Summary of Demersal Elasmobranch Studies in the Continental Platform of the Pacific of Costa Rica with Management and Conservation Strategies

Technical Report

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I. VISION OF THE PROJECT

Promote the sustainable management of the Costa Rican deep-water shrimp fishery that takes the life histories of sharks and rays into account.

II. GENERAL OBJECTIVE

Contribute towards the sustainable management of sharks and rays through the identification of vulnerable species and feeding areas and reproductive grounds in Pacific of Costa Rica.

III. SUMMARY OF THE RESULTS (March 2010– September 2011)

▶ Distribution

Overall, 214 trawls were conducted along the Pacific coast of Costa Rica. Trawls were classified into monthly scientific surveys (n = 80), commercial (n = 82) and annual latitudinal surveys (n = 52) (Fig. 1). A total of 24 elasmobranch species from 14 families and 5 orders were recorded (Table 1). The Brown smooth-hound shark (*Mustelus henlei*), the Velez ray (*Raja velezi*) and the Spiny-tail round ray (*Urotrygon aspidura*) represented over 70% of total abundance (n = 3022). The highest diversity occurred in the Central Pacific (Fig. 2). Additionally, the number of species decreased with increasing depth (highest diversity in shallow waters < 100 m; Fig. 3). *Raja velezi* was more abundant in the North Pacific at depths between 100-200 m, *M. henlei* was more common in the Central and South Pacific in shallow and intermediate depths (< 200 m) and the Peruvian torpedo (*Torpedo peruana*) was more abundant in the North Pacific at depths > 200 m. Most species exhibited a spatial segregation pattern in which immature individuals (neonates and juveniles) were more abundant in the Central Pacific, while adults were more common in the north.

