Wildlife Society Bulletin 1–11; 2019; DOI: 10.1002/wsb.1004

Original Article

Informing Sea Turtle Outreach Efforts to Maximize Effectiveness

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ABSTRACT Most sea turtle (Cheloniidae) species worldwide are endangered or threatened, with threats causing harm to sea turtles predominantly human-induced. Thus, prevention of further declines to these imperiled species will require alteration of human behaviors. Regulations, incentives, and environmental education are 3 strategies that could be used to alter human behavior. Our goal was to determine how to maximize effectiveness of one of these strategies—education efforts. We investigated knowledge deficiencies and light pollution behaviors of individuals living in a region with nesting sea turtles, in an effort to determine the best approach to promote sea turtle conservation. During 2014, we mailed a survey to 3,000 property owners in 4 coastal counties in Florida, USA, to achieve 3 objectives: assess what topic areas were misunderstood; discern who had knowledge deficiencies; and determine who had adopted turtle-friendly lighting practices. The best predictors of knowledge included geographic factors (county, proximity of residences to the beach), demographic characteristics (age), and behaviors (individual's beach visitation rates). One practice that can reduce harm to sea turtles was common: use of window treatments to reduce light pollution. However, other practices harmful to sea turtles were prevalent, including long durations of use of outdoor lighting and use of light bulbs with wavelengths that can disturb sea turtles. Our results suggest that educational efforts could be enhanced by specifically focusing on increasing awareness of the effects of human actions on sea turtles, targeting individuals who visit the beach infrequently and live far from it to foster greater connection with these ecosystems, and publicizing a variety of options that could reduce harm to sea turtles so individuals feel a sense of freedom of choice.

KEY WORDS behavior, environmental education, Florida, knowledge, lighting ordinance, sea turtle.

Coastal areas are highly valued by people for the amenities they provide, and as such are home to a large and growing proportion of the world's human population (Small and Nicholls 2003, Martinez et al. 2007). The large concentration of people in coastal regions and corresponding increase in beachfront infrastructure is accelerating destruction of the natural resources that attracted humans there in the first place (Beatley 1991, Defeo et al. 2009). The alarming severity of human modification to coastal regions is responsible for significant declines in many of the marine flora and fauna that depend on these biologically diverse areas (Beatley 1991, Defeo et al. 2009, Fuentes et al. 2016).

Human actions in coastal regions harm marine turtles offshore and onshore. Marine turtles (Cheloniidae) face a multitude of anthropogenic threats while offshore, including ingestion of and entanglement in marine debris (Wilcox et al. 2016), vessel strikes (Work et al. 2010), fisheries bycatch (Finkbeiner et al. 2011), ingestion of persistent organic pollutants (Clukey et al. 2018), and loss and degradation of foraging resources (NMFS and USFWS 2008). Sea turtles face an additional suite of anthropogenic threats while onshore, including disturbance of nesting adults and hatchlings by humans (Johnson et al. 1996), predation of eggs and hatchlings by nonnative wildlife introduced by humans (Stewart and Wyneken 2004, Kurz et al. 2012), entanglement in debris and recreational equipment on beaches (Wilcox et al. 2016), disorientation from ruts left by vehicles driven on beaches (Lamont et al. 2002, van de Merwe et al. 2012), destruction of dunes (Schlacher et al. 2016), loss of nesting habitat through beach erosion induced by human activities and establishment of shoreline stabilization structures (Witherington et al. 2011), and disorientation from artificial lighting (NMFS and USFWS 2008, Fuentes et al. 2016). Artificial

Received: 16 February 2018; Accepted: 20 March 2019
Published:

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illumination at beaches is particularly harmful because this lighting can prevent gravid females from coming ashore to lay eggs, inhibit hatchlings from emerging from nests, disorient adult females and hatchlings navigating from beaches back to sea, and confuse hatchlings that recently entered the sea (Witherington 1992, Salmon et al. 1995, Truscott et al. 2017). The destructive acts of humans has culminated in the listing of 6 of the world's 7 species of sea turtles as threatened or endangered (NMFS and USFWS 1991, 1992, 1993, 2008, 2011).

The majority of threats facing sea turtles are the result of human activities, so altering people's harmful behavior must be a tenet of conservation efforts to limit additional turtle declines (Fuentes et al. 2016). Three strategies that could be used to change human behavior include regulations (disincentives intended to suppress harmful actions), incentives (stimuli intended to encourage adoption of less harmful actions), and education (information transfer intended to foster awareness of negative impacts of human actions, and provide motivation to prompt voluntary adoption of solutions). Environmental education programs can be especially effective in promoting behavioral changes when they strive to not only foster awareness and understanding of environmental issues, but also hone skills so that individuals know how their actions can help resolve environmental problems (UNESCO 1977, Gardner and Stern 1996, Kaplan 2000, Steg and Vlek 2009). Environmentally responsible behavior is associated with peoples' familiarity with environmental problems, knowledge of how their own actions affect these problems, and awareness of low-cost ways to solve environmental problems (Hines et al. 1987, Kaiser and Fuhrer 2003, Steg and Vlek 2009).

Identification of knowledge deficiencies is a pressing need when developing cost-effective environmental education programs, allowing instructors to customize subject matter coverage to address misunderstandings. Knowledge regarding environmental issues can be partitioned into 3 categories when attempting to discern deficiencies: systems, action, and effectiveness knowledge (Kaiser and Fuhrer 2003, Frick et al. 2004). Systems knowledge is a general understanding of ecosystems and how the processes within them work; action knowledge refers to possible courses of action that can achieve particular environmental objectives or cause specific problems; and effectiveness knowledge allows individuals to choose from a pool of possible actions according to their understanding of the relative benefit or harm associated with each action (Frick et al. 2004). It has been argued that systems knowledge is germane to environmentally responsible behavior because this type of knowledge serves as the foundation upon which the other 2 knowledge types are built (Kaiser and Fuhrer 2003, Frick et al. 2004). When considering sea turtle conservation, this suggests that an understanding of general sea turtle ecology may be a necessary precursor for knowing how human actions could affect these animals. Discerning which knowledge deficiencies are most common prior to initiating extensive outreach programs would enable environmental educators to determine whether to focus on fostering general understanding of conceptual issues (systems knowledge), or on cognizance of how human actions can help resolve or exacerbate environmental problems (action and effectiveness knowledge), or both.

Understanding differences in existing knowledge levels of various segments of a target population prior to initiating outreach efforts enables educators to decide which audiences to concentrate on (McKenzie-Mohr 2011). Several factors that may be associated with knowledge deficiencies regarding sea turtles are geographic, such as how close individuals live to the beach and how recently local coastal lighting ordinances were established in the region where individuals live; others are demographic, such as age and gender; and some are behavioral, such as how often individuals visit the beach. Living in close proximity to or regularly visiting a place may foster an emotional attachment, increasing recreational and economic dependency on the place. Nearby residents and frequent visitors of natural places tend to be knowledgeable about these areas and form stronger bonds with them than those who live farther away or do not visit (Budruk et al. 2011, Kil et al. 2015). Also, local outdoor light-management efforts have been instated in some coastal communities in recognition of the importance of light in directing sea turtle orientation, potential negative ramifications of light pollution on turtle reproduction, and relative ease with which lighting could be managed relative to other threats facing turtles (Witherington and Martin 2000, Barshel et al. 2014). The longer the period of time since local lighting ordinances were passed, the greater the degree of awareness and understanding individuals may have regarding sea turtles. Socioemotional selectivity theory suggests that younger individuals are more knowledgeable and concerned about environmental issues than older individuals (Hines et al. 1987, Klineberg et al. 1998, Carstensen et al. 1999), and that women show greater knowledge and concern for the environment than men (Blocker and Eckberg 1997, Luchs and Mooradian 2012), which would mean greater knowledge of sea turtles would exist among younger and female individuals compared with older and male individuals. By determining proactively whether knowledge of sea turtles is influenced by these geographic, demographic, or behavioral characteristics, environmental educators can focus efforts on the most critical audiences.

