Herpetological Conservation and Biology 9(2):524−534.
Submitted: 12 May 2014; Accepted: 31 October 2014; Published: 31 December 2014.

NESTING CHARACTERISTICS OF OLIVE RIDLEY TURTLES (*LEPIDOCHELYS OLIVACEA*) ON EL NARANJO BEACH, NAYARIT, MEXICO

CATHERINE E. HART[1,2,6], CESAR LEY-QUIÑONEZ[3], ADRIAN MALDONADO-GASCA[4], ALAN ZAVALA-NORZAGARAY[3], AND F. ALBERTO ABREU-GROBOIS[5]

[1]*Centro Universitario de la Costa, Universidad de Guadalajara, Av. Universidad No. 203, 48280, Puerto Vallarta, Jalisco, México*
[2]*Red Tortuguera A.C., Tepic, Nayarit, México*
[3]*Instituto Politécnico Nacional, CIIDIR Unidad Sinaloa, Juan de Dios Bátiz Paredes No. 250, Col. San Joachin, 81101, Guasave, Sinaloa, México*
[4]*Instituto Tecnológico de Bahía de Banderas, La Cruz de Huanacaxtle, Bahía de Banderas, Nayarit, México*
[5]*Laboratorio de Genética, Unidad Académica Mazatlán, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Mazatlán, Sinaloa, México*
[6]*Corresponding author, e-mail: cehart03@gmail.com*

***Abstract.*—We analyzed relative abundance of nesting Olive Ridley Turtles, *Lepidochelys olivacea,* on El Naranjo beach, Mexico during 1993–2010, as well as seasonal and spatial distribution of nesting, size of nesting females, and hatching success of nests incubated artificially in polystyrene boxes. El Naranjo beach is located in Bahia de Jaltemba, Nayarit, Mexico where a local *non-governmental organization* protects a total of 8.3 km of coastline on the north side of the bay. A total of 2,571 nests were protected *ex situ* with a mean annual 144.5 ± 77.0 (mean ± SD) protected nests (range: 48–267), and 9,457 ± 5,424, hatchlings released (range: 1,850–23,467). During the months of beach monitoring (June-November) significant differences were observed in number of nesting events per month, with maximum nesting occurring between August–October. A total of 57 nesting females were measured during 2009 (n = 18) and 2010 (n = 39). Mean curved carapace length and width was 65.5 cm and 70.7 cm, respectively. Overall hatching success was a relatively high 74.7%. We recommend further research into artificial methods of incubation as this can be an important option in maintaining some populations of sea turtles.**

Key Words.—artificial incubation; nests; reproduction; sea turtles; solitary nesting

INTRODUCTION

The Olive Ridley Turtle (*Lepidochelys olivacea*) is the most abundant of all sea turtles (Pritchard 1997). Currently listed as *vulnerable* by the *International Union for Conservation of Nature (*IUCN), its population continues to decline (IUCN Red List of Threatened Species. Available from http://www.iucnredlist.org [Accessed 08 May 2014]). In Mexico, all sea turtles are categorized as endangered of extinction in the Mexican Red List (NOM-059-SEMARNAT-2010) due to several factors including the illegal harvest of turtles and their eggs and nesting habitat destruction (Diario Oficial de la Federación 2010).

Nesting by Olive Ridley Turtles is reported throughout the tropics with each female laying a mean clutch size of 105.3 eggs (Marquez 1990). This species has two reproductive strategies: mass nesting events known as arribadas and solitary nesting (Bernardo and Plotkin 2007; Tripathy 2008). On the Pacific coast of Mexico, both strategies have been reported (Eguchi et al. 2007).

Olive Ridley Turtles reach reproductive age relatively quickly at 13 y old (Zug et al. 2006) in comparison to some other sea turtle species (Loggerhead, *Caretta caretta*, ca. 30 y; Snover 2002). Nesting females lay between one and three clutches each year (Pritchard and Plotkin 1995) which is relatively low compared to Leatherbacks (*Dermochelys coriacea*, mean: 7 clutches; Reina et al. 2002), Loggerheads (mean: 3.2 clutches; Hawkes et al. 2005) and East Pacific Green Turtles (*Chelonia mydas agassizii*, mean: 3.1 clutches; Alvarado-Diaz et al. 2003). Annual remigration for nesting allows for easier detection of patterns in Olive Ridley populations which often demonstrate a year-to-year increase in nesting unlike the more erratic nesting trends seen in species with longer remigration periods (Miller 1997; Broderick et al. 2002; Schroeder et al. 2003).

In the East Pacific, Olive Ridley Turtles nest from the state of Baja California Sur in Mexico (Lopez-Castro et al. 2004) to Peru (Kelez et al. 2009) with nesting reported from July to March (Garcia et al. 2003). In the state of Nayarit, Mexico (Fig. 1), published information