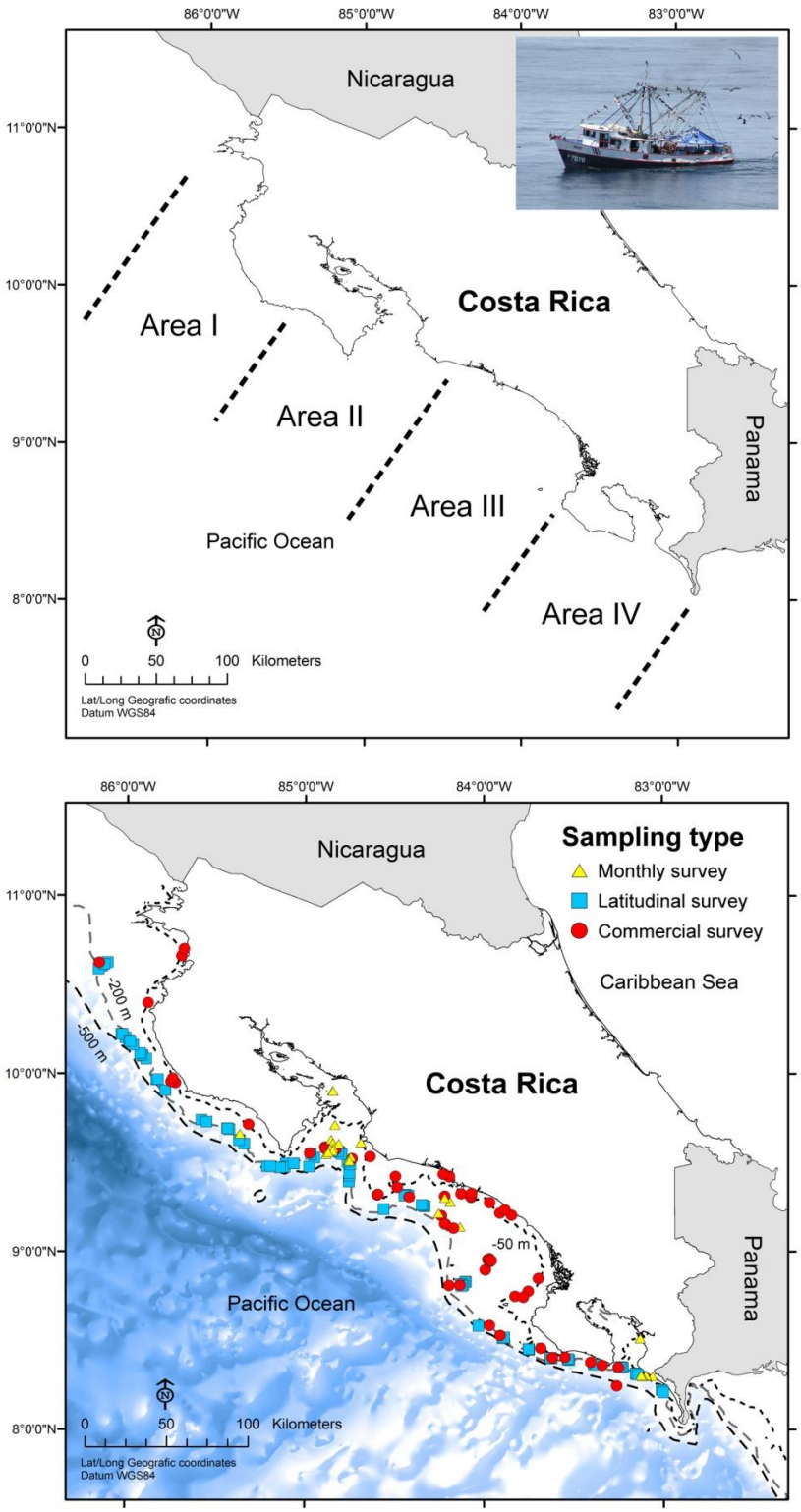

Figure 1. Map of Costa Rica illustrating the four fishing areas and trawling locations (monthly scientific surveys, commercial and annual latitudinal surveys) along the Pacific coast between March 2010 and September 2011.

Table 1. List of sharks and rays associated to commercial deep-water shrimp fishery along the Pacific of Costa Rica (March 2010 – September 2011).

Order	Family	Species	N	%	♀ (%)
Carcharhiniformes	Carcharhinidae	*Rhizoprionodon longurio*	6	0.2	50
	Sphyrnidae	*Sphyrna lewini*	2	0.1	50
	Triakidae	*Mustelus henlei*	570	18.4	29
		Mustelus lunulatus	128	4.1	46
Rajiformes	Rajidae	*Raja equatorialis*	76	2.5	68
		Raja velezi	754	24.3	46
	Rhinobatidae	*Rhinobatos leucorhynchus*	40	1.3	63
		Zapteryx xyster	395	12.7	65
	Urotrygonidae	*Urotrygon aspidura*	473	15.3	62
		Urotrygon chilensis	31	1.0	32
		Urotrygon nana	9	0.3	78
		Urotrygon munda	103	3.3	78
	Gymnuridae	*Gymnura marmorata*	1	<0.1	-
Squaliformes	Echinorhinidae	*Echinorhinus cookei*	11	0.4	100
Squatiniformes	Squatinidae	*Squatina californica*	53	1.7	58
Torpediniformes	Narcinidae	*Diplobatis ommata*	30	1.0	73
		Narcine entemedor	71	2.3	66
		Narcine vermiculatus	139	4.5	70
	Torpedinidae	*Torpedo peruana*	157	5.1	53
Myliobatiformis	Dasyatidae	*Dasyatis longa*	19	0.6	68
	Myliobatidae	*Aetobatus narinari*	2	0.1	50
	Mobulidae	*Mobula sp.*	1	<0.1	100
		Rhinoptera steindacneri	30	1.0	14

