TURTLE BY-CATCH IN THE SOUTHEASTERN CARIBBEAN SEA AND ADJACENT ATLANTIC WATERS CAUGHT BY THE VENEZUELAN PELAGIC LONGLINE FISHERY: PERIOD 1991-2013

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SUMMARY

Turtle by-catch information recorded by the Venezuelan Pelagic Longline Observer Program (VPLOP) sponsored by ICCAT's Enhanced Research Program for Billfish is reported for the period 1991-2013. A total of 99 turtles representing five species were reported, of which the majority were Dermochelys coriacea *(74.75%), followed by Chelonia mydas (12.12%), and the remaining three the species (*Caretta caretta, Eretmochelys imbricata, Lepidochelys olivacea*) represented under 10% of the proportion of the turtles caught during the time period analyzed. The status, disposition, estimated hook depth, approximate time of fishing, and available size of all turtle species caught during the time period, as well as its spatial distribution is reported in the document.*

RÉSUMÉ

Le présent document fournit des informations sur les prises accessoires de tortues recueillies dans le cadre du programme d'observateurs palangriers pélagiques du Venezuela (VPLOP), parrainé par le programme ICCAT de recherche intensive sur les istiophoridés, au titre de la période 1991-2013. Un total de 99 tortues représentant cinq espèces a été déclaré, la plupart étant des spécimens de l'espèce Dermochelys coriacea *(74,75%), suivie de l'espèce* Chelonia mydas *(12,12%). Les trois autres espèces* (Caretta caretta, Eretmochelys imbricata, Lepidochelys olivacea) *représentaient moins de 10% de la proportion des tortues capturées pendant la période étudiée. Le document fait état de l'état, de la disposition, de la profondeur estimée des hameçons, de l'heure approximative de la pêche et des données de taille disponibles de toutes les espèces de tortues capturées pendant la période temporelle, ainsi que de leur distribution spatiale.*

RESUMEN

Este documento presenta información acerca de la captura fortuita de tortugas consignada por el Programa de observadores de palangre pelágico de Venezuela (VPLOP), patrocinado por el Programa de investigación intensiva sobre marlines de ICCAT, y comunicada para el periodo 1991-2013. Se comunicó un total de 99 tortugas que representaban cinco especies, de las cuales la mayoría era D. coriacea *(74,75%), seguida de* C. mydas *(12,12%) y las otras tres especies (*C. caretta, E. imbricata, L. olivacea*) representaban menos del 10% de la proporción de tortugas marinas capturadas durante el periodo analizado. En este documento se presenta el estado, la disposición, la profundidad estimada del anzuelo, el momento aproximado de la pesca, las tallas disponibles para todas las especies de tortugas capturadas durante el periodo, así como su distribución espacial.*

KEYWORDS

Sea turtles, By-catch, Venezuela, Pelagic longline fishery, Caribbean Sea

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Introduction

Venezuela's beaches along the mainland and in its off-shore islands are the home of at least 29 recognized sea turtle nesting sites, in which the majority is located in the central and northeastern beaches of Venezuela (Dow *et al*., 2007). Of the 6 sea turtle species recognized in the ICCAT convention area, 5 species inhabit Venezuelan waters, namely, leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*); green, (*Chelonia mydas*), hawksbill, (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*) sea turtles. As a result of several anthropogenic mortality sources on many sea turtle populations all 6 species recognized in the ICCAT convention area are considered to be endangered (IUCN 2003). Venezuela has adopted specific regulations to prohibit domestic and international trade of sea turtles, parts, and products since 1996, as well as the protection of nests and nesting beaches (Quijada and Valladares 2004), and granted sea turtles special protection by subscribing to the Inter-American Convention for the Protection and Conservation of Marine Turtles (http://www.iacseaturtle.org/). However, regardless of the plans to protect and conserve sea turtle populations in Venezuela, incidental capture of sea turtles by different fishing gears in Venezuelan waters continued to take place. Until 2007, industrial shrimp trawling and the pelagic longline fishery were mostly responsible for the incidental capture of sea turtles in Venezuelan waters (Alió *et al.*, 2010). Thereafter, due to the national ban on industrial shrimp trawling, the only source of incidental catch of sea turtles in Venezuela after 2007 is the pelagic longline fishery. The present document analyzes the incidental catch of sea turtles caught by the industrial pelagic longline fishery that targets tropical tunas and tuna-like species in the Caribbean Sea and adjacent Atlantic waters for the period of 1991 through 2013.

