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Author(s): ALan F. Rees , Ali Al Hafez , Jane R. Lloyd , Nancy Papathansopoulou and Brendan J. Godley

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**Green Turtles, *Chelonia mydas*, in Kuwait:
Nesting and Movements**

**ALAN F. REES¹, ALI AL HAFEZ², JANE R. LLOYD³,
NANCY PAPATHANSOPOULOU⁴, AND
BRENDAN J. GODLEY¹**

¹*Marine Turtle Research Group, Centre for Ecology and
Conservation, University of Exeter, Cornwall Campus, TR10 9EZ,
UK [arees@seaturtle.org; b.j.godley@exeter.ac.uk];*

²*Marine Wildlife Protection Team, P. Code 92400, PO Box 558,
Ardya, Kuwait [alisenyar@gmail.com];*

³*University of Gloucestershire, Cheltenham, Gloucestershire,
GL50 2RH, UK [jane.r.lloyd@gmail.com];*

⁴*Biodiversity East, PO Box 214383, Dubai, UAE
[nancy@bio-e.org]*

ABSTRACT. – There is a paucity of information on the presence and nesting of green turtles, *Chelonia mydas*, in Kuwait, and known nesting habitats have been altered in recent years. Through beach monitoring and satellite telemetry, we determined that green turtle nesting is now limited to Qaru Island with 1–5 turtles nesting annually and that foraging habitats occur along the northern shore of Failaka Island ($n = 2$ turtles) and coastal region of central Saudi Arabia ($n = 1$ turtle). Foraging habitat in Kuwait overlaps with a coastal trap-fishery, raising concerns for the conservation of this depleted population.

Green turtle (*Chelonia mydas*) nesting has been recorded in the Persian/Arabian Gulf (herein referred to as The Gulf). Thousands of turtles nest each year on the islands of Saudi Arabia (Pilcher 2000), and a few nests have been recorded in the United Arab Emirates (Al Suweidi et al. 2012). No green turtle nesting has been documented in Qatar (Pilcher 2006). Green turtles nest on the beaches of Iran, mainly outside The Gulf in the Gulf of Oman (Mobaraki 2004); however, low-level nesting has been confirmed on several of Iran's islands within The Gulf (A. Mobaraki, pers. comm., September 2012). Several thousand green turtles nest each year outside The Gulf in Oman (Ross and Barwani 1982). This species also nests in Kuwait (Meakins and Al Mohanna 2004) along with hawksbill turtles (*Eretmochelys imbricata*) (Meakins and Al Mohanna 2004). Three other species of sea turtle are also known from the waters of Kuwait—loggerhead (*Caretta caretta*; Meakins and Al Mohanna 2000; Al Mohanna and George 2010); olive ridley (*Lepidochelys olivacea*; Bishop et al. 2007); and leatherback turtles (*Dermochelys coriacea*; Al Mohanna and Meakins 2000)—but no records of nesting exist.

There is a distinct lack of historic information on turtles in Kuwait. In their review of turtles in the Arabian region, Ross and Barwani (1982) provide no indication of turtle nesting in the country and that only one green turtle had been caught by a fisheries research vessel. The limited information that exists is derived from observations covering a little over the past decade (see citations above).

Until recently, green turtles in Kuwait had nested on Umm Al-Maradim (UAM), an island approximately 0.55 km long by 0.35 km wide (28.6798°N, 48.6520°E; Fig. 1) using a sand spit extending some 150 m from the main island (Meakins and Al Mohanna 2004). However, in 2005, construction of a large Coast Guard station including a harbor began, which led to reclamation of the green turtle nesting beach and cessation of nesting. The limited nesting activity reported from the mainland is all attributed to hawksbill turtles (unpubl. data, 2012), which means Qaru, an approximately circular sandy island less than 300 m in diameter (28.8174°N, 48.7765°E; Fig. 1) is likely the last remaining nesting area in Kuwait for green turtles.

To confirm the on-going loss of green turtle nesting from UAM and to quantify levels of green turtle nesting on Qaru, we undertook three nesting seasons of

monitoring on the islands (2009–2011), in addition to spot surveys undertaken in the preceding and following years (2008 and 2012). We also used satellite telemetry to assess movements and habitat use of adult-sized female green turtles both at and away from the nesting area.

