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Trace elements concentration in blood of nesting Kemp's Ridley turtles (*Lepidochelys kempii*) at Rancho Nuevo sanctuary, Tamaulipas, Mexico

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Abstract

The concentrations of trace elements including As, Zn, Cu, Se, Pb, Hg and Cd, were determined in the blood of nesting Kemp's ridley turtles (*Lepidochelys kempii*) at Rancho Nuevo sanctuary, Tamaulipas, Mexico during 2018–2020. The sequential concentrations analyzed were Zn> Se> Cu> As> Pb; while Cd and Hg concentrations were below the limits of detection (0.01 μg g^{-1}). No significant differences were observed between the concentrations of trace elements ($p > 0.05$) by year, except Se levels, possibly resulting from recorded seasonal differences in turtle size. No relationships among turtle size *vs* elements concentration were observed. In conclusion, essential and toxic trace elements concentrations in the blood of nesting Kemp's ridley turtles may be a reflex of the ecosystem in which the turtles develop, that is, with low bioavailability of elements observed in the trophic webs in the Gulf of Mexico.

Introduction

Coastal habitats are negatively impacted by waste produced through agriculture, mining, urbanization, fisheries, and the oil industry. These waste products are released into the environment increasing contamination levels [1–4] which affect the health of species and ecosystems [5,6]. Semi-enclosed seas are particularly affected where anthropogenic activities increase the bioavailability of trace elements. Due to their speciation capacity, trace elements are persistent in the environment [7]. Therefore, organisms are under continuous stress due to contamination [8–10]. Pollution levels increase through bioconcentration, bioaccumulation and biomagnification along the trophic web, affecting organisms such as sea turtles further up

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these networks altering their metabolic pathways and increasing the potential for disease and death [11–16].

Kemp's ridley turtles (*Lepidochelys kempii*) are considered the most critically endangered of all sea turtle species by the IUCN [17,18]. It is endemic to the Gulf of Mexico with 90% of the population nesting in Rancho Nuevo Sanctuary, Tamaulipas, Mexico [19,20]. Kemp's ridleys face multiple threats induced by environmental contamination present in the Gulf of Mexico caused by hydrocarbons, organochlorine compounds, carbamates, solid waste, pharmaceuticals, macro and microplastics and toxic trace elements [21–25]. The latter is of particular concern due to the dominant anthropogenic activities in the region [26,27]. These include fertilizer production, mining, and oil refining.

The oil industry is the principal contributor due to the large amounts of crude oil and waste products that have spilled into coastal areas over the years, apporting certain elements like Cd, Zn, Cu, Pb, As, Hg, etc. [28–30]. In 2010, the Gulf of Mexico was affected by the Deepwater Horizon oil spill [31], affecting Kemp's ridley foraging areas [32]. The incident impacted over 61,000 Kemp's ridley turtles that stranded directly or indirectly linked to this event and representing approximately 35% of a total estimated population of almost 178,000 in 2013. Current trends demonstrate that the species is recovering with recruits arriving to nesting beaches annually [33]. In addition, toxic elements remain a potential threat to Kemp's ridley turtles [31,34–36]. The present study aimed to quantify the concentrations of trace elements in blood of nesting Kemp's ridley turtles at Rancho Nuevo Sanctuary, Tamaulipas, Mexico. This information may be useful to provide a better understanding of bioaccumulation process and possible population health impacts on this endangered species.

Materials and methods

Sample collection

Blood samples were collected from nesting Kemp's ridley turtles at the Rancho Nuevo Sanctuary, Tamaulipas, Mexico (23˚10'54" N, - 97˚46'05" W) during the mass nesting arribada seasons occurring April to July 2018 to 2020. Blood was collected from the dorsal cervical sinus according to previous studies [37]. Briefly, once the turtle had finished ovipositing, the blood sample was collected by tilting the individual at a minimum angle of 30˚, supported by a mound of sand, and the neck was slightly stretched to increase blood flow to the anatomical region [38]. A total of 5 mL of blood was collected with 21Gx½ gauge double-ended syringe and needle and stored in 10 mL tubes with ethylenediaminetetraacetic acid (EDTA) as anticoagulant (Beckton-Dickinson, Franklin Lakes, NJ). The samples were refrigerated at 4˚C until laboratory processing [37].

Female biometrics and tagging

For each turtle, curved carapace length (CCL) notch to tip, straight carapace length (SCL) and curved carapace width (CCW) [39] were using calipers and a flexible measuring tape [45]. Each turtle was tagged on the second scale of their left flipper with one Inconel tag, and one intradermal passive integrated transponder (PIT) tag when available, in order. To record recaptures, each turtle underwent a visual examination and was assigned to the category best describing its general physical condition as: healthy or injured [40]. Body condition was established based on the concavity of the plastron [41] where a concave plastron indicated poor health, a flat plastron denoted a fair condition, and a convex shape reflected good health. The quantity and size of fibropapillomas were evaluated following the method by Work and Balazs [42] and epibiont load was categorized using a scale of 1 to 3 with 1 = mild: $<$20 epibionts; 2 = moderate: 20–50 epibionts; and 3 = high: $>$ 50 epibionts [43].

Trace elements analysis

Trace elements analyzed included Zn, Cu, Se, Hg, Pb, Cd and As. Acid digestions of the blood samples obtained were performed for their determination using methodology previously described [14]. An acid mixture of 5 mL of HNO_3 and HCl in a 4:1 ratio was added to 0.5 g of whole blood from each sample, using a microwave digestion system (MARS Xpress CEM). Each digestion was measured with deionized water in 25 mL volumetric polypropylene flask and refrigerated until analysis, which occurred in a period not exceeding 48 h after digestion to avoid volatilization or adsorption by the flask walls. Toxic and essential trace elements concentration analysis was performed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES, VARIAN 730-ES). The detection limits of the equipment were 0.5 mg kg^{-1} for Hg and 0.02 μg g^{-1} for all other elements analyzed.

