted in consequent depletion of energy reserves. The fact that these observations were made on consecutive nights with only 2-nights of survey suggests that the phenomenon might be relatively common. Based on the more extensive set of observations collected during this study, it would appear that the phenomena observed at platform Irene in 2007 and as reported to occur in the North Sea and the Gulf of Mexico occur infrequently at POCS platforms.

As reported in the literature, weather and moon cycle appear to affect the likelihood of birds being attracted to and potentially entrapped in platform lights. This appears especially true for nighttime migrants, which rely on celestial clues for navigation. If weather and/or moonlight conditions are such that access to this "celestial map" is impaired, birds (particularly landbirds) may be initially attracted to or seek temporary refuge on offshore platforms. Once reaching the platforms, they may become distracted, disoriented, or otherwise affected by the bright artificial lights of the platforms.

The apparent rarity of entrapment at POCS platforms would appear to be the result of significantly different environmental conditions and location of the migratory flyway than those that occur in the North Sea and Gulf of Mexico where entrapment has been documented. The migratory flyways for most seabirds are primarily located farther offshore than the relatively near-shore coastal region in which the POCS platforms are located; however, the passerines flyways are located farther inshore of the coast because of the need to transit the Santa Ynez and San Rafael mountains (Able 2004).

The occurrence of meteorological conditions, including high cloud cover and storm fronts, that obscure celestial and lunar light do not occur frequently in the active POCS region of California during the fall and spring migration. Also, given the topographic relief of the islands, it would appear that the majority of migrating bird species that may be flying over the Santa Barbara Channel pass above the low-lying marine layer that predominates in this region of California during much of the year, including spring and fall migration periods. Consequently, the geographic and

meteorological conditions necessary to support the attraction, disorientation, and entrapment of migrating birds, as observed in the North Sea and Gulf of Mexico, appear to be rare occurrences in the POCS during fall and spring migration time periods.

5.2 Study Objectives and Scientific Questions

At the commencement of this study, four scientific questions were posed:

- Are bird/platform interactions occurring at all platforms within the five POCS production fields?

  Conclusion: Bird/platform interactions were observed at each platform used as a survey base. Of the 3,300 sightings, less than 15 percent of the birds were observed interacting with platforms. Birds were found on or observed landing on a platform 281 times and flying near a platform 172 times, and were noted circling a platform (for a few passes) 12 times. A few seabird species, notably Brown Pelicans, Double-crested Cormorants, and Western Gulls, were observed habitually using the substructure of a platform for nighttime roosting. Occurrence of migratory landbirds on or near the structures was less frequent as might be expected, and was somewhat episodic. The utilization of the platforms by Peregrine Falcons suggests something more than opportunistic foraging may be occurring. Data are insufficient to draw conclusions regarding the frequency or nature of bird interactions at one platform versus another.

- Are there any daytime/nighttime differences in bird/platform interactions?

  Conclusion: The majority of bird/platform interactions observed during this study occurred during daytime hours (dawn or dusk), despite the fact that the survey effort focused on nighttime observations. Differences in daytime/nighttime interactions between platforms and migrating birds appear to be more a result of migration behavior than other physical platform factors. Bird species were observed at the time of day or night that reflected migratory behavior recorded in the literature. The one exception is the utilization of the platforms by Peregrine Falcons for foraging that occurred after dusk.

- Do platform lights have deleterious effects on bird behavior?

  Conclusion: Although extensive observations in the North Sea and the Gulf of Mexico and limited observations at platform Irene in 2007 suggest that they can, based on the more extensive hours of observation gathered at multiple POCS platforms under varying lunar and meteorological conditions during this study, it would appear that the phenomena occur infrequently at POCS platforms. No incidences of light disorientation or light entrapment by nocturnally migrating birds was observed during the 525 hours of nighttime observations collected from six platforms over multiple fall and spring migration periods during this study.

- If interactions are occurring, are the same bird species or bird groups (i.e., marine, non-marine) similarly involved at the various platforms?

  Conclusion: Similar bird guilds were observed at all platforms visited during the study. Although no statistical analysis was performed, one apparent seasonal difference is that Red-necked Phalaropes appeared more frequently in the Santa Barbara and Point Arguello regions during the spring migration period than during the fall. Only one flock of Red-

necked Phalaropes was observed during the fall 2010 field effort, and this occurred at one platform at the very beginning of field observations.

- What, if any, is the relationship of interactions with platform location relative to the mainland, the offshore Channel Islands, known flyways, geographic features known to affect migration routes, and proximity to nesting areas?

  Conclusion: Based on the nearly 680 hours of observations, platform encounters appeared to be mostly the result of random intersections of birds with platforms. The one exception appears to be the presence of Peregrine Falcons. Based on both daytime and nighttime observations, there does not appear to be any differences in bird occurrence or interaction with the platforms relative to their proximity to geographic features such as the mainland, the Channel Islands, or a key geographic boundary such as Point Conception or Point Mugu. This may be in part the result of the apparent, more broadly dispersed onshore migratory flyways through the Santa Barbara region that appears to result in less frequent bird encounters at platforms in general and apparent random occurrences at one platform versus another. Also, as suggested in the literature review of flyways through the Santa Barbara region, unlike in the Gulf of Mexico, North Sea, and along the Atlantic Coast, the main migration pathway for landbirds is not over the water where encounters with offshore platforms would be expected to occur (SBCo 2008), but farther inland. The topographic relief of the coastal ranges also appears to force the majority of migrating birds that may be flying over the Santa Barbara Channel to fly at a higher altitude. This allows them to fly above the lower altitude marine layer that predominates in this region of California, consequently limiting any blocking or obscuring of either celestial or lunar navigation clues and light.

- Are there any physical factors (e.g., lunar cycle, weather, wind conditions) that seem to contribute to the occurrence of bird/platform interactions?

  Conclusion: The presence of passerines at many of the platforms appears to be opportunistic and not influenced by physical characteristics of the structure or its location. Weather and moon cycle may have some affect on bird presence at the platforms by limiting visibility. If weather and/or moonlight conditions are such that access to this "celestial map" is impaired, birds (particularly landbirds) may seek temporary refuge on offshore platforms. Differences in low versus high fog/cloud cover may play some part in whether or not migrating birds can see the platforms at night (i.e., they may simply fly well above the platforms during a low ceiling of fog or cloud cover). During periods of high winds, few if any birds were observed.

  The occurrence of meteorological conditions, including high cloud cover and storm fronts, that obscure celestial and lunar light do not appear to occur frequently in the active POCS region of California during the periods of fall and spring migration.

5.3 Feasibility of Low-cost Remote Imaging Technology

Sporadic, ephemeral events are difficult to predict and challenging to observe, especially when resources necessitate that human observers be deployed on a schedule that samples only some of the possible times when significant events might occur.

The BirdCam, while not a substitute for human observation, provides an inexpensive visual technology for recording observational data on a nearly continuous schedule. In addition, its

collected data can be accessed in real time via an internet connection. In the case of this study, it provided additional data that corroborated the more general conclusions drawn from the results of human observations made during the same time period. By adding to and improving upon the BirdCam's present configuration of components, this kind of device has the potential to provide long-term continuous data sets on bird presence and behavior at POCS platforms. In its current configuration, the BirdCam will never replace human observance; however, as intended, it can gather internet-accessible observation data that can alert scientists to the occurrence of unusual bird presence or behavior, which can then be quickly followed up on with human observation. Key to its effectiveness is the deployment location on the platform and its connectivity to the internet, preferably via a Wi-Fi connection rather than a cell phone connection.

6.0 References

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7.0 Appendices

Appendix A Annotated Bibliography

Appendix B Remote Imaging Technology Feasibility Assessment

Appendix C Bird & Weather Field Observation Sheets (CD)

Appendix A
Annotated Bibliography

Able, K. P. and S. A. Gauthreaux Jr (1975). "Quantification of nocturnal passerine migration with a portable ceilometer." Condor 77(1): 92-96.

A portable ceilometer was used to observe low-altitude nocturnal bird migration in the southeastern United States. The narrow beam of light was directed vertically and observations were made with binoculars or a telescope pointed up the cone of light. The briefly illuminated birds can be counted as they pass through the field of observation and their flight directions noted. Number and direction of birds passing during a defined time interval was used to extrapolate "traffic rates". Practicality, limitations, and methods of quantifying data are discussed. Ceilometer data were compared with traffic rates obtained through radar tracking technology. The article concludes that the technique provides a simple, inexpensive, highly portable means of obtaining measures of migration magnitude that can be used in studies of night-to-night, seasonal, geographic, or weather-dependent variations in nocturnal migration.

Avery, M. L., P. F., Springer, and N. S. Dailey. 1978. Avian mortality at man-made structures: an annotated bibliography. U.S. Fish Wildl. Serv. FWS/OBS-78/58, 108 pp.

Annotated bibliography of 853 references pertaining to bird mortality due to collision and electrocution at human-made structures such as power transmission lines, radio and TV towers, lighthouses, cooling towers, buildings, and airport ceilometers. Includes subject, taxonomic, and geographic indexes. Revised in 1980 (see Avery et al. 1980).

Avery, M. L., P. F. Springer, and N. S. Dailey. 1980. Avian mortality at man-made structures: an annotated bibliography (revised). U.S. Fish Wildl. Serv. FWS/OBS-80/54, 152 pp.

Compilation of 1,042 references through February 1980, including 189 not in the original publication (Avery et al. 1978). Includes subject, taxonomic, and geographic indexes.

Baillie, S. M., G. J. Robertson, et al. (2005). Seabird data collected by the Grand Banks offshore hydrocarbon industry 1999-2002: results, limitations and suggestions for improvement. Canadian Wildlife Service Technical Report Series: v + 47pp.

Pelagic seabirds were counted by oil industry personnel from eight offshore oil and gas exploration, construction and production sites on the Grand Banks of Newfoundland, Canada from 1997 to 2002. This report is a summary and evaluation of that data.

We found that seabirds were more numerous around glory hole construction and long-term oil production sites than other installations. Of 27 species, Greater Shearwater and Black-legged Kittiwake numbers were the most common with a relative abundance of 55 and 27%, respectively, of total seabirds seen at the sites. Other species, forming 12% of birds present at sometime during the year, in rank order, were Northern Fulmar, Great Black-backed Gulls, Common Murres, Herring Gulls and Thick-billed Murres. The patterns of attendance generally reflected known migration periods. Greater Shearwater and Northern Fulmar numbers increased significantly from year to year, though causal mechanisms remain unclear. Anomalous sightings of Thick-billed Murres in summer and high number's of Cory's Shearwater appear to be an artifact of observer training. Thirty-four non-seabird species of birds and 6 species of marine mammals were recorded.

The majority of birds found stranded on platforms were Leach's Storm-Petrels (97%). Strandings occurred mainly in October (52%), September (32%) and August (15%). Overall, 74% of stranded birds were released, 3% died and only 3% were found with oil on their feathers. The fate of 23% of the stranded birds remains unclear as they were not recorded as dead or released.

The sheer volume of the data collected allowed us to use aggressive data filters to calculate mean and relative abundance estimates for seabirds at sea. However, we identified three general problem areas, namely study design, observer training, and inconsistencies in data management that reduced the power of the findings in this report. In terms of study design, seabird density estimates could not be calculated due to unlimited radius observations, attraction could not be assessed as behavior of birds was not consistently recorded, and the fate of all birds were not recorded once they were found stranded. Further, the logic of using timed counts from fixed platforms is flawed as an instantaneous count of all birds in a known area is the relevant measure needed to calculate seabird densities. Records of species not expected at certain times of year, an increase in density over the time period of the study and lack of information recorded on ages and plumages suggest some issues related to observer quality and training. Data management issues included the non-recording of days in which birds were not seen, inconsistencies in the format of the data, lack of detailed information on stranded bird encounters and data transcription errors.

We recommend that a standardized seabird monitoring and observer training program for the offshore operations in the Grand Banks region be implemented. Observer training, in-field evaluations and program assessment by seabird experts should be a fundamental part of this program. We have suggested guidelines and data management design that will overcome the major problems and data bias found in this study. If these improvements are implemented, an assessment of the possible attraction of seabirds to the platforms, better estimates of numbers of seabirds at risk around platforms, and the success of the stranded bird encounter program should be possible.

Baird, P. H. (1990). "Concentrations of seabirds at oil-drilling rigs." Condor 92(3): 768-771.

Shipboard surveys were made in the Bering Sea. The surveys were designed to determine which abiotic factors (e.g., salinity, temperature, hydrographic features) influenced seabird density and distribution. Results were consistent with other studies in that bird densities increased in proximity to oil production rigs during drilling activities.

Bourne, W. R. P. (1979). "Birds and gas flares." Marine Pollution Bulletin 10(5): 124-125.