METHODS

Preliminary investigations on Qaru and UAM began in 2008, with 2 brief visits to the islands in July and August, peak nesting for green turtles in neighboring Saudi Arabia (Pilcher 2000), and more dedicated surveys were continued between 2009 and 2011. Monthly fieldwork comprising periods of ≥ 8 d were undertaken between May and August. Patrols were undertaken at hourly intervals between dusk and dawn on Qaru. Curved carapace length (CCL) of turtles encountered was recorded, and photographs of the turtles' heads were taken for ID purposes. Track surveys were undertaken on UAM at least once per field period to look for green turtle emergences. The islands were surveyed once near the end of the nesting season (August) to confirm levels of green turtle nesting in 2012. Environmental conditions in the area, calm weather, and limited trampling of the beach were such that evidence of nesting from the entire season was still easily discernible.

To identify foraging locations of green turtles away from the nesting area, we undertook the first sea turtle satellite tracking in Kuwait and deployed 4 Kiwisat 101 Argos satellite tags (Sirtrack Ltd, Havelock North, New Zealand) using 2-part epoxy (Sika Anchorfix 3+, Athens, Greece) following established methods (Godley et al. 2002). Two tags were deployed on turtles that had completed unsuccessful nesting attempts on Qaru, 1 in 2009 and 1 in 2010 (Table 1). The final 2 tags were deployed on adult-sized female turtles that had been rehabilitated at Kuwait's Scientific Centre Aquarium, after becoming trapped in power-plant water intakes on the mainland at Fahaiheel (approximately 29.075°N, 48.143°E). These turtles were released at Kubbar Island (29.0719°N, 48.4924°E; Fig. 1) in November 2010 (Table 1), approximately 30 km from their capture site.

Location data were generated by Service Argos (Argos 2012) and were retrieved, compiled, and processed in the Satellite Tracking and Analysis Tool (STAT; Coyne and Godley 2005).

To reveal movements and general habitat use, location-data processing was undertaken similar to that of Rees et al. (2012). Positional data were filtered such that Argos location classes (LCs) 3, 2, 1, A, and B were included as per Witt et al. (2010), and locations requiring unlikely speed of travel ($> 3 \text{ km h}^{-1}$) or severe change in direction ($< 25^\circ$ turning angle) were omitted. Best daily location was obtained by choosing the highest quality LC, and to ensure temporal spread of positions, if 2 or more similar LCs existed per day, the one nearest to 1200 hrs, local time, was chosen. Sea depth was generated in STAT using

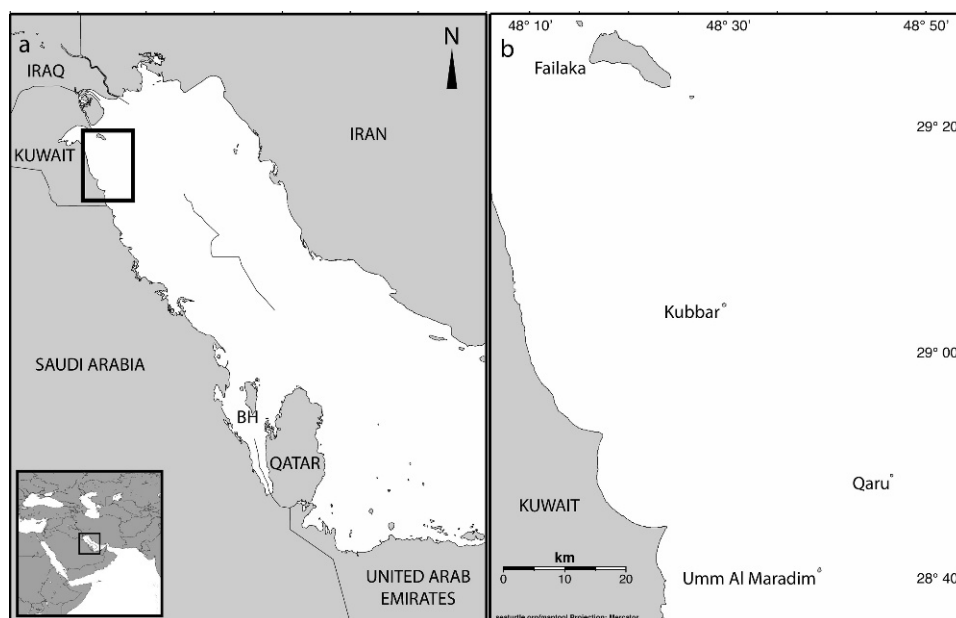


Figure 1. Location of Kuwait's islands in regional setting. a) Map of region showing Kuwait's neighboring countries. Rectangle indicates extent of map b. BH = Bahrain. b) Kuwait's main islands relevant to sea turtles presence.