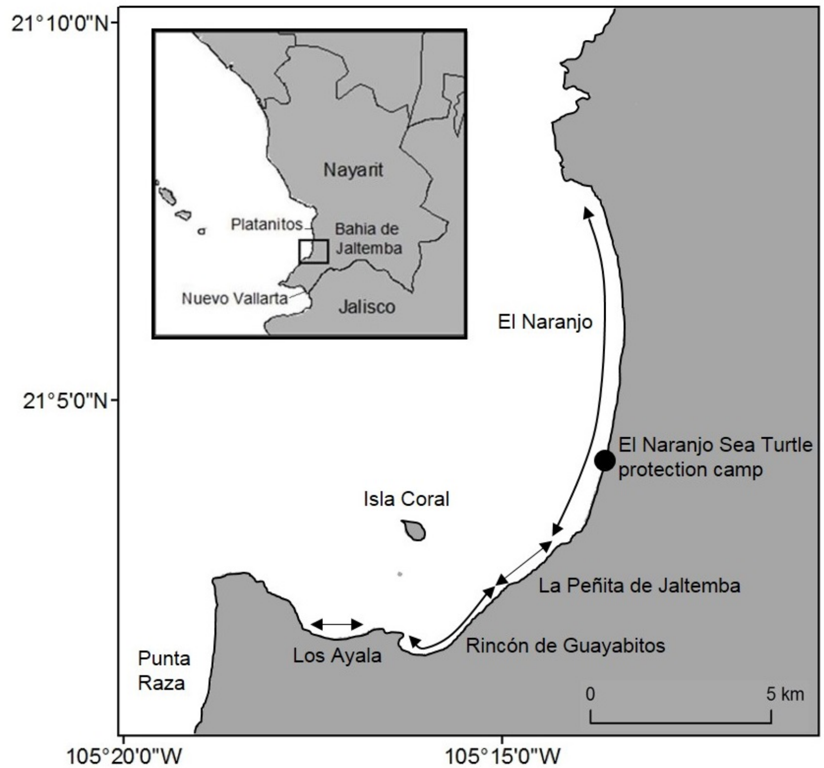

FIGURE 1. Location of Olive Ridley Turtle (*Lepidochelys olivacea*) nesting beaches and El Naranjo sea turtle protection camp in the Bahía de Jaltemba, Nayarit, Mexico.

of sea turtle nesting is lacking despite a 30 y history of conservation projects in the area. Although Bernardo and Plotkin (2007) estimated fewer than 10 Olive Ridley nests per year in Nayarit, Rodríguez-Zárate et al. (2013) report between 1,001–5,000 nests per year on Platanitos and Nuevo Vallarta beaches in this state. In Mexico, conservation of nesting beaches has largely taken the form of intensive beach management. Beaches are patrolled and eggs are collected from nests and transported for reburial in fenced-off beach hatcheries (Garcia et al. 2003) or placement in polystyrene boxes for artificial incubation (Arzola-González 2007). The aim of these practices is to increase hatching success by reducing hatchling mortality due to poaching, natural predators, changes in beach characteristics and meteorological events such as storm flooding and hurricanes(Garcia et al. 2003; Cornelius et al. 2007; Van Houtan and Bass 2007).

Artificial incubation of sea turtle eggs has been criticized (Mrosovsky 1982), but is a common practice in Mexico with 40% of camps registered with the National Protected Areas Commission (CONANP) on the central Pacific coast reporting artificial incubation of some or all nests during 2010 (Brown 2011). The bi-national Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) project used Styrofoam boxes to translocate and incubate more than 20,000 eggs from Mexico to the USA between 1978 and 1988 (Shaver 2005) where they were allowed to crawl down the beach at Padre Island before entering captivity (Fontaine and Shaver 2005). Hatchlings were maintained in captivity for a year and subsequently released into the Gulf of Mexico. Between 1996 and 2002, a total of 23 nesting females in Texas, USA were identified as having been reared through this head-starting project (Shaver and Wibbels 2007).

There has been much debate over the effect of moving nests from their original location to modified environments (Arzola-González 2007; Mrosovsky 2008). Such nests may experience differences in hatching success (Garcia et al. 2003) and sex ratios (Dutton et al. 1985) compared with those left *in situ.* Nests incubated in polystyrene boxes may experience cooler temperatures than those left on nesting beaches both *in situ* and in fenced off beach hatcheries (Arzola-González 2007). This is important as incubation temperature determines the sex of hatchlings, with cooler temperatures yielding male-biased sex ratios and warmer nests producing mainly female turtles (Mrosovsky 1994).

Information on Olive Ridley Turtle nesting in the Bahia de Jaltemba, Nayarit has been collected during conservation activities since 1993 by the *non-*

governmental organization (*NGO*) Grupos Ecologistas de Nayarit A.C. Herein we evaluate the spatial and temporal use by Olive Ridley Turtles on the main nesting beach El Naranjo to evaluate the current status of this rookery. We also assess hatching success of nests incubated artificially in Styrofoam boxes to provide information for future conservation efforts.

Materials and Methods

Study site.—The Bahia de Jaltemba is located in the state of Nayarit, Mexico (Fig. 1). The bay contains four solitary Olive Ridley Turtle nesting beaches: Rincon de Guayabitos (length 4 km), La Peñita de Jaltemba (2 km), Los Ayala (2 km), and El Naranjo (8.3 km). The majority of nesting is reported to occur where the El Naranjo Sea Turtle protection camp is located (21°4'0.89"N, 105°14'3.31"W). With the exception of El Naranjo, the nesting beaches are developed with hotels, condominiums and residential housing, and no longer have a dune system. Mangrove swamps exist behind El Naranjo beach which open to the sea during the rainy season.

Field surveys.—We recorded nesting on El Naranjo beach between 1993 and 2010. We monitored beaches two nights per week from 1993–1999 and seven nights a week from 2000 to 2010. We carried out field surveys on El Naranjo beach on foot or using a quad bike during peak nesting from July to November. During night time surveys, we patrolled the nesting beach at 2100, 0100, and 0500. We collected nests and transferred them to the turtle protection camp. We recorded the time that each nest was found and beach section in which nest was located (section 1 = km 0–2.7; section 2 = km 2.8–5.5; section 3 = km 5.6–8.3). Only data from 2001, 2002, 2004, 2006, 2007, 2009, and 2010 were available for analyses. During 2007 and 2009, we recorded the beach zone in which the female turtle nested. We classified sections as Intertidal (beach face to the berm), Open Beach (the berm to the vegetation line) and Beach (vegetation line to the dune). We measured the standard (notch to tip) curved carapace length (CCL) and curved carapace width (CCW) of nesting females during the 2009 and 2010 nesting seasons.

