# Trophic levels of fish species of commercial importance in the Colombian Caribbean

Camilo B. García & Cristian Camilo Contreras

Departamento de Biología, Universidad Nacional de Colombia, Av. Cra. 30 # 45 -03, Bogotá D.C., Colombia; cbgarciar@unal.edu.co, cccontrerasg@unal.edu.co

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**Abstract:** Ecological studies on commercial important fish species are of great value to support resource management issues. This study calculated trophic levels of those Colombian Caribbean fish species whose diet has been locally described. Usable diet data of 119 species resulted in 164 trophic level estimates. An ordinary regression model relating trophic level and fish size was formulated. The regression slope was positive and significantly different from zero ($p<0.05$) suggesting a scaling of trophic level with fish size. Both the list of trophic levels and the regression model should be of help in the formulation of trophic indicators and models of neotropical ecosystems. Rev. Biol. Trop. 59 (3): 1195-1203. Epub 2011 September 01.

**Key words:** trophic level, fishe size, Caribbean fishes, Colombia.

Quantitative knowledge of diet and hence trophic level of species is a key piece of information in our understanding of functioning of marine ecosystems. If fisheries are to be managed in the context of the ecosystem, a paramount input is the trophic level of the species involved, e. g., Stergiou *et al*. (2007); see Cury *et al*. (2005) and references there in and Vivas-Muñoz *et al*. (2008) for an application. In neotropical waters knowledge of fish diets is not scarce but the determination of trophic levels has been rarely intended.

The present work provides a list of trophic levels on the basis of diets determined locally in the Colombian Caribbean that may be useful as input for diagnostic tools, e.g. the fish in balance index of Pauly *et al*. (2000a), and ecotrophic and fishery models, e.g. ECOPATH type models (Christensen & Pauly 1992, Gascuel 2005). A regression model is proposed that relates size and trophic level as a last resort approach in case of absence of quantitative data of fish diets.

## MATERIALS AND METHODS

A bibliographic search was conducted including journals and thesis works developed for the Colombian Caribbean fish species of economic importance (Fig. 1). Those works with quantitative data (percentage weight) were preferred, although a recent approach may allow converting frequency data into percentage weight (Stobberup *et al*. 2009). Unidentifiable stomach material was excluded in percentage weight calculations. When a dietary study reported diets by size ranges, a trophic level was calculated for each size range of fish.

Trophic levels, defined as the sum of the trophic levels of prey weighted by their fraction in the predator´s diet plus one, were estimated using the application TrophLab (Pauly *et al*. 2000b). TrophLab allows for three levels of taxonomic resolution of diets and postulates trophic levels for preys in the diets. Thus for each species a list of the typical

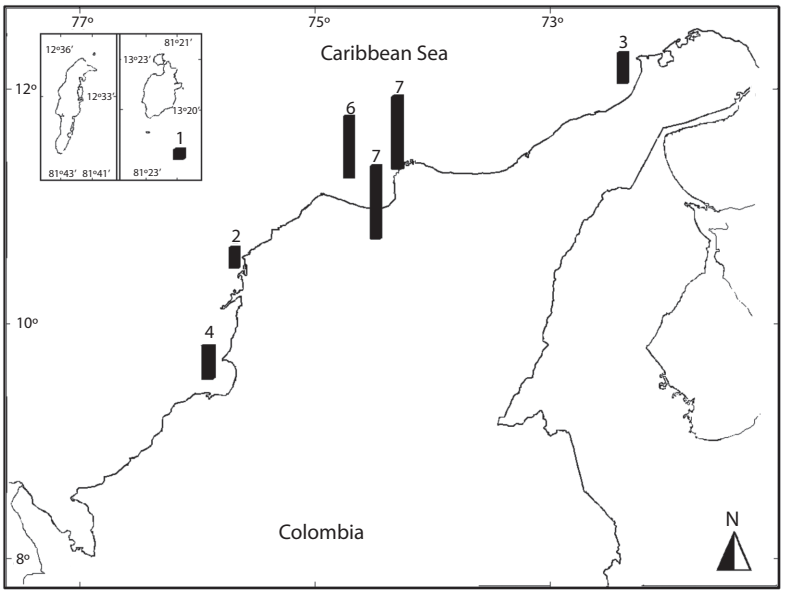


**Fig. 1.** Spatial distribution of documents on fish diets considered. Numbers on the bars are numbers of documents.

diet was constructed and percentage weight was assigned to items according to constrains in TrophLab.