The article reviews three accounts of birds reportedly attracted to gas flares with resulting mortality in North Sea oil fields in the mid-1970's. Accuracy of the second-hand accounts is evaluated. The article concludes that although such incidents occur, they are probably infrequent and are ultimately the result of weather phenomena driving migratory birds off-course to begin with. The article tends to downplay the significance of these events on the basis that mortality would likely have occurred through starvation or exhaustion regardless of the flaring.

Briggs, K. T., K. F. Dettman, et al. (1984). "Phalarope feeding in relation to autumn upwelling off California." l-62 in DN Nettleship, GA Sanger, and PF Springer (eds.), Marine birds: their feeding ecology and commercial fisheries relationships. Canadian Wildlife Service, Ottawa: 5.

ABSTRACT: A joint ship-aircraft-satellite study conducted off central and northern California examined the relationship of phalarope feeding to convergences and other physical and biological processes of upwelling. Phalaropes were most numerous where strong surface thermal gradients bordered upwelling waters. Birds collected off Point Reyes and Point Montara had fed primarily on fish eggs and euphausiids, while off Davenport copepods were the predominant prey. Thaliaceans and siphonophores dominated the zooplankton collected in shallow, oblique tows within 40 km of the coast.

Bruderer, B. (2003). "The radar window to bird migration." Avian Migration: 347–358.

The history and methodology of radar ornithology was comprehensively reviewed by Eastwood (1967) and updated by Bruderer (1997a). The present chapter gives an outline of the possibilities and limitations of the method, summarizes the main fields of research, and indicates recent achievements as well as chances for the future.

Bruderer, B., D. Peter, et al. (1999). "Behaviour of migrating birds exposed to X-band radar and a bright light beam." Journal of experimental biology 202(9): 1015.

Radar studies on bird migration assume that the transmitted electromagnetic pulses do not alter the behaviour of the birds, in spite of some worrying reports of observed disturbance. This paper shows that, in the case of the X-band radar 'Superfledermaus', no relevant changes in flight behaviour occurred, while a strong light beam provoked important changes. Large sets of routine recordings of nocturnal bird migrants obtained using an X-band tracking radar provided no indication of differing flight behaviour between birds flying at low levels towards the radar, away from it or passing it sideways. Switching the radar transmission on and off, while continuing to track selected bird targets using a passive infrared camera during the switch-off phases of the radar, showed no difference in the birds' behaviour with and without incident radar waves. Tracking single nocturnal migrants while switching on and off a strong searchlight mounted parallel to the radar antenna, however, induced pronounced reactions by the birds: (1) a wide variation of directional shifts averaging 8 degrees in the first and 15 degrees in the third 10 s interval after switch-on; (2) a mean reduction in flight speed of 2-3 m s-1 (15-30 % of normal air speed); and (3) a slight increase in climbing rate. A calculated index of change declined with distance from the source, suggesting zero reaction beyond approximately 1 km. These results revive existing ideas of using light beams on aircraft to prevent bird strikes and provide arguments against the increasing use of light beams for advertising purposes.

Bruinzeel, L.W., J. Van Belle, and L. Davids. 2009. In cooperation with F.J.T. van de Laar. The impact of conventional illumination of offshore platformsin the North Sea on migratory bird populations. A&W-rapport 1227 altenburg & Wymenga ecological onderzoek, Feanwalden

The North Sea has an important function in the ecology of migratory bird species. It was estimate that circa 50 million birds, consisting of at least 120 different species, migrate through the area as part of their annual migration cycle. Most nocturnally migrant birds in the North Sea are susceptive to artificial lights on offshore platforms. They can circle for prolonged periods of time (clockwise) around illuminated platforms in energy loss or death.

Scientific results unequivocally prove that conventional broad-spectrum illumination on platforms leads to attraction and disorientation of birds. By temporarily switching the lights on and off, it was shown that the lights were the key-factor. Additionally experiments in which the spectral composition of the lights was manipulated, showed that the harmful part of the spectrum consists of the long wave (red lights) fraction.

Of all the 120 species observed (in one autumn at one point in the North Sea), 72 species have been recorded as attracted to an illuminated platform at night, and of these 58 species were prone to collision risks with illuminated platforms.

The direct effect of platform lighting on mortality of bird species cannot be assessed directly in the field, since this requires a reliable registration of all victims. This is not possible because carcasses are hard to find at sea and disappear rapidly due to consumption by scavengers.

There is a gap in our understanding of nocturnal bird migration in the North Sea, it is therefore hard to link species specific casualties with geographically separated breeding sites.

It is possible, generally accepted and ecologically sound to compare estimated additional mortality due to illuminated platforms with 1% of the background mortality for species concerned. This approach is based on a EU 'rule of thumb' used to define exploitation of 'small numbers' of birds in the context of the EU Bird directive. This estimate is not dependent on a given population size.

Patterns of bird movements across the North Sea suggests that there are seven different main migration routes and the probability of encountering an illuminated platform varies with the followed migration route. The probability to encounter a platform with a sphere of influence of 1 km. Varies between 0.27 and 0.85 for the seven different routes. The encounter probability increases non-linear with an increased sphere of influence.

For a worst case scenario, it was estimated that 49 bird species are affected and subjected to mortality levels exceeding the threshold level of 1% of the annual mortality. Of these, 11 species are heavily affected and subjected to elevated mortality, exceeding the threshold by more than a factor of 20. A total of 13 species surpass the threshold by a factor 10-20 times.

The worst case scenario suggests that the most common species migrating across the North Sea (Redwing *Turdus iliacus*, Common blackbird *Turdus merula*, Song Thrush *Turdus philomelos*, Fieldfare *Turlus pilaris*, European Robin *Erithacus rubecula*, Skylark Aluada arvensis, Common Eider *Somateria molissima*, and Common Starling *Sturnus vulgaris*), all show high collision risks and all exceed the threshold by more than a factor of 10.

The worst-case scenario suggest that seven species make up the majority of all victims. The species group that is numerical mostly affected are the thrushes: 75% of all victims are Redwings, Common Blackbirds, Song Thrushes, and Fieldfares. The remaining 25% are mainly European Robins, Skylarks, and the Common starling. Only a small fraction of the total number of victims (3%) is divided over 40 other species. This study relies heavily on calculations that are based on assumptions. Future work should be focused on providing detailed empirical estimates.

Burke, C. M., G. K. Davoren, et al. (2005). "Seasonal and spatial trends of marine birds along offshore support vessel transects and at oil platforms on the Grand Banks." Offshore oil and gas environmental effects monitoring: approaches and technologies. Battelle Press, Columbus, Ohio: 587-614.

Our primary goal is to ensure the well being of seabirds and mammals on the Grand Banks through improved ecological understanding and environmental protection. Our major objective is to conduct year-round, scientifically robust surveys to document seabird and mammal diversity, distribution, and abundance in relation to hydrocarbon activity and oceanography. Surveys along a fixed support vessel route between St. John's, NL and offshore platforms are limited by narrow spatial coverage yet have wide temporal coverage and repeatability. Twenty-one surveys, including the first winter surveys to platforms, were conducted from 1999 through 2003. Oiled murres and dovekies, the species most susceptible to oil pollution, were recorded at the Hibernia platform during February and November when the risk of mortality due to thermal stress is greatest. Roosting gulls were recorded feeding at night on fish, apparently attracted by platform illumination. Marine mammals were observed at offshore platforms. Humpback and minke whales were the most common mammals and were seen within 5-10 meters of the Hibernia platform. The abundance of storm petrels and shearwaters near Hibernia was highest during fall and spring migratory periods, when millions of these species move onto the shelf. These are critical periods for potential mortality from flaring, oiling, and collisions. It is environmentally and ethically essential to continue independent, scientifically rigorous surveys of seabirds in relation to ongoing hydrocarbon activities. Assessments could be greatly enhanced with independent, year-round scientifically valid observation procedures on platforms. Without such surveys, it is impossible to document seabird mortality associated with marine hydrocarbon activity in eastern Canada, and hence not possible to effectively mitigate negative environmental effects.

Camphuysen, C. J., A. D. Fox, et al. (2004). Towards standardized seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K.: a comparison of ship and aerial sampling methods for marine birds, and their applicability to offshore wind farm assessments. NIOZ Report to COWRIE (BAM-0202002). Texel: 37pp.

The coastal and offshore waters of the UK are of global importance for several species of seabirds. The planned erection of large numbers of offshore wind turbines in these waters has underlined our lack of knowledge relating to the distribution, abundance and habitat requirements (foraging ecology) of marine birds. The document evaluates existing census techniques and determines the best currently available methods for defining bird distribution and abundance at sea. The underlying question is twofold: (1) what are the research objectives and what data are required for EIAs for offshore wind farms, and (2) how good are existing census techniques at fulfilling the objectives? Recommended methodologies for ship-based surveys and aerial surveys are provided.

Camphuysen, C. J. and S. Garthe (2004). "Recording foraging seabirds at sea: standardised recording and coding of foraging behaviour and multi-species foraging associations." Atlantic Seabirds 6(1): 1-32.

The European Seabirds at Sea (ESAS) database was established in the early 1980s using a common format. It contains the results of ship-based and aerial seabird surveys in the Northwest European waters, collected using standard methods. The emphasis has always been on mapping distribution patterns and variations in relative abundance, from which

seabird abundance estimates for certain sea areas could be made. The data have been used first to evaluate different sea areas in terms of their vulnerability for surface pollutants. Later studies put more emphasis on ecological aspects underlying seabird distribution and from this work a growing need for more adequate, but still standardised, coding of behaviour types emerged. In this manual, a coding system is introduced that allows specific coding of associations of birds and marine mammals with certain surface phenomena (including land), coding of multi-species feeding associations (feeding flocks) and coding of a variety of behaviour types, with emphasis on feeding behaviour and foraging interactions. In this coding method, the original aim and style of data collecting of seabirds at sea remains intact, and new data are therefore directly comparable with historical material. The coding is thought to be of interest for ESAS participants as well as other groups studying the behaviour of seabirds at sea.

Carlisle, J. D., S. K. Skagen, et al. (2009). "Landbird Migration in the American West: Recent Progress and Future Research Directions." The Condor 111(2): 211-225.

Our knowledge of avian behaviors during the nonbreeding period still lags behind that of the breeding season, but the last decade has witnessed a proliferation in research that has yielded significant progress in understanding migration patterns of North American birds. And, although historically the great majority of migration research has been conducted in the eastern half of the continent, there has been much recent progress on aspects of avian migration in the West. In particular, expanded use of techniques such as radar, plasma metabolites, mist-netting, count surveys, stable isotopes, genetic data, and animal tracking, coupled with an increase in multi-investigator collaborations, have all contributed to this growth of knowledge. There is increasing recognition that migration is likely the most limiting time of year for migratory birds, increasing the importance of continuing to decipher patterns of stopover ecology, identifying critical stopover habitats, and documenting migration routes in the diverse and changing landscapes of the American West. Here, we review and briefly synthesize the latest findings and advances in avian migration and consider research needs to guide future research on migration in the West.

Carter, H. R., D. L. Whitworth, et al. (2000). At-sea threats to *Xantus' murrelets* (Synthliboramphus *hypoleucus*) in the southern California Bight.

A large proportion of the small global population (<10,000-20,000 breeding individuals) of the Xantus' murrelet (*Synthliboramphus hypoleucus*) breeds and forages in the Southern California Bight (SCB) where murrelets face several potential at-sea threats, in addition to impacts at breeding colonies from predators. Using at-sea distribution from recent radio telemetry studies and other available information, we provide an overview of at-sea threats and their impacts in the SCB. From April to June in 1995 to 1997, radio-marked murrelets from Santa Barbara Island were distributed widely in the northwestern SCB, rarely using other regions. In June, these murrelets dispersed northward off the coast of central California. The main at-sea threat to murrelets in the SCB is oil pollution, especially: spills from tankers, oil platforms and pipelines in Santa Barbara Channel and off Point Conception; spills from tankers in marine traffic lanes near Santa Barbara Island and the Los Coronados Islands; and chronic oiling. The 1969 Santa Barbara Platform A oil spill probably had serious impacts on small murrelet colonies in the northern Channel Islands. Mortality from oil pollution has not been well established because of low potential for recovery of dead oiled murrelets.

Cochran, W. W. and R. R. Graber (1958). "Attraction of nocturnal migrants by lights on a television tower." The Wilson Bulletin 70(4): 378-380.