Nest data.—We incubated all nests artificially in polystyrene boxes (40 cm × 30 cm × 50 cm, wall thickness of 2 cm). The bottom of the boxes were pierced with 0.5 cm holes spaced at intervals of approximately 5 cm to allow for drainage (Mortimer 1999). We kept nests in the incubation room located within the turtle protection camp. The incubation room was constructed from corrugated metal laminates with a space of 30 cm between the top of the wall and the roof to allow for ventilation. We did not control or monitor temperature and humidity during conservation activities.

Hatchling data.—We evaluated nests once 20 hatchlings had emerged from the sand. We analyzed the hatching success of artificially incubated nests from 1993 until 2010 by calculating the proportion of live and dead neonates among the total number of eggs laid in each nest.

Statistical analysis.—To compare data from years with different monitoring effort, we present the number of nests documented per night (Fig. 2a). This was calculated by dividing the total number of nests documented during a given season by the number of days monitored. Arithmetic means are accompanied by ± standard deviation (SD). We used Kolmogorov-Smirnov test (KS) to determine data distribution and all data were normal. We used one-way analysis of variance to test for differences among number of nests per beach section, season, and month. Tukey's test was used for multiple comparisons in the event of a significant difference. We performed all statistical analyses using Minitab® 17.1.0 (Minitab Inc., State College, Pennsylvania, USA). We used a simple linear regression model for correlating the size of the adult females with the corresponding number of eggs. For all tests, $\alpha = 0.05$.

Results

Population trend.—The mean annual number of Olive Ridley Turtle nests recorded during intensive seven day per week beach monitoring (seasons 2000–2010) was 195.6 ± 51.1 (range: 93–267), and mean annual number of hatchlings released from artificially incubated nests during the same period was 12,610 ± 4,700 (range: 7,125–23,467). If we consider that Olive Ridley Turtles lay a mean of two clutches per season (range: 1–3; Pritchard and Plotkin 1995), then we estimate the current nesting population to be 98.3 females. Mean nesting density (seasons 2000–2010) was 24.5 nests per km of beach. Number of nests we relocated per day of monitoring was highest in 1995 with a mean of 2.0 nests per day and lowest in 2003 with 0.7 nests per day. Mean number of nests relocated per day during the entire study was 1.4 ± 0.4.

Hatching success.—Annual hatching success was variable during the study period (Fig. 2b) but did not fall below a 50% success rate. Hatching success was greatest in 2004 when 95.4% of eggs hatched producing 10,416 turtles, the lowest hatching success was registered in 2005 with only 50.3% of eggs hatching resulting in 7,302 turtles. Overall mean hatching success

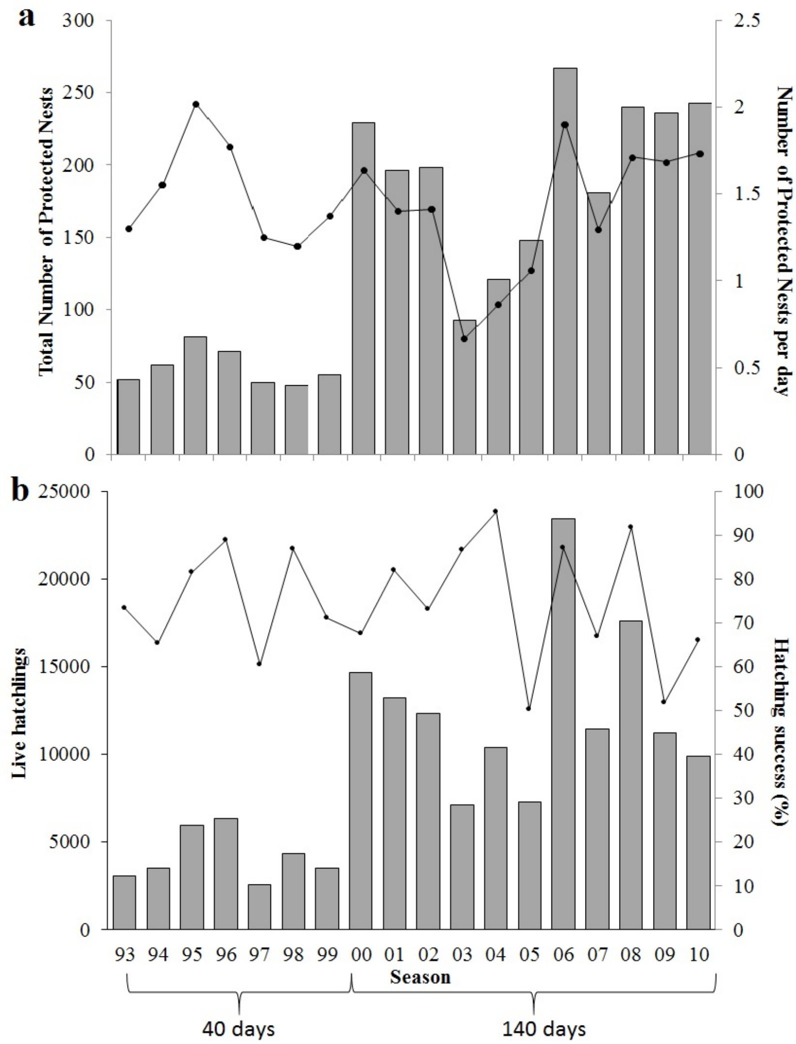

FIGURE 2. (a) Total number of Olive Ridley Turtle (*Lepidochelys olivacea*) nests protected (grey bars) and nests relocated per monitored day (black circles) between 1993–2010. (b) Total number of Olive Ridley hatchlings released per season (grey bars) and percentage hatching success per season (black circles) on El Naranjo beach.

was 74.7%. Number of hatchlings released varied between 2,555 in 1997 and 23,467 in 2006.