Ordinary last squares regression was used to relate trophic level with fish size (fish size transformed to natural logarithms as to linearize the relationship). Both maximum length reported and the mean between minimum and maximum length were tested. The last is a crude attempt to give representation of size spectra in the determination of trophic level of a given species. Total length and fork length were transformed to standard length by means of factors obtained from local photographs or from images located in FishBase (Froese & Pauly 2010) with the exception of elasmobranchs and some bony fishes that lack a caudal fin. Only bony fishes were used in the regression analysis.

## RESULTS

A total of 164 trophic levels for 119 fish species could be estimated (Table 1). These fishes represent about 20% of marine fishes known to occur in Colombian Caribbean waters (INVEMAR 2010). All fishes of fishery interest are included suggesting a bias towards those fishes. Most fishes have received only one dietary study but some had several (e.g. *Caranx crysus*, *C. hippos*, *Lutjanus synagris*, *Megalops atlanticus*, among others, Table 1). For those fishes with more than one dietary study estimation of trophic level was found to vary, probably due to a combination of different size ranges, with bigger fish tending to have higher trophic levels (see regression analysis below), and varying sample sizes used (Table 1). One additional source of variance is the taxonomic resolution of the original work.

Figure 2 shows the plot of trophic level (TL) vs. mean standard length (SL, plot of trophic level vs. maximum standard length not shown). The slope of both regressions (after transforming size to natural logarithms) is significantly different from zero ($p<0.05$) but the regression trophic level vs. ln (mean standard length) explains more variability in the data: 30% vs. 25% for the other approach. See Figure 2 for the equation.