It is prudent for planners of educational campaigns to carefully select only one or a small number of harmful behaviors to influence, because environmental education programs that highlight specific and achievable actions are more successful than those that promote sweeping generalizations or attempt to change a multitude of behaviors (Costanzo et al. 1986, McKenzie-Mohr 2011, Schultz 2011). Thus, investigating the incidence of human behaviors that could help or harm sea turtles can assist in prioritizing efforts to alter human actions. Light pollution is widely considered one of the most harmful threats to sea turtles, as well as one of the most easily managed (Salmon et al. 1995, Witherington and Martin 2000). Adult female sea turtles use light to navigate from the beach to the ocean following egg laying, as do hatchings after they emerge from nests (Witherington 1992, Truscott et al. 2017). This natural inclination is adaptive to turtles in undeveloped areas, guiding them away from dunes onshore and toward the brighter horizon over the open ocean. However, artificial lighting can lure turtles inland rather than out to sea, wasting turtles' limited energy reserves. Numerous behavioral options exist for those who live in coastal regions to minimize the amount of light perceived by sea turtles on the beach or near the shore, including the use of window treatments that shield indoor lights from illuminating outdoors, minimizing the time exterior lighting is on, and using bulbs that emit light in wavelengths less visible to sea turtles (Gaston et al. 2012). An understanding of the degree to which each of these light-disruption strategies is practiced would enable prioritization of messages for short-term educational campaigns (McKenzie-Mohr 2011, Schultz 2011, Kamrowski et al. 2015).

Our goal was to determine how to tailor education efforts to encourage sea turtle conservation. We investigated knowledge and behaviors of residents in coastal communities with nesting sea turtles to determine how to customize education efforts to change environmentally damaging human behavior. We used a 3-pronged approach that involved discerning knowledge deficiencies (i.e., determining what subject matter regarding sea turtles was least understood), identifying which segments of the human population had the most expansive knowledge deficiencies (i.e., determining who had misconceptions about sea turtles), and investigating patterns of engagement in environmentally responsible behaviors (i.e., determining adoption rates of sea turtle–friendly lighting practices). We predicted fewer deficiencies for systems knowledge (understanding of general sea turtle ecology) than for action and effectiveness knowledge (understanding of how human actions affect sea turtles), given that a general understanding of foundational concepts is a necessary antecedent to judging the effects of human actions (Monroe 1990, Kaiser and Fuhrer 2003). We predicted a positive relationship between sea turtle knowledge and beach visitation frequency; a negative relationship between sea turtle knowledge and distance of individuals' residence from the beach; a positive relationship between sea turtle knowledge and the length of time county lighting ordinances were in place; a negative relationship between sea turtle knowledge and age; and greater sea turtle knowledge for females than males. Lastly, we predicted that adoption rates of turtle-friendly practices would vary according to the degree of perceived inconvenience (Kaplan 2000, Steg and Vlek 2009). More specifically, we predicted that the use of window treatments would be more widespread than use of light bulbs with turtle-friendly wavelengths or restricted time periods for use of outdoor lighting.

STUDY AREA

We selected coastal northwestern Florida, USA, as the focus of this project because Florida provides a particularly pertinent example of anthropogenic threats to marine turtle conservation. This state ranks among the highest in the country in rates of human immigration, has more miles of coastline than any state besides Alaska, USA, and is home to the largest number of nesting sea turtles in the United States (Dodd 1988, Bjorndal et al. 2013, Fuentes et al. 2016, NOAA 2017). Five of the world's 7 sea turtle species occur in Florida, and all 5 are listed as either federally threatened or endangered (NMFS and USFWS 1991, 1992, 1993, 2008, 2011). Northwestern Florida is especially appropriate for such research because the region provides habitat for a genetically distinct group of nesting sea turtles that has declined in nest abundance in recent years, variation exists among the outdoor lighting ordinances in counties in this region, and to our knowledge, no previous researchers have attempted to evaluate knowledge of sea turtles or assess adoption rates of turtle-friendly practices in this region.

Our study area was 4 contiguous coastal counties in northwestern Florida (Fig. 1). These counties showed great variation in abundance of nesting sea turtles and human demographics. The mean number of sea turtle nests per km of coastline per year for the 5 years prior to this study (2009–2013) was 1.3, 1.5, 6.5, and 5.9 in Walton, Bay, Gulf, and Franklin counties, respectively (FFWC 2015). The 2 counties with the greatest sea turtle abundance, Franklin and Gulf counties, were less developed and had smaller human populations characterized by lower per capita income and older median ages than Bay and Walton counties (U.S. Census Bureau 2014, Swindall 2015). Franklin and Gulf counties were more rural and attracted residents and visitors who favored a natural coastal setting, whereas Walton and Bay counties catered to people who desired more urbanized coastal amenities. Sea turtle lighting ordinances were passed in Franklin County in 1998, in Gulf County in 2001, in Bay County in 2002, and in Walton County in 2009. Ordinances in Walton and Bay counties included conditions requiring efforts to educate the general public, while those in Gulf and Franklin counties only required education for individuals engaged in coastal construction projects (Barshel et al. 2014).

METHODS

Data Collection Stages

The first stage of our data collection involved a formal process to acquire expert opinion to ensure face validity of question topics (DeVellis 2012) There is no standardized and validated list of questions available to assess how knowledgeable people were about general sea turtle ecology in the coastal and nearshore environments (systems knowledge), or how knowledgeable people were about effects of humans on sea turtles in coastal and nearshore areas (action and effectiveness knowledge), and the number of questions that could be asked in a survey is limited. Therefore, to ensure we were asking questions about the most relevant topics in our survey, we assessed the extent to which questions covered the concepts they claim to measure, as judged by individuals with subject matter expertise (face validity).

