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TROPHIC INFERENCE IN TWO SYMPATRIC SHARKS, *SPHYRNA LEWINI* AND *CARCHARHINUS FALCIFORMIS* (ELASMOBRANCHII: CARCHARHINIFORMES), BASED ON STABLE ISOTOPE ANALYSIS AT MALPELO ISLAND, COLOMBIA

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Background. Elasmobranchs can play important roles in marine communities. But, relatively little is known about their diet, and movement. *Sphyrna lewini* (Griffith et Smith, 1834) consumes fishes, cephalopods, rays, and crustaceans. *Carcharhinus falciformis* (Müller et Henle, 1839) feed on fishes, cephalopods, crustaceans and sea turtles. To date, there are no studies available on the trophic ecology of sharks in Malpelo Island. The aim of this study was to describe the trophic ecology of *S. lewini* and *C. falciformis*, using stable isotope analysis of $\delta^{13}C$ and $\delta^{15}N$, to better understand the role of both shark species in the Malpelo Island ecosystem.

Material and methods. In January, February, and November 2013, specimens of *Sphyrna lewini* and *Carcharhinus falciformis* illegally caught at Malpelo Island were confiscated at the port of Buenaventura, Colombia. For each shark specimen, total length and sex were registered. Samples of muscle tissue were taken from the nape of all specimens. Each muscle sample was lyophilized for 24 h and analysed with lipid and urea extraction and without extraction. For each shark specimen, a subsample of ~1.0 mg was used for isotopic analysis.

Results. A total of 14 *Sphyrna lewini* (Griffith et Smith, 1834) and 12 *Carcharhinus falciformis* (Müller et Henle, 1839) were analysed. $\delta^{13}C$ values were similar between *S. lewini* (–16.3 ± 0.1‰) and *C. falciformis* (–16.5 ± 0.1‰). *Sphyrna lewini* showed a wider trophic niche than *C. falciformis,* with low trophic overlap (5%) between the two species. The $\delta^{15}N$ values of *S. lewini* (15.9 ± 0.11‰) were higher than those of *C. falciformis* (14.9 ± 0.09‰). In *C. falciformis*, $\delta^{13}C$ values were similar in both sexes (–16.5 ± 0.1‰), while $\delta^{15}N$ values were significantly different between males (14.6 ± 0.1‰) and females (15.0 ± 0.1‰). The trophic position of *S. lewini* was 5.25 ± 0.12, and that of *C. falciformis*, 5.48 ± 0.18, which suggests that both shark species occupy a high position in the marine food chain.

Conclusion. Both shark species co-occur at Malpelo Island, but they do not share food resources and feeding areas, and they probably feed far from the island, using it as a resting and cleaning area. This indicates the need for more research to increase biological and ecological knowledge of both species, particularly within marine protected areas and their influence areas throughout the Colombian Pacific.

Keywords: Trophic ecology, carbon isotopes, nitrogen isotopes, resource partitioning, trophic level

INTRODUCTION

Elasmobranchs can play important roles in marine communities, occupying a wide range of habitats as apex predators. However, relatively little is known about their abundance, diet, and movement (Baum et al. 2003, 2005, Heithaus et al. 2008, Hussey et al. 2012). Many shark species are in decline, mainly due to overfishing, bycatch, pollution, and habitat degradation (Baum et al. 2003, 2005, Dulvy et al. 2008).

Knowledge of diet, trophic position, movement patterns and habitat use of species have been recognized as critical factors in implementing successful conservation

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and management strategies of species and the environment (Hussey et al. 2012). The diets and trophic interactions of elasmobranchs are sometimes difficult to determine using traditional methods alone (e.g., gut content analysis, direct observations, tagging), however, a complementary technique is stable isotope analysis (SIA). SIA is an important, effective tool that can be applied to elasmobranch conservation research (Kim et al. 2012, Shiffman et al. 2012). This technique is based on the premise that heavy isotopes of an element are preferentially retained (e.g., nitrogen isotopes via protein amination/deamination, carbon isotopes via respiration) and that specific ratios of heavy to light isotopes are indicative of specific resource use (e.g., diet and habitat) (Wolf et al. 2009) and trophic position (Post 2002). This biogeochemical method allows quantitative analysis of dietary composition and foraging patterns over a range of spatial and temporal scales (MacNeil et al. 2005), as well as the examination of more complex questions pertaining to community dynamics, feeding strategies or diet, trophic position, and movement in aquatic organisms (Hussey et al. 2012).