Reference materials certified by the National Research Council of Canada (TORT-3) were used as quality controls and to determine the percentage of evaporation and recovery of the analyzed trace elements. Analyzes were performed in duplicate fortified with standards of reference (Perkin Elmer GFAAS Mixed Standard). Blanks (deionized water) were placed every eight samples and underwent the same digestion process to detect possible contamination [34,44]. The final digestions were clear and transparent; likewise, the recovery percentage of the analyzed trace elements was between 89–106%.

Statistical analysis

Data normality was assessed by the Kolmogorov Smirnov normality test. Statistical data were reported as arithmetic means ± standard error (mean ± SE) and range (minimum-maximum). Trace elements concentrations were presented in micrograms per gram wet weight (μg g^{-1}). The one-way analysis of variance (ANOVA) parametric test ($\alpha = 0.05$) and Tukey's multiple comparison test were used to assess differences regarding elements concentrations and individual biometry data. The Kruskal-Wallis test was used to analyze non-parametric data. A simple regression model ($R^2 > 50\%$) was performed to find the statistical relationship between the trace elements concentrations and the biometrics.

Ethics statement

Permits were granted in Mexico by Dirección General de Vida Silvestre/Secretaría para el Medio Ambiente y los Recursos Naturales (SEMARNAT) to study and manage wildlife samples or species. Permit numbers: SGPA/DGVS/04674/10 and SGPA/DGVS/003769/18.

Results and discussion

During the 2018 to 2020 nesting seasons, 83 blood samples were collected from nesting Kemp's ridley turtles at Rancho Nuevo beach, Tamaulipas, Mexico. All turtles captured were in good health, without wounds or external fibropapillomas and presented low or no epibiotic load. The average nesting female size was SCL of 60.66 ± 0.28 cm and a CCL of 65.315 ± 0.34 cm (Table 1). Turtles measured in 2020 were significantly smaller (SCL: 59.46 ± 0.33) than in

Table 1. Morphometric data (cm) of *L. kempii* turtles from Rancho Nuevo, Tamaulipas, Mexico, 2018–2020.

	Mean±SE	(min-max)
SCL	60.66±0.28	(55.74–65.88)
CCL	65.315±0.34	(59.20–71.80)
CCW	64.57±0.46	(56.60–72.60)

SCL = Straight Carapace Length. CCL = Curved Carapace Length. CCW = Curved Carapace Width.

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Table 2. Heavy metal concentrations reported in different areas (mean ± standar deviation, μg g^{-1} wet weight) in blood of Kemp´s ridley turtles.

Area	Nesting (*This study*)	Nesting (Wang, 2005)	Foraging (Orvik, 1997)	Foraging (Wang, 2005)	Foraging (Wang, 2005)	Foraging* (Perrault et al., 2017)
As	0.08±0.03	NA	NA	NA	NA	6.84±1.98d
Hg	ND	0.06±0.04	0.018 (0.0005–0.06)	0.01±0.009	0.01±0.01	0.04±0.04d
Cd	ND	0.01±0.01	NA	0.007±.005	0.01±0.005	0.02±0.01d
Cu	0.09±0.01	0.40±0.09	0.52 (0.21–1.3)	0.47±0.06	0.41±0.11	NA
Pb	0.06±0.02	0.05±0.02	0.001 (0.00–0.03)	0.02±0.03	0.03±0.03	0.01±0.004d
Se	0.14±0.05	NA	NA	NA	NA	4.11±1.83d
Zn	0.79±0.79	22.70±12.6	7.5(3.28–18.9)	3.9±1.47	6.71±4.46	NA

* = Analysis performed in red blood cells. **NA** = Not analyzed. **ND** = Not detected. In parentheses min-max when no standar deviation is reported.

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2018 (SCL: 62.77 cm ± 0.52) and 2019 (SCL: 61.88 cm ± 0.33) ($p < 0.05$). The turtles in this study were young females possibly laying their first clutch [45]. Kemp's ridley turtles become sexually mature between 8 and 12 years of age with a first clutch laid at an average size of SCL 61.8 ± 1.8 cm [19,20,45,46]. This is encouraging as new nesting females recruiting to this important rookery are contributing to the species recovery [45]. This coincides with Caillouet Jr [33] who found Kemp's ridley recruits in neritic areas and nesting beaches, corresponding to the age of maturation and nesting of turtles hatching after 2010. As previously stated, the Deepwater Horizon oil spill in the northeast of the Gulf of Mexico occurred during 2010 and directly or indirectly impacting 34.5% of the Kemp's ridleys population [32], this suggests that there are young adults in the nesting population that have not bioaccumulated high concentrations of toxic elements. The blood analysis documented that essential elements were more abundant compared to toxic ones, with a distribution Zn> Se> Cu> As> Pb. The concentrations of Hg and Cd were below detection limits (Table 2). No significant differences were observed between the concentrations of trace elements ($p > 0.05$) by year, except for Se, where concentrations were higher in 2018 than those found in 2020, $p = 0.035$ (Table 3). Similarly, Pb and Cu concentrations of 2020 samples were below detection limits.

Currently, work is underway to establish basal values of trace elements concentrations in nesting Kemp's ridley blood. Their bioavailability and bioaccumulation in sea turtles are influenced by multiple factors including species, life stage, diet, individual condition, climatic factors, and region [14,47–51]. Perhaps, feeding represent the main source of trace elements found in sea turtles [52]. The trophic position of the species plays a key role in bioaccumulation and biomagnification processes [14,53–55].

Table 3. Heavy metal concentrations (mean ± standar deviation, μg g^{-1} wet weight) in blood of nesting Kemp´s ridleys (*Lepidochelys kempii*) from Rancho Nuevo, Mexico, 2018–2020.