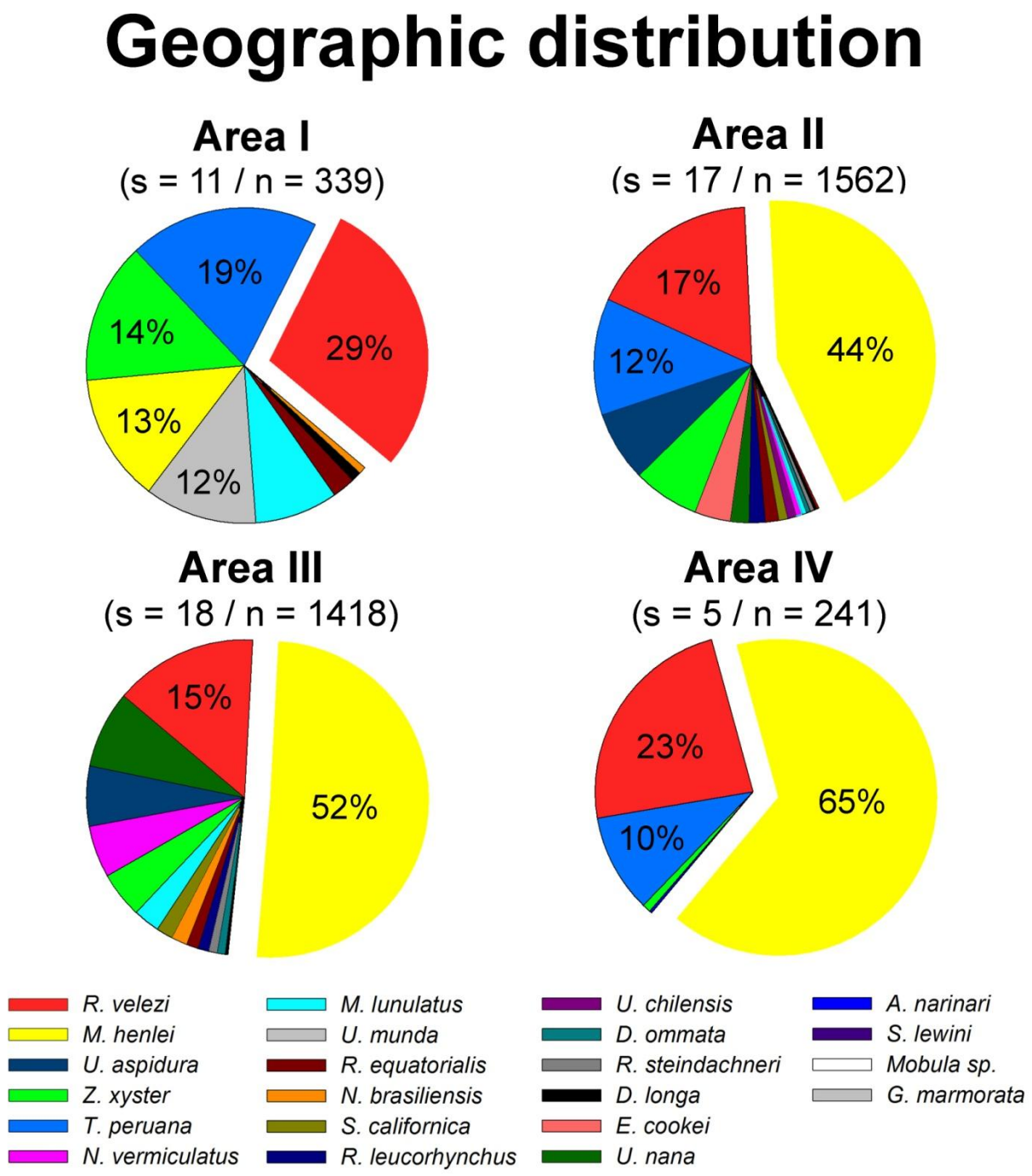

Figure 2. Species composition and abundance of sharks and rays in the four fishing areas along the Pacific coast of Costa Rica (March 2010 – September 2011). Number of individuals (n) and number of species (s) are shown above each graph (pies represent % CPUE – individuals / hr).