Methods

Data source

Sea turtle by-catch information was obtained from the Venezuelan Pelagic Longline Observer Program (VPLOP) sponsored by the Enhanced Research Program for Billfish of the International Commission for the Conservation of Atlantic Tunas (ICCAT). Initially developed in 1991, its main goal was to monitor billfish (including swordfish) catches from the Venezuelan pelagic longline (industrial) vessels targeting tropical tuna species and swordfish in the Caribbean Sea and adjacent waters of the Atlantic Ocean. The VPLOP operated on a year round basis until 2011, in 2012 and 2013 at-sea sampling continued at a reduced pace due to the implementation in 2012 of the National Observer Program by the Venezuelan Fishery Administration (INSOPESCA). The information recorded by the VPLOP, other than fishery operations and haul/gear information, the majority was on billfish and tuna species. Encounters with air breathing vertebrates were occasional (sea-birds) and rare (marine mammals), and since it was not a mandate of the VPLOP, the details of encounters were not included in the forms. However, in the case of sea turtles, information was recorded in the observer's note pads and margins in any of the forms. In the revision of the VPLOP undertaken in 2007, all information on sea turtles that appeared in the original data forms was included in the newly revised and updated digital data-base. All VPLOP observers had previous experience in the industrial shrimp trawling fishery observer program and were trained to identify sea turtles to species and collect length measurements, thus when trained for data collection for the Pelagic Longline Fishery, the recording of sea turtle information was part of their routine.

Observer coverage was based on the number of trips observed with respect to the overall number of trips made by the fleet every year, over the years it varied between 3 and 19.7% (**Figure 1**); between 1992 and 2004 observer coverage was above 10% with a maximum coverage in 2003. Thereafter, the VPLOP observer coverage began a steady drop reaching its minimum in 2011. The cause for the sustained drop in the observer coverage was mostly due to the increase in the number of fishing trips per year owing to the inclusion of new longline vessels.

Data analysis

The status, disposition, estimated hook depth, approximate time of fishing, and available size of all turtle species caught during the time period, as well as its spatial distribution is used in the analysis. The status was estimated as the proportion of sea turtles that are dead upon gear retrieval. The disposition was estimated whether a sea turtle was released or retained. Hook depth was defined as the approximate depth of the fishing gear and was estimated as the sum of the length of the line from the float to the mainline and the length of the gangion. The approximate time of fishing was estimated as the proportion of capture during night and day time. Metrics on the size of sea turtles, when available, were measured as carapace length (CL) and width (CW) in cm. The spatial distribution of fishing effort was estimated as mean number of hooks for each 1° square bin in the fishing area, and the total numbers of sea turtles caught were overlapped with the fishing effort spatial distribution.

Results and Discussion

The Venezuelan pelagic longline fleet extends its fishing operations up to 24°N (Arocha *et al*., 2013), but the spatial distribution of the fishing effort in mean number of hooks per 1° square bin covered by the VPLOP during 1991-2013 was restricted to south of 19°N because sea turtles were only caught in the Caribbean Sea and adjacent Atlantic waters (**Figure 2a**). Most of the fishing effort was concentrated in the Caribbean Sea during the whole time period, but the spatial distribution of fishing effort was separated into two time periods for the purpose of the present analysis. The early period was from 1991-1999 and the late period went from 2000 to the most recent year. The reason for the split in time periods was caused by the shift in fishing operations after 1999, when the fleet shifted its target entirely towards tropical tuna species and dropping its swordfish fishing operations after 1999 (see **Figure 1**). In the early period (1991-1999), mean fishing effort was concentrated in the Caribbean Sea, but it was broadly spread throughout the fishing area of the fleet; in the late period (2000-2013), mean fishing effort continued to be concentrated in the Caribbean Sea but it was less spread than in the early period, and it increased substantially in the area east of Trinidad in the Atlantic side (**Figure 2b**).