The scalloped hammerhead shark, *Sphyrna lewini* (Griffith et Smith, 1834), and silky shark, *Carcharhinus falciformis* (Müller et Henle, 1839), have a circumtropical distribution and occur in the Eastern Tropical Pacific (ETP) from southern California (USA) to Peru (Compagno 1984, Fischer et al. 1995, Robertson and Allen 2002). The species *S. lewini* and *C. falciformis* are listed as "Endangered" (Baum et al. 2007) and "Near Threatened" (Rigby et al. 2017), respectively, in the International Union for Conservation of Nature (IUCN) Red List.

Sphyrna lewini inhabits coastal and oceanic zones in tropical and subtropical seas of the world (Compagno 1984). In the ETP, *S. lewini* often forms schools around oceanic islands and seamounts (Klimley 1981, Klimley and Nelson 1981), particularly in marine protected areas, and makes vertical movements and horizontal migratory movements between Malpelo Island (Colombia), Cocos Island (Costa Rica), and the Galapagos Islands (Ecuador) (Bessudo et al. 2011a, 2011b). In the ETP, *S. lewini* consumes a wide variety of prey species, from benthic, neritic, and epipelagic fishes to cephalopods, rays, lobsters, shrimps, and crabs (Torres-Rojas et al. 2006, Estupiñán-Montaño et al. 2009, Torres-Rojas et al. 2010, Zanella et al. 2010, Galván-Magaña et al. 2013, Torres-Rojas et al. 2015).

The silky shark, *Carcharhinus falciformis*, is a tropical species abundant in oceanic and epipelagic areas (Compagno 1984). *Carcharhinus falciformis* feeds on a large number of prey species, from pelagic and coastal fishes (e.g., tunas, mullets, mackerel) to cephalopods, crustaceans, and sea turtles (Cabrera-Chávez-Costa et al. 2010, Duffy et al. 2015, Estupiñán-Montaño et al. 2017). This shark is considered a piscivorous predator, consuming mainly fishes of the Scombridae family (Duffy et al. 2015, Estupiñán-Montaño et al. 2017).

This is the first study of the trophic ecology of the sharks, *Sphyrna lewini* and *Carcharhinus falciformis*, in an area of sympatry, Malpelo Island. Malpelo Island is a marine reserve located ~490 km off the coast of Buenaventura, Colombia (Fig. 1). The species under study are the most abundant sharks at Malpelo Island. Thus, the aim of this study was to describe the trophic ecology of these two shark species, using stable isotope analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$), to better understand the role of both shark species in the Malpelo Island ecosystem.

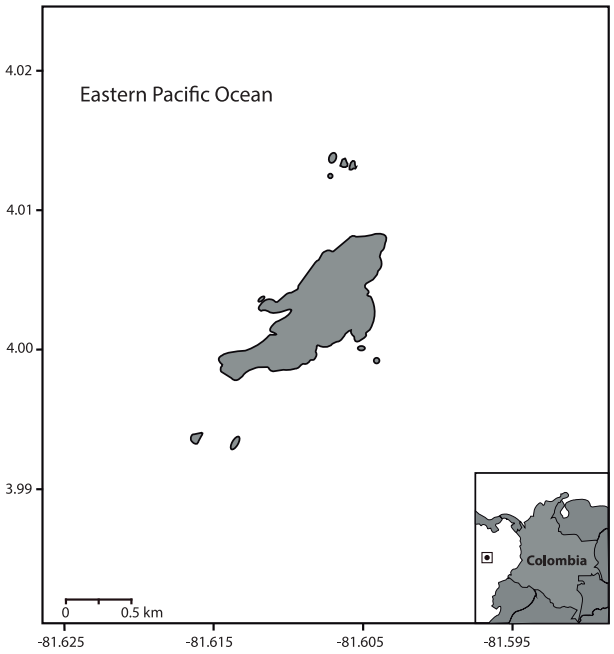

Fig. 1. Geographic location of Malpelo Island, Colombia

MATERIAL AND METHODS

In January, February, and November 2013, a total of 14 *Sphyrna lewini* and 12 *Carcharhinus falciformis* illegally caught at Malpelo Island were confiscated at the port of Buenaventura, Colombia. For each shark specimen, total length (TL, in cm) was measured and sex was determined. Samples of muscle tissue were taken from the nape of all specimens, stored in plastic bags, and frozen for transport to the laboratory.