General notes from authors on observations at a 984foot television tower located 10 miles west of Champaign, Illinois, and obtained evidence that nocturnal migrants may be attracted by the red lights which are placed at 140.foot intervals along the tower. Our observations indicate that confusion of nocturnal migrants by tower lights occurs only on nights when the ceiling is low, and migrants are apparently forced to fly near or below the 1000- to 3000.foot level. On clear nights or on nights when cloud cover is high, we learned, through the use of special audio equipment (unpublished manuscript) that numbers of high-flying migrants pass the vicinity of the tower without becoming confused.

Compton, D. (2008). Santa Barbara Audubon Society Spring Seabird Migration Census Report on 1999–2001 Data.

The report presents data from shore-based census of seabirds conducted during spring of 1999, 2000, and 2001. Data were compiled by volunteers organized through the local chapter of The Audubon Society. Surveys were done from a local promontory, Goleta Point using standardized methods of species identification and counting. Seasonal patterns of migration along the coast of Southern Santa Barbara are described for the three-year observation period.

County of Santa Barbara (2008). Lompoc Wind Energy Project. Final Environmental Impact Report. Appendix B.6 – Analysis of WSR-88D Data to Assess Nocturnal Bird Migration Over the Lompoc Wind Energy Project in California. DRAFT. Prepared by Aspen Environmental Group. County EIR No. 06EIR-00000-00004, State Clearinghouse No. 2006071008.

Weather Surveillance Radar, or NEXRAD (Next Generation Radar) was used to characterize patterns of nocturnal bird migration during the both fall and spring migratory seasons in 2006-07 over the western transverse ranges (Santa Ynez and San Rafael Mountains) of Northern Santa Barbara County. The study, which relied on archival radar data from nearby Vandenberg Air Force Base, was conducted in relation to a proposed wind turbine farm northwest of Lompoc, California. The study concluded that levels of nocturnal migration were low relative to other sites. The highest densities of birds were recorded at high altitude (e.g., 2,000 to 5,000 feet) just west of the Santa Ynez and San Rafael Mountains, approximately 20-40 miles east of the project site. The direction of migration observed in the spring was from the south-southeast (162º to 163º) and in the fall was from the north-northwest (332º to 333º). The results indicate that most overland migration in Santa Barbara County follows an inland route, cutting diagonally north-northwest from the Gaviota coast, rather than following the coastline around Point Conception or above the coastal ridges and project site. The observed peak migration periods were from mid-April to mid-May and from mid-August to the end of September. The analysis indicated that on days with adverse weather, little or no migration occurred.

Crawford, R. L. (1980). "Wind direction and the species composition of autumn TV tower kills in northwest Florida." The Auk: 892-895.

Data from tower kills at locations in northwest and peninsular Florida were evaluated to determine flight direction under various wind conditions.

Crawford, R. L. (1981). "Bird kills at a lighted man-made structure: often on nights close to a full moon." Amer. Birds 35: 913-914.

The article refutes the hypothesis that bird collisions with illuminated man-made structures (e.g., transmitting towers, lighthouses) does occur on nights with a full or near-full moon. Data from tower kills in Florida were compared with “moon phase” for those same nights. The data revealed that many bird kills were on nights near or at a full moon. The author

asserts that weather and magnitude of bird migration are the significant factors determining tower kills, based on other research cited.

Dailey, M. D. and D. J. Reish (1993). Ecology of the Southern California Bight: a synthesis and interpretation, Published Berkeley : University of California Press, c1993. Description xvi, 926 p. : ill., maps ; 26 cm.

ABSTRACT: Here is a benchmark study of one significant stretch of the Pacific Ocean, the Southern California Bight. Extending from Point Conception to the Mexican border and out to the 200-mile limit, these waters have never before been investigated in such detail, from so many points of view, by such an eminent group of scientists. The twenty-five expert contributors summarize everything known about the physical, chemical, geological, and biological characteristics of the area in individual chapters; the volume concludes with a synthesis of the information presented. In addition, chapters are devoted to the influence of humans on the marine environment and to the various laws and governmental agencies concerned with protecting it. Because Southern California is so heavily populated and because the ocean is a major recreational area for its people, the information in this unique volume will be invaluable for the region's planners and decision makers as well as for all those who study the globe's marine resources and ecology. Here is a benchmark study of one significant stretch of the Pacific Ocean, the Southern California Bight. Extending from Point Conception to the Mexican border and out to the 200-mile limit, these waters have never before been investigated in such detail, from so many points of view, by such an eminent group of scientists. The twenty-five expert contributors summarize everything known about the physical, chemical, geological, and biological characteristics of the area in individual chapters; the volume concludes with a synthesis of the information presented. In addition, chapters are devoted to the influence of humans on the marine environment and to the various laws and governmental agencies concerned with protecting it. Because Southern California is so heavily populated and because the ocean is a major recreational area for its people, the information in this unique volume will be invaluable for the region's planners and decision makers as well as for all those who study the globe's marine resources and ecology.

DeCandido, R. and D. Allen (2006). "Nocturnal hunting by Peregrine Falcons at the Empire State Building, New York City." The Wilson Journal of Ornithology: 53-58.

We report on nocturnal hunting by Peregrine Falcons (*Falco peregrinus*) at the Empire State Building in Manhattan, New York City. From 4 August through 13 November 2004, we saw Peregrine Falcons on 41 of 77 nights of observation. During this period, they hunted migrating birds on 25 evenings, with the first hunting attempt occurring an average of 119 min after sunset. Peregrine Falcons made 111 hunting attempts and captured 37 birds (33% success). Hunting success was highest in September, but was most often observed in October. Peregrines hunted migratory birds at night more frequently in autumn than in spring. Peregrines were significantly more likely to be present on autumn nights when >50 migrants were passing by the Empire State Building. Although the lights associated with skyscrapers are believed to disorient migrating birds and result in many bird-to-skyscraper collisions each year, Peregrine Falcons are able to take advantage of the situation. Skyscrapers provide hunting perches at altitudes often flown by nocturnal migrants, and disorientation caused by the lights sometimes results in birds circling skyscrapers and possibly becoming more vulnerable to predation by falcons.

Desholm, M., J. Bäckman, et al. (In press?). "Trends in radar ornithology."

The preliminary draft of this paper addresses four fundamental biological questions with regard to the shared arena of avian movement ecology and radar ornithology: 1) why move?, 2) how to move?, 3) when and where to move? and 4) what are the ecological and human consequences of movement. The paper describes current trends in the application of radar technology to monitor bird migration.

Desholm, M., A. D. Fox, et al. (2006). "Remote techniques for counting and estimating the number of bird–wind turbine collisions at sea: a review." Ibis 148(s1): 76-89.

Since the early 1990s, marine wind farms have become a reality, with at least 13 000 offshore wind turbines currently proposed in European waters. There are public concerns that these man-made structures will have a significant negative impact on the many bird populations migrating and wintering at sea. We assess the degree of usefulness and the limitations of different remote technologies for studying bird behaviour in relation to bird–turbine collisions at offshore wind farms. Radar is one of the more powerful tools available to describe the movement of birds in three-dimensional space. Although radar cannot measure bird–turbine collisions directly, it offers the opportunity to quantify input data for collision models. Thermal Animal Detection System (TADS) is an infra red-based technology developed as a means of gathering highly specific information about actual collision rates, and also for parameterizing predictive collision models. TADS can provide information on avoidance behaviour of birds in close proximity to turbine rotor-blades, flock size and flight altitude. This review also assesses the potential of other (some as yet undeveloped) techniques for collecting information on bird flight and behaviour, both pre- and post-construction of the offshore wind farms. These include the use of ordinary video surveillance equipment, microphone systems, laser range finder, ceilometers and pressure sensors.

Deutschlander, M. E., J. B. Phillips, et al. (1999). "The case for light-dependent magnetic orientation in animals." Journal of experimental biology 202(8): 891.

Light-dependent models of magnetoreception have been proposed which involve an interaction between the magnetic field and either magnetite particles located within a photoreceptor or excited states of photopigment molecules. Consistent with a photoreceptor-based magnetic compass mechanism, magnetic orientation responses in salamanders, flies and birds have been shown to be affected by the wavelength of light. In birds and flies, it is unclear whether the effects of light on magnetic orientation are due to a direct effect on a magnetoreception system or to a nonspecific (e.g., motivational) effect of light on orientation behavior. Evidence from shoreward-orienting salamanders, however, demonstrates that salamanders perceive a 90 degrees counterclockwise shift in the direction of the magnetic field under long-wavelength (>=500 nm) light. A simple physiological model based on the antagonistic interaction between two magnetically sensitive spectral mechanisms suggests one possible way in which the wavelength-dependent effects of light on the salamander's magnetic compass response might arise. Assuming that the wavelength-dependent characteristics of the avian magnetic response can be attributed to an underlying magnetoreception system, we discuss several hypotheses attempting to resolve the differences observed in the wavelength-dependent effects of light on magnetic orientation in birds and salamanders. By considering the evidence in the context of photoreceptor- and non-photoreceptor-based mechanisms for magnetoreception, we hope to encourage future studies designed to distinguish between alternative hypotheses concerning the influence of light on magnetoreception.

Drewitt, A. L. and R. H. W. Langston (2008). "Collision effects of wind-power generators and other obstacles on birds." Annuals of the New York Academy of Sciences 1134: 233-266.

There is extensive literature on avian mortality due to collision with man-made structures, including wind turbines, communication masts, tall buildings and windows, power lines, and fences. Many studies describe the consequences of bird-strike rather than address the causes, and there is little data based on long-term, standardized, and systematic assessments. Despite these limitations, it is apparent that bird-strike is a significant cause of mortality. It is therefore important to understand the effects of this mortality on bird populations. The factors, which determine avian collision risk, are described, including location, structural attributes, such as height and the use of lighting, weather conditions, and bird morphology and behavior. The results of incidental and more systematic observations of bird-strike due to a range of structures are presented and the implications of collision mortality for bird populations, particularly those of scarce and threatened species susceptible to collisions, are discussed. Existing measures for reducing collision mortality are described, both generally and specifically for each type of structure. It is concluded that, in some circumstances, collision mortality can adversely affect bird populations, and that greater effort is needed to derive accurate estimates of mortality levels locally, regionally, and nationally to better assess impacts on avian populations. Priority areas for future work are suggested, including further development of remote technology to monitor collisions, research into the causes of bird-strike, and the design of new, effective mitigation measures.

Erickson, W. P., G. D. Johnson, et al. (2005). "A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions." USDA Forest Service General Technical Report PSW-GTR-191. Available online at www. fs. fed. us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/1029-1042. pdf.

We estimate that from 500 million to possibly over 1billion birds are killed annually in the United States due to anthropogenic sources including collisions with human-made structures such as vehicles, buildings and windows, power lines, communication towers, and wind turbines; electrocutions; oil spills and other contaminants; pesticides; cat predation; and commercial fishing by-catch. Many of the deaths from these sources would be considered unlawful take under federal laws such as the Endangered Species Act, Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act. In this paper, we summarize this literature and provide the basis for the mortality projections form any of the apparent significant sources. Most of the mortality projections are based on small sample sizes, and on studies typically lacking adjustments for scavenging and searcher efficiency biases. Although the estimates for each source often range by an order of magnitude, the cumulative mortality from all these sources continues to be a concern.

Evans, W. R. and K. V. Rosenberg (1998). "Acoustic monitoring of night-migrating birds: a progress report." Proceedings RMRS.: 151.

This paper discusses an emerging methodology that uses electronic technology to monitor vocalizations of night-migrating birds. On a good migration night in eastern North America, thousands of call notes may be recorded from a single ground-based, audio-recording station, and an array of recording stations across a region may serve as a "recording net" to monitor a broad front of migration. Data from pilot studies in Florida, Texas, New York, and British Columbia illustrate the potential of this technique to gather information that cannot be gathered by more conventional methods, such as mist-netting or diurnal counts. For example, the Texas station detected a major migration of grassland sparrows, and a station in British Columbia detected hundreds of Swainson's Thrushes; both phenomena were not

detected with ground monitoring efforts. Night-flight calls of 35 species of migrant landbirds have been identified by spectrographic matching with diurnal calls recorded from known-identity individuals; call types of another 31 species are known, but are not yet distinguishable from other similar calls in several species complexes. Efforts to use signal-processing technology to automate the recording, detection, and identification of night-flight calls are currently under way at the Cornell Lab of Ornithology. Automated monitoring of night-flight calls will soon provide information on migration routes, timing, and relative migration density for many species of birds. Such information has application for conservation planning and management, as well as for assessing population trends.

Farnsworth, A., S. A. Gauthreaux Jr, et al. (2004). "A comparison of nocturnal call counts of migrating birds and reflectivity measurements on Doppler radar." Journal of Avian Biology 35(4): 365-369.