A total of 99 sea turtles were reported by the VPLOP during the period of 1991-2013. The numbers of sea turtles caught in both time periods (early and late) were almost similar (**Table 1**), in particular for the most common species caught, (*Dermochelys coriacea*, *Dc*) and *Chelonia mydas* (*Cm*), the rest of the species were caught in much smaller numbers and varied between time periods. The seasonal catch (trimesters or quarters) in numbers of sea turtles were mostly concentrated during the first three trimesters of the year with almost similar numbers of sea turtles caught per trimester, which was evident for *Dc* and *Cm* (**Table 2**). In *Caretta caretta* (*Cc*), the highest numbers of individuals caught were in the first trimester, for *Eretmochelys imbricata* (*Ei*) was in the third trimester, and the only specimen of *Lepidochelys olivacea* (*Lo*) was caught in the second trimester. Seasonal nominal catch rates by species, estimated as by-catch (number of sea turtles) per unit of effort × 1000 hooks (BPUE), showed that the highest BPUE for *Dc*, *Cc*, and all sea turtles combined were during the first trimester, for *Cm* was in the second trimester and for *Ei* was during the third trimester (**Table 2**). Total sea turtle BPUE for all years combined in the Caribbean Sea and adjacent Atlantic waters estimated from the VPLOP was 0.002898 sea turtles/hooks×1000. These estimates are low when compared to those of neighboring areas from the southwest Atlantic where combined sea turtle BPUE were in the order of 0.4718 (Domingo *et al*., 2006), but the VPLOP estimates were similar in relative values to another report for the same fishing area but with a different fishing gear, Venezuelan shrimp trawl (Alió *et al*., 2010).

Of the 99 sea turtles reported caught by the VPLOP, 81 had no information on the status of the specimen when the gear was retrieved because it was not mandated by the VPLOP; however, for the species that did have information 88% were alive when the gear was retrieved (**Table 3**). The species which had information (*Dc*, *Cm* and *Lo*) revealed that only 1 specimen of *Dc* and *Cm* was retrieved dead. Due to the Venezuelan regulations on sea turtles, all specimens were released at-sea in the same condition they were caught, with no record indication whether the specimens were entangled or hooked. However, verbal accounts when observers were debriefed indicated that the majority of the sea turtles caught were entangled.

Fishing operations are known to affect the capture of sea turtles, the Venezuelan pelagic longline fleet that targets mainly tropical tunas set their gear shallow, normally between 20 and 90 m in depth as reported by the VPLOP. The estimated depth of hooks when sea turtles were captured by the Venezuelan fleet varied between species (**Table 4**). The most common species (*Dc* and *Cm*) caught by the fleet extend over the range of the estimated hook depth; while *Cc* and *Ei* were caught when the hooks were set deeper (>40 m). The only specimen of *Lo* was caught when the hooks were set at the fleet´s maximum depth in the fishing area. Regardless of the fleet's operational change after 2000 when swordfish fishing operations were dropped, the frequency of day/night capture of sea turtles was favored by night sets; *Dc* was mostly caught during night sets followed by *Cc* and *Ei* (**Table 5**), the rest of the species were most frequent during day sets, although the number of specimens were low.

Other changes in the fleet operations after 2000 included changes in bait condition and hook type; some vessels decided to use circle hooks and most of the fleet added bait tank(s) with circulating sea water to accommodate live bait, mostly consisting of round sardinella (*Sardinella aurita*). Of the 39 sea turtles with information on bait type and condition, leatherback sea turtle specimens caught were split almost evenly when live (16 *Dc*) and dead (14 *Dc*) bait was used in longline sets. However, when dead bait was used in longline sets in which sea turtles were caught, the bait was squid. Most green turtles specimens and the only specimen of olive ridley caught was when live bait was used in the longline sets. Loggerheads (2) were caught when dead bait was used. Information on hook type with sea turtle by-catch information was available after 2006, 11 sea turtles (*Dc*, *Cm*) were caught when circle hooks were used, and 9 (*Dc*, *Cm*, *Lo*) were caught when J hooks were used.

Metrics on the size of sea turtles were available for 39 specimens; the majority was from leatherbacks (25) for which size frequency distribution was estimated (**Figure 3**). Mean size in carapace length ($\overline{CL}$) in leatherbacks was 104.2±4.4 cm, in loggerheads was 68.5±3.5 cm, and in green turtles was 75.8±5.9 cm (**Table 6**). Mean carapace length ($\overline{CL}$) measured in sea turtles reported by the VPLOP showed contrasting sizes with those caught in the same fishing area by the Venezuelan industrial shrimp trawl fishery (Alió *et al*., 2010), *Dc* caught with longlines showed smaller $\overline{CL}$ than those caught by shrimp trawls; while *Cm* ($\overline{CL}$) caught with longlines were larger than those caught with shrimp trawls. Only loggerheads were of similar $\overline{CL}$ in both fisheries. According to the different reports of size (CL) of first maturity in the region (*see* Alió *et al*., 2010), it would appear that most of the sea turtles reported caught by the VPLOP were non-mature specimens, with the exception of few specimens of *Dc* and *Cm*, although due to the nature of the longline fishery it is unlikely that mature or large adults of these species will be hauled on deck.