the General Bathymetric Chart of the Oceans (GEBCO; www.gebco.net) data set. Minimum travel speed was calculated between best daily locations using the Spherical Law of Cosines, and the change from migratory to foraging behavior was identified by visual detection of the turtle's movements becoming less directed and more convoluted. Kernelling for foraging area analysis was undertaken on a data set comprising the best daily location from unfiltered LCs 3, 2, and 1 (those attributed as typically having sub-kilometer accuracy by Argos), with the location nearest to 1200 hrs local time taken if 2 LCs of similar quality were received. Using Hawth's tools (www.spatialecology.com) in ArcGIS 9.3.1 (ESRI, Redlands, CA), we used a 1-km smoothing factor (h) in the fixed kernel density estimator method (Worton 1989) to define the 95% and 50% use levels, indicative of home range and core areas, respectively.

RESULTS AND DISCUSSION

Surveys verified that green turtles no longer nest on UAM but confirmed they are still nesting on Qaru. The number of nesting females is low (5 were observed in 2008, 1 in both 2009 and 2010, and 3 in 2011), and none of the turtles were observed nesting in more than 1 yr. Twelve

green turtle nests were recorded during the 1 field survey undertaken near the end of the season in 2012, which likely equates to 2–3 breeding females. Average curved carapace length of the nesting turtles recorded between 2008 and 2011 was 98.2 cm (SD = 4.0 cm, range 93–105 cm, $n = 10$). Three green turtles were observed on Qaru in 1998, with several additional nests seen on the beach (Meakins and Al Mohanna 2004); thus, the population may have remained small but stable for the past decade.

The satellite tag of the first nesting turtle (A) became dislodged soon after deployment. The turtle was observed without the tag, on the beach attempting to nest 2 d after deployment; hence, no useful data were derived from this tag. Transmissions from the second tagged turtle (B) spanned 121 d. Locations (near the nesting area) and associated sea depth data (periodic shifting from deeper to shallower water) suggested the turtle nested 3 times after tag deployment before departing the nesting area (Fig. 2). Using this telemetry-derived data in combination with track records, a clutch frequency of 5 is suggested for this turtle in 2010.

We obtained 10 high-quality locations for a nesting turtle (B) over the 28-d internesting period (36%), which enabled us define habitat use for that time (Fig. 3b).

Table 1. Data pertaining to the 4 green turtles equipped with satellite transmitters in Kuwait. Location = site of release/tagging; status = how the turtle was obtained; duration = lifespan of transmitter.

Turtle	Location	CCL (cm)	Status	Deployed	Duration (d)
A	Qaru Island	96.0	Nesting	12 Aug 2009	2
B	Qaru Island	105.0	Nesting	28 Jul 2010	121
C	Kubbar Island	98.8	Rehabilitated	7 Nov 2010	248
D	Kubbar Island	97.0	Rehabilitated	7 Nov 2010	238