TABLE 1
Trophic levels of 119 Colombian Caribbean fishes

| Species | Trophic Level | Size (mm) | Stomachs | Source |
|---|---|---|---|---|
| *Acanthostracion polygonius* | 2.33 | 135-200 | 10 | Navajas (1998) |
| *Acanthostracion quadricornis* | 2.15 | 130-180 | 3 | Navajas (1998) |
| *Acanthurus chirurgus* | 2.36 | 119-240 | 16 | Navajas (1998) |
| *Albula nemoptera* | 3.87 | 200-345 | 34 | Melo (1998) |
| *Albula vulpes* | 3.71 | 235-360 | 11 | Melo (1998) |
| *Alectis ciliaris* | 3.98 | 255-270 | 2 | Melo (1998) |
| *Aluterus monoceros* | 2.83 | 224-355 | 25 | Navajas (1998) |
| *Anisotremus surinamensis* | 3.68 | NR | 1 | Melo (1998) |
| *Anisotremus virginicus* | 3.78 | 208 | 1 | Melo (1998) |
| *Auxis thazard* | 4.50 | 229-320 | 7 | Moreno (1986) |
| *Bagre marinus* | 3.59 | 225-285 | 4 | Melo (1998) |
| *Bairdiella ronchus* | 3.78 | 55-191 | 623 | Torres (1994) |
| | 4.50 | NR | 3 | Jiménez (2008) |
| *Balistes vetula* | 3.46 | 168-366 | 11 | Schiller & García (2000) |
| | 3.05 | 67-370 | 76 | Martínez(1990) |
| *Balistes capriscus* | 3.39 | 125-300 | 179 | Duarte & Schiller (1997) |
| *Calamus penna* | 3.43 | 205-323 | 68 | Melo (1998) |
| *Calamus pennatula* | 3.41 | 235-275 | 6 | Melo (1998) |
| *Caranx crysos* | 4.30 | 264-313 | 3 | Melo (1998) |
| | 4.43 | 179-298 | 14 | Pinilla (1986) |
| | 4.48 | 306-340 | 20 | Pinilla (1986) |
| | 4.46 | 349-459 | 16 | Pinilla (1986) |
| | 4.49 | 157-472 | 380 | Reyes (1999) |
| *Caranx hippos* | 4.50 | 280-290 | 2 | Melo (1998) |
| | 4.37 | 167-250 | 50 | Pinilla (1986) |
| | 4.44 | 258-500 | 11 | Pinilla (1986) |
| | 4.50 | 509-792 | 14 | Pinilla (1986) |
| | 4.23 | NR | 3 | Jiménez (2008) |
| *Caranx latus* | 4.41 | 194-235 | 5 | Melo (1998) |
| *Carcharhinus signatus* | 4.44 | NR | 3 | Melo (1998) |
| *Cathorops mapale* | 3.77 | NR | 6 | Jiménez (2008) |
| *Cathorops spixii* | 3.67 | 86-343 | 108 | Santacruz (1989) |
| | 3.28 | 116-207 | 41 | Melo (1998) |
| *Centropomus ensiferus* | 4.28 | 93-160 | 4 | Bustos (2003) |
| | 4.24 | NR | 8 | Jiménez (2008) |
| *Centropomus undecimalis* | 4.07 | 75-162 | 10 | Bustos (2003) |
| | 4.40 | 114-852 | 223 | Sierra (1996) |
| *Chaetodipterus faber* | 3.12 | 130-255 | 60 | Melo (1998) |
| *Chaetodon ocellatus* | 3.51 | 70-125 | 8 | Navajas (1998) |
| *Chaetodon sedentarius* | 3.41 | 110-130 | 3 | Navajas (1998) |
| *Chilomycterus antillarum* | 3.50 | 140 | 1 | Navajas (1998) |
| *Chloroscombrus chrysurus* | 3.59 | 119-270 | 38 | Melo (1998) |
| *Conodon nobilis* | 3.88 | 132-290 | 103 | Melo (1998) |
| *Ctenosciaena gracilicirrhus* | 3.92 | 87-190 | 37 | Navajas (1998) |
| *Cynoscion jamaicensis* | 4.40 | NR | 8 | Jiménez (2008) |
| | 4.49 | 205-224 | 3 | Navajas (1998) |
| *Dasyatis americana* | 3.74 | 670-162 TL | 6 | Navajas (1998) |
| *Dasyatis guttata* | 4.02 | 154-710 DW | 19 | Mojica (2007) |
| | 3.43 | 440-1550 TL | 16 | Navajas (1998) |
| *Diapterus auratus* | 3.43 | 200 | 1 | Navajas (1998) |
| | 2.97 | 61-182 | 27 | Arenas & Acero (1992) |
| *Diapterus rhombeus* | 2.60 | 56 -110 | 79 | Arenas & Acero (1992) |
| *Diodon holocanthus* | 3.36 | 110-210 | 25 | Navajas (1998) |