Several studies have found that the peak in bird density in the atmosphere during nocturnal migration occurs before midnight, while the peak in vocalizations from migrating birds occurs after midnight, in the hours just before dawn. In a recent study, the patterns of calling from a single species of migrating birds correlated well with the patterns of density estimates of migrating birds. We test the null hypothesis that the patterns of reflectivity measurements and number of vocalizations during nocturnal migration are not related. We sampled radar data and nocturnal flight calls during spring and fall 2000 in northwestern South Carolina and southeastern New York. We analyzed changes in the hour-to-hour patterns of bird density and vocalizations for 556 hours on 58 nights. We also analyzed the night-to-night changes in the patterns of peak hour bird density and peak hour of vocalizations on 32 nights. We found that most of the hour-to-hour and night-to-night patterns of density and vocalization counts are significantly related and reject the null hypothesis. However, despite significant relationships between reflectivity measurements and vocalization counts, a great deal of variation in vocalization counts remains unexplained. These results suggest that factors other than bird density are responsible for the variation in vocalizing by migrating birds.

Farnsworth, A. and R. W. Russell (2007). "Monitoring flight calls of migrating birds from an oil platform in the northern Gulf of Mexico." Journal of Field Ornithology 78(3): 279-289.

Millions of birds migrate across the Gulf of Mexico each year. However, most studies of migration in this region involve sampling onshore locations during the day, potentially underrepresenting the diversity and abundance of migrants passing the region. We evaluated a potential solution to this problem by recording the flight calls of passing migrants from an oil platform located southeast of the Alabama coast in the Gulf of Mexico. We detected 2762 calls during 30 nights from 9 September to 2 November 1999, and were able to identify 2329 calls to species. Flight calls by nine species of birds represented 23% of all identified calls. The greatest number of calls during one night (1017 calls) and during a 1-h period (257 calls) were recorded on 10 September. The greatest number of calls was recorded 8 h after sunset, with a secondary peak 2 h after sunset. The peak prior to sunrise may indicate the formation of flocks at dawn, and the peak after sunset may have been caused by the first wave of migrants reaching the platform. However, call counts varied extensively, with 98% of all calls recorded during 13 nights and 40% on a single night, possibly resulting from hourly and nightly differences in bird numbers aloft, atmospheric conditions, and artificial lighting conditions. Although recording on oil platforms can be difficult because of mechanical, wind, and wave noise, our results suggest great potential for describing the species composition of passing vocal migrants and the temporal patterns of flight-calling behavior if quiet recording locations can be found. Moreover, flight call

monitoring could be a critically important tool for bird conservation in this region, given recent proposals to develop wind power and the potential bird mortality associated with such developments.

Garrett, K. and J. Dunn (1981). Birds of southern California: status and distribution, Los Angeles Audubon Society.

A summary of the distribution, abundance and seasonal status of Southern California's 500+ bird species. Seasonal abundance and predicted location are provided using simplified bar graphs. Species accounts include geographical and seasonal status in detail along with ecological requirements, some subspecies status and unusual records. Area of coverage includes all of Southern California to the northern borders of Santa Barbara and Ventura counties.

Gauthreaux Jr, S. A. and C. G. Belser (2006). "Effects of artificial night lighting on migrating birds." Ecological Consequences of Artificial Night Lighting: 67-93.

This chapter provides a review of literature on the attraction of birds to light at night. How and why birds are attracted to light and the mechanisms of avian vision are examined. Examples of light attraction, organized by type of lighting: lighthouses and lightships; floodlights and ceilometers; city lights and horizon glows; fires and flares; and broadcast and communication towers are reviewed. Observations of the response of migratory birds to lights on communication towers are reported. Recommendations to minimize light attraction of migrating birds and reduce associated mortality are offered.

Gauthreaux Jr, S. A. and J. W. Livingston (2006). "Monitoring bird migration with a fixed-beam radar and a thermal-imaging camera." Journal of Field Ornithology 77(3): 319-328.

Previous studies using thermal imaging cameras (TI) have used target size as an indicator of target altitude when radar was not available, but this approach may lead to errors if birds that differ greatly in size are actually flying at the same altitude. To overcome this potential difficulty and obtain more accurate measures of the flight altitudes and numbers of individual migrants, we have developed a technique that combines a vertically pointed stationary radar beam and a vertically pointed thermal imaging camera (VERTRAD/TI). The TI provides accurate counts of the birds passing through a fixed, circular sampling area in the TI display, and the radar provides accurate data on their flight altitudes. We analyzed samples of VERTRAD/TI video data collected during nocturnal fall migration in 2000 and 2003 and during the arrival of spring trans-Gulf migration during the daytime in 2003. We used a video peak store (VPS) to make time exposures of target tracks in the video record of the TI and developed criteria to distinguish birds, foraging bats, and insects based on characteristics of the tracks in the VPS images and the altitude of the targets. The TI worked equally well during daytime and nighttime observations and best when skies were clear, because thermal radiance from cloud heat often obscured targets. The VERTRAD/TI system, though expensive, is a valuable tool for measuring accurate bird migration traffic rates (the number of birds crossing 1609.34 m [1 statute mile] of front per hour) for different altitudinal strata above 25 m. The technique can be used to estimate the potential risk of migrating birds colliding with man-made obstacles of various heights (e.g.,, communication and broadcast towers and wind turbines)—a subject of increasing importance to conservation biologists.

Gehring, J., P. Kerlinger, et al. (2009). "Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions." Ecological Applications 19(2): 505-514.

Estimates suggest that each year millions of birds, predominantly Neotropical migrating songbirds, collide with communication towers. To determine the relative collision risks that different nighttime Federal Aviation Administration (FAA) communication tower obstruction lighting systems pose to night-migrating birds, we compared fatalities at towers with different systems: white strobe lights only; red strobe-like lights only; red, flashing, incandescent lights only; and red, strobe-like lights combined with non-flashing, steady-burning, red lights. Avian fatality data used to compare these tower light systems were collected simultaneously in Michigan on 20 consecutive days during early morning hours during peak songbird migration at 24 towers in May and September 2005 (total = 40 days). Twenty-one towers were 116–146 m above ground level (AGL), and three were ≥305 m AGL. During the two 20-day sample periods, we found a mean of 3.7 birds under 116–146 m AGL towers equipped with only red or white flashing obstruction lights, whereas towers with non-flashing/steady-burning lights in addition to the flashing lights were responsible for 13.0 fatalities per season. Kruskal-Wallis test, ANOVA, Student's t test, and multiple comparisons procedures determined that towers lit at night with only flashing lights were involved in significantly fewer avian fatalities than towers lit with systems that included the FAA “status quo” lighting system (i.e.,, a combination of red, flashing lights and red, non-flashing lights). There were no significant differences in fatality rates among towers lit with red strobes, white strobes, and red, incandescent, flashing lights. Results from related studies at the same towers in May and September 2004 and September 2003 provide ancillary support for these findings. Our results suggest that avian fatalities can be reduced, perhaps by 50–71%, at guyed communication towers by removing non-flashing/steady-burning red lights. Our lighting change proposal can be accomplished at minimal cost on existing towers, and such changes on new or existing towers greatly reduce the cost of tower operation. Removing non-flashing lights from towers is one of the most effective and economically feasible means of achieving a significant reduction in avian fatalities at existing communication towers

Herbert, A. D. (1970). "Spatial disorientation in birds." The Wilson Bulletin 82(4): 400-419.

The authors established that birds possess various senses to determine their spatial orientation. The visceral senses give a bird an indication of its body position in space and of the "G" forces acting upon its body during aerial gyrations. The "tactile" senses of the feathers give the bird an indication of the airflow pressures on either side of its body and wings and allow the bird to sense a bank or a spiral dive. The proprioceptive senses give the bird an indication of its body position relative to its head. The vestibular apparatus can sense the bird's equilibrium. All of these senses, the author hypothesizes, whether singly or in concert, are insufficient for the bird to maintain a proper spatial orientation and that the eyes are the predominant organ of spatial orientation, and for gaining cues to maintain spatial orientation. However, the author further hypothesizes, where there are discrepancies between the visual and sensory cues, the visual cues will be accepted rather than the sensory cues. That the sensory cues still have sufficient effect to cause a mental block or confusion. The bird has not enough knowledge to analyze the situation and is therefore unable to take any true corrective action. The consequences of the situation is that the bird suffers from spatial disorientation and, in some cases, complete vertigo. The only conclusion is that birds are susceptible and suffer from spatial disorientation, and further that the causes of spatial disorientation in birds are exactly the same as those which affect the human pilot, namely; (a) the loss of true visual cues to the horizontal; (b) inexperience

in flying under such conditions where visual cues are lost; (c) conflict between the sensory and visual cues to orientation; (d) entering an unusual position without being aware of it; plus (e) the lack of knowledge and reasoning ability when dealing with unnatural phenomena.

Hueppop, O., J. Dierschke, et al. (2006). "Bird migration studies and potential collision risk with offshore wind turbines." Ibis 148(s1): 90-109.

Worldwide, Germany is the leading country in the use of wind energy. Since sites for the erection of wind turbines became scarce on land, ambitious plans for the offshore regions have arisen. There have been applications for 33 sites within the German Exclusive Economic Zone in the North and Baltic Seas, some of which entail several hundred individual turbines. Eleven pilot projects are approved, and two others rejected. As several hundred million birds cross the North and Baltic Seas at least twice every year, the Offshore Installations Ordinance says that licensing will not be given if the obstacles jeopardize bird migration. Birds are potentially endangered by offshore wind farms through collisions, barrier effects and habitat loss. To judge these potential risks, the occurrence of birds in space and time as well as details on their behaviour in general (migration, influence of weather) and their behaviour when facing wind farms (flight distances, evasive movements, influence of light, collision risk) need to be determined. Furthermore, the influences of construction and maintenance works must be considered. Since 2003, we have investigated year-round bird migration over the North Sea with regard to offshore wind farms. The main objectives were to assess data on the aforementioned aspects of bird migration over sea. These data can contribute to, for example, estimations of collision risks at offshore wind farms, the possible impacts on bird populations and possible mitigation measures. Results from measurements with different techniques, including radar, thermal imaging, and visual and acoustic observations, were compiled. The findings confirm that large numbers of diurnal and nocturnal migrants cross the German Bight. Migration was observed all year round but with considerable variation of intensity, time, altitude and species, depending on season and weather conditions. Almost half of the birds fly at 'dangerous' altitudes with regard to future wind farms. In addition, the number of individuals in reverse migration is considerable, which increases the risk of collision. We demonstrated that, especially under poor visibility, terrestrial birds are attracted by illuminated offshore obstacles, and that some species collide in large numbers. Passerines are most frequently involved in collisions. Even if the findings regarding collisions at a research platform cannot be directly applied to offshore wind farms, they do show that on a few nights per year a large number of avian interactions at offshore plants can be expected, especially in view of the number and planned area of projected wind farms. We suggest abandonment of wind farms in zones with dense migration, turning off turbines on nights predicted to have adverse weather and high migration intensity, and actions to make wind turbines more recognizable to birds, including modification of the illumination to intermittent rather than continuous light, as the most appropriate mitigation measures. We further conclude that a combination of methods is necessary to describe the complex patterns of migration over the sea. The recordings are to be continued with the aim of refining the results presented here, and of developing a model for 'forecasting' bird migration over the German Bight. We expect more information on avoidance behaviour and collisions after the construction of a pilot wind park.

Imber, M. J. (1975). "Behaviour of petrels in relation to the moon and artificial lights." Notornis 22(4): 302-306.

Petrels, especially Procellariidae and Hydrobatidae, visit their breeding places in lesser numbers on moonlit nights than on darker nights. This is probably caused by poor feeding conditions because prey do not come so near the surface on moonlit nights. Fledgling petrels, mainly Procellariidae, are particularly liable to be attracted to artificial lights situated near the breeding colony. It is suggested that nocturnal-feeding petrels are instinctively attracted to light sources because they exploit bioluminescent prey. A small proportion of fledglings seem to be initially misled by this instinct.

Jones, J. and C. M. Francis (2003). "The effects of light characteristics on avian mortality at lighthouses." Journal of Avian Biology 34(4): 328-333.

The generation of artificial light by human activity can have far-reaching detrimental impacts upon a wide variety of organisms. A great deal of attention has been paid to well-lit buildings, television towers, and communication towers as sources of mortality for nocturnally migrating songbirds. However, despite being among the first human structures known to generate migratory bird kills, little is known about the current impact of lighthouses on birds, or the impact of light design. We examined the impact of a lighthouse on nocturnal avian migrants at Long Point, Lake Erie, Ontario, Canada. From 1960–1989, mean annual kills were 200 birds in spring, and 393 in autumn, with kills of up to 2000 birds in a single night. In 1989, the Long Point lighthouse was automated, with a simultaneous change in beam characteristics – the new beam is narrower and less powerful. This change brought about a drastic reduction in avian mortality at the lighthouse to a mean of only 18.5 birds per year in spring, and 9.6 in autumn from 1990–2002. Our results highlight the effectiveness of simple changes in light signatures in reducing avian light attraction and mortality during migration.