Seasonality.—Although conservation efforts do not cover the whole of the Olive Ridley Turtle nesting season reported for the central Mexican Pacific (July-March; Garcia et al. 2003), in 10 years of monitoring on El Naranjo beach (2001–2010), we observed a mean of 35.9 (± 15.4, range = 1–95) nesting events per monitored month. We found significant differences ($F_{5,54}$ = 10.43; P = 0.009) among the months of beach monitoring (June-November), with maximum nesting occurring between August-October (Fig. 3).

Spatial distribution of nesting.—We found significant differences in the number of nests ($F_{2,529}$ = 5.08; P = 0.033) among beach sections. Turtles nested with significantly greater frequency in beach sections 1 and 2 compared with section 3 (P < 0.05; Fig. 4). Beach section 2, with 46.9% of nesting, had little human development. Section 1, with 40.9% of nesting, was backed by the local town La Colonia Paraiso Escondido; however, differences between these two sections were not significant. The area with lowest nesting was section 3 with 12.2% of nests, a zone characterized by mangrove habitat. In 2007 and 2010, there were no significant differences between beach zones ($F_{2,320}$ = 0.16, P = 0.710). There were, however, significant differences ($F_{2,320}$ = 15.06, P = 0.027) between beach zones for

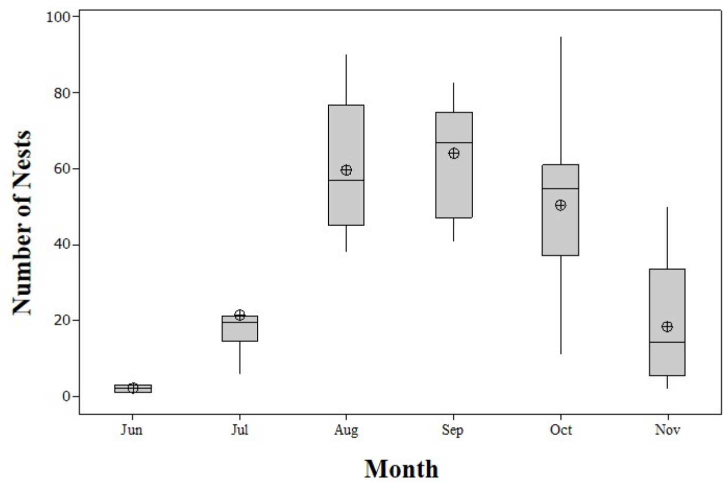

FIGURE 3. Mean seasonal variability of total nests laid (2001, 2002, 2004, 2006, 2007, 2009, 2010). Differences among months were significant (KS: $P = 0.056$; ANOVA: $F_{5,54} = 10.43$; $P = 0.009$). Box plots are the central 50% of data. The three horizontal lines of the box plots represent quartiles (25%, 50%, and 75% of the distribution) and the vertical lines represent the range. The circle is the mean value for each box plot.

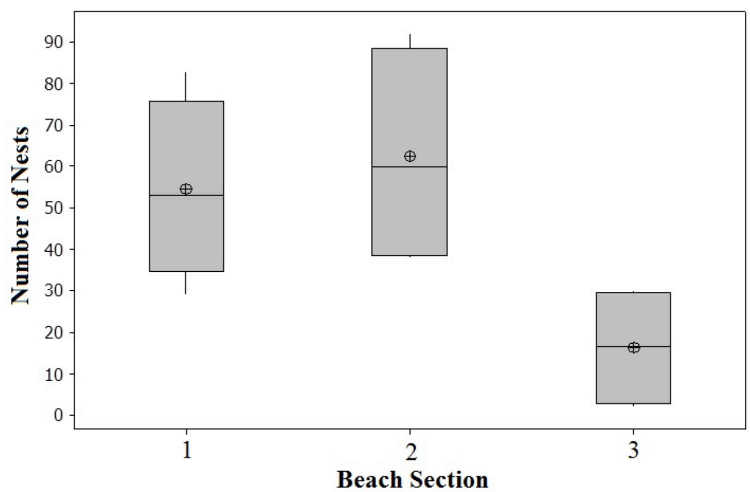

FIGURE 4. Beach section along the length of El Naranjo beach. Section 1 = km 0–2.7; Section 2 = km 2.8–5.5; Section 3 = km 5.6–8.3. Differences among beach sections were significant (KS: $P = 0.150$; ANOVA: $F_{2,529} = 5.08$; $P = 0.033$). Box plots are the central 50% of data. The three horizontal lines of the box plots represent quartiles (25%, 50%, and 75% of the distribution) and the vertical lines represent the range. The circle is the mean value for each box plot.

2007 and 2010 combined (Fig. 5), with more nests documented in Open Beach (82.7%) compared with Intertidal (12%) or Beach (5.2%) zones.

Female size.—We measured 57 nesting females during 2009 (n = 18) and 2010 (n = 39). Mean curved carapace length (CCL) and width (CCW) was 65.5 cm (55–72 cm) and 70.7 cm (66–76 cm), respectively. There was no significant relationship between the size of the adult females and number of eggs laid ($r^2 = 0.044$; $P = 0.140$).