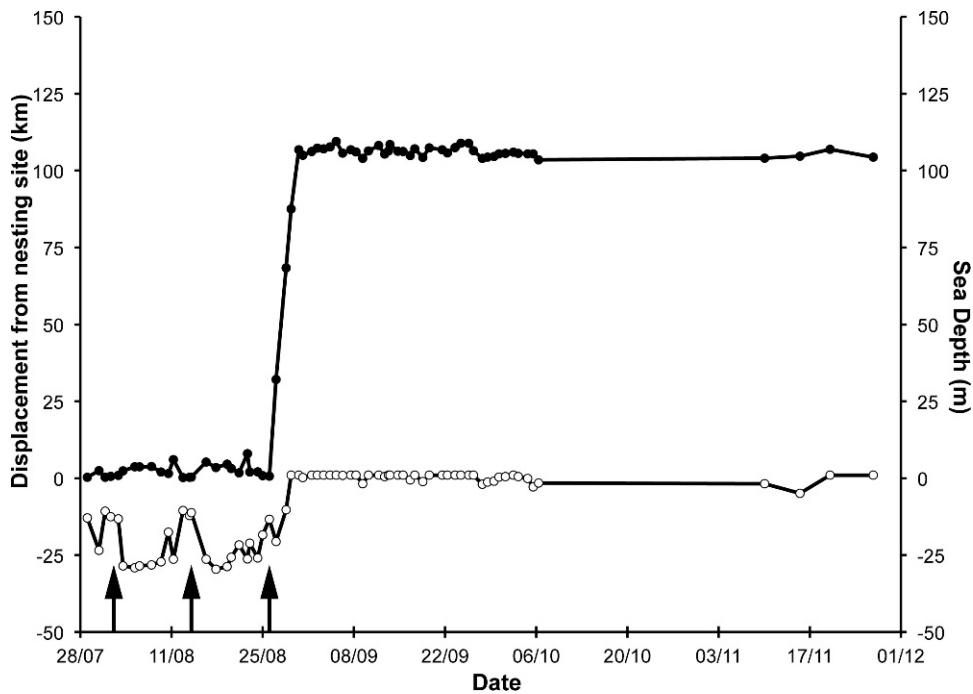


Figure 2. Sea depth and displacement from nest site for a green turtle tracked from Qaru Island, Kuwait. Arrows indicate inferred nesting events. Limits in Argos location accuracy and the bathymetry layer combine to show minimum sea depth of approximately 10 m during the interesting period and close to 0 m during the majority of the foraging period. Filled circles = displacement; open circles = sea depth; date = dates within 2010.

Core interesting habitat covered 3.8 km², encompassing the nesting site. However, sample size needs to be increased to verify this is the preferred interesting habitat of this population. After completing breeding, the tagged turtle migrated approximately 105 km south, to very shallow seas in Saudi Arabia (27.8890°N, 48.9928°E; Figs. 2 and 3) where it was tracked for another 89 d. We obtained 19 high-quality locations over the initial 31-d foraging period (62%), which revealed a core foraging area and home range extent of 5.3 and 26.0 km², respectively, although these values are likely to be artificially reduced because of the low number of locations used. This was followed by a 35-d gap in transmissions before several low-quality locations were received over a 17-d period (see Fig. 2). The final locations indicated the turtle was still resident in the same foraging location.

The 2 tracked rehabilitated turtles, from unknown breeding populations, both swam in the opposite direction of the turtle that had nested in Kuwait and established long-term residencies along the northern shore of Failaka Island (29.4587°N, 48.3295°E; Fig. 4) 180 km north of the nesting turtle's overwintering site. After an 11-d migration, evidently including several days west of the island in Kuwait Bay, turtle C remained near Failaka Island for the remaining 227-d duration of the tag's operation (Fig. 4a). We obtained 109 d with high-quality locations over the 227-d foraging period (48%), which revealed a core foraging area and home range extent of 14.5 and 64.9 km², respectively, for this

individual that extended along most of the north side of Failaka. Turtle D took 4 d to migrate to Failaka Island. In February 2011, it undertook a 200-km, 26-d round-trip south to the border with Saudi Arabia (Fig. 4c) and finally settled near Failaka Island for a further 118 d (Fig. 4b). We obtained 104 d with high-quality locations over a 188-d foraging period (55%), which revealed a core foraging area and home range extent of 8.4 and 75.9 km², respectively, for this individual that was mostly restricted to the northernmost point of Failaka.

All 3 turtles tracked for periods in foraging sites revealed very particular location selection using sub-80-km² home ranges, which is similar to that found in the Mediterranean (Broderick et al. 2007). Green turtles generally display small, defined home ranges, but their foraging ecology is dependent on the extent of suitable habitat within a region together with turtle size and water temperature (Seminoff et al. 2002). Precise habitats of the animals tracked here are unknown; however, home ranges are located in shallow coastal conditions that would be suitable for sea grass and algae growth, which comprise the main food source of adult green turtles (Bjorndal 1997). Mapping marine sea grass and algal pastures in the northern Gulf region would, therefore, help to identify the extent of potential green turtle foraging habitat and, if supplemented with further tracking or in-water research, would facilitate directed conservation measures.