Each muscle sample was lyophilized for 24 h and analysed with lipid and urea extraction (lipid-free) and without extraction (Bulk). Lipid and urea extraction was performed following the procedure described by Kim and Koch (2012). After drying, each sample was homogenized using an agate mortar to produce a very fine powder. For each shark specimen, a subsample of 0.3–1.0 mg of powder was obtained and loaded into a tin capsule for isotopic analysis. To know if lipid extraction was necessary, the C ÷ N ratios of both sets of samples (Free-lipid and Bulk) were measured. A C ÷ N mass ratio < 3.5 indicated there was no effect of lipid content (Post et al. 2007).

Isotope ratios were measured using a Thermo Scientific™ Delta V Plus™ isotope-ratio mass spectrometer (IRMS), with ConFlo IV interface and a Costech™ elemental analyser, in the chemistry laboratory of the *Centro Interdisciplinario de Ciencias Marinas, Instituto Politécnico Nacional* (CICIMAR-IPN) in La Paz, Mexico. Isotope ratios are presented using δ notation:

$$\delta^h X = \left(\frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right) \times 1000$$

where X is the element, h is the high mass number, R_{sample} is the heavy-to-light isotope ratio, and R_{standard} is Vienna Pee Dee Belemnite for carbon and AIR for nitrogen. Units are parts per thousand (‰). The precision of the method was ± 0.3‰ and ± 0.1‰ for C and N stable isotopes, respectively.

The trophic position (TP) was calculated using the equation proposed by Post (2002):

$$TP = \lambda + \left(\frac{\delta^{15}\text{N}_{\text{predator}} - \delta^{15}\text{N}_{\text{base}}}{\Delta_n} \right)$$

where λ is the TP of the base (i.e., the most important prey species for each predator); $\delta^{15}N_{predator}$ and $\delta^{15}N_{base}$ are the isotopic signatures of the predator and the base, respectively; and Δ_n is the trophic discrimination factor (TDF), 3.7 ± 0.4‰ (Kim et al. 2012). The bases used for TP estimates were chosen from stomach contents studies (Estupiñán-Montaño et al. 2009, 2017) and the mixing model (Parnell et al. 2013). For *Sphyrna lewini*, the base comprised the squids *Dosidicus gigas* (λ = 4.14) (Pauly and Zeller 2015), $\delta^{15}N$ = 10.1 ± 1.3‰ (Bolaños unpublished*), *Ommastrephes bartramii* (λ = 4.20) (Pauly and Zeller 2015), $\delta^{15}N$ = 10.0 ± 0.4‰), and *Lolliguncula* (*Loliolopsis*) *diomedeae* (λ = 3.90) (Pauly and Zeller 2015), $\delta^{15}N$ = 12.5 ± 0.2‰ (Bolaños unpublished*), and the fish *Larimus argenteus* (λ = 3.10) (Pauly and Zeller 2015), $\delta^{15}N$ = 12.6 ± 0.7‰ (Bolaños unpublished*, Calle-Moran unpublished**). For *Carcharhinus falciformis*, the base comprised *D. gigas*, *O. bartramii*, and *Sthenoteuthis oualaniensis* (λ = 4.09) (Pauly and Zeller 2015), $\delta^{15}N$ = 10.4 ± 0.18 ‰ (Calle-Moran unpublished) *Auxis thazard* (λ = 4.37) (Pauly and Zeller 2015), $\delta^{15}N$ = 10.4 ± 0.9‰ (Bolaños unpublished*, Calle-Mora unpublished**), *Anchoa* spp. (λ = 3.46) (Pauly and Zeller 2015), $\delta^{15}N$ = 10.9 ± 0.6‰ (Páez-Rosas et al. 2012) (Fig. 2).

Isotopic niche breadth and trophic overlap between species and sexes were estimated using SIBER (Stable Isotope Bayesian Ellipses in R) (Jackson et al. 2011) from the SIAR package (Stable Isotope Analysis in R) (Parnell and Jackson 2013). This analysis uses measurements based on ellipses calculated by a covariance matrix that defines their shape and area (Jackson et al. 2011) to show the trophic niche breadth (standard ellipse corrected area, SEA_c). With this method it is possible to obtain the overlap between ellipses, where values close to 1 represent high trophic overlap (Jackson et al. 2011).