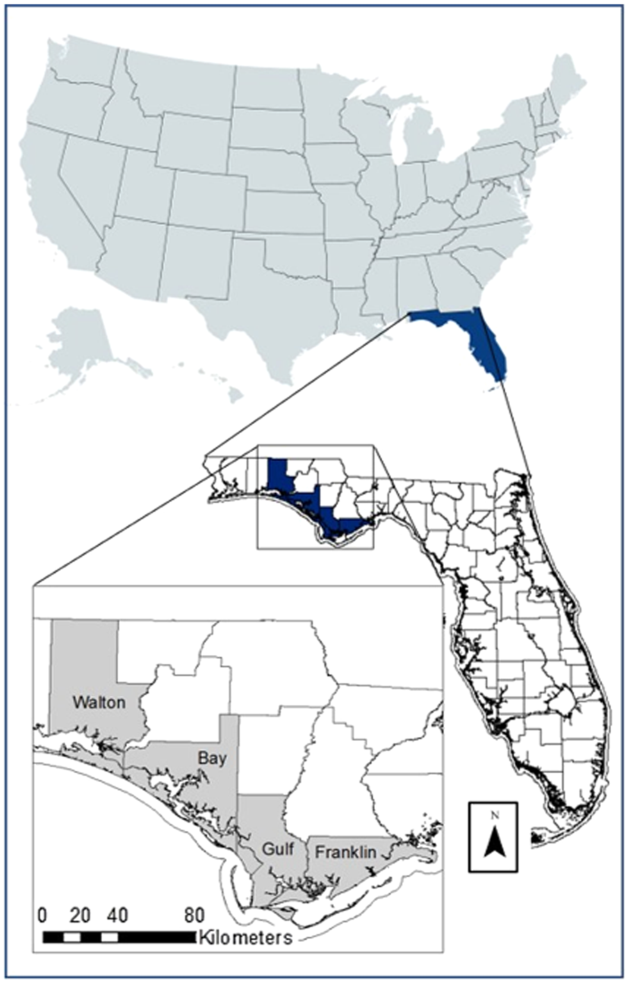

Figure 1. Map showing the state of Florida within USA, and the 4 coastal counties in northwestern Florida where the mail survey assessing behavior and knowledge of sea turtles was distributed during 2014.

We developed a list of 16 topics we believed to be most relevant to systems knowledge and 21 topics we believed to be most relevant to action and effectiveness knowledge, and sent these lists to 23 individuals with expertise on sea turtles in northwestern Florida. Experts were academicians; biologists working for federal agencies, state agencies, or nongovernmental organizations; and longstanding sea turtle monitoring volunteers. Experts were asked to rate each topic on the first list according to how important it was in assessing knowledge about general sea turtle ecology in coastal and nearshore areas (on a scale of 1 to 5, with ‘1’ indicating low importance and ‘5’ indicating high importance), and use a similar ranking system to rate the importance of topics on the second list in assessing knowledge of how to minimize the harm human actions can cause to sea turtles (Supporting Information). Ten individuals responded, and we addressed those 10 topics with the greatest average scores pertaining to general sea turtle ecology through survey questions to assess systems knowledge. We used those 10 topics with the greatest average score pertaining to minimizing human harm to assess action knowledge and effectiveness knowledge, providing face validity (DeVellis 2012).

The second stage of data collection involved a pilot survey. We developed a 4-page survey instrument with 41 questions. Section 1 included 11 multiple-choice questions: 1 question asked the number of times the respondent visited the beach during the past summer, and the remaining 10 questions asked about his or her behaviors on the beach or in nearshore areas. Section 2 contained 10 multiple-choice and true–false questions related to the respondent’s knowledge about sea turtles and their habitats (systems knowledge). Section 3 contained 4 multiple-choice and true–false questions to assess the respondent’s knowledge of how human behaviors affect sea turtles and their habitats (action knowledge), and 6 multiple-choice and true–false questions on the relative benefit or harm of specific human behaviors to sea turtles and their habitats (effectiveness knowledge). Each knowledge question had “I don’t know” as an answer option to prevent respondents from feeling pressured to guess (Schuman and Presser 1981). Section 4 of the survey consisted of 4 items that asked about the respondent’s occupation, decade of birth, gender, and proximity of their residence to the beach.

We obtained names and postal addresses of property owners in each of the 4 counties from county property appraiser's offices. We removed properties owned by Limited Liability Companies, Incorporations, Trustees, and banks from these lists, as well as property owners whose mailing addresses were outside the United States. We then randomly selected property owners to receive the pilot survey or final survey using a random number generator (SPSS 22.0; International Business Machines Corporation, Armonk, NY, USA). A letter accompanied the survey to inform recipients that the survey was being conducted to gain a better understanding of who uses coastal areas and what they know about sea turtles, how their addresses were selected, how they should complete and return the survey, and who to contact with questions. The letter and survey were both approved by the University of Florida Institutional Review Board (UFIRB #2013-U-1399). We mailed pilot surveys to the addresses of 15 randomly selected property owners in each of the 4 counties, and 13 were returned. Based on feedback from returned pilot surveys, minor changes were made to increase clarity of questions.

The third stage of data collection involved the final survey. We mailed 3,000 surveys in June 2014 (750 randomly selected property owners in each county), using envelopes coded to distinguish the recipients' county of residency and name. We collected data following the general principles of the Tailored Design Method, mailing a reminder postcard 1 week after the initial survey, and a second survey 1 week after the reminder postcard to those individuals who had not yet responded (Dillman et al. 2008).

Data Analysis

We compared demographic and behavioral characteristics of early versus late respondents to determine whether these groups differed systematically (Armstrong and Overton 1977). Individuals who respond after more prompting tend to be more similar demographically to nonrespondents than to individuals who respond immediately. We made comparisons of 2 demographic and 1 behavioral characteristic (gender, age category, and frequency of visits to the beach) between the first 100 and last 100 surveys returned by mail, using chi-square tests.

We derived a composite score to represent systems, action, and effectiveness knowledge for each respondent that ranged from 0 to 1. After awarding one point for correct responses (to reward respondents when they knew answers), and zero points for incorrect responses and for answering "I don't know" (to avoid rewarding respondents when they did not know answers), we calculated scores for each knowledge type by dividing the total number of points earned by the total number of questions. We then conducted an exploratory factor analysis to check the number of constructs measured by questions assessing each knowledge type (principal components factor extraction, varimax rotation method, with Kaiser normalization). We found that after removing 1 of 10 questions that measured systems knowledge and retaining all questions for action ($n = 4$) and effectiveness ($n = 6$) knowledge, all factors loaded on a single construct for each of the 3 knowledge scales (Hair et al. 2010). We then computed Cronbach's alpha to assess internal consistency of items in each composite knowledge scale, and found it was adequate: the 9 questions measuring systems knowledge had Cronbach $\alpha = 0.74$; the 4 questions measuring action knowledge had $\alpha = 0.66$; and the 6 questions measuring effectiveness knowledge had $\alpha = 0.73$.

We used one-way analysis of variance (ANOVA) to evaluate if there were differences in composite knowledge (all 3 knowledge types combined) among individuals who visited the beach with different regularity, individuals with residences located at different distances from the beach, individuals from different counties, individuals of different ages, or between individuals of different genders. For those factors where significant differences among means were identified, we used Tukey's *post hoc* tests to identify which groups differed.

We investigated adoption rates of sea turtle–friendly lighting practices during turtle nesting season of those respondents who reported residences within walking distance of the beach. The 3 practices investigated were use of window treatments to restrict outdoor light pollution at night, number of hours outdoor lights were on after sunset, and types of bulbs used for exterior lighting. We coded all responses into "least damaging," "moderately damaging," and "most damaging" categories to represent the level of harm each behavior could cause to sea turtles (Table 1). We then used chi-square tests to evaluate whether there were relationships between adoption of sea turtle–friendly lighting behavior and county. We performed all statistical analyses in SPSS 25.0 (IBM 2016), and considered $\alpha = 0.05$ as the threshold of significance for all tests.

RESULTS

Of the 3,000 surveys mailed, we were made aware of 14 delivered to ineligible individuals or individuals unable to respond. The final returned sample consisted of 889 property owners, for an adjusted response rate of 29.8%. We found no differences between early versus late respondents in the demographic and behavioral characteristics investigated (age: $\chi^2_4 = 8.36$, $P = 0.09$; gender: $\chi^2_2 = 0.95$, $P = 0.62$; beach visitation frequency: $\chi^2_4 = 4.53$, $P = 0.34$), and therefore, concluded that nonresponse bias was not of critical concern.