Notably, the tracked turtles of unknown nesting origin overwintered in an area far distant to the tracked

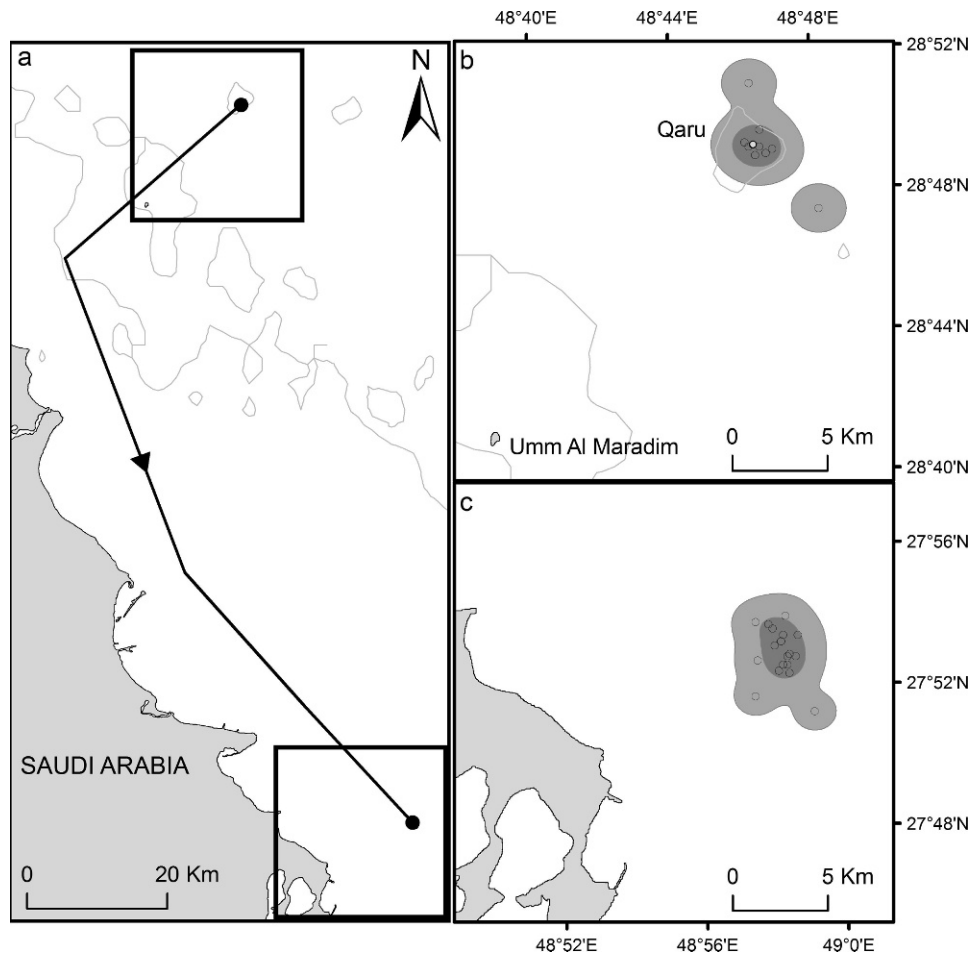


Figure 3. Postnesting migration and spatial use of an adult female green turtle tracked from Qaru Island, Kuwait. a) Basic route of the 3-d migration from the nesting site in the north to foraging location in the south. b) Internesting habitat use around Qaru Island. c) Postnesting foraging habitat use in Saudi Arabia. Dark and pale shaded areas in parts b and c are 50% and 95% use distributions, respectively. The 20-m bathymetry contour is depicted for reference.

nesting turtle, which may indicate they derive from the far larger population nesting in Saudi Arabia (Pilcher 2000). Genetic characterization of the nesting locations is lacking. With such information, it would be possible to determine any divergence between the Kuwait and Saudi Arabian breeding populations and ascertain whether Kuwait's small population represents a marginal population sourced from the Saudi Arabian stock or a distinct breeding colony and, hence, its importance to the biological diversity of the species.

A type of coastal fish trap called *hadra* is used around Failaka Island and other areas in Kuwait, and turtle bycatch has been recorded at this island (Papathanasopoulou 2010) and elsewhere (Meakins and Al Mohanna 2004). Hence, as with other locations (McClellan and Read 2009) it is clear that spatial overlap between fishing and green turtle foraging habitats that impacts on turtle survivorship exists in Kuwait.