TABLE 1 (Continued)
Trophic levels of 119 Colombian Caribbean fishes

| Species | Trophic Level | Size (mm) | Stomachs | Source |
|---|---|---|---|---|
| *Elegatis bippinulata* | 4.24 | 260-530 | 42 | Posada (2005) |
| *Elops saurus* | 3.60 | 305-440 | 2 | Melo (1998) |
| | 4.32 | 192-715 | 449 | Santos & Arboleda (1993) |
| | 4.35 | NR | 9 | Jiménez (2008) |
| *Eucinostomus argenteus* | 3.75 | 70-154 | 76 | Navajas (1998) |
| | 3.29 | 97-123 | 11 | Arenas &Acero (1992) |
| *Eucinostomus gula* | 3.58 | 80-160 | 63 | Navajas (1998) |
| | 3.15 | 61-101 | 7 | Arenas & Acero (1992) |
| | 3.37 | 78-101 | 68 | Santacruz (1989) |
| *Eucinostomus harengulus* | 3.22 | 94-110 | 9 | Arenas & Acero (1992) |
| *Eucinostomus melanopterus* | 3.14 | 80-114 | 23 | Arenas & Acero (1992) |
| *Eugerres plumierii* | 3.08 | 94-266 | 38 | Navajas (1998) |
| | 3.09 | 78-216 | 155 | Arenas & Acero (1992) |
| *Euthynnus alletteratus* | 4.47 | 184-643 | 65 | Moreno (1986) |
| | 4.49 | 240-530 | 46 | Posada (2005) |
| *Fistularia petimba* | 4.50 | 105-680 | 4 | Navajas (1998) |
| *Fistularia tabacaria* | 4.50 | 636-713 | 3 | Navajas (1998) |
| *Gerres cinereus* | 3.23 | 155-255 | 2 | Navajas (1998) |
| | 3.04 | 62-139 | 54 | Arenas & Acero (1992) |
| | 3.46 | 65-139 | 23 | Santacruz (1989) |
| *Haemulon album* | 3.71 | 320 | 1 | Melo (1998) |
| *Haemulon aurolineatum* | 3.58 | 86-235 | 24 | Melo (1998) |
| *Haemulon bonariense* | 4.26 | NR | 6 | Jiménez (2008) |
| *Haemulon melanurum* | 3.42 | 60-235 | 3 | Melo (1998) |
| *Haemulon plumierii* | 3.82 | 104-285 | 155 | Rojas & Botero (1987) |
| | 3.27 | 10-245 | 5 | Melo (1998) |
| *Haemulon steindachneri* | 3.57 | 80-285 | 90 | Melo (1998) |
| *Hemicaranx amblyrhynchus* | 3.80 | 135-299 | 2 | Melo (1998) |
| *Holocentrus ascensionis* | 3.47 | 180-220 | 7 | Navajas (1998) |
| *Isopisthus parvipinnis* | 4.50 | NR | 6 | Jiménez (2008) |
| *Larimus breviceps* | 4.38 | 110-195 | 14 | Navajas (1998) |
| *Lepophidium profundorum* | 3.92 | 100-280 TL | 72 | Santacruz (1989) |
| *Lutjanus analis* | 4.10 | 210 a 460 | 110 | Duarte & García (1999a) |
| | 4.04 | NR | 126 | Arévalo (1996) |
| *Lutjanus apodus* | 4.11 | 184-334 | 3 | Navajas (1998) |
| *Lutjanus griseus* | 4.50 | 426 | 1 | Navajas (1989) |
| *Lutjanus jocu* | 4.42 | 260-525 | 10 | Navajas (1989) |
| *Lutjanus mahogoni* | 4.47 | 200-225 | 4 | Navajas (1989) |
| *Lutjanus purpureus* | 3.59 | 150 | 1 | Navajas (1989) |
| *Lutjanus synagris* | 3.83 | 110-320 | 94 | Duarte & García 1999b) |
| | 3.92 | 87-301 | 106 | Martínez (1990) |
| | 4.00 | 86-249 | 91 | Santacruz (1989) |
| | 4.10 | NR | 116 | Arévalo (1996) |
| | 4.06 | NR | 4 | Jiménez (2008) |
| *Lutjanus vivanus* | 3.93 | 102-290 | 7 | Navajas (1998) |
| *Megalops atlanticus* | 4.16 | 305-470 | 2 | Navajas (1989) |
| | 4.13 | 93-205 | 101 | Cataño & Garzón (1994) |
| | 4.29 | 206-317 | 93 | Cataño & Garzón (1994) |
| | 4.43 | 318-495 | 108 | Cataño & Garzón (1994) |
| *Menticirrhus littoralis* | 4.09 | 227-244 | 4 | Navajas (1998) |
| *Micropogonias furnieri* | 3.23 | 63-325 | 246 | Escobar (1994) |
| | 3.98 | 167-353 | 29 | Navajas (1998) |
| *Mugil curema* | 2.00 | 67-194 | 276 | Bustos *et al*. (2004) |
| *Mugil incilis* | 2.23 | 60 -293 | 15 | Velasco (1985) |