Metal	2018	2019	2020	Statistical test
Zn	1.02±0.17 (0.09–2.37)	0.70±0.14 (0.10–2.14)	0.67±0.13 (0.10–2.27)	$p = 0.207$
Cu	0.09±0.002 (26) (0.07–0.11)	0.09±0.002 (28) (0.06–0.11)	ND	$p = 0.523$
Pb	0.06±0.005 (21) (0.02–0.11)	0.06±0.003 (26) (0.03–0.10)	ND	$p = 0.339$
As	0.09±0.007 (24) (0.04–0.16)	0.08±0.003 (23) (0.05–0.11)	0.07±0.004 (24) (0.04–0.12)	$p = 0.193$
Se	0.17±0.02^{a} (8) (0.08–0.25)	0.15±0.01^{ab} (11) (0.06–0.21)	0.12±0.005^{b} (18) (0.08–0.16)	$p = 0.035$
Cd	ND	ND	ND	NA
Hg	ND	ND	ND	NA

ND = Not detected; NA = Not analyzed

n^a = Number of samples above the detection limit. Letters indicate significant difference between groups. Statistical test: ANOVA.

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The diet of Kemp's ridley turtles varies depending on their life stage. Blue crabs (*Callinectes sapidus*) are the principal food of adult kemps ridleys, while juveniles feed mainly on tunicates around nearshore islands. During the post hatchling pelagic stage little is known about their diet [56–58]. These changes in diet, may result in varying levels of trace elements in Kemp's ridleys throughout their life.

Zn was the most common element in organisms of the essential elements analyzed, plays a vital function in the growth and development and acts as a detoxifier [59], by induction metallothioneins [52,60]. However, high Zn levels can be toxic [7] and deficiencies in nesting turtles can decrease the number of eggs laid, and result in hatchling deformities [55]. This element occurs in higher levels in green turtles (*Chelonia mydas*), due to their herbivorous diet as adults, which includes algae that bioaccumulate Zn [44].

The Zn concentrations found in this study were lower (0.79 ± 0.08 μg g-1) than those previously reported for this population [61,62]. It has been mentioned that Zn concentrations are also dependent on age and size, with larger turtles accumulating higher concentrations of this element [62]. Cu is essential for growth and development even at low concentrations [48,59,63]. During vitellogenesis, both Cu and Zn concentrations decrease in nesting turtles due to the vertical transfer from the female to her eggs [63]. In addition, turtles present little or no feeding during nesting, reducing potential bioaccumulation during this period [48,51]. However, turtles nest two to three times per season [20,64], so essential elements concentrations may decrease over the nesting season [48].

Se is another essential element for sea turtles [48,65], which has antioxidant, immunological and thyroid functions [66]. Previously, a positive relationship between Hg and Se has been identified, as Se participates in the Hg detoxification processes in organisms. This correlation has not been previously reported in Kemp's ridley turtles, possibly as a result of the low levels of Hg in the population documented herein [57]. Although high concentrations can be toxic and cause neurological and dermal damage and decreased sea turtle hatching success [14,66,67]. The concentrations identified in this study were lower than those reported in other species of sea turtles worldwide [14,34,68,69].

Previous studies have shown that the distribution of essential and toxic elements in sea turtle blood presents higher levels of essential elements than toxic ones [62,69,70]. This distribution may be affected when intoxication or pathological responses occur; for example, a study in Brazil reported higher concentrations of Pb compared to Zn and Cu in *C. mydas* when these turtles presented fibropapillomatosis [50].

This study identified similar Pb levels to those previously reported (0.05 μg g-1) in Kemp's ridley turtles [62]. Despite the occurrence of the largest oil disaster in the Gulf of Mexico in 2010 [71], there has been no variation in blood Pb levels (Table 2) in the Kemp's ridley nesting turtles analyzed. However, Pb contamination has been present in the marine environment as a result of leaded gasoline, which through combustion, releases Pb into the environment and transported through biogeochemical cycles to the oceans. Most likely, Pb levels have decreased since policy change to unleaded gasoline [52,72,73]. However, it is important to continue monitoring Pb levels as this highly toxic metal can affect the nervous system and fetus development, cause infertility, immunosuppression, and osteoporosis due to its mimicry to Ca [7,35,72,74]. It has been considered that a low concentration of Pb in sea turtles should be less than 0.5 μg g^{-1} [75], therefore, the levels of Pb found in the nesting Kemp's ridley turtles in this study can be considered normal for the species. These acceptable levels are consistent with those reported in nesting olive ridley turtles (*Lepidochelys olivacea*) at 0.19 ± 0.03 μg g^{-1} in the Mexican Pacific [72].

Cd is considered one of the toxic metals with the highest impact and importance in ecotoxicology [7]. Cd can cause kidney, neurological and bone damage, is carcinogenic and teratogenic even at low levels in sea turtles [15,76]. Furthermore, maternal transfer of Cd to turtle eggs occurs through vitellogenin and proteins similar to Se (selenoproteins), a process that happens in competition with other essential elements [48,59,60,76]. Species such as loggerhead (*Caretta caretta*), green, and olive turtles present higher loads of Cd due to their diet. For example, green turtles feed on algae that bioaccumulate Cd, while other turtle diets include cephalopods which introduce Cd to their diet [34,52,77]. Blood Cd levels in Kemp's ridleys were below detection limits due to the low bioavailability; consistent with those reported by previous studies (0.007 to 0.02 μg g^{-1}) for both juveniles and adults [35,61,62].

As is a toxic element that frequently occurs in low concentrations in sea turtles [2]. Although it occurs mainly in organic form, which is less toxic, the inorganic fraction of this element (2–10%) can be toxic to sea turtles [2,77] and may generate immune responses such as oxidative stress [35] and possible liver and kidney damage [78]. As has only been reported in one previous study in juvenile Kemp's ridleys foraging in Florida, USA [35]. The study reported higher levels of As than those found in this present study (Table 2). This is possibly related to the diet of the juvenile turtles which consists principally of tunicates which are bioacummulators of As [79] as compared to adult Kemp's ridley diet based on crustaceans [35,56,80].