Lebbin, D. J., M. G. Harvey, et al. (2007). "Nocturnal Migrants Foraging at Night by Artificial Light." Wilson Journal of Ornithology 119(3): 506-508.

Artificial lights can have detrimental effects on nocturnal migrant birds and other wildlife, yet some species of typically diurnal insectivorous birds are capable of foraging at night under artificial illumination. Here, we report observations of at least 15 wood-warbler species (Parulidae), one tyrant-flycatcher (Tyrannidae), and one mimid (Mimidae) foraging at night in areas illuminated by powerful artificial lights. To our knowledge, our observations represent the first report of a mixed-species flock of birds foraging on insects attracted to artificial lights or within foliage illuminated by artificial lights at night.

Lehman, P. E. (1994). The Birds of Santa Barbara County, California, Vertebrate Museum, University of California.

This is a regional account of the status and distribution of birds in Santa Barbara County, California. Seasonal occurrence of migratory species is provided. A chapter entitled “Bird Migration and the Seasons” is especially relevant to the present study.

Longcore, T. and C. Rich (2004). "Ecological light pollution." Frontiers in Ecology and the Environment 2(4): 191-198.

Ecologists have long studied the critical role of natural light in regulating species interactions, but, with limited exceptions, have not investigated the consequences of artificial night lighting. In the past century, the extent and intensity of artificial night lighting has increased such that it has substantial effects on the biology and ecology of species in the wild. We distinguish “astronomical light pollution”, which obscures the view of the night

sky, from "ecological light pollution", which alters natural light regimes in terrestrial and aquatic ecosystems. Some of the catastrophic consequences of light for certain taxonomic groups are well known, such as the deaths of migratory birds around tall lighted structures, and those of hatchling sea turtles disoriented by lights on their natal beaches. The more subtle influences of artificial night lighting on the behavior and community ecology of species are less well recognized, and constitute a new focus for research in ecology and a pressing conservation challenge.

Rich, C., and T. Longcore. (eds.). 2006. Ecological consequences of artificial night lighting. Island Press, Washington, D.C.

This book edited by Rich and Longcore includes chapters authored by leading scientists that discuss concerns and current knowledge about artificial lighting on mammals, birds,reptiles, amphibians, fish, invertebrates and plants.

Longcore, T., C. Rich, et al. (2008). "Height, Guy Wires, and Steady-Burning Lights Increase Hazard of Communication Towers to Nocturnal Migrants: A Review and Meta-Analysis." The Auk 125(2): 485-492.

Communication towers in North America kill millions of birds annually, and most of these are Neotropical species that migrate at night. Estimates of total annual mortality in the United States are about 4–5 million to an order of magnitude greater. In 2000, the USFWS proposed guidelines to minimize avian collisions with communication towers. In November 2006, the Federal Communications Commission (FCC) announced a "notice of proposed rulemaking" that sought input on a proposal to require changes to tower design to reduce avian mortality. Here, we review and analyze the literature on the features of towers that can be regulated, particularly tower design and placement, to provide a scientific basis for regulation of tower construction and operation. We prepared an earlier version of this review for the American Bird Conservancy and other conservation groups in response to a "notice of inquiry" issued by the FCC in 2003 to gather information on collisions between birds and communication towers.

Kelly, J.F. and R.L Hutto. 2003. An east-west comparison of migration in North American wood warblers. Condor 107: 197-211.

Abstract: That western and eastern songbird migration routes are distinct ecological systems has been proposed for over 100 years. Nonetheless, this distinction has not been widely recognized nor have there been any comparative studies that quantitatively evaluate the differences and similarities between western and eastern songbird migration systems. We drew from previously published research on wood warblers to highlight patterns in stopover ecology that suggest fundamental differences between western and eastern migrants. In particular, we compared biogeography, evolutionary relationships, and stopover ecology of wood warblers from western and eastern North America and found: (1) multiple lines of evidence that indicate western wood warblers are geographically isolated from eastern conspecifics or congeners throughout the annual cycle, (2) eastern and western wood warbler taxa are distinct evolutionary units, (3) migrant wood warblers captured in the Southwest tended to carry lower fat loads and be comprised of more after-hatch-year birds than is typical of eastern migrants, (4) frugivory is unknown in wood warblers endemic to the Northwest or Southwest and (5) relative to other regions and seasons, riparian vegetation is heavily used by western wood warblers in the spring. We think that further examination and synthesis of these differences would yield a more mechanistic understanding of Nearctic-Neotropical avian migration. On this basis, we elaborate our view that (1) an improved understanding of western songbird migration

ought to be a high priority for science, conservation, and education, and (2) large-scale coordinated research efforts would be the most effective strategy for advancing our knowledge of passerine migration in the West.

Krijgsveld, K. L., S. M. J. van Lieshout, et al. (2003). "Baseline studies North Sea wind farms: strategy of approach for flying birds." Bureau Waardenburg bv, and Alterra, commissioned by the National Institute for Coastal and Marine Management, The Hague, The Netherlands.

Bureau Waardenburg and Alterra in cooperation will study the effects of the Near Shore Wind Farm on flight paths, flight altitudes and flux of marine birds and non-marine migrating birds. In this publication we present the study design of the first part of this study, in which the flight patterns of birds are determined in the reference situation before the construction of wind turbines has started.
In chapter 1 we introduce the project by describing its background and the research goals. In chapter 2 we present the specific study aims; separated in fluxes, flight altitudes, and flight paths of birds. Subsequently we discuss which species of birds are of interest. In chapter 3 we give a brief overview of the methods that will be used to measure the flight patterns. These consist of three main components: radar observations, visual observations and ship-based observations on seaducks. In chapter 4 the methods and techniques that will be used are described in full detail. We start with a description of the study site and the location where measurements will be performed, and how we deal with spatial and temporal variation in flight patterns (§4.1). Secondly the radar equipment used for the observations is described (§4.2 and §4.3). This includes an elaboration on the techniques involved and on the necessities for calibration of echoes. In § 4.5 we describe the methods used to perform visual observations, and in §4.6 subsequently the methods to link the radar and visual observation in order to add species information to the radar signals. The chapter is concluded by discussing effects of environmental conditions and the ways to mobilise existent data on marine birds. Chapter 5 deals with the techniques used for data analysis. In Chapter 6 we summarize the research activities in a time frame.

Marquenie, J. Donners, M., Poot, H., Steckel, W. and de Wit, B. (2008) "Adapting the spectral composition of artifi cial lighting to safeguard the environment", Petroleum and Chemical Industry Conference Europe – Electrical and Instrumentation Applications. Nederlandse Aardolie aatschappij (NAM), The Netherlands, Vol. 5, Iss. 10-12, June 2008, pp. 1-6.

Over 60 million birds, of many species, cross the North Sea each year, twice. Light has a significant impact on migratory birds at sea, as it can attract and trap birds at large illuminated structures, such as off shore platforms. We first studied the behaviour of birds around offshore platforms and secondly tested the effect of the presence of lighting, the intensity and type of lights and the light colour on bird behaviour. As a conclusion, about 10% of the North Sea migrating bird populations are impacted by offshore installations. We developed a light spectrum that can be applied off shore, offering safety to both humans and birds. A field demonstration test, involving the exchange of lights to the new colour on a gas production platform has demonstrated a reduction of bird reaction of at least 50 to 90 %. Finally, the compliance to explosion safety requirements has been demonstrated. It is expected that the bird-friendly lighting will become the new standard for any installation situated in areas with bird migration.

Marquenie, J. M. (2007). "Green light To Birds–Investigation into the Effect of Bird-Friendly Lighting." Netherlandse Aardolie Maatschappij.

In May 2007, the external radiating light sources on a gas production platform in the North Sea was been exchanged for a special made light source - low in spectral red. The

environmental effectiveness was been evaluated during the bird autumn migration, between October 5 and 8, 2007. Dense flocks of songbirds, wader birds and ducks were observed. Also some co-migrating owls were seen. Weather conditions, to assess the impact of the new lighting were extremely favorable: light fog and almost complete cloud cover.

The observed species and numbers were compared with assessments from previous years. Periods of comparable weather conditions were selected and the same observer was employed in order to assure full comparability of assessment techniques. Based on this comparison it is concluded that 2-10 times less birds are negatively impacted (circling around the installation for a prolonged period of time) by the new light source as by the original standard white (tube lights) and orange (sodium high pressure lights) lighting. Also the number of birds actually landing on the platform was decreased. The negative impact on birds therefore was significantly reduced.

McCrary, M. D., D. E. Panzer, et al. (2003). "Oil and gas operations offshore California: status, risks, and safety." Marine Ornithology 31(1): 43-49.

Offshore oil operations in California are conducted from 23 platforms in Federal waters (> 5 km from shore) and 10 platforms and related facilities in State waters (< 5 km), distributed over an area of about 20,000 km2 along the southern coast of the state. In 2000, approximately 36 million barrels (bbl) of oil were produced from Federal waters, all of which was transmitted to shore by pipeline. In comparison, approximately 260 million bbl of crude oil and distillates (e.g., gasoline) are transported by tanker along the California coast each year. The largest oil spill from offshore oil operations in California was the 1969 80,000-bbl Santa Barbara spill, which resulted in the loss of thousands of birds. This spill was a pivotal event for both the environmental movement in the U.S.A. and for offshore oil safety. After 1969, the rules and regulations governing offshore oil were rewritten and new rules were developed. Since 1969, only one spill from oil and gas operations offshore California has resulted in documented seabird mortality, the 163-bbl Platform Irene pipeline spill off Point Arguello in 1997, which resulted in the loss of more than 700 birds. Only a few small spills have occurred since 1969. However, based on the amount of offshore oil expected to be produced in California over the next 28 years and the number of spills that have occurred in the past, the risk of a spill of 1,000 bbl or greater occurring during that period is estimated at 41.2 percent for Federal operations and 8.4 percent for State operations (reflecting the much smaller volume of oil produced and transported in State waters).

Miles, W., S. Money, R. Luxmoore, and R.W. Fumes. 2010. Effects of artificial lights and moonlight on petrels at St. Kilda, Bird Study. 57:2, 244-251.

When moonlight levels are low, shearwaters and storm-petrels are attracted to artificial lighting at night at St Kilda and may be killed, but impacts are lessened by deliberate light reduction measures. The study obtained nightly numbers of Manx Shearwaters *Puffinus puffinus* , Leach's Storm-petrels *Oceanodroma leucorhoa* and European Storm-petrels *Hydrobates pelagicus* attracted by artificial lights were recorded in September and October from 2005 to 2008. Effects of experimental reductions to light emissions in 2007 and 2008 were assessed, together with variation in annual moonlight, mortality rates, and age of birds found. Study results showed that reductions to light emissions caused a decrease in numbers of Leach's Storm-petrels attracted, but had less effect on attraction of Manx Shearwaters. Only juveniles were found, the majority after nights with little or no moonlight, and mortality was extremely infrequent. Only one European Storm-petrel was found, and Leach's Storm-petrel and Manx Shearwater totals were small compared with

estimated breeding totals at St Kilda. The study concluded that the numbers of petrels attracted to artificial lights on St Kilda were low. However, reductions to light emissions were still beneficial in reducing numbers of young that became disorientated, grounded, or died during fledging periods. Therefore, reductions to light emissions should be encouraged. A review of this phenomenon across the UK found it to be rare in breeding areas away from St Kilda.

Montevecchi, W. A. (2006). "Influences of artificial light on marine birds." Ecological Consequences of Artificial Night Lighting: 94–113.

Sources of artificial lighting in the marine environment (e.g., lighthouses, offshore oil and gas platforms, light-induced fisheries) and their direct and indirect influences on seabirds are reviewed. The cumulative effects of artificial lighting with other sources of environmental risk are considered. Different species and age classes of marine birds exhibit different degrees of attraction, and hence vulnerability, to artificial lighting. Mortality associated with artificial lighting threatens populations of rare and endangered species. Current levels of mitigative action are non-existent or inadequate to address problems posed by artificial lighting.

Montevecchi, W. A., F. K. Wiese (1999). "Seabird attraction to offshore platforms and seabird monitoring from support vessels and other ships: Literature review and monitoring designs." Prepared for Canadian Association of Petroleum Producers by Memorial University of Newfoundland, St. John's, Newfoundland and University of New Brunswick, Saint John. New Brunswick 35.