TABLE 1 (Continued)
Trophic levels of 119 Colombian Caribbean fishes

| Species | Trophic Level | Size (mm) | Stomachs | Source |
|---|---|---|---|---|
| *Mustelus canis* | 3.87 | 265-487 | 8 | Melo (1998) |
| *Myripristis jacobus* | 3.51 | 125-155 | 9 | Navajas (1998) |
| *Narcine bancroftii* | 3.60* | 109-594 TL | 79 | Moreno *et al*. (2009) |
| *Narcine brasiliensis* | 3.55 | 240-470 TL | 8 | Melo (1998) |
| *Ocyurus chrysurus* | 4.31 | 75-376 | 123 | Rojas & Botero (1987) |
| *Oligoplites palometa* | 4.45 | 56-280 | 86 | Duque *et al*. (1996) |
| *Oligoplites saurus* | 4.48 | 60-249 | 282 | Duque *et al*. 1996) |
| *Opisthonema oglinum* | 2.36 | NR | 12 | Jiménez (2008) |
| | 3.30 | 34-288 | 64 | Navajas (1998) |
| *Pellona harroweri* | 3.37 | 34-91 | 21 | Críales (2003) |
| | 3.67 | 67-221 | 15 | Navajas (1998) |
| *Polydactylus virginicus* | 3.90 | 140-222 | 19 | Navajas (1998) |
| *Pomacanthus paru* | 2.03 | 114 | 1 | Navajas (1998) |
| *Pomadasys corvinaeformis* | 3.35 | 96-400 | 44 | Melo (1998) |
| *Pomadasys crocro* | 3.50 | NR | 1 | Melo (1998) |
| *Priacanthus arenatus* | 3.89 | 130-290 | 16 | Melo (1998) |
| *Prionotus punctatus* | 3.74 | 145-240 | 2 | Melo (1998) |
| *Pristipomoides aquilonaris* | 4.14 | 150-200 | 6 | Navajas (1998) |
| *Pseudopeneus maculatus* | 3.76 | 69-147 | 74 | Santacruz (1989) |
| | 4.05 | 104-190 | 14 | Melo (1998) |
| *Rhinesomus bicaudalis* | 3.14 | 180-280 | 2 | Navajas (1998) |
| *Rhinobatos percellens* | 3.70 | 319-575 | 24 | Melo (1998) |
| *Rhinoptera bonasus* | 3.59 | 554 | 1 | Melo (1998 |
| *Rhomboplites aurorubens* | 4.20 | 150-205 | 7 | Navajas (1998) |
| *Saurida normani* | 4.46 | 155-237 | 3 | Navajas (1998) |
| *Scomberomorus brasiliensis* | 4.45 | 295-605 | 11 | Navajas (1998) |
| | 4.50 | 167-583 | 56 | Moreno (1986) |
| | 4.50 | NR | 5 | Jiménez (2008) |
| *Scomberomorus cavalla* | 4.50 | 270-946 | 11 | Moreno (1986) |
| *Scorpaena plumieri* | 3.30 | 165-224 | 9 | Melo (1998) |
| *Selar crumenophthalmus* | 3.97 | 150-257 | 37 | Melo (1998) |
| | 4.13 | 182-191 | 23 | Pinilla (1986) |
| | 4.09 | 201-218 | 57 | Pinilla (1986) |
| | 4.30 | 226-261 | 13 | Pinilla (1986) |
| *Selene brownii* | 4.38 | 95-280 | 39 | Melo (1998) |
| *Selene setapinnis* | 3.60 | 120-210 | 8 | Melo (1998) |
| *Selene vomer* | 3.97 | 145-304 | 39 | Melo (1998) |
| *Seriola rivoliana* | 4.34 | 220-260 | 3 | Melo (1998) |
| *Seriola zonata* | 3.54 | 255 | 1 | Melo (1998) |
| *Serranus atrabranchus* | 4.01 | 70 | 1 | Melo (1998) |
| *Sphoeroides greeleyi* | 3.09 | 35-102 | 337 | Londoño (1994) |
| *Sphoeroides testudineus* | 3.35 | 52-210 | 329 | Londoño (1994) |
| *Sphyraena barracuda* | 4.50 | >427 | 51 | Bent (2006) |
| *Sphyraena guachancho* | 4.40 | 285.443 | 5 | Navajas (1998) |
| *Sphyraena picudilla* | 4.48 | 215-362 | 6 | Navajas (1998) |
| *Stellifer griseus* | 4.50 | NR | 6 | Jiménez (2008) |
| *Stephanolepis setifer* | 2.62 | 137 | 1 | Navajas (1998) |
| *Syacium micrurum* | 3.50 | 105-130 | 3 | Navajas (1998) |
| *Thunnus atlanticus* | 4.48 | 176-748 | 26 | Moreno (1986) |
| *Trachinotus carolinus* | 3.50 | 340 | 1 | Melo (1998) |
| *Trachinotus falcatus* | 3.23 | 370-393 | 2 | Melo (1998) |
| *Trichurus lepturus* | 4.47 | 490-1120 TL | 12 | Melo (1998) |
| | 4.50 | NR | 5 | Jiménez (2008) |
| *Umbrina broussonetti* | 4.07 | 145-210 | 15 | Navajas (1998) |