The spatial distribution of all sea turtles species reported by the VPLOP is presented in **Figure 4a**. In the early period, the majority (47) of the sea turtles caught in the Caribbean Sea were where the highest concentration of fishing effort occurred and only several (3) were caught in the Atlantic side; while in the late period, sea turtle by-catch was reduced and spread out in the Caribbean Sea (30), and it was increased in the Atlantic side (16) in areas of higher fishing effort concentration. Capture of leatherback turtles during the early time period were concentrated around the off-shore islands of Venezuela in the Caribbean Sea where most of the fishing effort was deployed; while in the later period leatherbacks continued to be concentrated in the Caribbean Sea but in lesser numbers, in contrast with the early period the number leatherbacks turtles in the Atlantic side increased where the fishing effort was higher, east of Trinidad (**Figure 4b**). The spatial distribution of green turtles, and loggerheads, hawksbill and olive ridley are presented in **Figure 5a** and **b**. Green turtles are present in both time periods in the Caribbean Sea and the Atlantic side in low numbers (**Figure 5a**), the number of green turtles were higher in the Caribbean Sea during the early period, and in the Atlantic side during late period. Loggerheads were all captured in the Caribbean Sea, most of them during the early period (**Figure 5b**), hawksbills were also caught only in the Caribbean Sea but in higher numbers during the late time period, and the only specimen of olive ridley was caught in the Atlantic side off Surinam.

According to the "State of the World's Sea Turtles" (http://www.seaturtlestatus.org/) most of the nesting and crawling sites recorded for Venezuelan beaches are concentrated in areas of high sea turtles by-catch by the VPLOP (**Figure 6**). Important crawls of leatherbacks are found in the eastern Caribbean beaches (green rectangle, **Figure 6**), while the off-shore islands (red rectangle, **Figure 6**) are important crawl sites for all sea turtles species caught in the Caribbean Sea by the VPLOP. However, it is noteworthy that regardless of the fact that the fishing effort of the Venezuelan longline fleet is concentrated around areas of important sea turtle nesting sites, the by-catch catch rates (BPUE) of sea turtles estimated in this document are low in comparison to other neighboring areas. Reports of sea turtle by-catch in the Venezuelan Artisanal Off-Shore (VAOS) pelagic longline fishery that operates in the same area of the VPLOP has reported minimal catches of sea turtles. In a recent study in the VAOS fishery, only 2 sea turtles were recorded caught from a sample of 977 sets observed during July 2011-March 2014 (Arocha *et al*., 2014). Further studies and enhanced monitoring of sea turtles in the Caribbean Sea and adjacent Atlantic water are needed to understand the low BPUE observed in the southern Caribbean Sea. The newly created National Observer Program of INSOPESCA appears to be heading in that direction by including specific data forms (see **Appendix 1**) directed to record detailed information on sea turtle by-catch in all tuna and tuna-like directed fisheries in Venezuela.

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Table 1. Numbers of sea turtles by species reported by the VPLOP during the period of 1991-2013. *Cc*, *Caretta caretta*; *Cm*, *Chelonia mydas*; *Dc*, *Dermochelys coriacea*; *Ei*, *Eretmochelys imbricata*; and *Lo*, *Lepidochelys olivacea*.

Periods	*Cc*	*Cm*	*Dc*	*Ei*	*Lo*	Total
Early, 1991-99	6	7	37	1	-	51
Late, 2000-13	2	5	37	3	1	48
Total	8	12	74	4	1	99

Table 2. Seasonal (trimesters) sea turtle by-catch reported by the VPLOP during the period of 1991-2013. BPUE, by-catch (numbers of sea turtles)/hooks×1000. **Bold** BPUE indicate the highest seasonal values.

Fishing effort	*T1 Jan - Mar*		*T2 Apr - Jun*		*T3 Jul - Sept*		*T4 Oct – Dec*		*Total years*	
Total number of hooks × 1000	6670.0		7631.7		9897.7		9957.8		34157.2	
Species	**n**	**BPUE**	**n**	**BPUE**	**n**	**BPUE**	**n**	**BPUE**	**n**	**BPUE**
Leatherback, Dc	22	**0.003298**	21	0.002752	27	0.002728	4	0.000402	74	0.002166
Green, Cm	4	0.000600	5	**0.000655**	3	0.000303	-	-	12	0.000351
Loggerhead, Cc	4	**0.000600**	1	0.000131	2	0.000202	1	0.000100	8	0.000234
Hawksbill, Ei	-	-	1	0.000131	3	**0.000303**	-	-	4	0.000117
Olive Ridley, Lo	-	-	1	0.000131	-	-	-	-	1	0.000029
Total by-catch all species	30	**0.004498**	29	0.003800	35	0.003536	5	0.000502	99	0.002898

Table 3. Numbers of sea turtles by species reported alive or dead at haul back during VPLOP fishing operations during the period of 1991-2013. Unk indicates unknown status of the specimens when retrieved by the gear.