The normality and homoscedasticity of isotope data were tested using the Shapiro–Wilk and Levene's test, respectively. The parametric Student's *t*-test and the nonparametric Wilcoxon signed-rank test were used to determine statistical differences in C ÷ N ratio among shark species and sexes. All tests were performed using a significance level (α) of 0.05. Statistical analyses and figures were obtained using the R statistical package (R Core Team 2014).

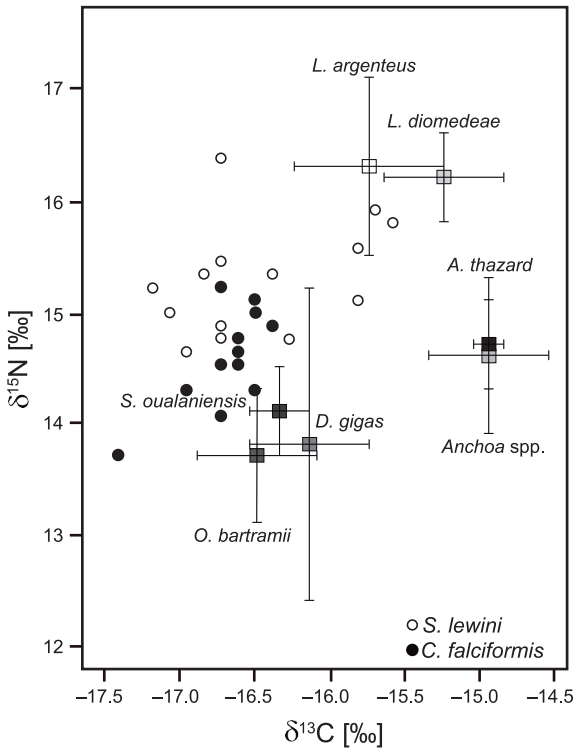

Fig. 2. Mixing model for *Sphyrna lewini* and *Carcharhinus falciformis* at Malpelo Island, Colombia

RESULTS

The lengths of *Sphyrna lewini* ranged from 151.1 to 195.2 cm TL (mean ± SE: 135.25 ± 19.9 cm TL). *Carcharhinus falciformis* lengths ranged between 112.4 and 245.7 cm TL (mean ± SE: 147.96 ± 10.6 cm TL).

For *Sphyrna lewini*, the C ÷ N ratios of the bulk and lipid-free samples ranged from 2.71 to 3.19 and from 2.99 to 3.19, respectively. For *Carcharhinus falciformis*, the C ÷ N ratio ranged from 2.81 to 3.10 (bulk samples) and from 2.81 to 3.07 (lipid-free samples). We found significant statistical differences in C ÷ N ratio between bulk and lipid-free samples (Table 1), likely an effect of the lipid extraction process (Hussey et al. 2012). However, since C ÷ N values were lower than 3.5 (Post et al. 2007), all the analyses were performed using the $\delta^{13}C$ and $\delta^{15}N$ values of bulk samples.

No statistical difference was observed in $\delta^{13}C$ values between *Sphyrna lewini* and *Carcharhinus falciformis* (Wilcoxon signed-rank test, W = 77, P = 0.74). However, Student's *t*-test showed a significant difference in $\delta^{15}N$ values between the two species (t = –3.85, d.f. = 23.99, 95% IC = –0.93 to –0.28, P = 0.001; Table 1, Fig. 3).

* Bolaños N. 2009. Ecología trófica de juveniles de tiburón martillo *Sphyrna zygaena* (Linnaeus, 1758) en aguas ecuatorianas. Master thesis. Centro Interdisciplinario de Ciencias Marinas, La Paz, México.

** Calle-Moran M. 2010. Ecología trófica del tiburón zorro pelágico *Alopias pelagicus* en Santa Rosa de Salinas, Pacífico ecuatoriano. Master thesis. Universidad Nacional Autónoma de México, México DF, México.

In *Sphyrna lewini*, it was not possible to carry out the analysis between sexes because the sharks sampled were landed without fins (dorsal, pectoral, and pelvic). For *Carcharhinus falciformis*, comparisons between sexes indicated no statistical difference in $\delta^{13}C$ values (Wilcoxon signed-rank test, $W = 12.5$, $P = 0.464$), however, there was a significant difference in $\delta^{15}N$ values, with females being enriched in $\delta^{15}N$ (Wilcoxon signed-rank test, $W = 0$, $P = 0.005$; Table 2, Fig. 4).