TABLE 1 (Continued)
Trophic levels of 119 Colombian Caribbean fishes

| Species | Trophic Level | Size (mm) | Stomachs | Source |
|---|---|---|---|---|
| *Umbrina coroides* | 3.92 | NR | 4 | Jiménez (2008) |
| | 3.44 | 131-205 | 84 | Navajas (1998) |
| *Upeneus parvus* | 4.28 | 160-175 | 3 | Melo (1998) |

Unless otherwise stated size measure is standard length. NR=Not reported, TL=Total length, DW=Disk width. * As reported in Moreno *et al*. (2009).

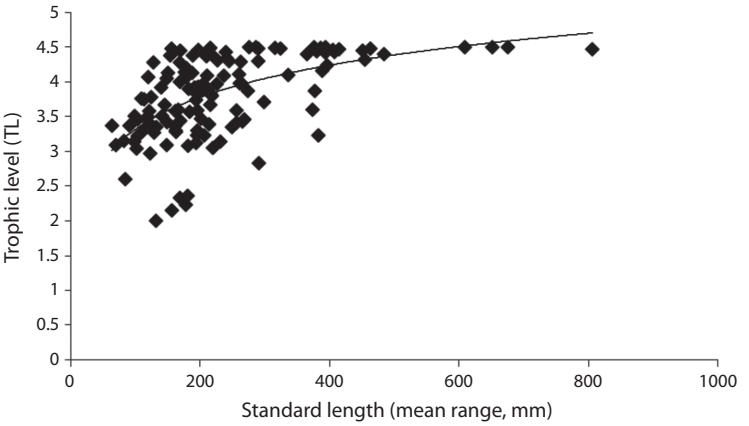


**Fig. 2.** Relationship between mean range standard length (SL) and trophic level (TL) in some Colombian Caribbean bony fishes. Regression equation was: TL=0.2678+0.6622*ln(mean SL), $r^2$=0.30, $p<0.05$.

## DISCUSSION

Much work remains to be done. Spatial coverage of studies is quite uneven with the bulk of the work done in the central Colombian Caribbean thus spatial cover must be improved as spatial comparisons would be informative. It is unfortunate that a substantial amount of work has not been published as it is contained in gray literature (thesis works). No work has attempted to follow temporal changes in diets and only few have come close to size-based changes in diets. However, our results suggest that trophic level increases with size for a given species (Table 1).

The trophic levels reported here should be viewed with care. Size structure should be taken into account and be given adequate weight in calculations. A weakness in the regression model presented here as a predictive tool is the uneven number of stomachs of fishes size range. Clearly, size is not everything as it explains a relative low percentage in trophic level variation (via a logarithmic relationship), although it may be the single most important factor. For instance, Romanuk *et al*. (2010), using a much bigger data set, found that fish size explained about 20% of fish trophic level variation, while phylogeny explained an additional 17%. Nevertheless, it is hoped that both the trophic level list and the regression presented here turns out to be useful to researchers in the neotropics and elsewhere.

## ACKNOWLEDGMETS

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## RESUMEN

Estudios ecológicos de especies de peces importantes comercialmente son de gran valor como insumos en temas de manejo. Aquí se presenta estimaciones del nivel trófico de aquellas especies de peces del Caribe colombiano cuya dieta ha sido descrita localmente. Información utilizable sobre 119 especies resulto en 164 estimaciones de nivel trófico. Se propone un modelo de regresión ordinaria entre el nivel trófico y el tamaño de los peces. La pendiente resultó positiva y significativamente diferente de cero ($p<0.05$) lo cual sugiere una relación moduladora entre el nivel trófico y el tamaño de los peces. Tanto la lista de niveles tróficos como el modelo de regresión, deben ser de ayuda en la formulación de indicadores tróficos y modelos de los ecosistemas neotropicales.

**Palabras clave:** nivel trófico, talla de peces, peces del Caribe, Colombia.

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