Discerning Knowledge Deficiencies

The range of variation in the percentage of respondents who correctly answered each question pertaining to systems knowledge exceeded that for questions pertaining to other knowledge types (range from 2% to 55% for systems knowledge, 44% to 80% for action knowledge, and 29% to 68% for effectiveness knowledge; Table 2). The subject matter least well-understood pertained to sea turtle diets, the importance of dunes to sea turtles, where sea turtles spend the first year of their life, which light colors are harmful to sea turtles, energy budgets of sea turtles, and which human actions cause damage to seagrass beds. The subject matter that was most widely known pertained to which authorities to notify when sea turtles become

Table 1. Coding used for survey questions asking about adoption of sea turtle-friendly lighting behavior in northwestern Florida, USA, during 2014.

Question topic	Answer options	Degree of harm
What tactics do you use to shield windows at night?[a]	blinds/curtains/shades/window tint[b]	Least
	≥1 of the options above, in combination with 'none'	Moderate
	none	Most
How long do you leave outdoor lights on after sunset?	no lights after sunset	Least
	<2 hr/2–4 hr	Moderate
	4–6 hr/≥6 hr	Most
What types of bulbs do you use in exterior lighting?[a]	red or amber LED / low pressure sodium[b]	Least
	yellow "bug" lights, or this with ≥1 of the options above	Moderate
	Incandescent/fluorescent/don't know[b]	Most

[a] Respondents were instructed to check all answer choices that apply.
[b] Any one of these answer options, or any combination of these answer options would result in categorization to this degree of harm.

entangled in fishing gear, dangers posed by beach furniture to nesting sea turtles, importance of keeping beaches used by nesting sea turtles dark at night, means of reducing nutrient pollution of coastal waters through runoff, ecological importance of beach wrack, and harm caused when humans walk through dunes.

Identifying Who Has Knowledge Deficiencies

The ANOVA on composite knowledge identified significant multivariate main effects for beach visitation ($F_{4,717} = 7.52$, $P < 0.001$), proximity to the beach ($F_{3,717} = 5.45$, $P = 0.001$), county ($F_{3,717} = 2.81$, $P = 0.04$), and age ($F_{4,717} = 3.41$, $P = 0.01$), but no effect for gender ($F_{1,717} = 0.16$, $P = 0.69$). In accordance with predictions, knowledge showed an increasing trend as beach visitation rates increased (Table 3; Fig. 2A). *Post hoc* tests indicated that respondents who did not visit the beach at all the previous summer or visited the beach only a few times had lower knowledge than people who visited 2–3 times/month or more ($P \leq 0.002$ for each of the 3 more frequent visitation categories). Also in accordance with predictions, knowledge was lower among individuals with residences far from the beach than individuals with residences closer to the beach (Table 3; Fig. 2B). Respondents who lived >20 minutes driving time to the beach had lower knowledge than those who lived closer ($P \leq 0.001$ for all 3 distance categories). As expected, individuals in the county with the oldest lighting ordinance (Franklin) had greater knowledge

Table 2. Percentage of respondents who provided correct answers for each survey question assessing knowledge of sea turtles in northwestern Florida, USA, during 2014.

Question description	Question type[a]	Knowledge type assessed	% of correct responses
Is beach wrack an important food source for wildlife on beaches	T/F	Systems	55.1%
What are important nursery grounds for sea turtles	MC	Systems	46.6%
Do 5 species of threatened or endangered sea turtles nest in Florida	T/F	Systems	44.4%
How many years do sea turtles live	MC	Systems	35.8%
Where on the beach do sea turtles nest	MC	Systems	34.5%
How much energy do sea turtles have directly after hatching	T/F	Systems	28.9%
Which light colors negatively affect sea turtles	MC	Systems	26.9%
Where do loggerhead sea turtles spend the first years of their life	T/F	Systems	14.4%
Do sea turtles on land use dunes to guide themselves toward the ocean	T/F	Systems	12.9%
What is the most important food source for green sea turtles	MC	Systems	12.9%
What is the most important food source for leatherback sea turtles	MC	Systems	6.1%
What is the most important food source for Kemp's ridley sea turtles	MC	Systems	2.0%
What is the most important food source for loggerhead sea turtles	MC	Systems	1.8%
Which agency should be notified of turtles entangled in fishing gear	MC	Action	79.6%
Does furniture on the beach overnight negatively affect sea turtles	T/F	Action	70.3%
What is the most effective means of water pollution prevention	MC	Action	66.5%
Does seawall installation protect sea turtle nesting habitat	T/F	Action	43.9%
Which is least harmful to turtles: walking over marked nests, keeping the beach dark, leaving trash on the beach	MC	Effectiveness	68.1%
Which is more harmful to turtles: swimming during nesting season or walking over dunes	T/F	Effectiveness	53.9%
Which impact from driving motorized vehicles on the beach is most harmful: noise, ruts, exhaust	MC	Effectiveness	49.9%
Which impact from fishing is least harmful to turtles: hook in flipper, entanglement in monofilament, ingestion of a plastic lure	MC	Effectiveness	47.7%
Is shielding outdoor lighting as safe for sea turtles as lack of lighting	T/F	Effectiveness	42.6%
Which impact on seagrass beds is least harmful to turtles: shading from docks, wading by people, or ripping by propellers	MC	Effectiveness	29.4%

[a] T/F = true/false; MC = multiple choice.

Table 3. Scores for composite knowledge, systems knowledge, action knowledge, and effectiveness knowledge grouped according to respondents' beach visitation frequency, proximity of their residence to the beach, their county of residence, and their age for a survey on sea turtle knowledge in northwestern Florida, USA, during 2014.

		Composite knowledge		Systems knowledge		Action knowledge		Effectiveness knowledge	
Descriptor	***n***	$\bar{x}$	**SE**	$\bar{x}$	**SE**	$\bar{x}$	**SE**	$\bar{x}$	**SE**
Beach visitation frequency last summer									
Not at all	129	0.363	0.022	0.196	0.021	0.533	0.026	0.382	0.026
A few times	335	0.432	0.014	0.275	0.013	0.613	0.016	0.447	0.016
2–3 times/month	124	0.527	0.022	0.331	0.021	0.747	0.025	0.567	0.025
About once per week	71	0.570	0.030	0.372	0.028	0.756	0.034	0.609	0.033
More than once per week	91	0.553	0.026	0.393	0.025	0.757	0.029	0.589	0.029
Residence proximity to the beach									
Walk to the beach	336	0.494	0.014	0.314	0.013	0.694	0.016	0.526	0.016
Drive within 5 min	106	0.482	0.025	0.329	0.023	0.667	0.028	0.507	0.028
Drive within 5–20 min	135	0.510	0.022	0.319	0.020	0.703	0.025	0.532	0.025
Drive >20 min	174	0.363	0.019	0.218	0.018	0.549	0.022	0.391	0.022
County									
Bay	201	0.447	0.019	0.286	0.018	0.649	0.022	0.447	0.022
Franklin	245	0.523	0.017	0.329	0.016	0.725	0.020	0.561	0.020
Gulf	209	0.447	0.019	0.286	0.018	0.630	0.022	0.494	0.022
Walton	203	0.426	0.019	0.268	0.018	0.610	0.022	0.451	0.022
Age									
<43 yr old	71	0.433	0.030	0.305	0.028	0.596	0.035	0.470	0.035
44–53 yr old	134	0.486	0.022	0.330	0.021	0.692	0.025	0.514	0.025
54–63 yr old	186	0.493	0.019	0.304	0.018	0.701	0.021	0.524	0.021
64–73 yr old	226	0.493	0.017	0.309	0.016	0.690	0.020	0.519	0.021
>73 yr old	132	0.372	0.022	0.217	0.021	0.544	0.026	0.400	0.026
Gender									
Female	395	0.466	0.013	0.284	0.012	0.657	0.015	0.503	0.015
Male	346	0.464	0.014	0.305	0.013	0.660	0.016	0.486	0.016

than individuals in counties with more recent ordinances ($P \leq 0.020$ for all 3 counties; Table 3; Fig. 2C). Contrary to predictions, knowledge did not show a continuous trend with age. However, individuals in the oldest age category (>73 yr old) had lower knowledge than individuals in all younger categories ($P \leq 0.002$ for these age categories; Table 3; Fig. 2D).