DISCUSSION

Trends.—The number of nests protected at El Naranjo demonstrates the success of conservation efforts in reducing poaching. Poaching of nests remains a problem along the Pacific coast of Mexico with large numbers of nests being taken for human consumption on unprotected beaches (Garcia et al. 2003). Mean nesting density during intensive beach monitoring (seven nights per week) was 23.6 nests per km of beach which is lower than nesting density reported on beaches in Jalisco where densities have been reported to vary between 30 to 150 nests per km (Garcia et al. 2003). However the

FIGURE 5. Number of nests laid in each beach zone. Intertidal: beach face to the berm; Open beach: the berm to the vegetation line and Beach: vegetation line to the dune. Statistical differences (KS: $P = 0.056$; ANOVA: $F_{2,320} = 15.06$; $P = 0.027$). Box plots are the central 50% of data. The three horizontal lines of the box plots represent quartiles (25%, 50%, and 75% of the distribution). The circle is the mean value for each box plot.

nesting density for Olive Ridley Turtles is lower in Baja California Sur (BCS) with 300 to 400 nests reported per season (UABCS/WWF. 2004) for the southern point of the peninsula. Specifically a mean density of 2.55 nests per ha was reported on Las Barracas Beach, BCS during 2000 (Lopez-Castro et al. 2004).

Although nesting density at El Naranjo beach is low compared with beaches further south, conservation efforts on El Naranjo beach remain important. The conservation project's location close to Rincon de Guayabitos, a popular tourist destination for people from surrounding cities of Tepic and Guadalajara allows for large numbers of people to receive environmental education and participate in outreach activities through which human consumption of turtles and their byproducts may be reduced (Schneller and Baum 2011). Depredated nests (by humans or other animals) were not consistently recorded by the community conservationists and therefore could not be included and so the true nesting density may be higher. The change in monitoring effort from 1999 to 2000 (two to seven nights a week) is the cause for the increase in recorded nests and not a result in changes in Olive Ridley Turtle population's breeding effort. However, when we consider the number of nests relocated per day of monitoring during the entire study (1993–2010) mean daily nests per season (June-November) has varied between 0.7 and 2.0 nests per day of monitoring with no discernible pattern.

Mean hatching success.—Mean hatching success from Olive Ridley Turtle nests incubated in polystyrene boxes at El Naranjo sea turtle protection camp is higher than the values reported for Olive Ridley nests in the Mexican states of Baja California (Lopez-Castro et al. 2004), Sinaloa (Arzola-Gonzalez 2007), Jalisco (Garcia et al. 2003), and Indonesia (Maulany et al. 2012), regardless of incubation technique (Table 1). Hatchlings do not need to expend the same amount of energy emerging from a nest incubated in a Styrofoam Box than those incubated in beach hatcheries or in natural nests as there is only a few cm of sand above the eggs. Also, since nests incubated in boxes are often cleaned sooner than hatchery nests to reduce the number of hatchlings unable to emerge from the bottom level of the nest due to the confined environment, the number of hatchlings that die within the nest chamber is reduced compared with the mortality within other incubation methods. In well managed incubation rooms were pests species are controlled, nests within polystyrene boxes are less likely to be infected than those within beach hatcheries where pests are harder to control as they can pass from nest to nest with little impediment. The relatively low level nesting at El Naranjo beach allows managers to dedicate more time to checking and cleaning nests once the hatchlings from the first level of eggs emerge, and this may be a reason for the high hatching success at this project. Projects that have greater number of nests

Table 1. Comparison of reported hatching success (%) data for Olive Ridley Turtles (*Lepidochelys olivacea*). Polystyrene box: Clutch incubated within polystyrene box; Beach Hatchery: Fenced off area of beach where clutches are moved and reburied for protection against predators; *in situ*: nest left undisturbed in the nest cavity excavated by the female turtle. BCS: Baja California Sur. Ten nests from BCS, Mexico (*) were affected by a storm and were removed from the analysis.

Incubation Method	Success (%)	Area	Sample size (nests)	Author
Polystyrene Box	74.7 (±13.5)	Nayarit, Mexico	2571	Present study
In situ	73.7	BCS, Mexico	45*	Lopez-Castro et al. 2004
In situ	67.9	Sinaloa, Mexico	1071	Arzola-Gonzalez 2007
Beach Hatchery	64.1	Sinaloa, Mexico	926	Arzola-Gonzalez 2007
Polystyrene Box	46.9	Sinaloa, Mexico	969	Arzola-Gonzalez 2007
In situ	66	Jalisco, Mexico	ND	Garcia et al. 2003
Beach Hatchery	59	Jalisco, Mexico	130	Garcia et al. 2003
In situ	0	Indonesia	30	Maulany et al. 2012
Beach Hatchery	54.2–73.6	Indonesia	109	Maulany et al. 2012

usually use beach hatcheries. Projects with large numbers of nesting females may be slower in getting nests from where the female laid them and into a beach hatchery as they often need to stop multiple times during a beach patrol to wait for multiple females to finish laying her eggs and/or collect recently laid nests. This means that many hours may have passed between collecting the first nest of the patrol and its incubation within the hatchery and may be a cause for lower hatching success in some hatcheries.

Seasonality.—Nesting seasonality on El Naranjo beach is similar to that of the majority of Olive Ridley Turtle nesting rookeries studied in the East Pacific (Drake 1996; Garcia et al. 2003; Lopez-Castro et al. 2004). Olive Ridley Turtles are reported to nest year round but typically exhibit a distinct nesting peak during the rainy season. Due to limited resources, protection of nests was focused on those months with the highest levels of nesting. Nonetheless, limiting conservation efforts to the peak nesting period may hinder the ability to identify changes in seasonality that have occurred at numerous sea turtle rookeries worldwide (Weishampel et al. 2004; Pike et al. 2006; Hawkes et al. 2007). However, limiting nest protection to the rainy season nesting peak allows for small-scale community conservation projects to be economically viable. These projects protect nests and beaches that would most likely be overlooked by governments and larger NGOs. However, protecting reduced rookeries is important to help conserve genetic diversity and species distribution (McClenachan et al. 2006). Community conservation projects are often responsible for the protection of such sites as they often operate in areas close to towns where sea turtle populations were previously abundant but are now diminished due to habitat modification and human depredation of turtles and their nests.