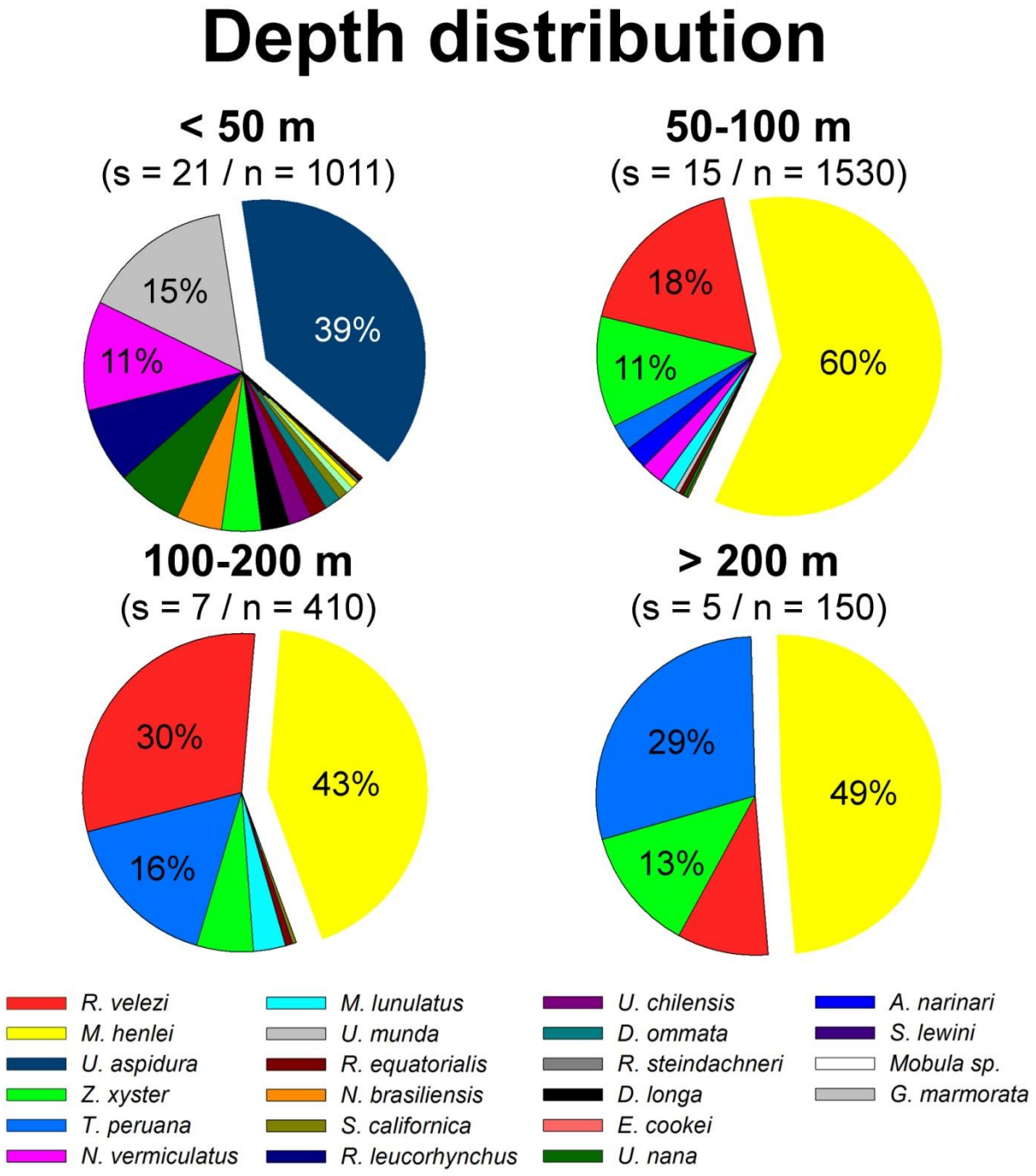

Figure 3. Species composition and abundance of sharks and rays in the four depth categories along the Pacific coast of Costa Rica (March 2010 – September 2011). Number of individuals (n) and number of species (s) are shown above each graph (pies represent % CPUE – individuals / hr).