Evaluating Adoption of Practices that Reduce Light Pollution

The most widely adopted practice that reduced light pollution was use of window treatments. Greater than 90% of respondents reported use of one or more window-shielding tactic. Adoption rate varied among counties ($\chi^2_3 = 9.41$, $P = 0.02$), with fewer individuals than expected using shielding options in Franklin County (84%; all other counties 93–98%).

The period of time outdoor lights were left on after sunset was variable, with 50.7% of respondents reporting no or limited use (0–2 hr/night), 40.3% reporting 2–4 hours/night, and 9.1% reporting ≥4 hours/night. There was variation in duration of use of outdoor lights among counties ($\chi^2{}_6 = 16.12$, $P = 0.01$), with more individuals than expected in Gulf and Franklin counties refraining from using exterior lights entirely (63% and 56%, respectively). The largest percentage of individuals leaving exterior lights on for ≥4 hours after sunset occurred in Walton and Bay counties (14% and 11%, respectively).

Most respondents (69.7%) reported use of light bulbs outdoors that were harmful to sea turtles, incandescent and fluorescent bulbs, or did not know what type of bulbs they used. Only 9.1% reported exclusive use of bulbs that cause least harm to sea turtles, red or amber LED lights or low-pressure sodium lights. Twice as many (21.4%) reported use of yellow 'bug' lights, either exclusively or in combination with those that cause least harm. The type of bulbs used for exterior lighting did not vary among counties ($\chi^2{}_6 = 8.26$, $P = 0.22$).

DISCUSSION

Discerning Knowledge Deficiencies

Knowledge deficiencies regarding sea turtles were fairly extensive, particularly regarding basic sea turtle biology. This outcome would be of concern if individuals must possess a foundation of systems knowledge before action and effectiveness knowledge can be acquired, as has been previously suggested (Kaiser and Fuhrer 2003, Frick et al. 2004). However, our data do not support the assertion that knowledge of sea turtle biology is a necessary underpinning for understanding how human actions affect sea turtles. In fact, mean scores for action and effectiveness knowledge exceeded those of systems knowledge, and the percentage of individuals who provided correct responses to questions regarding action and effectiveness knowledge exceeded those of systems knowledge, suggesting that a general understanding of sea turtle biology is not critical to understanding effects of human actions on sea turtles or judging the relative degree of effect of various human actions on sea turtles.

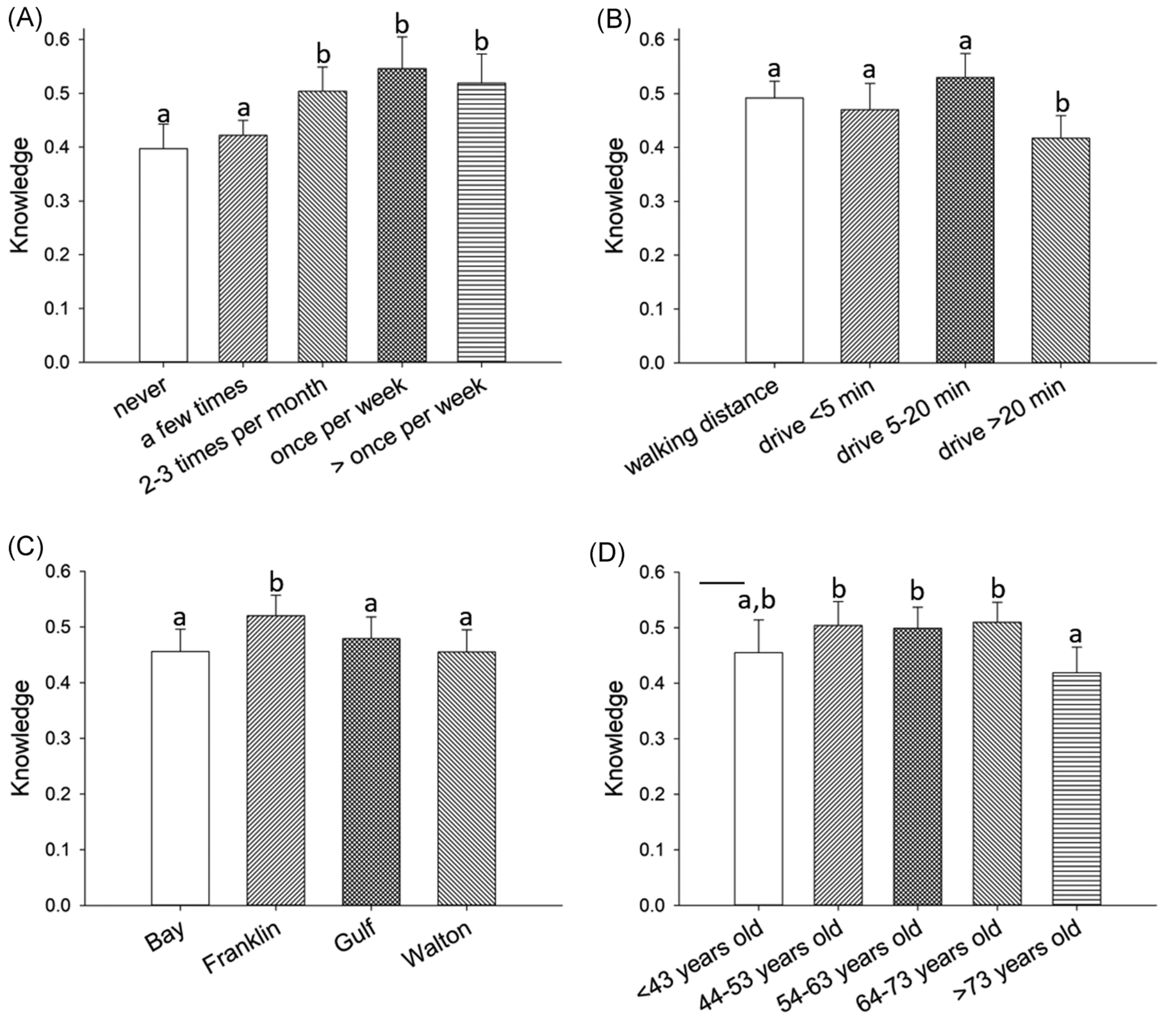

Figure 2. Scores for knowledge of individuals in northwestern Florida, USA, pertaining to sea turtles during 2014 according to A) how frequently they visited the beach during the previous summer, B) proximity of their residence to the beach, C) their county of residence, and D) their age. Letters atop bars denote significant differences ($P < 0.05$) among categories.