Location of nesting.—Most nesting occurred in section 2 of the 8.3 km-long beach, where lighting (present in section 1) and mangrove habitat (present in section 3) are absent. The latter section has a population of American Crocodiles (*Crocodylus acutus*), that may occur on the beach at night during turtle nesting season (Catherine E. Hart, pers. obs.), and this could explain why turtles use this section less frequently. With regard to beach zone, turtles preferred to nest on the open beach from the berm to the vegetation line which is typical of Olive Ridley Turtles as reported in previous studies (Lopez-Castro et al. 2004). This beach zone may be chosen for presenting adequate temperature and humidity for successful nest incubation (Arzola-González 2007). Moreover the energetic costs of nesting and likelihood of disorientation of female turtles may be reduced. However the selection of Open Beach may result in the loss of nests due to beach erosion (Spanier 2010).

Artificial incubation of nests has been criticized due to the possible modification of temperatures and therefore sex ratios (Mrosovsky 1982; Dutton et al. 1985). This technique is still widely employed within community conservation projects due to benefits including reduced cost and space. Although initial investment is needed in the construction of an incubation room and equipment to monitor temperature and humidity, for small scale projects, long-term cost is often reduced compared with protecting nests *in situ* spread out over many kilometers where poachers greatly out-number conservationists. Beach hatcheries have many similar costs to incubation in boxes (hatchery construction and temperature monitoring) with the added need for someone to be employed to look after the hatchery during the day. Space needed for incubation is reduced as nests can be stacked vertically which is useful where suitable incubation habitat no longer exists or is at a premium due to coastal development. Since the passing of a new law in 2012 to regulate the methods used in sea turtle nesting conservation projects (Diario Oficial de la Federación 2013), the use of polystyrene boxes is being actively discouraged by the Mexican conservation authorities but continue to be used as a contingency method in the event of beach erosion, extreme temperatures, and theft from beach hatcheries. We recommend further research into the effects of artificial methods of incubation on sea turtle embryos and the resulting hatchlings as under certain circumstances (e.g., high levels of nest depredation, beach erosion, and extreme climatic conditions) artificial incubation remains a viable option to maintain certain sea turtle populations.

Community conservation projects are key to the protection of widely distributed species vulnerable to exploitation. Through community grass roots activities, populations can be maintained while human use of turtles can be reduced or redirected (ecotourism), and local perceptions of a species' ecological values can be enhanced. Nevertheless, care must be taken to ensure the collection and storage of useful data, not only to evaluate project success, but also to identify trends in the species studied. Clearly, all nesting activities: nest, stolen/depredated nests, and false crawls need to be recorded consistently. The recording of data on monitoring effort including number of km patrolled per night would be useful at this project and others in the area so as to be able to compare number of nests per unit effort among beaches. Hatching success was relatively high in artificially incubated nests but if this incubation method is to be continued, temperature and humidity should be monitored and maintained at suitable levels. We recommend that a number of nests should be left *in situ* (if predation is controlled) and in a beach hatchery per season so as to provide information on hatching success for these methods for this rookery. The information presented here on hatching success and nesting density constitutes essential baseline information against which future results can be compared and only thus can trends be gauged and conservation gains be evaluated.

Acknowledgments.—The El Naranjo Sea Turtle protection camp has been supported by thousands of members of the public since its beginnings in 1993. The NGO Los Grupos Ecologistas de Nayarit A.C. has been responsible for the project during its entire history and we thank Vicente Peña Aldrete, Ricardo Villaseñor, and Cesar Altamirano Vazquez for their dedication to sea turtle conservation in the Bahia de Jaltemba. We acknowledge the support of Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) with special mention to Jesus Romero for issuing of permits, and Secretaría de Desarrollo Social (SEDESOL) for funding received during various sea turtle nesting seasons. CEH would like to thank the Consejo Nacional de Ciencia y Tecnología (CONACYT) Mexico for support through a Ph.D. Scholarship.

LITERATURE CITED

Alvarado-Diaz, J., E. Arias-Coyotl, and C. Delgado-Trejo. 2003. Clutch frequency of the Michoacan Green Sea Turtle. Journal of Herpetology 37:183–185.

Arzola-Gonzalez, J.F. 2007. Humedad y temperatura en nidos naturales y artificiales de Tortuga Golfina *Lepidochelys olivacea* (Eschssholtz 1829). Revista de Biología Marina y Oceanografía 42:377–383.

Bernardo, J., and P.T. Plotkin. 2007. An evolutionary perspective on the *arribada* phenomenon and reproductive behavioral polymorphism of Olive Ridley Sea Turtles (*Lepidochelys olivacea*). Pp. 59–87 *In* Biology and Conservation of Ridley Sea Turtles. Plotkin, P.T. (Ed.). The Johns Hopkins University Press, Maryland, USA.

Broderick, A.C., F. Glen, B.J. Godley, and G.C. Hays. 2002. Estimating the number of Green and Loggerhead Turtles nesting annually in the Mediterranean. Oryx 36:227–235.

Brown, L. 2011. The effects of artificial incubation on Olive Ridley (*Lepidochelys olivacea*) hatchlings. Undergraduate Dissertation, University of Exeter, Penryn, Cornwall, UK. 32 p.