	Alive	*Dead*	*Unk*
Dc	12	1	61
Cm	3	1	8
Lo	1	-	-
Cc, Ei	-	-	12
Total	**18**	**2**	**81**

Table 4. Estimated (*e*-) hook depth (m) of longline fishing operations when sea turtles were reported caught by the VPLOP during the period of 1991-2013.

	Min. e-hook depth (m)	*Max. e-hook depth (m)*
Cc	50	73
Cm	22	74
Dc	29	78
Ei	41	81
Lo	82	82

Table 5. Frequency of sea turtle reported catch in numbers by the VPLOP during 1991-2013 during day and night fishing operations.

	Day sets	*Night sets*
Cc	1	7
Cm	7	5
Ei	3	4
Lo	1	-
Dc	25	49
Total	**37**	**65**

Table 6. Size metrics (in cm) of sea turtles by species reported by the VPLOP during the period of 1991-2013. CW is carapace width and CL is carapace length.

	N	*Min. CW*	*mean CW*	*Max. CW*	*Min. CL*	*mean CL*	*Max. CL*
Cc	8	40	57.5	70	50	68.5	78
Cm	5	57	66.0	72	60	75.8	93
Dc	25	37	79.0	140	56	104.2	170
Lo	1	-	80	-	-	66	-
Total	**39**						

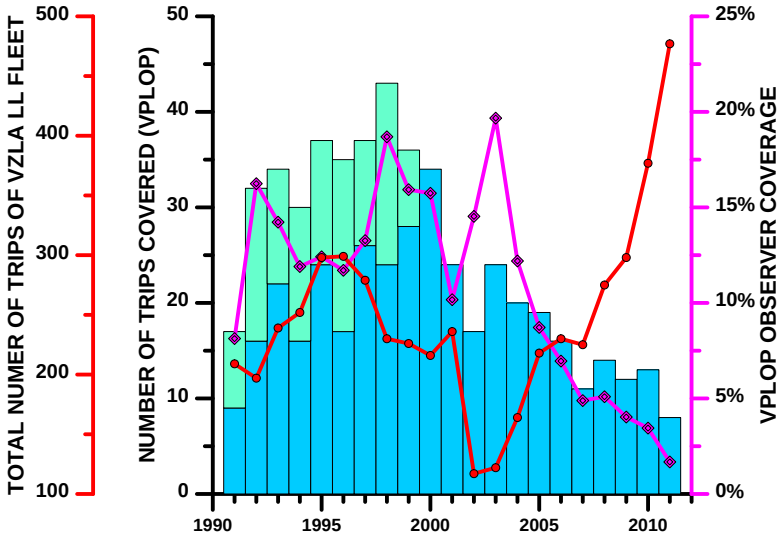

Figure 1. Total number of trips of the Venezuelan longline fleet, number of trips covered by the VPLOP, and annual observer coverage of the Venezuelan pelagic longline fleet from 1991 to 2011. Blue bars represent tuna directed trips and green bars represent swordfish directed trips.