The TP estimated for *Sphyrna lewini* was in the range of 3.83–5.94, and that of *Carcharhinus falciformis* was in the range of 5.10–5.81. For *C. falciformis*, the estimated TP was between 5.36 and 5.65 (mean ± SE = 5.51 ± 0.03) for males, and between 5.31 and 5.81 (5.63 ± 0.04) for females. The relative TP of *S. lewini* and *C. falciformis* suggests that both species occupy a high position in the marine food chain (Table 3).

There was little isotopic overlap between *Sphyrna lewini* and *Carcharhinus falciformis* (5%; Fig. 3), and the isotopic niche of *C. falciformis* ($SEA_c = 0.20$, $n = 12$) was narrower than that of *S. lewini* ($SEA_c = 0.64$, $n = 14$; Fig. 3).

DISCUSSION

Several studies about the trophic ecology of *Sphyrna lewini* report that this species feeds on cephalopods, fishes, rays, and crustaceans (Torres-Rojas et al. 2006, Estupiñán-Montaño et al. 2009, Torres-Rojas et al. 2010, Zanella et al. 2010, Galván-Magaña et al. 2013, Torres-Rojas et al. 2015). This species is considered as an important consumer of cephalopods in the eastern Pacific (Estupiñán-Montaño et al. 2009, Galván-Magaña et al. 2013) and feeds mainly in oceanic zones (Loor-Andrade et al. 2015).

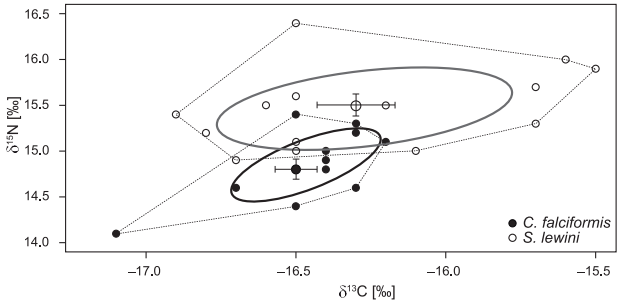

Fig. 3. Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ (mean ± SE) in *Sphyrna lewini* and *Carcharhinus falciformis* at Malpelo Island, Colombia

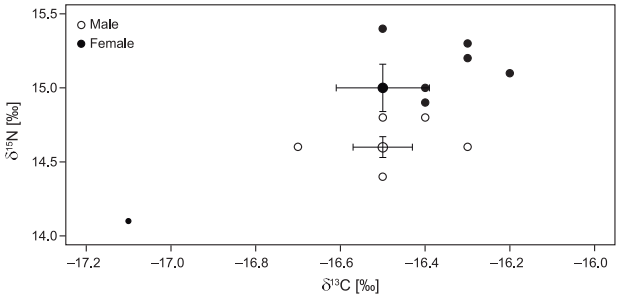

Fig. 4. Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ (mean ± SE) by sex in *Carcharhinus falciformis* at Malpelo Island, Colombia

Table 1

$\delta^{13}C$ and $\delta^{15}N$ values, isotopic range and C ÷ N ratio of *Sphyrna lewini* and *Carcharhinus falciformis* samples, with (bulk) and without (lipid-free) lipid and urea extraction

Species	Variable	Lipid-free [‰]	Bulk [‰]	Difference [‰]		Statistic	95%IC (lower)	95%IC (upper)	*P*
				Range	Mean ± SE				
S. lewini	$\delta^{13}C$	–16.0 ± 0.13	–16.3 ± 0.12	–0.05 to 0.78	0.26 ± 0.07	$W = 55$	–0.699	0.100	0.135
	$\delta^{15}N$	15.9 ± 0.11	15.5 ± 0.12	–0.41 to 0.83	0.43 ± 0.09	$W = 32.5$	–0.800	0.100	0.008
	C ÷ N	3.09 ± 0.02	2.91 ± 0.03	0 to 0.33	0.18 ± 0.03	$W = 157$	0.100	0.200	<0.05
C. falciformis	$\delta^{13}C$	–16.3 ± 0.06	–16.5 ± 0.07	–0.07 to 0.46	0.19 ± 0.05	$W = 34$	–0.3	–0.00003	0.028
	$\delta^{15}N$	15.3 ± 0.09	14.9 ± 0.11	–0.09 to 0.86	0.46 ± 0.09	$t = –3.29$	–0.716	–0.117	0.002
	C ÷ N	3.05 ± 0.01	2.89 ± 0.02	0 to 0.25	0.15 ± 0.02	$W = 128$	0.099	0.200	0.002

Values are mean ± standard error of the mean (SE).