Hg concentrations obtained in the present study were below detection limits (<0.5 mg kg^{-1}). Previous studies [57] reported a Hg concentration of 0.024 μg g^{-1} in juvenile Kemp's ridley turtles highlighting that Hg vertical transmission has not been observed during vitellogenesis in this species. Most likely, exposure to this toxic element may occur during the pelagic stages, and during growth, Hg levels decrease through excretion. Hg can present pathologies in sea turtles, even in low concentrations of 0.009 μg g^{-1}, may cause immunosuppression [53,54,78], and be a cofactor in the development of fibropapillomas [35].

Trace elements levels in water and organisms such as fish, red crabs (*Chaceon quinquedens*) and blue crabs (*Callinectes sapidus*), are low, particularly Cd and Hg, since these are not bioavailable in the water column or sea turtle prey in the Gulf of Mexico [81,82]. Sediments their present low concentrations of Cd and Hg, whereas Zn and Pb may be found at higher levels. Interestingly, these elements remain trapped in the sediments and are not bioavailable for organisms, including benthivorous species [81].

Statistically significant relationships have been observed among Cd, Pb and As *vs* Zn and Cu, since these two essential elements can act as detoxifiers of toxic elements [59], through the induction of metallothioneins in sea turtles [52,60]. In addition, Se plays an important role as an antagonist and detoxifier of toxic elements such as Hg [6,34,66]. A positive relationship between trace elements concentrations and turtle life stage has been observed [77,83]. However, in the present study no relationships were identified, neither between elements analyzed nor between turtle size *vs* trace elements concentration (R^2<50%). Similar results were reported previously for juvenile Kemp's ridley turtles [41]; therefore, bioconcentration is not associated with age unlike other sea turtle species.

Conclusions

Kemp's ridley turtles demonstrated low levels for most trace elements analyzed in their blood. This may be reflective of the ecosystem in which the turtles develop, that is, with low bioavailability of trace elements observed in the trophic webs in the Gulf of Mexico. The low levels of these contaminants present in the potential prey of Kemp's ridley turtles, most likely do not represent a risk to the health of this nesting population. However, some toxic trace elements such as Hg can present speciations such as methylmercury, that at low concentrations, produce sublethal toxicity at the cellular level and immunosuppression. Currently, there are no maximum permissible limits of trace metals for sea turtles and no published blood reference values for Kemp's ridley turtles. Therefore, it is difficult to establish the concentration at which sea turtle health is at risk, particularly for metals such as Cd and Hg. Further research is needed on the speciation of some metals like mercury and the possible health impacts on endangered Kemp's ridley turtles and should consider using equipment with greater precision to study the low levels of Cd and Hg found in this study, as these metals are important in ecotoxicology.

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References

1. Wilcox B, Aguirre AA. One Ocean, One Health. EcoHealth. 2004; 1(3):211–2. https://doi.org/10.1007/s10393-004-0122-6
2. Cortés-Gómez AA, Romero D, Girondot M. The current situation of inorganic elements in marine turtles: A general review and meta-analysis. Environ Pollut. 2017; 229:567–85. Epub 2017/07/09. https://doi.org/10.1016/j.envpol.2017.06.077 PMID: 28688307.
3. Ruiz-Fernandez AC, Sanchez-Cabeza JA, Perez-Bernal LH, Gracia A. Spatial and temporal distribution of heavy metal concentrations and enrichment in the southern Gulf of Mexico. Sci Total Environ. 2019; 651(Pt 2):3174–86. Epub 2018/11/23. https://doi.org/10.1016/j.scitotenv.2018.10.109 PMID: 30463167.
4. Turner RE, Rabalais NN. The Gulf of Mexico. In: Sheppard C, editor. World Seas: an Environmental Evaluation. 3: Ecological Issues and Environmental Impacts. 2th ed: Academic Press; 2019. p. 445–64.
5. Aguirre AA, Tabor G. Global Factors Driving Emerging Infectious Diseases. Annals of the New York Academy of Sciences. 2008;1149. https://doi.org/10.1196/annals.1428.052 PMID: 19120161