Our findings suggest that future education efforts could strive to augment action and effectiveness knowledge rather than investing limited resources bolstering systems knowledge. Feelings of helplessness are a major barrier to adoption of environmentally responsible behavior; therefore, promoting understanding of the positive and negative consequences of personal actions can move people from apathy to environmentally responsible behaviors (Kaplan 2000). This means focusing educational efforts on explaining how people's actions affect sea turtles, such as how choice of outdoor light bulbs and orientation of light fixtures can affect the ability of turtles to navigate, how boat propellers can harm sea grass beds, how fertilizer application can be timed to minimize nutrient runoff into coastal waters, and how tall vegetation or other visual barriers could be placed strategically to prevent light from reaching beaches.

Identifying Who Has Knowledge Deficiencies

Our findings support the contention that regular visitation to natural places is an important factor governing environmental knowledge (Chawla 1998). Experience in the outdoors is considered one of the most important factors in developing personal connections with the environment (Tanner 1980, Palmer et al. 1996). The emotional bond between people and places is an important component of environmentally responsible behavior: greater levels of place attachment are associated with more pro-environmental behavioral intentions (Tonge et al. 2015, Ramkissoon and Mavondo 2017). Education efforts that incorporate a field-based component, transporting individuals to the beach, could nurture place attachment and interconnection with coastal resources by creating meaningful memories for those who do not regularly visit (Schultz 2000, Jorgenson and Nickerson 2016).

Our results support previous research showing that environmental knowledge has a spatial dimension. We found that knowledge was greater among individuals who lived closer to the beach than those who lived farthest away. People who live in close proximity to natural areas tend to have greater knowledge of environmental problems and ultimately engage in more conservation behaviors (Eisenhauer et al. 2000). Such individuals may feel a sense of personal responsibility for them, and are therefore more likely to exhibit stewardship behaviors (Larson and Santelmann 2007). Individuals living farther from a recreation area may have different reasons for attachment to these areas (Budruk et al. 2011, Kil et al. 2015). Our research suggests that the content provided in environmental education programs may need to vary according to the location where education events occur.

Lighting ordinances are regulations enacted to directly reduce artificial lighting, but they may also indirectly increase knowledge and awareness of sea turtle conservation issues. Our data support this idea, in that we found that knowledge of sea turtles was greatest in the county that had a lighting ordinance in place longest (Franklin). Although this early ordinance did not require education of the general public as did those for the 2 counties that adopted ordinances most recently (Bay and Walton), the ordinance itself likely had exposed residents to some turtle-friendly lighting principles during the previous 16 years. However, use of bulbs in the wavelengths least harmful to sea turtles was least common in this county, suggesting that effectiveness knowledge was lacking, or that such knowledge did not translate into environmentally responsible behavior. Convenience or conflicting social norms may influence behavior to a greater degree than knowledge (McDonald et al. 2014). Also, Franklin County has the sparsest human population density and greatest percentage of respondents living close to the beach. Residents of rural areas experience nature differently than those in urban areas, with rural individuals often more directly dependent on their natural environment and therefore more deeply connected to natural resources (Sharp and Adua 2009). Again, our findings suggest that environmental education programs may need to vary according to the location of these outreach efforts.

We found that individuals in the oldest age group had significantly less knowledge than people in younger age groups, which corresponds with previous research in which younger people tended to have greater knowledge about environmental issues (Hines et al. 1987, Carstensen et al. 1999, Lieflander et al. 2013). One possible explanation for this finding is the emphasis on increasing environmental awareness which has been occurring at various levels of formal education programs during more recent decades (Hodson 2003, Volk and Cheak 2003, Haigh 2005). Our results suggest that environmental education efforts that target the elderly could reduce knowledge deficiencies.

Adoption of Turtle-friendly Practices

Evaluation of the efficacy of intervention approaches used to change human behavior has been an active area of research for decades (Gardner and Stern 1996, Steg and Vlek 2009, McKenzie-Mohr 2011). Some common principles that have emerged from this body of work are a need to identify target behaviors that cause substantial environmental harm, a need to consider why individuals engage in these behaviors, and a need to promote a variety of less harmful alternatives to individuals so they feel a sense of ownership of their eventual choices (Stern 2000, Steg and Vlek 2009). Light pollution is an ideal issue to address with education campaigns because this is widely considered an ecological problem caused directly by human actions (Salmon et al. 1995, Witherington and Martin 2000). Our findings indicate that despite recent adoption of lighting ordinances in all 4 counties studied, the majority of respondents living in close proximity to the beach are not employing practices that could reduce harm to sea turtles. The widespread use of window shielding treatments we found was likely a function of this having the lowest degree of perceived inconvenience, and actually providing a degree of comfort to humans while also helping sea turtles (Steg and Vlek 2009). A better understanding of reasons behind reluctance to reduce use of outdoor lighting or use less harmful bulbs could help develop future light pollution reduction campaigns. A logical next step in developing a campaign aimed at changing human lighting practices would be an effort to engage the public in discussions about light reduction alternatives (Kamrowski et al. 2014, McDonald et al. 2014).

Psychological research indicates that promoting positive behavior alternatives is more likely to induce change than attempts to curtail or prevent damaging behaviors, suggesting that efforts to promote use of turtle-friendly bulbs and fixtures may be more effective than attempting to limit the period of use of outdoor lights (Van de Velde et al. 2010, Mir et al. 2016). Many people are reluctant to adopt behaviors they believe will reduce their quality of life, yet often choose environmentally responsible options when those choices do not create a burden (Kaplan 2000). Education efforts showcasing the variety of turtle-friendly lighting bulbs and fixture options available, and that also present information on grant programs to retrofit lighting at little cost to property owners, could reduce widespread outdoor lighting practices that disorient turtles by appealing to people's motivation to choose their own solution to problems (Kaplan 2000).

MANAGEMENT IMPLICATIONS

This study provides several implications for development of sea turtle education programs. First, education efforts could be most helpful if they help individuals gain awareness and understanding of how their actions benefit or harm sea turtles, highlighting specific human behaviors that affect these animals. Second, education efforts could be especially helpful if they target individuals with limited connection to beaches and the wildlife that occur there, such as those who live far away or visit infrequently, to foster a sense of place attachment with these ecosystems and greater human connections with the wildlife there. Third, short-term campaigns could be especially helpful if they publicize a variety of options that could reduce harm to sea turtles so individuals feel a sense of ownership of their behavioral choices.

ACKNOWLEDGMENTS

We thank the volunteers of the St. Joseph Peninsula Turtle Patrol, Gulf County Board of County Commissioners, MRD and Associates, and all study participants for their invaluable contributions. We also thank anonymous reviewers and the Associate Editor for improving the manuscript. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

LITERATURE CITED

Armstrong, J. S., and T. S. Overton. 1977. Estimating nonresponse bias in mail surveys. Journal of Marketing Research 14:396–402.

Barshel, N., R. Bruce, C. Grimm, D. Haggitt, B. Lichter, and J. McCray. 2014. Sea turtle friendly lighting: a model ordinance for local governments. https://www.law.ufl.edu/_pdf/academics/clinics/conservation-clinic/SeaTurtleFriendlyWholeReport.pdf. Accessed 15 Apr 2019.

Beatley, T. 1991. Protecting biodiversity in coastal environments—introduction and review. Coastal Management 19:1–19.