Table 2

$\delta^{13}C$ and $\delta^{15}N$ values, isotopes range and estimated trophic position (TP) of *Sphyrna lewini* and *Carcharhinus falciformis* at Malpelo Island, Colombia

Species	Sex	*n*	$\delta^{13}C$ [‰]		$\delta^{15}N$ [‰]	
			Range	Mean ± SE	Range	Mean ± SE
S. lewini	ND	14	–16.9 to –15.5	–16.0 ± 0.13	14.9 to 16.4	15.9 ± 0.11
C. falciformis	Both	12	–17.1 to –16.2	–16.3 ± 0.06	14.1 to 15.4	15.3 ± 0.09
	Males	5	–16.7 to –16.3	–16.5 ± 0.07	14.4 to 14.8	14.7 ± 0.07
	Females	7	–17.1 to –16.2	–16.5 ± 0.11	14.9 to 15.4	15.0 ± 0.16

ND = not determined, SE = standard error of the mean.

Table 3

Trophic position estimated for *Sphyrna lewini* and *Carcharhinus falciformis*, based on important prey species (mixing model and stomach contents studies)

Prey species	Higher taxon (class)	*Sphyrna lewini*				*Carcharhinus falciformis*			
		Contribution [%]		Trophic position		Contribution [%]		Trophic position	
		Mean	Range	Range	Mean ± SE	Mean	Range	Range	Mean ± SE
Dosidicus gigas	Cephalopoda	21.0	0.0–42.0	4.66–5.85	5.55 ± 0.04	19.0	0.0–36.0	5.36–5.81	5.65 ± 0.04
Ommastrephes bartramii	Cephalopoda	26.0	0.0–51.0	3.83–5.94	5.65 ± 0.04	22.0	0.1–42.0	5.31–5.65	5.51 ± 0.03
Lolliguncula (Loliolopsis) diomedeae	Cephalopoda	0.6	0.0–18.0	4.66–4.84	4.77 ± 0.04	0.9	0.0–22.0	—	—
Larimus argenteus	Actinopterygii	0.7	0.0–21.0	3.83–4.01	3.95 ± 0.04	10.0	0.0–24.0	—	—
Sthenoteuthis oualaniensis	Cephalopoda	20.0	0.0–39.0	—	—	19.0	0.0–36.0	5.10–5.43	5.29 ± 0.03
Auxis thazard	Actinopterygii	0.9	0.0–24.0	—	—	11.0	0.0–25.0	—	—
Anchoa spp.	Actinopterygii	0.9	0.0–24.0	—	—	10.0	0.0–25.0	—	—
Overall		—	—	3.83–5.94	5.25 ± 0.12	—	—	5.10–5.81	5.48 ± 0.18

SE = standard error of the mean.

The $\delta^{13}C$ values obtained in this study for *Sphyrna lewini* (–16.3 ± 0.1‰) agree with those obtained by Loor-Andrade et al. (2015) (–15.9 ± 0.4‰), who reported depleted values of $\delta^{13}C$ for this species. These values are characteristic of the oceanic zone (Niño-Torres et al. 2006, Páez-Rosas et al. 2014), because coastal food webs are generally enriched in ^{13}C compared with those offshore due to the influence of benthic primary production (France 1995, Tanaka et al. 2008) or upwelling (Burton and Koch 1999, Graham et al. 2010). The similarity of the results may be due to: (1) the high mobility of *S. lewini* throughout the ETP (Bessudo et al. 2011b); (2) the metabolic turnover rate of muscle tissue, between 345 and 555 days (MacNeil et al. 2005, Logan and Lutcavage 2010); and (3) the consumption of several cephalopod species in neritic and oceanic areas (epipelagic and mesopelagic zones; Estupiñán-Montaño et al. 2009, Galván-Magaña et al. 2013).