6. Komoroske LM, Lewison RL, Seminoff JA, Deheyn DD, Dutton PH. Pollutants and the health of green sea turtles resident to an urbanized estuary in San Diego, CA. Chemosphere. 2011. https://doi.org/10.1016/j.chemosphere.2011.04.023 PMID: 21549409
7. Ali H, Khan E. Trophic transfer, bioaccumulation, and biomagnification of non-essential hazardous heavy metals and metalloids in food chains/webs—Concepts and implications for wildlife and human health. Human and Ecological Risk Assessment: An International Journal. 2019; 25(6):1353–76. https://doi.org/10.1080/10807039.2018.1469398
8. Huanxin W, Lejun Z, Presley B. Bioaccumulation of heavy metals in oyster (*Crassostrea virginica*) tissue and shell. Environmental Geology. 2000; 39:1216–26. https://doi.org/10.1007/s002540000110
9. Liu X, Huang D, Zhu Y, Chang T, Liu Q, Huang L, et al. Bioassessment of marine sediment quality using meiofaunal assemblages in a semi-enclosed bay. Mar Pollut Bull. 2015; 100(1):92–101. Epub 2015/10/01. https://doi.org/10.1016/j.marpolbul.2015.09.024 PMID: 26422122.
10. VishnuRadhan R, Eldho TI, Vethamony P, Saheed PP, Shirodkar PV. Assessment of the environmental health of an ecologically sensitive, semi-enclosed, basin—A water quality modelling approach. Mar Pollut Bull. 2018; 137:418–29. Epub 2018/12/07. https://doi.org/10.1016/j.marpolbul.2018.10.035 PMID: 30503451.
11. Gray J. Biomagnification in Marine Systems: The Perspective of an Ecologist. Marine pollution bulletin. 2002; 45:46–52. https://doi.org/10.1016/s0025-326x(01)00323-x PMID: 12398366
12. Drouillard KG. Biomagnification. In: Jørgensen SE, Fath BD, editors. Encyclopedia of Ecology. 1. Oxford: Academic Press; 2008. p. 441–8.
13. Sander LC, Schantz MM, Wise SA. Environmental Analysis: Persistent Organic Pollutants. Liquid Chromatography. 2013:337–88. https://doi.org/10.1016/B978-0-12-415806-1.00013–9
14. Ley-Quiñónez C, Zavala-Norzagaray AA, Espinosa-Carreón TL, Peckham H, Marquez-Herrera C, Campos-Villegas L, et al. Baseline heavy metals and metalloid values in blood of loggerhead turtles (*Caretta caretta*) from Baja California Sur, Mexico. Marine Pollution Bulletin. 2011; 62(9). https://doi.org/10.1016/j.marpolbul.2011.06.022 PMID: 21788056
15. Nava-Ruíz C, Méndez-Armenta M. Efectos neurotóxicos de metales pesados (cadmio, plomo, arsénico y talio). Archivos de Neurociencias. 2011; 16(3):140–7.
16. Rai PK, Lee SS, Zhang M, Tsang YF, Kim KH. Heavy metals in food crops: Health risks, fate, mechanisms, and management. Environ Int. 2019; 125:365–85. Epub 2019/02/12. https://doi.org/10.1016/j.envint.2019.01.067 PMID: 30743144.
17. MTSG. Marine Turtle Specialist Group. *Lepidochelys kempii*, Kemp's Ridley Sea Turtle. The IUCN Red List of Threatened Species. 1996. https://doi.org/10.2305/IUCN.UK.1996.RLTS.T11533A3292342.en
18. Wibbels T, Bevan E. A Historical Perspective of the Biology and Conservation of the Kemp's Ridley Sea Turtle. Gulf of Mexico Science. 2016; 33:129–37. https://doi.org/10.18785/goms.3302.02
19. Márquez R. Synopsis of Biological Data on the Kemp' s Ridley Turtle, *Lepidochelys kempii* (Garman, 1880). NOAH Technical Memorandum NMFS-SEFSC-343. 1994:91.
20. Lara-Uc MM, Mota-Rodríguez C. Conociendo a la Tortuga Lora (*Lepidochelys kempii*) (Garman, 1880): BIOMA, La naturaleza en tus manos.; 2014. 39–46 p.
21. Friend M, Franson C. Field Manual of Wildlife Diseases: General Field Procedures and Diseases of Birds: USGS-National Wildlife Health Center; 1999.
22. Clark RB. Marine Pollution. 6th edition ed. New York, USA.: Oxford University Press; 2001. 248 p.
23. Zenker A, Cicero MR, Prestinaci F, Bottoni P, Carere M. Bioaccumulation and biomagnification potential of pharmaceuticals with a focus to the aquatic environment. Journal of environmental management. 2014; 133:378–87. Epub 2014/01/15. https://doi.org/10.1016/j.jenvman.2013.12.017 PMID: 24419205.
24. Caron AGM, Thomas CR, Berry KLE, Motti CA, Ariel E, Brodie JE. Ingestion of microplastic debris by green sea turtles (*Chelonia mydas*) in the Great Barrier Reef: Validation of a sequential extraction protocol. Mar Pollut Bull. 2018; 127:743–51. Epub 2018/02/25. https://doi.org/10.1016/j.marpolbul.2017.12.062 PMID: 29475719.
25. Aguirre AA, Gardner S, Marsh J, Delgado S, Limpus C, Nichols W. Hazards Associated with the Consumption of Sea Turtle Meat and Eggs: A Review for Health Care Workers and the General Public. EcoHealth. 2006; 3:141–53. https://doi.org/10.1007/s10393-006-0032-x
26. Botello AV, Rendon von Osten J, Gold-Bouchot G, Agraz-Hernández C. Golfo de México: contaminación e impacto ambiental: diagnóstico y tendencias. 2th ed. Univ. Autón. de Campeche, Univ. Nal. Autón. de México, Instituto Nacional de Ecología.2005. 695 p.
27. Benitez JA, Cerón-Bretón RM, Cerón-Bretón JG, Rendón-Von-Osten J. The environmental impact of human activities on the Mexican coast of the Gulf of Mexico: review of status and trends. Environmental Impact II2014. p. 37–50.

28. Vazquez V, Sharma L, Perez-Cruz F. Concentrations of elements and metals in sediments of the south-eastern Gulf of Mexico. Environmental Geology. 2002; 42(1):41–6. https://doi.org/10.1007/s00254-001-0522-7

29. Páez-Osuna F. Fuentes de metales en la zona costera marina. In: Botello AV, Rendon von Osten J, Gold-Bouchot G, Agraz-Hernández C, editors. Golfo de México Contaminación e Impacto Ambiental: Diagnóstico y Tendencias. 2th ed. Univ. Autón. de Campeche, Univ. Nal. Autón. de México, Instituto Nacional de Ecología.2005. p. 329–42.

30. Muhammad SA, Abubakar SI, Babashani H, Asagbra AE, Alhassan AJ. Assessment of heavy metals concentration in crude oil contaminated water samples of three communities of Ikpokpo, Atanba, and Okpele-ama of Gbaramatu Kingdom, along the Escravos River in Warri South West Local Government Area of Delta State, Nigeria. International Journal of environmental and Pollution Research. 2020;Vol. 8(3):41–59.

31. Wibbels T, Bevan E. *Lepidochelys kempii*. The IUCN Red List of Threatened Species 2019: eT11533A142050590. 2019. http://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T11533A142050590.en.

32. Gallaway B, Gazey W, Wibbels T, Bevan E, Shaver D, George J. Evaluation of the Status of the Kemp's Ridley Sea Turtle After the 2010 Deepwater Horizon Oil Spill. Gulf of Mexico Science. 2016; 33:192–205. https://doi.org/10.18785/goms.3302.06

33. Caillouet C. Jr Excessive Annual Numbers of Neritic Immature Kemp's Ridleys May Prevent Population Recovery. Marine Turtle Newsletter. 2019; 1(158):1–9.