In 1999, researchers at Memorial University of Newfoundland and the University of New Brunswick compiled an extensive report outlining issues associated with seabird conservation and offshore oil and gas activity on the Grand Bank of eastern Canada. This report involved 1) a comprehensive literature review of seabird attraction to offshore platforms and 2) an assessment of the scientific feasibility of monitoring fluctuations in the spatial and temporal distributions and abundances of seabirds from support vessels. The report proposed a multi-agency, cooperative research program that would ultimately generate public confidence in offshore hydrocarbon developments in eastern Canada and provide the oil industry with information necessary to manage their operations and minimize impacts on seabirds. A draft report of the document was distributed and fully discussed at a 2-day workshop with oil industry and seabird ecology experts at Memorial University. This final report incorporates the comments and suggestions of reviewers made at the workshop and in subsequent communication with reviewers.

Poot, H., B. J. Ens, et al. (2008). "Green light for nocturnally migrating birds." Ecology and Society 13(2): 47.

The nighttime sky is increasingly illuminated by artificial light sources. Although this ecological light pollution is damaging ecosystems throughout the world, the topic has received relatively little attention. Many nocturnally migrating birds die or lose a large amount of their energy reserves during migration as a result of encountering artificial light sources. This happens, for instance, in the North Sea, where large numbers of nocturnally migrating birds are attracted to the many offshore platforms. Our aim is to develop bird-friendly artificial lighting that meets human demands for safety but does not attract and disorient birds. Our current working hypothesis is that artificial light interferes with the magnetic compass of the birds, one of several orientation mechanisms and especially important during overcast nights. Laboratory experiments have shown the magnetic

compass to be wavelength dependent: migratory birds require light from the blue-green part of the spectrum for magnetic compass orientation, whereas red light (visible long-wavelength) disrupts magnetic orientation. We designed a field study to test if and how changing light color influenced migrating birds under field conditions. We found that nocturnally migrating birds were disoriented and attracted by red and white light (containing visible long-wavelength radiation), whereas they were clearly less disoriented by blue and green light (containing less or no visible long-wavelength radiation). This was especially the case on overcast nights. Our results clearly open perspective for the development of bird-friendly artificial lighting by manipulating wavelength characteristics. Preliminary results with an experimentally developed bird-friendly light source on an offshore platform are promising. What needs to be investigated is the impact of bird-friendly light on other organisms than birds.

Reed, J. R., J. L. Sincock, et al. (1985). "Light attraction in endangered procellariiform birds: reduction by shielding upward radiation." The Auk 102(2): 377-383.

Autumnal attraction to man-made lighting causes heavy mortality in fledgling Hawaiian seabirds: Newell's Shearwater (*Puffinus auricularis newelli*), Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*), and Band-rumped Storm-Petrel (*Oceanodroma castro*). These threatened, endangered, and rare species (respectively) approach and circle lights on their first flight from mountain nesting colonies on the island of Kauai to the sea. We shielded lights of the largest resort to prevent upward radiation on alternate nights during two fledgling seasons. Shielding decreased attraction by nearly 40%. Most attraction occurred 1-4 h after sunset. Full moon dramatically decreased attraction, a phenomenon that has both theoretical and management implications. Received 11 May 1984, accepted 16 November 1984.

Richardson, W. J. (1978). "Timing and amount of bird migration in relation to weather: a review." Oikos: 224-272.

Relationships of short-term weather to daily migration intensity are reviewed, with sections for each weather variable, for waterfowl, shorebirds and hawks, and for reverse migration. Selecting factors, methodology, hypotheses and results to date are summarized, generalizations about migration-weather relationships are extracted from the pooled results, and high-priority research topics are identified. Ultimate factors responsible for present responses are thought to include aspects of weather en route and a the take-off point and destination. Proximate factors affecting the probability of take-off may include variables useful in predicting, as well as those that measure, aspects of weather with selective significance. Causative and coincidental relationships remain difficult to separate, and at least a few birds migrate in almost any weather conditions. However, maximum numbers migrate with fair weather, with tailwinds and with temperature, pressure and humidity conditions that accompany tailwinds. Correlations with weather differ among populations with different flight directions. General patterns of responses appear to be modified by special selecting factors that apply to certain groups - soaring hawks tend to fly on days with strong updrafts, landbirds migrating along coasts prefer onshore to offshore winds, and transients in unsuitable habitats seem less likely to wait for favourable travelling conditions.

Richardson, W. J. (2000). Bird migration and wind turbines: migration timing, flight behavior, and collision risk. Report prepared by LGL Ltd. Environmental Research Associates.

Seasonal migration is one of the main activities of birds that can bring them into the proximity of wind turbines. Several studies in the U.S.A. and Europe have focused on the possibility that significant numbers of migrating birds might be killed by collisions with wind turbines either during the daytime or at night. Many types of birds migrate primarily at night, when they may be less able to see and avoid tall structures intersecting their flight paths. It is well known that large numbers of night-migrating birds are occasionally killed by collisions with tall towers, buildings, smokestacks, etc. Ever since the first "modern" wind turbines were built, there has been concern that significant numbers of migrating birds might collide with them, notwithstanding the fact that wind turbines are not as tall as the structures commonly associated with large kills of night migrants.

At a symposium concerning the effects of wind turbines on migrating birds, the author presents background information for other methodological papers presented during the symposium that are relevant to wind power developments. The paper summarizes existing knowledge about seasonality, hourly timing, and flight behavior of migrating birds, emphasizing aspects likely to affect the risk of collisions with wind turbines based on studies of flight behavior done in the U.S.A., Canada and Europe over the past 40-45 years, both by radar and by direct visual methods.

Rodriguez, A. and B. Rodriguez (2009). "Attraction of petrels to artificial lights in the Canary Islands: effects of the moon phase and age class." Ibis 151(2): 299-310.

The extent and intensity of artificial night lighting has increased with urban development worldwide. The resulting light pollution is responsible for mortality among many Procellariiformes species which show nocturnal activity on their breeding grounds. Here, we report light-induced mortality of Procellariiformes during a 9-year study (1998–2006) on Tenerife, the largest island of the Canary archipelago. A total of 9880 birds from nine species were found grounded, the majority being Cory's Shearwaters *Calonectris diomedea* (93.4%). For this species the majority of grounded birds were fledglings (96.4%), which fall apparently while leaving their nesting colony for the first time; for the smaller species (storm-petrels) adult birds were more often grounded than fledglings. For almost all species, grounding showed a seasonal pattern linked with their breeding cycle. Certain phases of the moon influenced grounding of Cory's Shearwater, with the extent of grounding being reduced during phases of full moon. The percentage of fledglings attracted to lights in relation to the fledglings produced annually varied between species and years (0–1.3% for the Madeiran Storm-petrel *Oceanodroma castro*; 41–71% for Cory's Shearwater). Mean adult mortality rates also varied between species (from 0.4% for the European Storm-petrel *Hydrobates pelagicus* and the Cory's Shearwater, to 2.3% for the Manx Shearwater *Puffinus puffinus). Here we show that light-induced mortality rates are of concern, at least for petrels* and small shearwaters. Thanks to efforts involving civil cooperation, 95% of grounded birds have been returned to the wild. To minimize the impact of artificial lights on petrels we recommend several conservation measures: continuing rescue campaigns, alteration of light signatures and reduction of light emissions during the fledging peaks. Furthermore, we recommend that a monitoring program for petrel populations be implemented, as well as further studies to assess the fate of released fledglings and continued research to address why petrels are attracted to lights.

Rubega, Margaret A., Douglas Schamel and Diane M. Tracy. 2000. Red-necked Phalarope (*Phalaropus lobatus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online. http://bna.birds.cornell.edu/bna/species

Provides information on individual bird species natural history.

Russell, R. W. (2005). Interactions between migrating birds and offshore oil and gas platforms in the northern Gulf of Mexico: Final Report., U.S. dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, L.A.: 348 pp.

The ecology of trans-Gulf migration and the influence of petroleum production platforms on migratory birds was studied in the Gulf of Mexico from 1998-2000. The study addressed the following questions: 1) which species are trans-Gulf migrants? 2) are there specific migration routes across the Gulf of Mexico? 3) when do migrants use platforms for stopovers, and how does the timing of platform use relate to the seasonal and diel timing of trans-Gulf migration as well as weather? 4) how many individual migrants use platforms for stopovers, and how are the numbers of migrants using platforms related to total trans-Gulf migration traffic aloft? 5) what is the condition of migrating birds that stop on platforms, and what factors determine how long they stay? 6) during stopovers, do migrants use platforms in predictable ways? 7) how many migrants that stop on platforms depart successfully versus die there, and why do some birds die?

Platforms have three primary proximate impacts on migrant birds: 1) they provide habitat for resting and refueling; 2) they induce nocturnal circulations; and 3) they result in some mortality through collisions. Platforms appeared to be suitable stopover habitats for most species, and most of the migrants that stopped over on platforms probably benefited from their stay, particularly in spring. Many of these migrants were able to feed successfully, and some appeared to achieve rates of mass gain that exceeded what is typical in terrestrial habitats. Even the individuals that do not feed probably benefit physiologically from the availability of the platforms. Migrants may be affected by sources of fatigue other than total depletion of fat stores, such as excessive accumulation of lactic acid, failure of the nerve-muscle junction, or upset of central nervous coordination. These types of fatigue may be eliminated by simple rest. Many of the migrants that rested quietly on the platforms for hours to days were probably recovering from such sources of fatigue.

Migrants used platforms in highly nonrandom ways and selected specific platform microhabitats (i.e.,, used alternative microhabitats no-randomly), much in the same way that they select specific habitats during terrestrial stopovers. Preferred platform microhabitats were species-specific and generally consistent between spring and fall. Platforms may facilitate the evolution of trans-Gulf migration strategies in certain species by providing “steppingstones” that allow incipient migrants to cross the Gulf successfully via a series of shorter flights.

Peregrine Falcons are perhaps the most striking beneficiaries of platforms. This species, which formerly was near extinction, underwent a dramatic population recovery that was temporally coincident with the period of fastest expansion of the platform archipelago in the Gulf. The majority of juveniles in the North American population of this species now use oil platforms in the northern Gulf during the fall for resting and hunting. Their behavior and the similarity of ecological circumstances to the Mediterranean Sea, where a related species has evolved a strategy of breeding on islands during the fall when abundant trans-Mediterranean migrant landbird prey are available for provisioning young, suggests that

Peregrine Falcons might eventually establish a breeding population on the Gulf platform archipelago.

Migrants sometimes arrived at certain platforms shortly after nightfall and proceeded to circle those platforms for variable periods ranging from minutes to hours. These circulations clearly occurred because nocturnal migrants were attracted to platform lights, and tended to occur on overcast nights. It is believed that circulations are maintained when birds get inside the cone of light surrounding the platform and are reluctant to leave, seemingly becoming trapped by the surrounding "wall of darkness" and the loss of visual cues to the horizon. Circulations put birds at risk for collision with the platform or with each other, and result in non-useful expenditure of energy.

Collisions with platforms were most common in fall because most migrants were aloft over the platforms during hours of darkness in that season. Available information suggests that the platform archipelago may cause roughly 200,000 collision deaths per year, which is negligible compared to other anthropogenic sources of mortality. However, several lines of evidence suggest that future development of the eastern Gulf of Mexico may result in a disproportionately large increase in collision mortality in fall trans-Gulf neotropical migrants.

Squires, W.A. and H.E. Hanson. 1918. The destruction of birds at the lighthouses on the coast of California. Condor 20:6-10.

The article discusses the information obtained from questionnaires submitted to and completed by lighthouse keepers for lighthouses along the California coast relative to bird strikes and attraction to the lighthouse light. They then discuss these observations relative to the California coastline and east coast occurrences of bird strikes and mass mortalities. Although dated, the article provides information on birds along the coast of California and their behavior relative to attraction by lighthouses prior to the extensive urbanization of the California coastline.

Storrer Environmental Services (2007). Results of Nighttime Avian Surveys on Platform Irene, Santa Barbara County, California [May 14 – 16, 2007]. Letter report to N. Minick (Santa Barbara County Planning & Development Department) dated May 21, 2007.

Nighttime surveys were performed over a two-day period on OCS petroleum Platform Irene off the waters of Northern Santa Barbara County. Observations of migrating landbirds and seabirds interacting with the structures are described. Apparent entrainment by flocks of migrating Wilson's Phalaropes and disorientation by mixed flocks of migrant passerines were recorded.

Storrer Environmental Services (2008). "Results of Nighttime Avian Surveys on Platform Irene, Santa Barbara County, California [December 22 – 24, 2008]." Letter report to N. Minick (Santa Barbara County Planning & Development Department) dated December, 2008.

Nighttime surveys were conducted over a two-day period on OCS petroleum Platform Irene off the waters of Northern Santa Barbara County. Limited observations of resident marine birds a peregrine falcon suggest use of the platform for roosting. The surveys were a compliment to spring surveys on Platform Irene conducted in May of 2007.