The results of this study support the hypothesis of Bessudo et al. (2011a, 2011b), who suggest that during the night, *Sphyrna lewini* leaves Malpelo Island, probably to feed. The negative values of $\delta^{13}C$ observed in this study for *S. lewini* tissues (Tables 1 and 2) are characteristic of oceanic zones (Niño-Torres et al. 2006, Páez-Rosas et al. 2014), where *S. lewini* would consume epipelagic and mesopelagic cephalopods (e.g., *Dosidicus gigas*, *Histioteuthis* spp., *Mastigoteuthis* spp., and *Sthenoteuthis oualaniensis*) (Estupiñán-Montaño et al. 2009, Galván-Magaña et al. 2013). Furthermore, the wide isotopic niche suggests that *S. lewini* feeds in both coastal and oceanic environments, or that there are individual differences in diet.

The silky shark, *Carcharhinus falciformis*, feeds mainly on teleosts but also on cephalopods and crustaceans (Cabrera-Chávez et al. 2010, Duffy et al. 2015, Estupiñán-Montaño et al. 2017) and, occasionally, on sea turtles (Estupiñán-Montaño et al. 2017, Acevedo unpublished*). This species is considered to be a selective predator in the ETP, with a preference for the scombrid genus *Thunnus* (see Duffy et al. 2015, Estupiñán-Montaño et al. 2017), which normally inhabits oceanic zones and forms schools near seamounts. Previous results are in line with those of the present study, as the depleted ^{13}C values obtained here (Tables 1 and 2) are typical of oceanic areas. The narrow isotopic niche observed in this study suggests that *C. falciformis* has a reduced habitat use, with narrow depth (0 to 85 m) (Kohin et al. 2006, Filmalter et al. 2010) and temperature range (26 to 30ºC) (Kohin et al. 2006).

The enriched values of $\delta^{15}N$ in its muscle tissue suggest that *Sphyrna lewini* spans primary to tertiary consumer roles (TP Range: 3.4–6.6) (Hussey et al. 2015) (Table 3), and that *Carcharhinus falciformis* has a tertiary consumer role (Hussey et al. 2015) (Table 3), occupying high trophic levels in the marine ecosystem of Malpelo Island and the ETP. These results agree with other studies that have estimated a high trophic position for sharks (Cortés 1999, Bornatowski et al. 2014, Li et al. 2014, Hussey et al. 2015, Estupiñán-Montaño et al. 2017).

Our results suggest that *Sphyrna lewini* and *Carcharhinus falciformis* co-occur around of Malpelo Island, with resource partitioning, similar to other reports for sympatric species (Bethea et al. 2004, Papastamatiou et al. 2006, Vaudo and Heithaus 2011). Our results further support the theoretical prediction that the diets of co-occurring species of sharks differ and that sharks with very similar diets do not co-occur (Papastamatiou et al. 2006).

These sympatric sharks co-occur in Malpelo Island, but they do not share their isotopic niche in a significant way. This result may be caused by: (1) the trophic specialization of both species, which reduces interspecific competition; or (2) different habitat use, with *Sphyrna lewini* showing greater horizontal and vertical movements (Bessudo et al. 2011a, 2011b), and *Carcharhinus falciformis* being more limited in its movements by its physiological characteristics, which restrict it to narrower niches (Kohin et al. 2006, Filmalter et al. 2010).

* Acevedo G. 1996. Contribución al estudio de la biología y la dinámica poblacional de los tiburones de la familia Carcharhinidae (Chondricthyes: Lamniformes) en la Ensenada de Panamá. Thesis. Facultad de Ciencias, Universidad del Valle, Cali, Colombia.

In conclusion, this study suggests that *Sphyrna lewini* and *Carcharhinus falciformis* do not feed around Malpelo Island, but they may use Malpelo Island as a resting and cleaning area (Klimley and Nelson 1984, Klimley et al. 1993). There is a need for more research to increase biological and ecological knowledge of both species, which will allow us to understand their role, particularly within marine protected areas throughout the Eastern Pacific Ocean. This study contributes to the knowledge of the trophic ecology of *S. lewini* and *C. falciformis* in the largest marine protected area of the Colombian Pacific, the Malpelo Fauna and Flora Sanctuary (Malpelo FFS), and the Eastern Tropical Pacific (ETP). This information helps to understand the role of the two most abundant shark species at Malpelo Island. Our results will help to develop management and conservation plans for these sympatric species in this marine protected area.

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