34. Zavala-Norzagaray AA, Ley-Quinonez CP, Espinosa-Carreon TL, Canizalez-Roman A, Hart CE, Aguirre AA. Trace elements in blood of sea turtles *Lepidochelys olivacea* in the Gulf of California, Mexico. Bull Environ Contam Toxicol. 2014; 93(5):536–41. Epub 2014/06/25. https://doi.org/10.1007/s00128-014-1320-8 PMID: 24957795.

35. Perrault JR, Stacy NI, Lehner AF, Mott CR, Hirsch S, Gorham JC, et al. Potential effects of brevetoxins and toxic elements on various health variables in Kemp's ridley (*Lepidochelys kempii*) and green (*Chelonia mydas*) sea turtles after a red tide bloom event. Sci Total Environ. 2017;605–606:967–79. Epub 2017/07/12. https://doi.org/10.1016/j.scitotenv.2017.06.149 PMID: 28693110.

36. Barraza AD, Komoroske LM, Allen C, Eguchi T, Gossett R, Holland E, et al. Trace metals in green sea turtles (*Chelonia mydas*) inhabiting two southern California coastal estuaries. Chemosphere. 2019; 223:342–50. Epub 2019/02/21. https://doi.org/10.1016/j.chemosphere.2019.01.107 PMID: 30784740.

37. Sykes JMt, Klaphake E. Reptile Hematology. Clin Lab Med. 2015; 35(3):661–80. Epub 2015/08/25. https://doi.org/10.1016/j.cll.2015.05.014 PMID: 26297412.

38. Eckert KL, Bjorndal KA, Abreu-Grobois FA, Donnelly M. Técnicas de Investigación y Manejo para la Conservación de las Tortugas Marinas. Grupo especialista en Tortugas Marinas. UICN/CSE Publicación No. 4.2000. 270 p.

39. Bolten AB. Techniques for measuring sea turtles. Research and management techniques for the conservation of sea turtles IUCN/SSC Marine Turtle Specialist Group Publication No 4. 1999:248 p.

40. Labrada-Martagón V, Méndez-Rodríguez LC, Gardner SC, López-Castro M, Zenteno-Savín T. Health Indices of the Green Turtle (*Chelonia mydas*) Along the Pacific Coast of Baja California Sur, Mexico. I. Blood Biochemistry Values. Chelonian Conservation and Biology. 2010; 9(2):162–72. https://doi.org/10.2744/ccb-0806.1

41. Thomson J, Burkholder D, Heithaus M, Dill L. Validation of a Rapid Visual-Assessment Technique for Categorizing the Body Condition of Green Turtles (*Chelonia mydas*) in the Field. Copeia. 2009; 2009:251–5. https://doi.org/10.1643/CE-07-227

42. Work TM, Balazs GH. Relating tumor score to hematology in green turtles with fibropapillomatosis in Hawaii. J Wildl Dis. 1999; 35(4):804–7. Epub 1999/11/26. https://doi.org/10.7589/0090-3558-35.4.804 PMID: 10574546.

43. Deem SL, Norton TM, Mitchell M, Segars A, Alleman AR, Cray C, et al. Comparison of blood values in foraging, nesting, and stranded loggerhead turtles (*Caretta caretta*) along the coast of Georgia, USA. J Wildl Dis. 2009; 45(1):41–56. Epub 2009/02/11. https://doi.org/10.7589/0090-3558-45.1.41 PMID: 19204334.

44. Ley-Quiñónez CP, Zavala-Norzagaray AA, Rendon-Maldonado JG, Espinosa-Carreon TL, Canizales-Roman A, Escobedo-Urias DC, et al. Selected heavy metals and selenium in the blood of black sea turtle (*Chelonia mydas agasiizzi*) from Sonora, Mexico. Bull Environ Contam Toxicol. 2013; 91(6):645–51. Epub 2013/09/28. https://doi.org/10.1007/s00128-013-1114-4 PMID: 24072261.

45. Caillouet C Jr, Shaver D, Jr A, Owens D, Pritchard P. Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) Age at First Nesting. Chelonian Conservation and Biology. 2011; 10:288–93. https://doi.org/10.2744/CCB-0836.1

46. Schmid J, Tucker A. Comparing Diets of Kemp's Ridley Sea Turtles (*Lepidochelys kempii*) in Mangrove Estuaries of Southwest Florida. Journal of Herpetology. 2018; 52:252–8. https://doi.org/10.1670/16-164

47. Deem SL, Dierenfeld ES, Sounguet GP, Alleman AR, Cray C, Poppenga RH, et al. Blood values in free-ranging nesting leatherback sea turtles (*Dermochelys coriacea*) on the coast of the Republic of Gabon. J Zoo Wildl Med. 2006; 37(4):464–71. Epub 2007/02/24. https://doi.org/10.1638/05-102.1 PMID: 17315430.

48. Guirlet E, Das K, Girondot M. Maternal transfer of trace elements in leatherback turtles (*Dermochelys coriacea*) of French Guiana. Aquat Toxicol. 2008; 88(4):267–76. Epub 2008/06/21. https://doi.org/10.1016/j.aquatox.2008.05.004 PMID: 18565604.

49. Labrada-Martagon V, Rodriguez PA, Mendez-Rodriguez LC, Zenteno-Savin T. Oxidative stress indicators and chemical contaminants in East Pacific green turtles (*Chelonia mydas*) inhabiting two foraging coastal lagoons in the Baja California peninsula. Comp Biochem Physiol C Toxicol Pharmacol. 2011; 154(2):65–75. Epub 2011/03/08. https://doi.org/10.1016/j.cbpc.2011.02.006 PMID: 21377544.