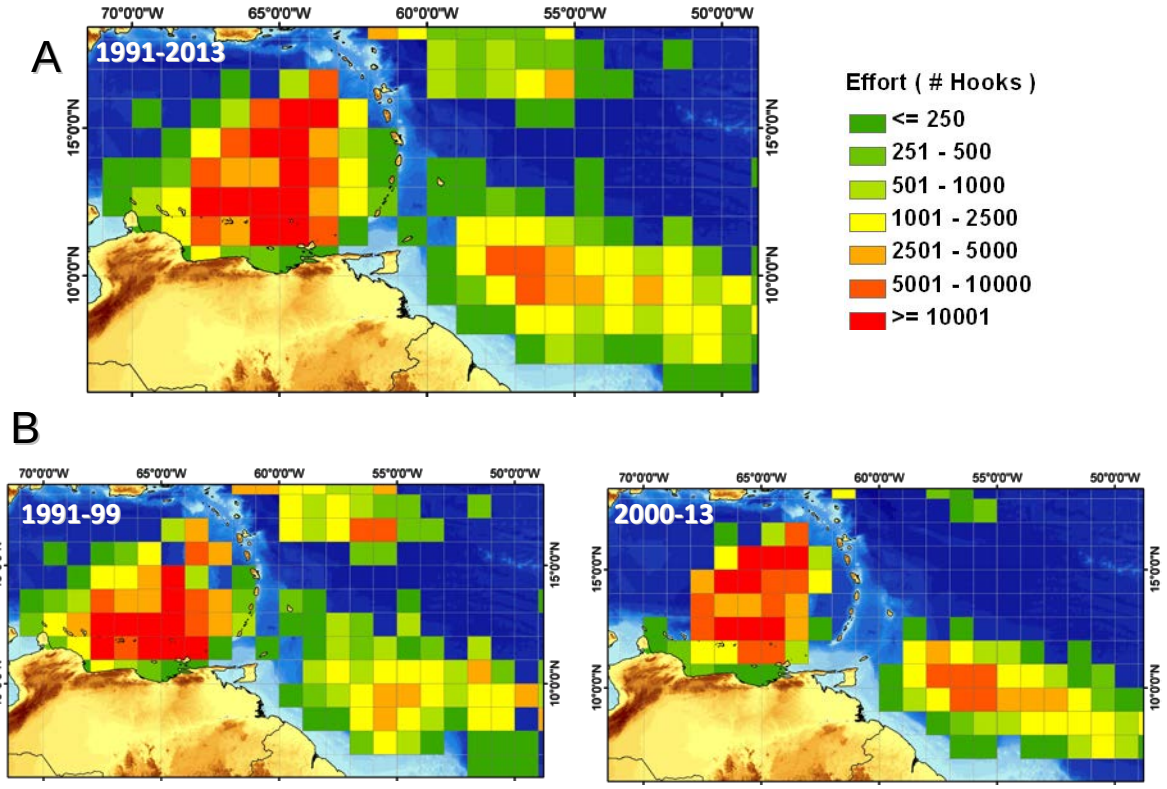

Figure 2. **A**, Mean total fishing effort (number of hooks) in observed sets during 1991-2013 by the VPLOP in 1° square bins. **B**, Mean fishing effort (number of hooks) in the early (1991-1999) and late (2000-2013) period in observed sets during 1991-2013 by the VPLOP in 1° square bins.

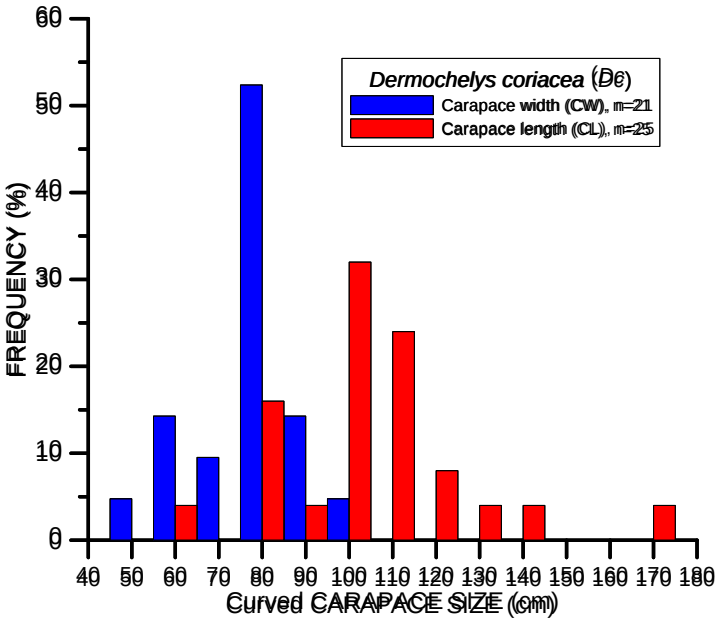

Figure 3. Size frequency distribution of leatherback sea turtles (*Dc*) recorded as curved carapace length and width by the VPLOP during fishing operation in 1991-2013.