▶ Feeding ecology

A total of 1559 stomachs from 17 elasmobranch species were analyzed. Crustaceans (64%) and teleost fishes (22%) were the most important taxonomic groups in their diet. Most of the species occupied intermediate trophic levels (TL: 3.5 - 3.7); however, some species such as the Peruvian torpedo (*T. peruana*) and the Pacific angel shark (*Squatina californica*) occupied higher trophic levels (TL: > 4.0), which suggests that these species may play an important ecological role in demersal ecosystems along the Costa Rican Pacific. Overall, there was a high dietary overlap between *R. velezi*, *M. henlei*, *Z. xyster* and *T. peruana*. Ontogenetic shifts in the diet of immature (mainly shrimps and smaller invertebrates) and mature individuals (teleost fishes and stomotapods) were detected, as well as clear geographic differences in diet composition (North Pacific – teleost fishes vs. Central Pacific – crustaceans). For example, close to the Humedal Nacional Térraba-Sierpe (Central Pacific) crustaceans were the most important group in the diet of immature *R. velezi* (IRI = 92%), *M. henlei* (IRI = 79%) and *Z. xyster* (IRI = 92%), while in the North Pacific, teleost fishes were more frequent in adult diets. These results suggest that differences in habitat use and ontogenetic dietary shifts may help reduce intra and inter-specific competition for resources.

▶ Reproductive ecology

The smooth hound shark, *M. henlei* exhibited a well-defined sexual segregation pattern: males were more abundant in deeper waters (> 100 m), while females were common in shallow waters (< 100 m). Most gravid females and immature individuals were found in the outside the Térraba-Sierpe delta and Golfo de Nicoya, which suggests that these areas may be acting as nurseries or Essential Fish Habitats for *M. henlei*. The size at maturity for this species was 39 cm total length (LT) for males and 43 cm TL for females.

The majority of captured *R. velezi*, were neonates or adults, as juveniles were absent between 40-350 m deep. This species used unidentified areas to grow until it achieves sexual maturity, between 57 and 60 cm total length. Gravid females were caught between 50-215 m deep, while neonates were captured in shallow waters (50-65 m). It is likely that adult females inhabit deep waters, but deposit their egg capsules in shallow waters. In this case, both habitats should be protected to assure the long term conservation of the species.

During the study period, a smaller sample of *Z. xyster* and *T. peruana* was obtained, mainly of neonates and juveniles. Only two gravid females of *Z. xyster* were found. This species reaches maturity between 44 and 49 cm TL, while *T. peruana* matures at a larger size (54–64 cm LT), and therefore it is probable that this species has a lower rate of population increase. However, the epipelagic habits of this species imply that the probability of capture is less than for the other three species that present demersal habits. The small sample size may also be due to their larger size, which allows them to benefit from the use of turtle excluder devices (TEDs).

▶ Identification of reproductive areas

All gravid females and most neonates were found in coastal waters, <50 m deep. Within coastal waters several reproduction areas were identified, distinguished by a high abundance of neonates and gravid females: Golfo de Papagayo, Golfo de Nicoya, wetlands of Manuel Antonio and Quepos and the Humedal Nacional Térraba-Sierpe (Fig. 4).