Bjorndal, K. A., B. A. Schroeder, A. M. Foley, B. E. Witherington, M. Bresette, D. Clark, R. M. Herren, M. D. Arendt, J. R. Schmid, A. B. Meylan, P. A. Meylan, J. A. Provancha, K. M. Hart, M. M. Lamont, R. R. Carthy, and A. B. Bolten. 2013. Temporal, spatial, and body size effects on growth rates of loggerhead sea turtles (*Caretta caretta*) in the northwest Atlantic. Marine Biology 160:2711–2721.

Blocker, T. J., and D. L. Eckberg. 1997. Gender and environmentalism: results from the 1993 General Social Survey. Social Science Quarterly 78:841–858.

Budruk, M., S. A. W. Stanis, I. E. Schneider, and D. H. Anderson. 2011. Differentiating place attachment dimensions among proximate and distant visitors to two water-based recreation areas. Society & Natural Resources 24:917–932.

Carstensen, L. L., D. M. Isaacowitz, and S. T. Charles. 1999. Taking time seriously—a theory of socioemotional selectivity. American Psychologist 54:165–181.

Chawla, L. 1998. Significant life experiences revisited: a review of research on sources of environmental sensitivity. Journal of Environmental Education 29:11–21.

Clukey, K. E., C. A. Lepczyk, G. H. Balazs, T. M. Work, Q. X. Li, M. J. Bachman, and J. M. Lynch. 2018. Persistent organic pollutants in fat of three species of Pacific pelagic longline caught sea turtles: accumulation in relation to ingested plastic marine debris. Science of the Total Environment 610:402–411.

Costanzo, M., D. Archer, E. Aronson, and T. Pettigrew. 1986. Energy-conservation behavior—the difficult path from information to action. American Psychologist 41:521–528.

Defeo, O., A. McLachlan, D. S. Schoeman, T. A. Schlacher, J. Dugan, A. Jones, M. Lastra, and F. Scapini. 2009. Threats to sandy beach ecosystems: a review. Estuarine Coastal and Shelf Science 81:1–12.

DeVellis, R. F. 2012. Scale development: theory and applications. Third edition. SAGE, Thousand Oaks, California, USA.

Dillman, D. A., J. D. Smyth, and L. M. Christian. 2008. Internet, mail and mixed-mode surveys: the tailored design method. Third edition. Wiley, Hoboken, New Jersey, USA.

Dodd, C. K. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). United States Fish and Wildlife Service, Biological Report 88(14). Washington D.C., USA.

Eisenhauer, B. W., R. S. Krannich, and D. J. Blahna. 2000. Attachments to special places on public lands: an analysis of activities, reason for attachments, and community connections. Society & Natural Resources 13:421–441.

Finkbeiner, E. M., B. P. Wallace, J. E. Moore, R. L. Lewison, L. B. Crowder, and A. J. Read. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation 144:2719–2727.

Florida Fish and Wildlife Commission [FFWC]. 2015. Statewide nesting beach survey program loggerhead nesting data, 2009–2013. Florida Fish and Wildlife Conservation Commission, http://myfwc.com/research/wildlife/sea-turtles/nesting/loggerhead/. Accessed 10 Feb 2015.

Frick, J., F. G. Kaiser, and M. Wilson. 2004. Environmental knowledge and conservation behavior: exploring prevalence and structure in a representative sample. Personality and Individual Differences 37:1597–1613.

Fuentes, M. M. P. B., C. Gredzens, B. L. Bateman, R. Boettcher, S. A. Ceriani, M. H. Godfrey, D. Helmers, D. K. Ingram, R. L. Kamrowski, M. Pate, R. L. Pressey, and V. C. Radeloff. 2016. Conservation hotspots for marine turtle nesting in the United States based on coastal development. Ecological Applications 26:2706–2717.

Gardner, G. T., and P. C. Stern. 1996. Environmental problems and human behavior. Allyn and Bacon, Boston, Massachusetts, USA.

Gaston, K. J., T. W. Davies, J. Bennie, and J. Hopkins. 2012. Reducing the ecological consequences of night-time light pollution: options and developments. Journal of Applied Ecology 49:1256–1266.

Haigh, M. 2005. Greening the university curriculum: appraising an international movement. Journal of Geography in Higher Education 29:31–48.

Hair Jr., J. F., W. C. Black, B. J. Babin, and R. E. Anderson. 2010. Multivariate data analysis. Seventh edition. Prentice Hall, Upper Saddle River, New Jersey, USA.

Hines, J. M., H. R. Hungerford, and A. N. Tomera. 1987. Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. Journal of Environmental Education 18:1–8.

Hodson, D. 2003. Time for action: science education for an alternative future. International Journal of Science Education 25:645–670.

IBM. 2016. IBM SPSS statistics for Windows, Version 24.0. IBM, Armonk, New York, USA.

Johnson, S. A., K. A. Bjorndal, and A. B. Bolten. 1996. Effects of organized turtle watches on loggerhead (*Caretta caretta*) nesting behavior and hatchling production in Florida. Conservation Biology 10:570–577.

Jorgenson, J. D., and N. P. Nickerson. 2016. Attachment to tourism destinations: the role of memory and place attachment. *In* 47th Annual International Conference of the Travel and Tourism Research Association, 15–17 Jun 2016, Vail, Colorado, USA. University of Massachusetts. https://scholarworks.umass.edu/ttra/2016/Academic_Papers_Visual/2. Accessed 28 Jan 2019.

Kaiser, F. G., and U. Fuhrer. 2003. Ecological behavior's dependency on different forms of knowledge. Applied Psychology—an International Review-Psychologie Appliquee-Revue Internationale 52:598–613.

Kamrowski, R. L., S. G. Sutton, R. C. Tobin, and M. Hamann. 2014. Potential applicability of persuasive communication to light-glow reduction efforts: a case study of marine turtle conservation. Environmental Management 54:583–595.

Kamrowski, R. L., S. G. Sutton, R. C. Tobin, and M. Hamann. 2015. Balancing artificial light at night with turtle conservation? Coastal community engagement with light-glow reduction. Environmental Conservation 42:171–181.

Kaplan, S. 2000. Human nature and environmentally responsible behavior. Journal of Social Issues 56:491–508.

Kil, N., S. M. Holland, and T. V. Stein. 2015. Experiential benefits, place meanings, and environmental setting preferences between proximate and distant visitors to a National Scenic Trail. Environmental Management 55:1109–1123.

Klineberg, S. L., M. McKeever, and B. Rothenbach. 1998. Demographic predictors of environmental concern: it does make a difference how it's measured. Social Science Quarterly 79:734–753.

Kurz, D. J., K. M. Straley, and B. A. DeGregorio. 2012. Out-foxing the red fox: how best to protect the nests of the endangered loggerhead marine turtle *Caretta caretta* from mammalian predation? Oryx 46: 223–228.

Lamont, M. M., H. F. Percival, and S. V. Colwell. 2002. Influence of vehicle tracks on loggerhead hatchling seaward movement along a northwest Florida beach. Florida Field Naturalist 30:77–109.

Larson, K. L., and M. V. Santelmann. 2007. An analysis of the relationship between residents' proximity to water and attitudes about resource protection. Professional Geographer 59:316–333.

Lieflander, A. K., G. Frohlich, F. X. Bogner, and P. W. Schultz. 2013. Promoting connectedness with nature through environmental education. Environmental Education Research 19:370–384.