50. da Silva CC, Klein RD, Barcarolli IF, Bianchini A. Metal contamination as a possible etiology of fibropapillomatosis in juvenile female green sea turtles *Chelonia mydas* from the southern Atlantic Ocean. Aquat Toxicol. 2016; 170:42–51. Epub 2015/11/30. https://doi.org/10.1016/j.aquatox.2015.11.007 PMID: 26615366.

51. Sinaei M, Bolouki M. Metals in Blood and Eggs of Green Sea Turtles (*Chelonia mydas*) from Nesting Colonies of the Northern Coast of the Sea of Oman. Arch Environ Contam Toxicol. 2017; 73(4):552–61. Epub 2017/06/21. https://doi.org/10.1007/s00244-017-0421-x PMID: 28631031.

52. Cortés-Gómez AA, Fuentes-Mascorro G, Romero D. Metals and metalloids in whole blood and tissues of Olive Ridley turtles (*Lepidochelys olivacea*) from La Escobilla Beach (Oaxaca, Mexico). Mar Pollut Bull. 2014; 89(1–2):367–75. Epub 2014/10/11. https://doi.org/10.1016/j.marpolbul.2014.09.035 PMID: 25301056.

53. Day RD, Segars AL, Arendt MD, Lee AM, Peden-Adams MM. Relationship of blood mercury levels to health parameters in the loggerhead sea turtle (*Caretta caretta*). Environ Health Perspect. 2007; 115 (10):1421–8. Epub 2007/10/17. https://doi.org/10.1289/ehp.9918 PMID: 17938730; PubMed Central PMCID: PMC2022655.

54. Day RD, Keller JM, Harms CA, Segars AL, Cluse WM, Godfrey MH, et al. Comparison of mercury burdens in chronically debilitated and healthy loggerhead sea turtles (*Caretta caretta*). J Wildl Dis. 2010; 46 (1):111–7. Epub 2010/01/22. https://doi.org/10.7589/0090-3558-46.1.111 PMID: 20090024.

55. Trocini S, Warren K, O'Hara A, Bradley S, Robertson I. Health and hatching success of two Western Australian loggerhead turtle (*Caretta caretta*) nesting populations [Doctor of Philosophy thesis]: Murdoch University; 2013.

56. Witzell W, Schmid J. Diet of immature Kemp's ridley turtles (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, Southwest Florida. Bulletin of Marine Science. 2005; 77:191–200.

57. Innis C, Tlusty M, Perkins C, Holladay S, Merigo C, Weber ES. Trace Metal and Organochlorine Pesticide Concentrations in Cold-Stunned Juvenile Kemp's Ridley Turtles (*Lepidochelys kempii*) from Cape Cod, Massachusetts. Chelonian Conservation and Biology. 2008; 7(2):230–9. https://doi.org/10.2744/ccb-0707.1

58. Seney EE. Diet of Kemp's Ridley Sea Turtles Incidentally Caught on Recreational Fishing Gear in the Northwestern Gulf of Mexico. Chelonian Conservation and Biology. 2016; 15(1):132–7. https://doi.org/10.2744/ccb-1191.1

59. Ehsanpour M, Afkhami M, Khoshnood R, Reich KJ. Determination and maternal transfer of heavy metals (Cd, Cu, Zn, Pb and Hg) in the Hawksbill sea turtle (*Eretmochelys imbricata*) from a nesting colony of Qeshm Island, Iran. Bull Environ Contam Toxicol. 2014; 92(6):667–73. Epub 2014/04/08. https://doi.org/10.1007/s00128-014-1244-3 PMID: 24705701.

60. Paez-Osuna F, Calderon-Campuzano MF, Soto-Jimenez MF, Ruelas-Inzunza JR. Trace metals (Cd, Cu, Ni, and Zn) in blood and eggs of the sea turtle *Lepidochelys olivacea* from a nesting colony of Oaxaca, Mexico. Arch Environ Contam Toxicol. 2010; 59(4):632–41. Epub 2010/04/17. https://doi.org/10.1007/s00244-010-9516-3 PMID: 20396874.

61. Orvik LM. Trace metal concentration in blood of the Kemp's ridley sea turtle (*Lepidochelys kempii*) [Master´s thesis]: Texas A&M University; 1997.

62. Wang H-C. Trace metal uptake and accumulation pathways in kemp´s ridley sea turtles (*Lepidochelys kempii*) [Doctor of Philosophy thesis]: Texas A&M University; 2005.

63. Ikonomopoulou MP, Olszowy H, Limpus C, Francis R, Whittier J. Trace element concentrations in nesting flatback turtles (*Natator depressus*) from Curtis Island, Queensland, Australia. Mar Environ Res. 2011; 71(1):10–6. Epub 2010/10/12. https://doi.org/10.1016/j.marenvres.2010.09.003 PMID: 20933265.

64. Carreras C. Tortuga lora–*Lepidochelys kempii*. In: Salvador A, Marco A, editors. Enciclopedia Virtual de los Vertebrados Españoles. Museo Nacional de Ciencias Naturales, Madrid.2013.

65. Innis C, Merigo C, Dodge K, Tlusty M, Dodge M, Sharp B, et al. Health Evaluation of Leatherback Turtles (*Dermochelys coriacea*) in the Northwestern Atlantic During Direct Capture and Fisheries Gear Disentanglement. Chelonian Conservation and Biology. 2010; 9(2):205–22. https://doi.org/10.2744/ccb-0838.1

66. Perrault J, Wyneken J, Thompson LJ, Johnson C, Miller DL. Why are hatching and emergence success low? Mercury and selenium concentrations in nesting leatherback sea turtles (*Dermochelys coriacea*) and their young in Florida. Mar Pollut Bull. 2011; 62(8):1671–82. Epub 2011/07/05. https://doi.org/10.1016/j.marpolbul.2011.06.009 PMID: 21722926.