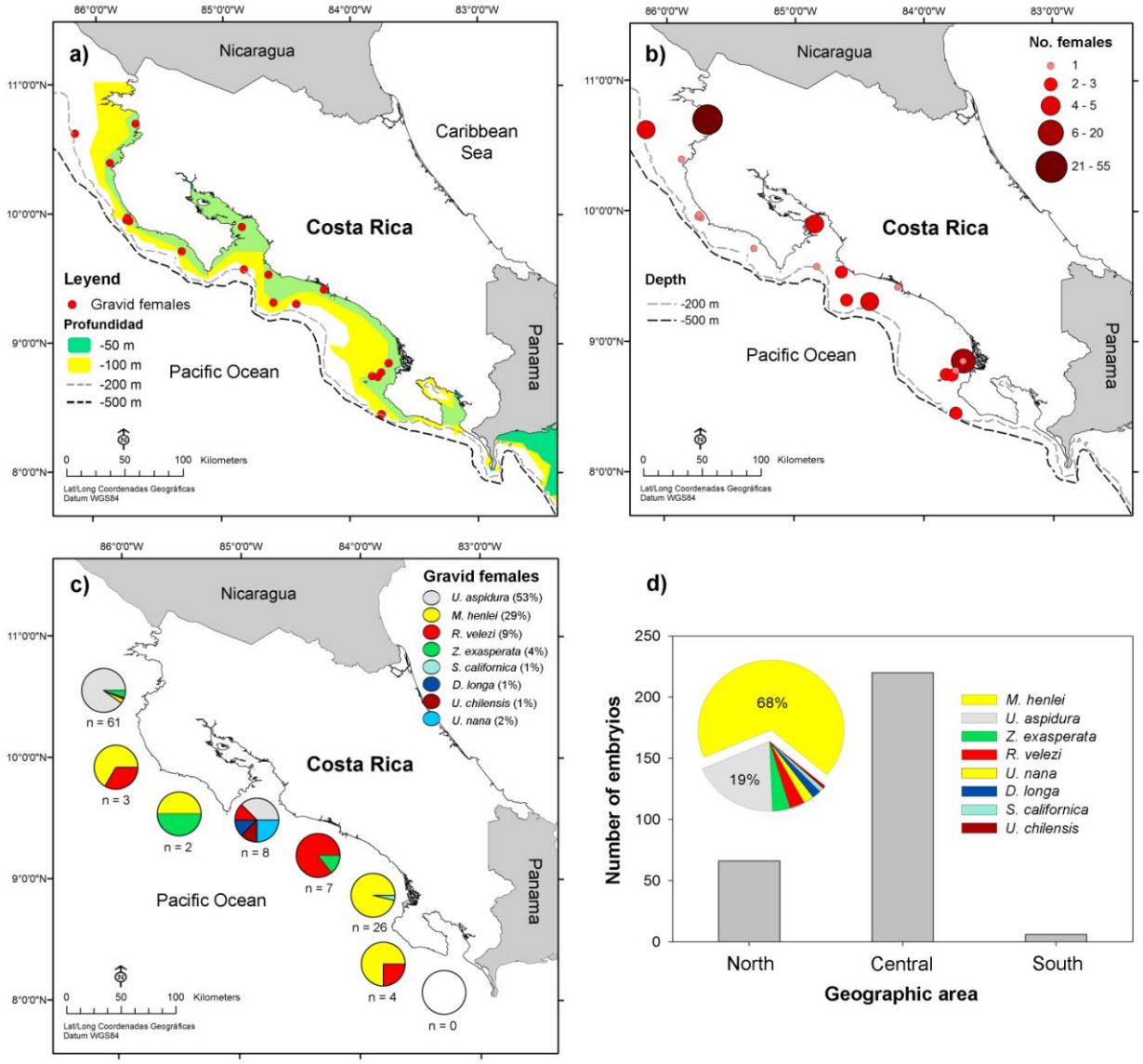

Figure 4. a) Distribution, b) abundance c) species composition and d) number of embryos found inside gravid females captured along the Pacific coast of Costa Rica (March 2010 – September 2011).

▶ Management measures

- Goal # 1: Reduction of the trawling fishery`s environmental impact

Result #1: The highest shark and ray diversity was found in waters <100 m, mainly in the Central Pacific (Table 1, Fig. 1, Fig. 2). Most gravid females were captured in shallow waters (<50 m) in areas surrounding coastal wetlands, such as Quepos-Manuel Antonio, and the Humedal Nacional Tèrraba-Sierpe (Fig. 3).

- ***Measure #1:*** Establish areas where shrimp trawling is prohibited in the Central Pacific, <50 m.

Result #2: Between November 2010 and April 2011, shrimp catches declined sharply and the "congrio" (*Brotula clarkae*) formed large reproductive aggregations in shallow waters. As a result, the semi-industrial trawling fleet targeted the "congrio" during this period. The 29 commercial trawls conducted in shallow waters (10 - 60 m deep) in 2010 and 2011, indicate that 90% of the catch at this depth level consists of commercial and non-commercial fish, including 20 species of sharks and rays.