Tasker, M. L., P. H. Jones, et al. (1984). "Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach." The Auk 101(3): 567-577.

The authors reviewed the methods used to study seabirds at sea from ships, discuss the problems posed in making reliable observations in relation to the design of research programs, and describe a method currently in use around the seas of Great Britain. We suggest a framework for future studies, incorporating features likely to stabilize bias. The key items in this recommendation are (1) the use of a band transect in order to provide density estimates, and (2) a method to correct for movement of flying birds in the band transect in order to minimize bias caused by such movement. Received 13 October 1982, accepted 5 December 1983.

Telfer, T. C., J. L. Sincock, et al. (1987). "Attraction of Hawaiian seabirds to lights: conservation efforts and effects of moon phase." Wildlife Society Bulletin 15(3): 406-413.

The authors compared trends in the number of Hawaiian Petrels (*Pterodroma sandwichensis*; formerly Dark-rumped Petrels [*P. phaeopygia sandwichensis*]) and Newell's Shearwaters
(*Puffinus auricularis newelli*) seen visiting Kauai, Hawaii, on ornithological radar in 1978 through 1985. The authors report on the number of birds that had been recovered, the noticeable effect of moon phase on seabird fallout, and the seasonality and geographical distribution of fallout.

Van de Laar, F.J.T. 2007 Green lights to birds; investigations into the effect of bird friendly lighting. NAM Locatie L15-FA-1, December 2007

In May 2007, the external radiating light sources on gas production platform L15, in the Dutch North Sea were exchanged for a special made light source which was low in spectral red wavelength light. L15 is situated in the North Sea, about 20 km Northwest of the island Vlieland. The environmental effectiveness of these new lights were determined during the bird autumn migration, between October 5 and 8, 2007. Dense flocks of songbirds, wader birds and ducks were observed. Also some co-migrating owls were seen. Weather conditions, to assess the impact of the new lighting were extremely favorable: light fog and almost complete cloud cover.

The observed species and numbers were compared with assessments from previous years. Periods of comparable weather conditions were selected and the same observer was employed in order to assure full comparability of assessment techniques. Based on this comparison it is concluded that 2-10 times less birds are negatively impacted (circling around the installation for a prolonged period of time) by the new light source as by the original standard white (tube lights) and orange (sodium high pressure lights) lighting. Also the number of birds actually landing on the platform was decreased. The negative impact on birds therefore was significantly reduced. For technical reasons, a limited number of light sources was not yet replaced during our observation period. The presented results are underestimating the effect if all external lights would have been replaced. It is also concluded that a North Sea wide approach would be needed and that application of this new light source could reduce the number of impacted birds from about 6 million to less than 600.000.

Verheijen, F. J. (1985). "Photopollution: artificial light optic spatial control systems fail to cope with. Incidents, causation, remedies." Experimental Biology 44(1): 1.

The term photopollution is proposed for artificial light having adverse effects on wildlife. The differences between natural and artificial light are discussed in relation to the concepts of orientation, disorientation, misorientation and abnormal orientation. The ways in which optic orientation systems are attuned to natural illumination conditions are analysed, and it is shown why they therefore may fail to cope with artificial light. It is concluded that for many nocturnally active animals a natural light-field between sunset and sunrise is a requirement for survival. A review is given of data on a) bird kills at man-made lighted obstacles, and b) the interference of artificial light with nest site selection by female sea turtles and water-finding by hatchlings at nesting beaches. Conventional remedies against the hazards of photopollution are critically reviewed and new ones are suggested. It is emphasized that measures should aim not only at reducing threats to a species or population but also at preventing suffering in individual animals.

Verstraeten, W. W., B. Vermeulen, et al. (2010). "Webcams for Bird Detection and Monitoring: A Demonstration Study." Sensors 10.

Better insights into bird migration can be a tool for assessing the spread of avian borne infections or ecological/climatologic issues reflected in deviating migration patterns. This paper evaluates whether low budget permanent cameras such as webcams can offer a valuable contribution to the reporting of migratory birds. An experimental design was set up to study the detection capability using objects of different size, color and velocity. The results of the experiment revealed the minimum size, maximum velocity and contrast of the objects required for detection by a standard webcam. Furthermore, a modular processing scheme was proposed to track and follow migratory birds in webcam recordings. Techniques such as motion detection by background subtraction, stereo vision and lens distortion were combined to form the foundation of the bird tracking algorithm. Additional research to integrate webcam networks, however, is needed and future research should enforce the potential of the processing scheme by exploring and testing alternatives of each individual module or processing step.

Wiese, F. K., W. A. Montevecchi, et al. (2001). "Seabirds at Risk around Offshore Oil Platforms in the North-west Atlantic." Marine Pollution Bulletin 42(12): 1285-1290.

Seabirds aggregate around oil drilling platforms and rigs in above average numbers due to night lighting, flaring, food and other visual cues. Bird mortality has been documented due to impact on the structure, oiling and incineration by the flare. The environmental circumstances for offshore hydrocarbon development in North-west Atlantic are unique because of the harsh climate, cold waters and because enormous seabird concentrations inhabit and move through the Grand Banks in autumn (storm-petrels, Oceanodroma spp), winter (dovekies, Alle alle, murres, Uria spp), spring and summer (shearwaters*, Puffinus spp*). Many species are planktivorous and attracted to artificial light sources. Most of the seabirds in the region are long-distance migrants, and hydrocarbon development in the North-west Atlantic could affect both regional and global breeding populations. Regulators need to take responsibility for these circumstances. It is essential to implement comprehensive, independent arm's length monitoring of potential avian impacts of offshore hydrocarbon platforms in the North-west Atlantic. This should include quantifying and determining the nature, timing and extent of bird mortality caused by these structures. Based on existing evidence of potential impacts of offshore hydrocarbon platforms on seabirds, it is difficult to understand why this has not been and is not being, systematically implemented.

Wiltschko, R. K. Stapput, P. Thalau, and W. Witschko. 2010. Directional orientation of birds by the magnetic field under different light conditions. J.R. Soc. Interface 7L8163-8177.

This paper reviews the directional orientation of birds with the help of the geomagnetic field under various light conditions. Two fundamentally different types of response can be distinguished. (i) Compass orientation controlled by the inclination compass that allows birds to locate courses of different origin. This is restricted to a narrow functional window around the total intensity of the local geomagnetic field and requires light from the short-wavelength part of the spectrum. The compass is based on radical-pair processes in the right eye; magnetite-based receptors in the beak are not involved. Compass orientation is observed under 'white' and low-level monochromatic light from ultraviolet (UV) to about 565 nm green light. (ii) 'Fixed direction' responses occur under artificial light conditions such as more intense monochromatic light, when 590 nm yellow light is added to short-wavelength light, and in total darkness. The manifestation of these responses depends on the ambient light regime and is 'fixed' in the sense of not showing the normal change between spring and autumn; their biological significance is unclear. In contrast to compass orientation, fixed-direction responses are polar magnetic responses and occur within a wide range of magnetic intensities. They are disrupted by local anesthesia of the upper beak, which indicates that the respective magnetic information is mediated by iron-based receptors located there. The influence of light conditions on the two types of response suggests complex interactions between magnetoreceptors in the right eye, those in the upper beak and the visual system.

Wiltschko, W., U. Munro, et al. (1993). "Red light disrupts magnetic orientation of migratory birds." Nature 364(6437): 525-527.

The transduction mechanisms and the neurophysiological basis of magnetoreception in birds are still largely unexplained, even though the role of the magnetic compass in the orientation of birds is fairly well understood. The discussion on magnetoreception in birds and terrestrial vertebrates focuses mainly on two mechanisms: small particles of magnetite and biochemical bi-radical reactions of excited macromolecules. When the bi-radical hypothesis was first proposed, magnetic resonance phenomena in the retina were suggested as the primary processes, which led to the question of whether magnetoreception was light-dependent. Homing experiments6 and electrophysiological evidence from pigeons have produced evidence consistent with such a mechanism. An effect of the spectral composition of light on magnetic compass orientation in amphibians has recently been described: under blue light of 450 nm and below, newts oriented as they did under the full spectrum, whereas they showed a roughly 90° counterclockwise shift when tested under wavelengths at or above 500 nm. Here we report the first orientation tests on migratory birds under light of different wavelengths; the results suggest a light-dependent process that appears to differ from that reported in newts.

Yen, P. P. W., W. J. Sydeman, et al. (2006). "Spring-time distributions of migratory marine birds in the southern California Current: Oceanic eddy associations and coastal habitat hotspots over 17 years." Deep Sea Research Part II: Topical Studies in Oceanography 53(3-4): 399-418.

ABSTRACT: We used a 17-year time series of shipboard observations to address the hypothesis that marine birds associate with persistent hydrographic features in the southern California Current System (CCS). Overall, approximately 27,000 km of ocean habitat were surveyed, averaging 1600 km per cruise. We identified mesoscale features (eddy centers and the core of the California Current), based on dynamic height anomalies, and considered habitat associations for seven migratory seabird species: black-footed

albatross (*Phoebastria nigripes*), Cook's petrel (*Pterodroma cookii*), Leach's storm-petrel (*Oceanodroma leucorhoa*), dark shearwaters (mainly sooty shearwater *Puffinus griseus*, with a few short-tailed shearwaters *Puffinus tenuirostris*), northern fulmar (*Fulmarus glacialis*), red phalarope (*Phalaropus fulicaria*), and red-necked phalarope (*Phalaropus lobatus*). We explored associations (presence/absence and density relationships) of marine birds with mesoscale features (eddies, current jet) and metrics of primary productivity (chlorophyll a and nitrate concentrations). Mesoscale eddies were consistently identified in the study region, but were spatially and temporally variable. The resolved eddies were large-scale features associated with meanders of the equatorward-flowing California Current. Cook's petrel was found offshore with no specific habitat affinities. Black-footed albatross, red phalarope, and Leach's storm petrel were found in association with offshore eddies and/or the core of the California Current, but the functional relationship for these species varied, possibly reflecting differences in flight capabilities. The more coastal species, including the shearwaters, fulmar, and red-necked phalarope, were positively associated with proxies of primary productivity. Of the hydrographic habitats considered, the upwelling region of Point Conception appears to be an important “hotspot” of sustained primary production and marine bird concentrations. Point Conception and other similar coastal locations (upwelling cells) may warrant protection as key foraging grounds for seabirds.

Appendix B:
Remote Imaging Technology Feasibility Assessment

1.0 Introduction

Preliminary examination of evidence gathered during the spring 2010 field season indicated that interactions between migratory birds and brightly lit offshore oil and gas platforms located on the Pacific Outer Continental Shelf (POCS), while observed to occur in the past (SES 2007), likely happen infrequently and on a schedule difficult to predict. As a result, scheduling the human resources required to make meaningful, detailed quantitative and behavioral observations of such interactions was problematic. Although virtually all-avian migration through the Santa Barbara Channel and San Pedro Basin regions occurs within seasonal windows of a few months each spring and fall, budget limitations accommodated field deployments of only 20-24 days per migration period each season. Moreover, the POCS contains 23 oil and gas production platforms, only a small number of which could be monitored practically by human observers within the limitations of the current study.

Human observer deployment to platforms was scheduled with careful consideration for the breadth of geographic, meteorological, lunar, tidal and other factors identified as possible influences to the occurrence of bird/platform interactions. Yet the Research Team felt that it would be prudent to investigate additional means of recording data during periods when platform observers were not present. Otherwise, we reasoned, we might "miss" ephemeral but important events simply because no trained bird observer happened to be present during their occurrence.

Tests performed with various photographic and video cameras sensitive to both normal and Infrared (IR) light on several platforms during the fall 2010 field effort suggested that imagery could be captured with sufficient resolution to reveal the nighttime presence or absence of birds, and perhaps record limited details describing species composition and behavior. Moreover, the team reasoned that an accurate, "real-time" indicator of bird activity around even a single platform, when accessed on a daily basis through cell phone or internet linkage, might guide tactical assignment of crucial but limited human resources through the course of the field season as it progressed.

Developing a remotely accessible camera system of practical size, durability and cost therefore became a study goal that resulted in a proposal to assemble such a tool. The resulting device was colloquially identified as the "BirdCam." This Appendix describes BirdCam design, deployment and operation, and provides a brief analysis of the imagery it captured during its operation on Platform Gina through part of the fall 2011 field season.