Luchs, M. G., and T. A. Mooradian. 2012. Sex, personality, and sustainable consumer behavior: elucidating the gender effect. Journal of Consumer Policy 35:127–144.

Martinez, M. L., A. Intralawan, G. Vazquez, O. Perez-Maqueo, P. Sutton, and R. Landgrave. 2007. The coasts of our world: ecological, economic and social importance. Ecological Economics 63:254–272.

McDonald, R. I., K. S. Fielding, and W. R. Louis. 2014. Conflicting social norms and community conservation compliance. Journal for Nature Conservation 22:212–216.

McKenzie-Mohr, D. 2011. Fostering sustainable behavior. New Society, Gabriola Island, British Columbia, Canada.

Mir, H. M., K. Behrang, M. T. Isaai, and P. Nejat. 2016. The impact of outcome framing and psychological distance of air pollution consequences on transportation mode choice. Transportation Research Part D-Transport and Environment 46:328–338.
Monroe, M. 1999. What works: a guide to environmental education and communication programs for practitioners and donors. New Society Publishers, Gabriela Island, British Columbia, Canada.
National Marine Fisheries Service, and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1991. Recovery plan for U.S. population of Atlantic green turtle (*Chelonia mydas*). Washington, D.C., USA.
National Marine Fisheries Service, and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. Washington, D.C., USA.
National Marine Fisheries Service, and U.S. Fish and Wildlife Service [NMFS and USFWS]. 1993. Recovery plan for the hawksbill turtle (*Eretmochelys imbricata*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico. Washington, D.C., USA.
National Marine Fisheries Service, and U.S. Fish and Wildlife Service [NMFS and USFWS]. 2008. Recovery plan for the Northwest Atlantic population of the loggerhead sea turtle (*Caretta caretta*). Washington, D.C., USA.
National Marine Fisheries Service, and U.S. Fish and Wildlife Service [NMFS and USFWS]. 2011. Bi-national recovery plan for the Kemp's Ridley sea turtle (*Lepidochelys kempii*). Washington, D.C., USA.
National Oceanic and Atmospheric Administration [NOAA]. 2017. Shoreline website. https://shoreline.noaa.gov/. Accessed 15 Apr 2019.
Palmer, J., P. Corcoran, and J. Suggate. 1996. Formative experiences of environmental educators. Environmental Education 52:5–8.
Ramkissoon, H., and F. T. Mavondo. 2017. Pro-environmental behavior: critical link between satisfaction and place attachment in Australia and Canada. Tourism Analysis 22:59–73.
Salmon, M., M. G. Tolbert, D. P. Painter, M. Goff, and R. Reiners. 1995. Behavior of loggerhead sea turtles on an urban beach. 2. Hatchling orientation. Journal of Herpetology 29:568–576.
Schlacher, T. A., S. Lucrezi, R. M. Connolly, C. H. Peterson, B. L. Gilby, B. Maslo, A. D. Olds, S. J. Walker, J. X. Leon, C. M. Huijbers, M. A. Weston, A. Turra, G. A. Hyndes, R. A. Holt, and D. S. Schoeman. 2016. Human threats to sandy beaches: a meta-analysis of ghost crabs illustrates global anthropogenic impacts. Estuarine Coastal and Shelf Science 169:56–73.
Schultz, P. W. 2000. Empathizing with nature: the effects of perspective taking on concern for environmental issues. Journal of Social Issues 56:391–406.
Schultz, P. W. 2011. Conservation means behavior. Conservation Biology 25:1080–1083.
Schuman, H., and S. Presser. 1981. Questions and answers in attitude surveys: experiments on question form, wording, and context. Academic Press, New York, New York, USA.
Sharp, J., and L. Adua. 2009. The social basis of agro-environmental concern: physical versus social proximity. Rural Sociology 74:56–85.
Small, C., and R. J. Nicholls. 2003. A global analysis of human settlement in coastal zones. Journal of Coastal Research 19:584–599.
Steg, L., and C. Vlek. 2009. Encouraging pro-environmental behaviour: an integrative review and research agenda. Journal of Environmental Psychology 29:309–317.
Stern, P. C. 2000. Toward a coherent theory of environmentally significant behavior. Journal of Social Issues 56:407–424.
Stewart, K. R., and J. Wyneken. 2004. Predation risk to loggerhead hatchlings at a high-density nesting beach in southeast Florida. Bulletin of Marine Science 74:325–335.
Swindall, J. E. 2015. Factors influencing sea turtle conservation in northwest Florida: landowner knowledge, values, and behaviors. Thesis. University of Florida, Gainesville, USA.
Tanner, T. 1980. Significant life experiences—a new research area in environmental education. Journal of Environmental Education 11:20–24.
Tonge, J., M. M. Ryan, S. A. Moore, and L. E. Beckley. 2015. The effect of place attachment on pro-environment behavioral intentions of visitors to coastal natural area tourist destinations. Journal of Travel Research 54:730–743.
Truscott, Z., D. T. Booth, and C. J. Limpus. 2017. The effect of on-shore light pollution on sea-turtle hatchlings commencing their off-shore swim. Wildlife Research 44:127–134.
U.S. Census Bureau. 2014. 2010 census detailed county profiles. http://edr.state.fl.us/content/area-profiles/2010-census-detailed-county/index.cfm. Accessed 15 Apr 2019.
United Nations Educational, Scientific and Cultural Organization [UNESCO]. 1977. Intergovernmental Conference on Environmental Education, Tbilisi (USSR) 14–26 Oct 1977: final report. United Nations, Paris, France.
van de Merwe, J. P., E. J. West, and K. Ibrahim. 2012. Effects of off-road vehicle tyre ruts on the beach dispersal of green sea turtle *Chelonia mydas hatchlings*. Endangered Species Research 18:27–34.
Van de Velde, L., W. Verbeke, M. Popp, and G. Van Huylenbroeck. 2010. The importance of message framing for providing information about sustainability and environmental aspects of energy. Energy Policy 38:5541–5549.
Volk, T. L., and M. J. Cheak. 2003. The effects of an environmental education program on students, parents, and community. Journal of Environmental Education 34:12–25.
Wilcox, C., N. J. Mallos, G. H. Leonard, A. Rodriguez, and B. D. Hardesty. 2016. Using expert elicitation to estimate the impacts of plastic pollution on marine wildlife. Marine Policy 65:107–114.
Witherington, B. E. 1992. Behavioral-responses of nesting sea-turtles to artificial lighting. Herpetologica 48:31–39.
Witherington, B., S. Hirama, and A. Mosier. 2011. Sea turtle responses to barriers on their nesting beach. Journal of Experimental Marine Biology and Ecology 401:1–6.
Witherington, E. E., and R. E. Martin. 2000. Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches. Florida Marine Research Institute Technical Report TR-2, St. Petersburg, USA.
Work, P. A., A. L. Sapp, D. W. Scott, and M. G. Dodd. 2010. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. Journal of Experimental Marine Biology and Ecology 393:168–175.

Associate Editor: Peterson.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Task 1. Experts were asked to identify the most important topics to assess people's knowledge about general sea turtle ecology in coastal and nearshore areas, using a scale from 1 to 5 (with '1' indicating 'low importance' and '5' indicating 'high importance').

Task 2. Experts were asked to identify the most important topics to assess people's knowledge about how to minimize the harm caused to sea turtles by human activity, using a scale from 1 to 5 (with '1' indicating 'low importance' and '5' indicating 'high importance')