Cornelius, S.E., R. Arauz, J. Fretey, M.H. Godfrey, R. Marquez-M, and K. Shanker. 2007. Effect of land-based harvest of *Lepidochelys*. Pp. 231–251 *In* Biology and Conservation of Ridley Sea Turtles. Plotkin, P.T., (Ed.). The Johns Hopkins University Press, Maryland, USA.

Diario Oficial de la Federación. 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010. Protección Ambiental-Especies Nativas de México de Flora y Fauna Silvestres-Categorías de Riesgo y Especificaciones para su Inclusión, Exclusión o Cambio-Lista de Especies en Riesgo. Diario Oficial de la Federación, D.F., México. 19 p.

Diario Oficial de la Federación. 2013. Norma Oficial Mexicana NOM-162-SEMARNAT-2012. Que establece las especificaciones para la protección, recuperación y manejo de las poblaciones de las tortugas marinas en su hábitat de anidación. Diario Oficial de la Federación, D.F., México.

Drake, D.L. 1996. Marine turtle nesting, nest predation, hatch frequency, and nesting seasonality on the Osa Peninsula, Costa Rica. Chelonian Conservation and Biology 2:89–92.

Dutton, P.H., C.P. Whitmore, and N. Mrosovsky. 1985. Masculinisation of Leatherback Turtle *Dermochelys coriacea* hatchlings from eggs incubated in Styrofoam boxes. Biological Conservation 31:249–264.

Eguchi, T., T. Gerrodette, R.L. Pitman, J.A. Seminoff, and P.H. Dutton. 2007. At-sea density and abundance estimates of the Olive Ridley Turtle *Lepidochelys olivacea* in the eastern tropical Pacific. Endangered Species Research 3:191–203.

Fontaine, C., and D. Shaver. 2005. Head-starting the Kemp's Ridley Sea Turtle, *Lepidochelys kempii*, at the NMFS Galveston Laboratory, 1978–1992: A review. Chelonian Conservation and Biology 4:838–845.

Garcia, A., G. Ceballos, and R. Adaya. 2003. Intensive beach management as an improved sea turtle conservation strategy in Mexico. Biological Conservation 111:253–261.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2005. Status of nesting Loggerhead Turtles *Caretta caretta* at Bald Head Island (North Carolina, USA) after 24 years of intensive monitoring and conservation. Oryx 39:65–72.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2007. Investigating the potential impacts of climate change on a marine turtle population. Global Change Biology 13:1–10.

Kelez, S., X. Velez-Zuazo, F. Angulo, and C. Manrique. 2009. Olive Ridley *Lepidochelys olivacea* nesting in Peru: The Southernmost Records in the Eastern Pacific. Marine Turtle Newsletter 126:5–9.

Lopez-Castro, M.C., R. Carmona, and W.J. Nichols. 2004. Nesting characteristics of the Olive Ridley Turtle (*Lepidochelys olivacea*) in Cabo Pulmo, southern Baja California. Marine Biology 145:811–820.

Marquez, R. 1990. FAO Species Catalogue. Sea turtles of the World. An annotated and illustrated catalogue of sea turtle species known to date. FAO Fisheries Synopsis, 11 (125).

Maulany, R.I., D.T. Booth, and G.S. Baxter. 2012. Emergence success and sex ratio of natural and relocated nests of Olive Ridley Turtles from Alas Purwo National Park, East Java, Indonesia. Copeia 2012:738–747.

McClenachan, L., J.B.C. Jackson, and M.J.H. Newman. 2006. Conservation implications of historic sea turtle nesting beach loss. Frontiers in Ecology and the Environment 4:290–296.

Miller, J.D. 1997. Reproduction in sea turtles. Pp. 51–81 *In* The Biology of Sea Turtles. Lutz, P., and J.A. Musick (Eds.). CRC Press, Boca Raton, Florida, USA

Mortimer, J.A. 1999. Reducing threats to eggs and hatchlings: hatcheries. Pp. 175–178 *In* Research and Management Techniques for the Conservation of Sea Turtles. Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois, and M. Donnelly (Eds.). Consolidated Graphic Communications, Blanchard, Pennsylvania, USA.

Mrosovsky, N. 1982. Sex ratio bias in hatchling sea turtles from artificially incubated eggs. Biological Conservation 23:309–314.

Mrosovsky, N. 1994. Sex ratios of sea turtles. Journal of Experimental Zoology 270:16–27.

Mrosovsky, N. 2008. Against oversimplifying the issues on relocating turtle eggs. Environmental Management 41:465–467.

Pike D.A., R.L. Antworth, and J.C. Stiner. 2006. Earlier nesting contributes to shorter nesting seasons for the Loggerhead Sea Turtle, *Caretta caretta*. Journal of Herpetology 40:91–94.

Pritchard, P.C.H., and P.T. Plotkin. 1995. Olive Ridley Sea Turtle, *Lepidochelys olivacea.* Pp. 123–139 *In* Plotkin, P.T. (Ed.). National Marine Fisheries Service and US Fish and Wildlife Service Status Reviews of Sea Turtles listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Springs, Maryland.

Pritchard, P.C.H. 1997. Evolution, phylogeny, and current status. Pp. 1–28 *In* The Biology of Sea Turtles. Lutz, P.L., and J.A. Musick (Eds.). CRC Press, Boca Raton, Florida, USA.

Reina, R.D., P.A. Mayor, J.R. Spotila, R. Piedra, and F.V. Paladino. 2002. Nesting ecology of the Leatherback Turtle, *Dermochelys coriacea*, at Parque Nacional Marino Las Baulas, Costa Rica: 1988–1989 to 1999–2000. Copeia 2002:653–664.