- ***Measure #2:*** The efficiency of the modified nets that successfully reduced bycatch in Chile`s *Heterocarpus reedi* fishery (see Queirolo *et al.* 2011a,b) should be tested in the Costa Rican *Heterocarpus vicarious* fishery, as they operate at similar depths.

- ***Measure #3:*** Up to 25% of landings may be of by-catch destined for human consumption.

- ***Measure #4:*** Establish a monitoring and surveillance program for the shrimp trawling fishery that includes both onboard observers and landing supervision.

Result #3: The average discard rate estimated from scientific survey data was of 92.7%. Discards include 67 fish species, 20 crustacean species and approximately 20 mollusk species.

- ***Measure #5:*** Evaluate efficiency of bycatch reduction devices (BRD) that have yielded positive results in Australian tropical fisheries. The recommended BRDs are: "*square mesh window attachment", "radial escapement device", "fisheye bycatch reduction device", "Popeye fishbox bycatch reduction device"* (Robins *et al* 1999, Hartil *et al.* 2006, Raudzens 2007, Petersen *et al.* 2008, Patterson & Tudman 2009). Bycatch reduction devices use different strategies, some consist of rigid barriers that exclude large sized animals from the catch, while others consist of larger mesh pores inside the bag that allow fish to escape.

▶ Goal #2: Shark and ray conservation

Result #4: Several shark and ray reproduction areas were identified along the Pacific coast of Costa Rica. The areas, listed in order of importance are:

1. Térraba - Sierpe delta
2. Golfo de Nicoya
3. Wetlands of Manuel Antonio and Quepos
4. Golfo de Papagayo.

- ***Measure #6****:* The shark and ray Essential Fish Habitats identified in this study should be protected. The highest priority site is the area between the Tèrraba – Sierpe delta and the Isla

del Caño. A biological corridor in which trawling is prohibited should be created between this area and the Marino Ballena National Park (<50 m) (Fig. 4).

Result #5: The Costa Rican shrimp trawling fishery includes 24 species of sharks and rays (14 families and 5 orders) in its bycatch. This group`s life history strategies coupled with the lack of catch records may result in the unnoticed, yet drastic reduction of population sizes (Dulvy *et al.* 2000).

- ***Measure #7****:* Monitor shark and ray catch tendencies through onboard observer programs. The necessary information should be registered per fishing trip: vessel name, captain`s name, vessel traits, fishing trip dates, fishing areas used, trawling hours per depth category (0-50 m, 50-100 m, 100-200 m, 200-350 m, > 350 m), number of individual of each species caught in each depth category, number of commercialized specimens per species.

Result #6: Several voids of information were detected**:**
Although several gravid females were found during the 2010-2011 sampling period, a clear reproductive season has not been identified. Future studies should be aim to:

1. Identify the habitats utilized by female smooth hound sharks (*M. henlei*), juvenile rays (*R. velezi*) and adult electric rays (*T. peruana*) along the Pacific continental platform of Costa Rica.Determine size at maternity and fecundity for the ray (*R. velezi), th*e guitarfish (*Z. xyster) an*d electric ray (*T. peruana*).
2. *Descri*be the reproductive cycle of the most abundant shark a*n*d ray species.
3. Determine the size at maturity for less *abundant spe*cies.

- ***Measure #8****: The c*ontinuation of this *project wil*l allow us to generate detailed information on seasonal reproductive patterns of the most abundant shark and ray species in the shrimp fishery`s bycatch. This information will allow is to develop management strategies (e.g. seasonal and area fishing closures) in order to protect reproductive aggregations or gravid females.

▶ **Goal #3: Social and political impact**

- ***Measure #9****:* Transfer the information generated by this project to the stakeholders, including the fishery, academic, governmental and conservation sectors.

- ***Measure #10****:* The recommendations issued in this technical report should be incorporated into coastal and marine resource management plans and fishery management plans.