67. Perrault JR, Miller DL, Garner J, Wyneken J. Mercury and selenium concentrations in leatherback sea turtles (*Dermochelys coriacea*): population comparisons, implications for reproductive success, hazard quotients and directions for future research. Sci Total Environ. 2013;463–464:61–71. Epub 2013/06/25. https://doi.org/10.1016/j.scitotenv.2013.05.067 PMID: 23792248.

68. Villa CA, Flint M, Bell I, Hof C, Limpus CJ, Gaus C. Trace element reference intervals in the blood of healthy green sea turtles to evaluate exposure of coastal populations. Environ Pollut. 2017; 220(Pt B):1465–76. Epub 2016/11/09. https://doi.org/10.1016/j.envpol.2016.10.085 PMID: 27825845.

69. Escobedo Mondragón M, Luzardo OP, Zumbado M, Rodríguez-Hernández Á, Rial Berriel C, Ramírez-Gomez HV, et al. Incidence of 49 elements in the blood and scute tissues of nesting hawksbill turtles (*Eretmochelys imbricata*) in Holbox Island. Regional Studies in Marine Science. 2021; 41:101566. https://doi.org/10.1016/j.rsma.2020.101566.

70. Camacho M, Oros J, Boada LD, Zaccaroni A, Silvi M, Formigaro C, et al. Potential adverse effects of inorganic pollutants on clinical parameters of loggerhead sea turtles (*Caretta caretta*): results from a nesting colony from Cape Verde, West Africa. Mar Environ Res. 2013; 92:15–22. Epub 2013/09/04. https://doi.org/10.1016/j.marenvres.2013.08.002 PMID: 23998796.

71. McClain CR, Nunnally C, Benfield MC. Persistent and substantial impacts of the Deepwater Horizon oil spill on deep-sea megafauna. 2019; 6(8):191164. https://doi.org/10.1098/rsos.191164 PMID: 31598269

72. Paez-Osuna F, Calderon-Campuzano MF, Soto-Jimenez MF, Ruelas-Inzunza JR. Lead in blood and eggs of the sea turtle, *Lepidochelys olivacea*, from the Eastern Pacific: concentration, isotopic composition and maternal transfer. Mar Pollut Bull. 2010; 60(3):433–9. Epub 2009/11/10. https://doi.org/10.1016/j.marpolbul.2009.10.004 PMID: 19897213.

73. Cortés-Gomez AA, Romero D, Santos J, Rivera-Hernandez JR, Girondot M. Inorganic elements in live vs dead nesting olive ridley marine turtles in the Mexican Pacific: Introducing a new statistical methodology in ecotoxicology. Sci Total Environ. 2020:143249. Epub 2020/11/14. https://doi.org/10.1016/j.scitotenv.2020.143249 PMID: 33183810.

74. Liu J, Goyer RA. Chapter 23. Toxic Effects of Metals. In: Klaassen CD, Watkins JB, editors. Casarett & Doull's Essentials of Toxicology. 2th ed. New York, NY: The McGraw-Hill Companies; 2010.

75. Storelli MM, Storelli A, D'Addabbo R, Marano C, Bruno R, Marcotrigiano GO. Trace elements in loggerhead turtles (*Caretta caretta*) from the eastern Mediterranean Sea: overview and evaluation. Environmental Pollution. 2005; 135(1):163–70. https://doi.org/10.1016/j.envpol.2004.09.005 PMID: 15701403

76. Harris H, Benson S, Gilardi K, Poppenga R, Work T, Dutton P, et al. Comparative health assessment of Western Pacific leatherback turtles (*Dermochelys coriacea*) foraging off the coast of California, 2005–2007. Journal of wildlife diseases. 2011; 47:321–37. https://doi.org/10.7589/0090-3558-47.2.321 PMID: 21441185

77. Jerez S, Motas M, Canovas RA, Talavera J, Almela RM, Del Rio AB. Accumulation and tissue distribution of heavy metals and essential elements in loggerhead turtles (*Caretta caretta*) from Spanish Mediterranean coastline of Murcia. Chemosphere. 2010; 78(3):256–64. Epub 2009/12/05. https://doi.org/10.1016/j.chemosphere.2009.10.062 PMID: 19959203.

78. Ley-Quiñónez C, Rossi-Lafferriere N, Espinoza-Carreon T, Hart C, Peckham SH, Aguirre AA, et al. Associations between trace elements and clinical health parameters in the North Pacific loggerhead sea turtle (*Caretta caretta*) from Baja California Sur, Mexico. Environmental Science and Pollution Research. 2017; 24(10). https://doi.org/10.1007/s11356-017-8556-x PMID: 28238183

79. Eisler R. CHAPTER 12—Tunicates. In: Eisler R, editor. Compendium of Trace Metals and Marine Biota. 1. Amsterdam: Elsevier; 2010. p. 583–98.

80. Schmid JR, Bolten AB, Bjorndal KA, Lindberg WJ, Percival HF, Zwick PD. Home Range and Habitat Use by Kemp's Ridley Turtles in West-Central Florida. The Journal of Wildlife Management. 2003; 67(1):196–206. https://doi.org/10.2307/3803075

81. Adams DH, Engel ME. Mercury, lead, and cadmium in blue crabs, *Callinectes sapidus*, from the Atlantic coast of Florida, USA: a multipredator approach. Ecotoxicology and environmental safety. 2014; 102:196–201. Epub 2014/02/11. https://doi.org/10.1016/j.ecoenv.2013.11.029 PMID: 24507459.

82. Perry H, Isphording W, Trigg C, Riedel R. Heavy metals in red crabs, *Chaceon quinquedens*, from the Gulf of Mexico. Mar Pollut Bull. 2015; 101(2):845–51. Epub 2015/11/22. https://doi.org/10.1016/j.marpolbul.2015.11.020 PMID: 26589640.

83. Register AL. Effects of Heavy Metal Pollution on the Loggerhead Sea Turtle [Master´s thesis]. Loma Linda, California: Loma Linda University; 2011.