In conclusion, 5 yrs of field observations and satellite telemetry has highlighted that Kuwait hosts a tiny population of breeding green turtles compared with

regionally important sites with thousands of nesting turtles in Saudi Arabia (Pilcher 2000) and Oman (Ross and Barwani 1982). However, within Kuwait, Qaru Island represents the last remaining nesting site for this species and, hence, a nationally important nesting habitat for a population at critically low levels. Consequently, measures should be taken to minimize anthropogenic disturbance at this site and prevent any developments that may further impact nesting and hatching success; in doing so, the hawksbill turtles nesting there will also be afforded protection. Also, the nesting turtle's migration to coastal waters of Saudi Arabia indicates that full protection of this endangered population requires binational conservation measures. However, two green turtles tracked to Failaka Island for extended periods and bycatch in *hadra* around the country is indicative that Kuwait may host important numbers of foraging turtles, equal in importance to its nesting populations. Investigation into the in-water abundance and distribution of turtles in Kuwait as well as precise levels of turtle bycatch and mortality in

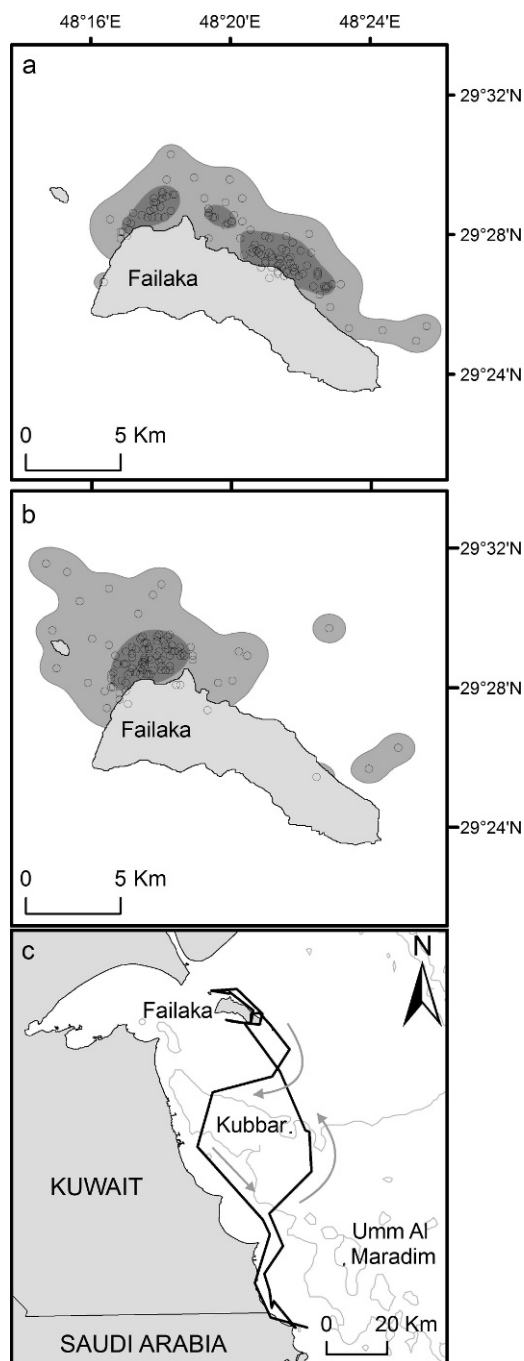


Figure 4. Foraging area selection and migration of 2 adult-sized female green turtles released on Kubbar Island after rehabilitation at the National Aquarium of Kuwait. a) Foraging habitat for turtle C. b) Foraging habitat for turtle D. In parts a and b, the dark and pale shaded areas are 50% and 95% use distributions, respectively. c) Route of turtle D's 200-km round-trip migration undertaken in February 2011, which was proceeded and followed by extended periods in a defined foraging area depicted in part b. Locations during the migrations from Kubbar Island were too infrequent and inaccurate to plot a meaningful route for either turtle. The 20-m bathymetry contour is depicted for reference.

hadrar and other fishing gear should, therefore, be prioritized.

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