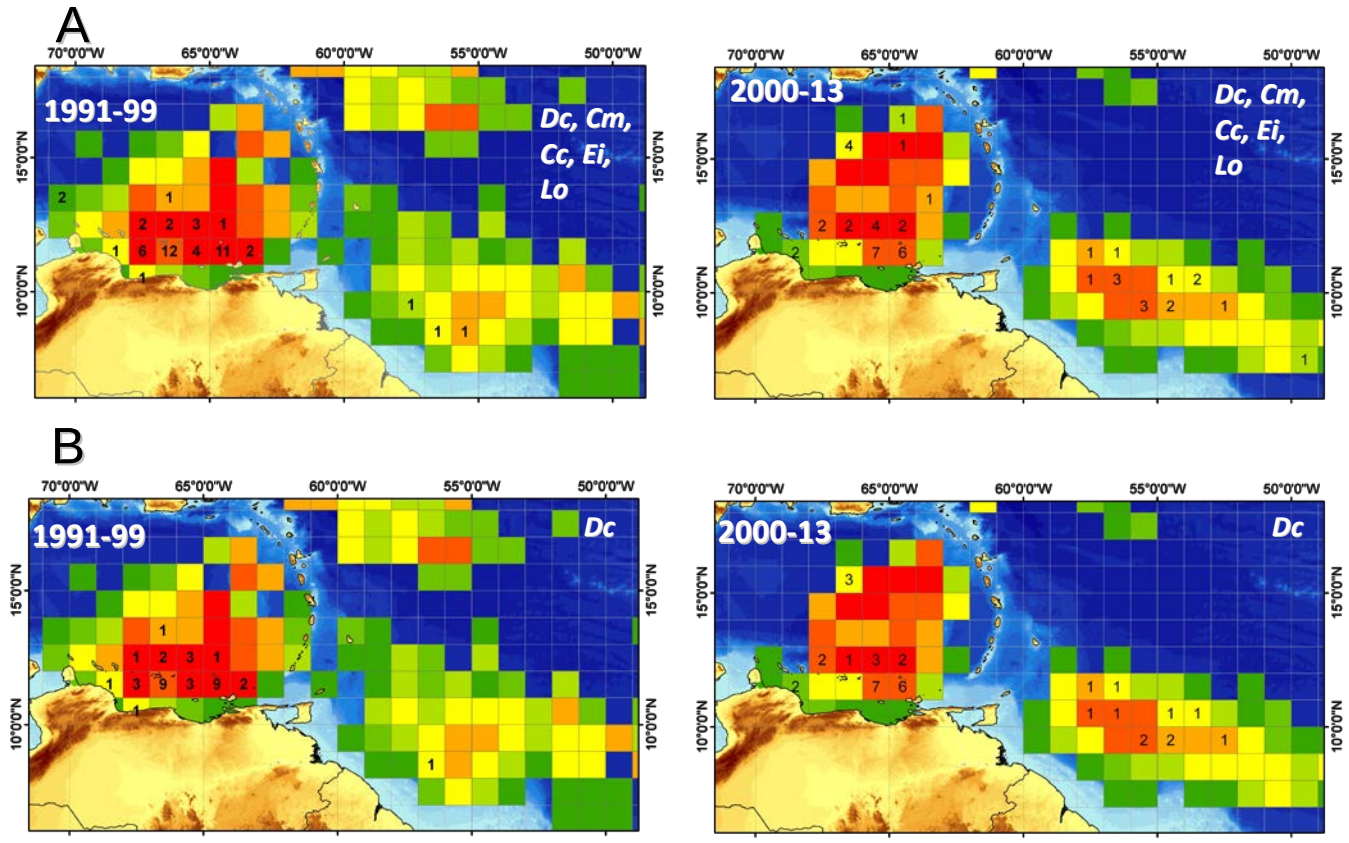

Figure 4. **A,** numbers of all sea turtles combined in 1°square bins during the early (1991-1999) and late (2000-2013) period. **B,** numbers of leatherback sea turtles in 1°square bins during the early (1991-1999) and late (2000-2013) period.