2.0 BirdCam Components

Research into commercially available, remotely operated day/night cameras revealed a surprisingly large number of products. Most were aimed at the hunter/outdoorsman demographic and marketed variously under names like "game camera," "trail camera," "scouting camera" or "hunter's camera." Security cameras were also investigated. Although none of these systems offered the full suite of capabilities we explored with individual high-end components in 2010, several offered impressive camera specifications, software to remotely manage camera operation, field-tested integration with cell phone and internet networks, self-contained solar chargers, and rugged,

weatherproof protection. Costs for operational systems averaged $2,000 to $3,500, with more specialized systems costing more than $10,000 to assemble and custom configure. The components we selected cost under $3,000. Access to imagery recorded by BirdCam and control of its operational parameters was remotely performed through connection to shore-based cellular phone networks.

2.1 Remote Camera Package - BuckEye Cam Orion - Model RC-5030

An integrated, weatherproof, battery operated camera system capable of automatically capturing high resolution still (2048 x 1536 pixels) and video (640 x 480 pixels) images in both visible light and IR. This device was able to store images on an internal disc, and/or transmit them wirelessly to a PC computer located nearby.

2.2 PC Base Computer - Acer Aspire One, 1.6 GHz, 2GB RAM, 300GB disc, with Windows 7

A small notebook computer that made possible the viewing and/or transmission of imagery via Internet or cell phone, and that contained software allowing remote modification of all camera settings. This computer's 300GB hard drive provided abundant, critically important, on-site disc capacity that accommodated back-up storage of all recorded imagery. Figure A-1 provides a schematic of BirdCam's various components.

2.3 Verizon 4G Cellular Modem - LG-VL600 LG VL

A USB connectable, external modem equipped with a cellular antenna that enables linkage with an onshore Verizon cell phone network.

2.4 Ruggedized, 6V Solar Battery Charger

The solar battery charger, consisting of a small solar panel and power converter is the primary means of charging the system's internal batteries and ensuring uninterrupted function and independence from platform power.

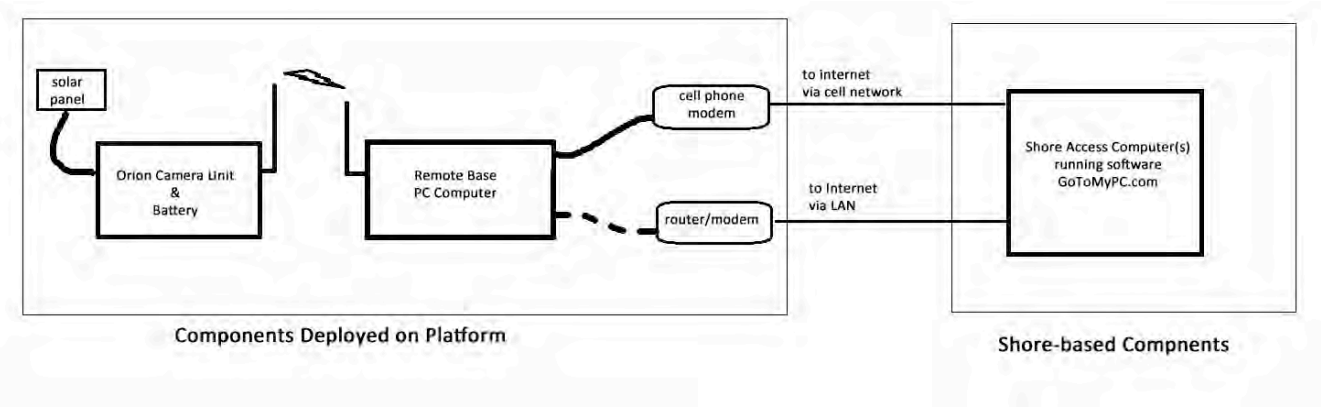

Figure A-1: Figure A-1 schematically shows the configuration of BirdCam's various components.

3.0 Methods

A variety of offshore platforms encompassed by the current study were considered as potential sites for BirdCam deployment and evaluating its proof of concept (Table A-1). Platform Gina was selected as the best site because of its proximity to shore (access to cell phone network antennae); its proximity to researcher residences (people able to perform impromptu troubleshooting); and the results of our 2010 field season (which suggested Platform Gina might experience activity of interest more than others).

TABLE A-1: Platforms considered for deployment of BirdCam listing characteristics important in the selection of ideal deployment location.]

Platform	Approximate Distance from Shore Access Base	Cell Service/Access	Internet Service/Access
Irene	28 miles	No/No	Yes/No
Hermosa	36 miles	Yes/Yes	Yes/No
Habitat	11 miles	Yes/Yes	Yes/No
Edith	10 miles	Yes/Yes	No
Gina	6 miles	Yes/Yes	Yes/No

Offshore platforms are large, multileveled, non-uniformly lighted structures where camera placement so crucial to obtaining useful data is often constrained by operational safety requirements. In this study, BirdCam was located on a subdeck handrail, high above and away from maintenance activity or production equipment (Figure A-2).

From this elevated vantage, pointing toward the southeast, the camera was able to obtain images that show a corner of the platform's upper deck and its lighting fixtures, while also revealing a portion of the sky, open ocean and mainland shore, at the horizon (Figures A-3 and A-4).

Figure A-2: Platform location where BirdCam was located

Photos were captured in an unbroken stream day and night, with a new image recorded every 5 minutes, each at a resolution of 2048 x 1536 pixels, the highest value possible with the given equipment. Depending on degree of illumination, the unit's automatic exposure meter determined whether its normal light or IR camera was operational. Both cameras captured images with nearly Identical framing. Location, date, time of day, moon phase and temperature show as data burned into the picture area. Qualitative characterization of the weather at the time each image was captured is visually observable in each frame. All imagery was recorded as individual JPEG files to the hard disc of the BirdCam's dedicated PC computer.

Figures A-3: Close-up image of BirdCam showing the camera unit in green camouflage box, solar panel and antenna. Note simple attachment to vertical handrail support with hose-clamps and wooden shim.]

FIGURE A-4: The scene captured by BirdCam on 29 May 2011 at 5:20 AM showing the area covered by BirdCam imagery.

4.0 Results

4.1 Data

Between 5 May and 10 June 2011, a 34-day period, BirdCam continuously recorded 9,844 images. Of these, 5,235 were captured "at night" (between the hours of 6:00 PM and 6:00 AM); the remaining 4,609 images were shot during the day when platform lighting was not operational. All images collected by BirdCam on Platform Gina (1.84 GB of data) are contained on the DVD that accompanies this appendix.

Of the 5,235 nighttime images, 110 shots (2%) revealed the presence of a bird on or near the platform. Many of these images record the presence of a single bird that had not moved in the interval between shots. Adjusting for these duplications, the imagery documents only four separate events when individual birds flew, landed or perched on the platform within BirdCam's view. During a period of operation spanning more than 400 hours (34 days times 12 hours per night), BirdCam recorded birds on the platform for a total of 6 hours and 38 minutes. Only one species of bird, western gull (*Larus occidentalis*), was recorded in these images, and in all cases, the pictured birds were shown roosting casually on top of platform equipment or on a handrail within a few feet of bright lights (Figure A-5).

FIGURE A-5: One of the nighttime frames captured by BirdCam while a bird was present within view. First image of pair shows ability to zoom captured image with little loss of resolution.

4.2 Quality of Imagery

Figure A-6 shows a representative example of imagery captured during this study enlarged to its maximum practical magnification. At this magnification, when birds approach platform lighting close enough to be brightly illuminated by it, image resolution is sufficient to reveal pertinent field marks and other details likely to allow identification at least to order, and often to family genus or

species level. In cases where birds approach the platform but remain more than about 100 feet away from the structure, imagery would likely provide less information regarding numbers of birds or their identities.

4.3 System Reliability

Operating as a stand-alone system recording imagery directly to disc, the BirdCam was remarkably robust and dependable. The fact that imagery was continuously stored on local media in the camera unit or on the platform-deployed base computer provided exceptional confidence that important data would be available for evaluation at such time as it proved practical and convenient to retrieve the equipment from the platform and to download stored pictures directly.

Remotely accessing the deployed system from shore proved far less reliable. During those times when a cellular phone network connection could be maintained, the system provided excellent access to imagery recorded on the platform and to the control of the camera system itself. But uninterrupted network connections proved difficult to maintain for more than about 5 days at a time on average.

FIGURE A-6: One of the nighttime frames, enlarged to its maximum practical magnification, captured by BirdCam while a bird was present within view. Resolution is sufficient to conclusively identify the pictured species, which is a western gull (*Larus occidentalis*).

Like conventional cell phone calls, which are notoriously liable to be "lost" unexpectedly for reasons difficult to determine or prevent, the BirdCam connection with on-shore cell networks frequently experienced "drop out" that rendered the remote access aspects of the system inoperable. Once the connection between BirdCam and shore has been broken, it can only be reestablished again through the actions (a single mouse click on the BirdCam's deployed computer) of someone on the platform. Without the generous assistance of the operations staff on Platform Gina, maintaining consistent remote access with BirdCam through the extended field season would not have been possible

Despite numerous efforts to troubleshoot the issue of remote access reliability, we were unable to determine the causes of the network interruptions we experienced. Communication with Verizon support staff strongly suggested that the problem lay in the limitations of the cellular network itself, not in the BirdCam system or the way in which it was deployed. Improvements in cellular technology may improve reliability of this feature in the future. Programming the platform base computer to automatically disconnect and then reconnect on a set schedule (e.g., every day at noon), regardless of whether network connections were operable, might improve dependability in this regard or enabling the BirdCam to connect to a platform's WIFI network.

5.0 Discussion

Periodic remote examination of BirdCam imagery recorded on Platform Gina during the spring 2011 field season indicated that a five-minute interval provided a good balance between temporal detail (i.e. how often an image was captured) and the project staffing resources required to examine and evaluate the resulting data. BirdCam's photo interval could have been modified remotely during the field season to shoot stills images or videos taken more frequently had such modification been deemed desirable. The detail and resolution of BirdCam images allowed species identification and gross characterization of behavior in most cases where birds were present.

Because of operator placement requirements, BirdCam imagery recorded on Platform Gina captured only one corner of one of the structure's upper decks, and therefore presents only a limited picture of events that might have occurred out of view. Moreover, in its present configuration, which employs the supplied IR camera, BirdCam is capable of "seeing" to only a limited degree out into the dark beyond the reach of platform lighting. The addition of more camera units, and the addition of true "night-vision," heat-sensing cameras to each of them would improve the scope of captured imagery and increase its interpretive power.

Even operating within the limitations of its current design iteration, BirdCam images provide a pool of continuous, remote observations that agree with and validate the intermittent observations of human investigators collected on this and other platforms during this study; that few birds are observed attracted to or using the platforms at night.

BirdCam's intended use in the study was two-fold. To 1) test BirdCam's Proof of Concept and 2) could BirdCam detect birds exhibiting light entrapment behavior (i.e., circling the platform continuously for a prolonged period of time and/or striking platform lights and structures) as reported by SES (2007). The images gathered by BirdCam over the 34-days of its deployment showed no evidence of birds exhibiting light entrapment behavior.

BirdCam's placement on platform Gina, although not ideal, provided an effective view from one corner of the platform that would have been expected to be able to capture birds flying in close proximity to the platform or colliding with the deck lights. Even though images were collected every 5-minutes, it can be assumed that if any birds had been entrapped by platform lights that BidCam's placement and focal length (100 feet) would have recorded it. Review of the 5,235 low light and IR nighttime images revealed no evidence of birds flying past the platform or behaving in an erratic manner. This fact may be the result of limitations in BirdCam to detect and record birds flying past the platform, that very few birds flew past the platform at night, or that birds flew past the platform during the 5-minute interval when BirdCam was not recording an image. Additional deployment of BirdCam will be necessary to fully evaluate its capabilities for nighttime observations along with side-by-side human/camera observations to validate its effectiveness and accuracy.

6.0 Conclusion

Sporadic, ephemeral events are difficult to predict and challenging to observe, especially when resources necessitate that human observers be deployed on a schedule that samples only some of the possible times when significant events might occur.

BirdCam, while not a substitute for human observation, provides an inexpensive visual technology for recording observational data on a nearly continuous schedule whose collected data can be accessed for real time review via an Internet connection. In the case of this study, it provided additional data that corroborated the more general conclusions drawn from the results of human observations made during the same time period. By adding to and improving upon BirdCam's present configuration of components, this kind of device has the potential to provide long-term continuous data sets on bird presence and behavior at POCS platforms. In its current configuration, it will never replace human observers, but as intended, it is capable of gathering Internet accessible observation data that can alert scientists to the occurrence of unusual bird presence or behavior that can be followed up quickly with human observation. Key to its effectiveness is the deployment location on the platform and its connectivity to the Internet, preferably via a WIFI connection rather than a cell phone connection.

BirdCam Images

Appendix C
Bird & Weather Field Observation Sheets (CD)