Rodríguez-Zárate, C.J., A. Rocha-Olivares, and L.B. Beheregaray. 2013. Genetic signature of a recent metapopulation bottleneck in the Olive Ridley Turtle (*Lepidochelys olivacea*) after intensive commercial exploitation in Mexico. Biological Conservation 168:10–18.

Schneller, A.J., and P.A. Baum. 2011. The emergence of associational life in Mexico's Wild West: pioneering civic participation, sea turtle conservation, and environmental awareness in Baja California Sur. Voluntas 22:259–282.

Schroeder, B.A., A.M. Foley, and D.A. Bagley. 2003. Nesting patterns, reproductive migrations, and adult foraging areas of Loggerhead Turtles. Pp. 114–124 *In* Loggerhead Sea Turtles. Bolten, A.B., and B.E. Witherington (Eds.). Smithsonian Institution Press, Washington, D.C., USA.

Shaver, D.J. 2005. Analysis of the Kemp’s Ridley imprinting and Headstart Project at Padre Island National Seashore, Texas, 1978–88, with subsequent nesting and stranding records on the Texas Coast. Chelonian Conservation and Biology 4:846–859.

Shaver, D., and T. Wibbels. 2008. Headstarting Ridley Sea Turtles. Pp. 297–323 *In* Biology and Conservation of Ridley Sea Turtles. Plotkin, P.T. (Ed.). The Johns Hopkins University Press, Baltimore, Maryland, USA.

Snover, M.L. 2002. Growth and ontogeny of sea turtles using skeletochronology: methods validation and application to conservation. Ph.D. Dissertation, Duke University, Durham, North Carolina, USA. 144 p.

Spanier, M.J. 2010. Beach erosion and nest site selection by the Leatherback Sea Turtle *Dermochelys coriacea* (Testudines: Dermochelyidae) and implications for management practices at Playa Gandoca, Costa Rica. Revista de Biología Tropical 58:1237–1246.

Tripathy, B. 2008. An assessment of solitary and arribada nesting of Olive Ridley Sea Turtles (*Lepidochelys olivacea*) at the Rushikulya Rookery of Orissa, India. Asiatic Herpetological Research 11:136–142.

UABCS/WWF. 2004. Taller de Conservación de Tortugas Marinas en el Noroeste Mexicano. Rodríguez Valencia, J.A. (Ed.). Reporte del Taller. WWF-México PGC-04-S120-D62.

Van Houtan, K.S., and O.L. Bass. 2007. Stormy oceans are associated with declines in sea turtle hatching. Current Biology 17:R590–R591.

Weishampel, J.F., D.A. Bagley, and L.L.M. Ehrhart. 2004. Earlier nesting by Loggerhead Sea Turtles following sea surface warming. Global Change Biology 10:1424–1427.

Zug, G.R., M. Chaloupka, and G.H. Balazs. 2006. Age and growth in Olive Ridley Sea Turtles (*Lepidochelys olivacea*) from the north-central Pacific: a skeletochronological analysis. Marine Ecology 27:263–270.

Catherine E. Hart is a marine biologist currently completing her Ph.D. at the Centro Universitario de la Costa, Universidad de Guadalajara, Mexico. She received her B.S. from Instituto Tecnológico de Bahía de Banderas and M.S. in conservation and biodiversity from the University of Exeter (UK). She currently coordinates the Red Tortuguera A.C. and is an adviser on sea turtle nesting for Grupo Tortuguero de las Californias A.C. Her current interests include the effects of temperature and incubation techniques on sea turtle embryos and neonates and the role that community groups play in the conservation of sea turtles in northwest Mexico. (Photographed by L. Angel Tello Sahagun).

César P. Ley-Quiñónez is a Research Scientist and Technical Administrator with the Sinaloa Health Services, Mexico. His research focuses on ecotoxicology and wildlife conservation. César holds a Ph.D. degree from Universidad Autónoma de Sinaloa, Mexico. (Photographed by C.P. Ley-Quiñónez).

Adrian Maldonado-Gasca is a Professor and Research Scientist at the Instituto Tecnológico de Bahía de Banderas. He received his B.S. in Marine Biology from Universidad Autónoma de Baja California Sur, his M.S. in Marine Biology from the Centro de Investigación y Estudios Avanzados del IPN Unidad Mérida and is currently completing his Ph.D. in Ecology at the Universidad de Barcelona, Spain. His research has focused on ecology and conservation biology of sea turtles in nesting and feeding habitats in Yucatan Peninsula and northwest Mexico. (Photographed by Andy R. Roose).

Alan Zavala-Norzagaray is a biologist who received his Ph.D. from the Universidad de Autónoma de Sinaloa, Mexico. He received his B.S. from Universidad de Occidente and M.S. in Natural Resources and Environmental in National Polytechnic Institute CIIDIR-Sinaloa, where he is currently a Research Professor, Coordinator of the Wildlife Program, and an adviser on sea turtle foraging areas for Grupo Tortuguero de las Californias A.C. His current interests include the ecology and conservation medicine of sea turtles in foraging areas and the role that community groups play in the conservation of sea turtles in northwest Mexico. (Photographed by A.A. Zavala-Norzagaray).

Alberto Abreu-Grobois is a Research Scientist at the Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. He received his Ph.D. in Population Genetics from University College Swansea, Wales, United Kingdom (1983). Since then he has worked at the Mazatlan Research Station of the ICML where he heads the Genetics Laboratory. His research focuses on conservation genetics of sea turtle populations and on temperature effects on morphometrics and fitness of sea turtle hatchlings. (Photographed by Raquel Briseño).