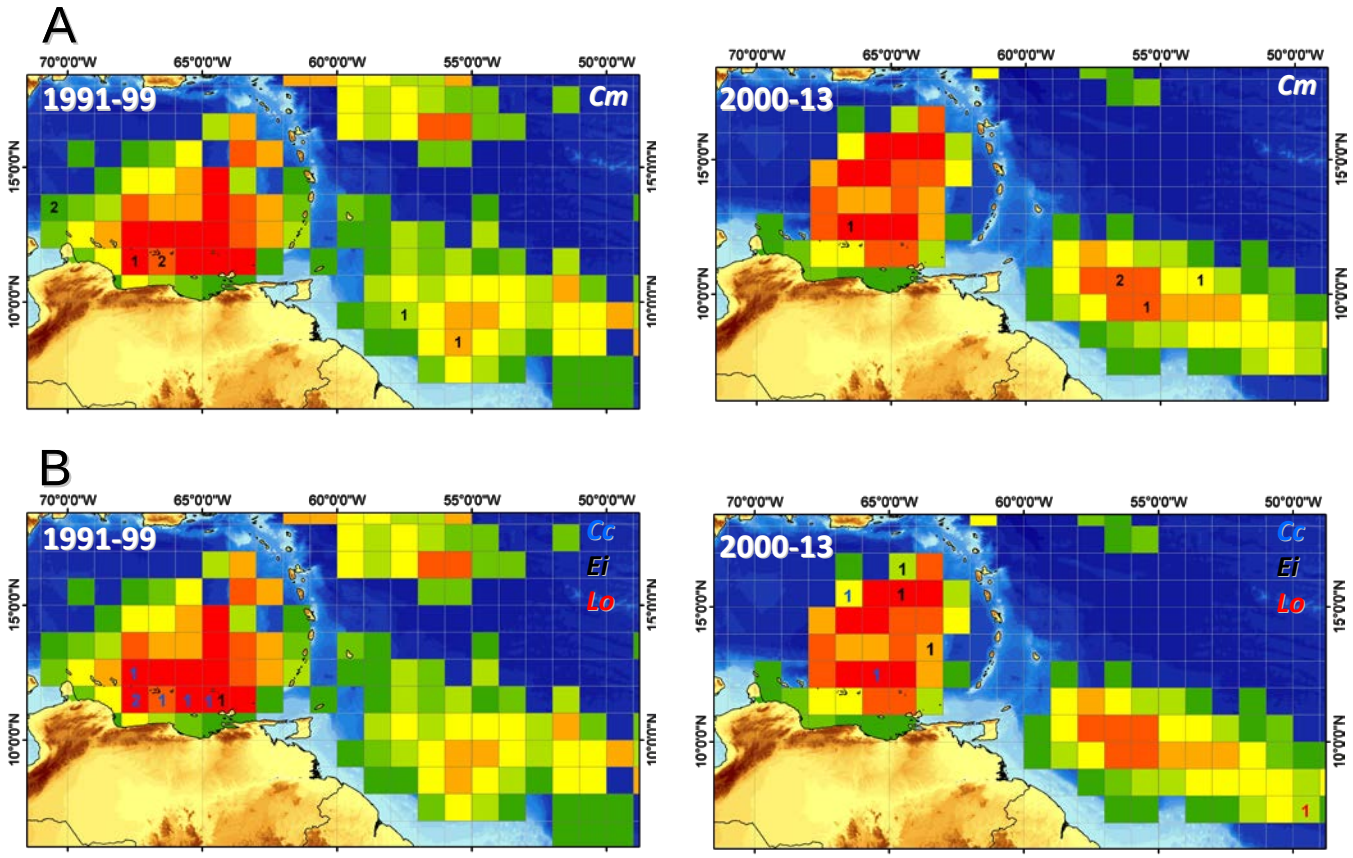

Figure 5. **A,** numbers of green sea turtles in 1°square bins during the early (1991-1999) and late (2000-2013) period. **B,** numbers of loggerhead, hawksbill and olive ridley sea turtles in 1°square bins during the early (1991-1999) and late (2000-2013) period.

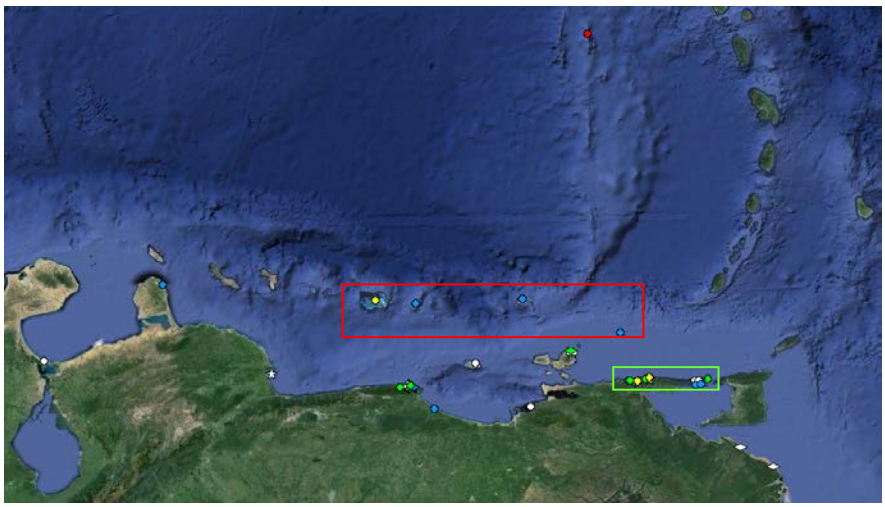

Figure 6. Map showing sea turtle nesting and crawling sites in Venezuela (http://www.seaturtlestatus.org/). See text for colored rectangle explanation.