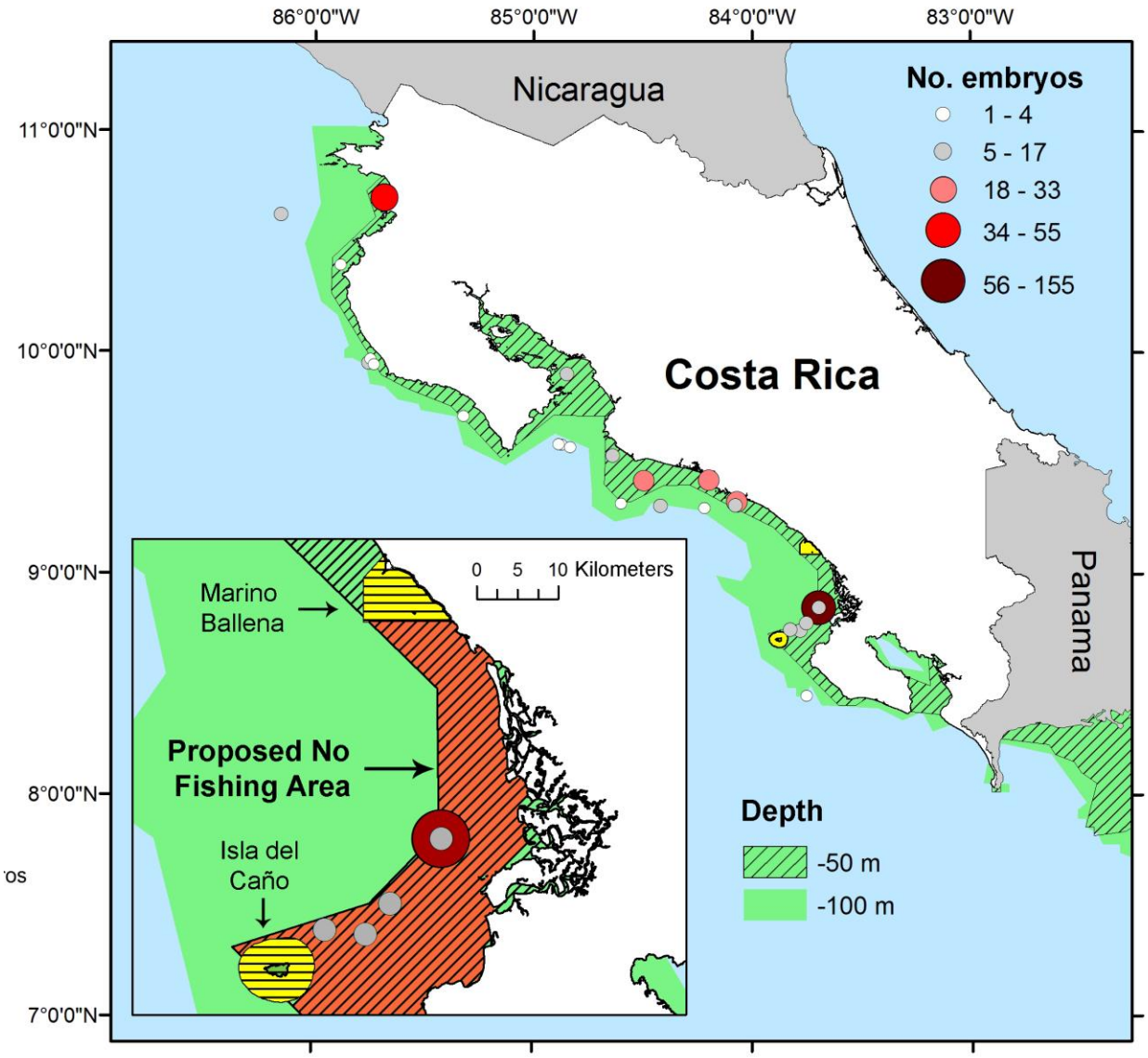

Figure 5. Map of the proposed No Fishing Area between the Marino Ballena National Park and the Isla del Caño Biological Reserve.

V. ACKNOWLEDGEMENTS

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