Chapter

Fish and Fisheries of the Eastern Coast of Mexico, with Emphasis on Coral Reef Species

Carlos González-Gándara and Ernesto A. Chávez

Abstract

The state on knowledge of fish communities associated with coral reefs of the southern Gulf of Mexico (Veracruz, Campeche bank), and eastern Yucatan on the Caribbean is reviewed, in addition to a description of the main fisheries of the area. The review includes coral reef fish of Veracruz, the Campeche Bank, and reefs running along the Caribbean coast up to the border with Belize. Data recorded suggest that the heterogeneity of different levels (region, reef and reef zone) may be responsible for a larger number of niches available, promoting higher specific diversity that is more evident in the Caribbean reefs. The environmental conditions create patterns of differential abundance among the three zones. The main regional fisheries include more than 60 species and the current yield suggests a 30% reduction compared to catch volumes recorded a few years ago. The changes in coral coverage and the fishing pressure over coral reefs have exerted effects on species of fishing importance.

Keywords: coral reefs, fish community, southern Gulf of Mexico, Mexican Caribbean

1. Introduction

The fish fauna of the south Gulf of Mexico, the Campeche Bank and the Caribbean coast of Yucatan Peninsula comprise the northernmost extreme of the tropical sea, included in the region known as the Caribbean province in the tropical belt of Eastern America. This region has a high species diversity combing a marine shelf covered by terrigenous sediments and coral reefs, allowing the possibility to maintain a diverse fish community, supporting the statement that between 66 and 89% of marine fish species are dwellers of coral reefs and reef-associated habitats [1].

Ichthyofaunal research in the reefs of the Gulf of Mexico and the Mexican Caribbean is just over 50 years old. The first formal documents allude to the components of Alacranes reef, Yucatan [2], Blanquilla reef, Veracruz [3] and Cozumel, Quintana Roo [4]. However, the knowledge of the ichthyological components of both the southern Gulf of Mexico and the Mexican Caribbean is incomplete, because sampling efforts have been isolated and dispersed over time [5]. Among the works that synthesize the regional ichthyofauna stand out Díaz-Ruiz et al., Schmitter-Soto, and Schmitter-Soto et al. [5–7] for the Mexican Caribbean, as well as Chávez and Beaver [8] for reef systems of the southern Gulf of Mexico.

The publications that have addressed the structure of fish communities (richness, distribution, relationship with environmental factors, etc.) are numerous, some of them correspond to particular systems, such as the Veracruz Reef System [9], Cozumel [10]; or Chinchorro Bank [11]. Others include a general analysis of the reef fish communities of the Gulf of Mexico [12] and the Caribbean [13–15]. Fishing contributes to degradation of coral reefs and the fisheries associated to these ecosystems, includes a smaller component of coral reef dwelling species [16, 17]. This chapter summarizes the information published so far, comparing the ichthyological components and their relative abundance. In addition, an assessment of the most important fisheries associated with the reef structures of the southern Gulf of Mexico and the Mexican Caribbean is made.

2. The habitats

The eastern Gulf of Mexico and the Mexican coast of the Caribbean Sea are a heterogeneous region where three subzones can be defined by the characteristics of the habitat, the western Gulf, the Yucatan platform, also known as Campeche Bank, and the Caribbean coast of the Yucatan peninsula [18]. Despite these regions hold some differential characteristics, the fish fauna has many similarities, and despite the Caribbean coast holds essentially a coral reef habitat, there are many common fish species along these areas. It is considered that more than 100 fish species are closely associated to coral reefs and hard bottoms [8], so preservation of integrity of these communities is important to the economic and ecological health of this region.

The south Gulf of Mexico, from the border with the USA, is considered of tropical nature, where two main habitats are well defined, one which may be subdivided into two main ecosystem types, the first one is shrimp grounds, strongly associated to coastal lagoons and mangroves; the other one is the coral reef ecosystems divided in two subregions (Veracruz and Campeche reefs). The coast of Veracruz contains more than 100 coral reef structures [19] divided in three systems: the Lobos Tuxpan Reef System (LTRS), the Veracruz Reef System (VRS) and the Tuxtlas Reef System (TRS) [20]. Most reefs in Veracruz develop under stress conditions (turbidity and thermal stress) due to their proximity to the coast [21] and the drainage of the ten hydrological basins that flow towards the Veracruz coast [22]. According to their geomorphology, the Veracruz's reefs are: platform, fringing and submerged banks. Zonation of the platform-type reefs (crest, lagoon, windward and leeward slopes) is defined by the benthic components [21, 23–26] resulting from wave exposure, ocean currents, suspended sediments, and turbidity [27, 28]. Coral coverage of these reefs is 15 to 25% [21, 26]. Veracruz's submerged banks have an irregular to oval or semicircular shape, with a depth ranging from 1 to 40 m [19]. Although there are few studies, the coral coverage of these reefs is less than 10% [29, 30], excepting Blake reef, whose coral coverage is higher than 15% [31]. Fringing reefs are small formations (<1.0 km long) in central Veracruz, whose coral cover is less than 10% [32]. In the south, there is a strip of approximately 3.5 km [33] (**Figure 1**, **Table 1**).

The coral formations of the Campeche Bank (CBRS) are geomorphologically divided in two: platform-type or emergent (Arcas) and submerged banks (Banco Pera), among them, Alacranes reef (22 km long), is on the north of Yucatan peninsula, at 150 km from the coast [34] (**Figure 1**, **Table 1**). Jordán-Dahlgren [35] refers to up to 46 structures in this region. Platform-type reefs present a similar zoning to that observed in Veracruz reefs [24, 25]. Their depth ranging from 1 to 44 m [35, 36].

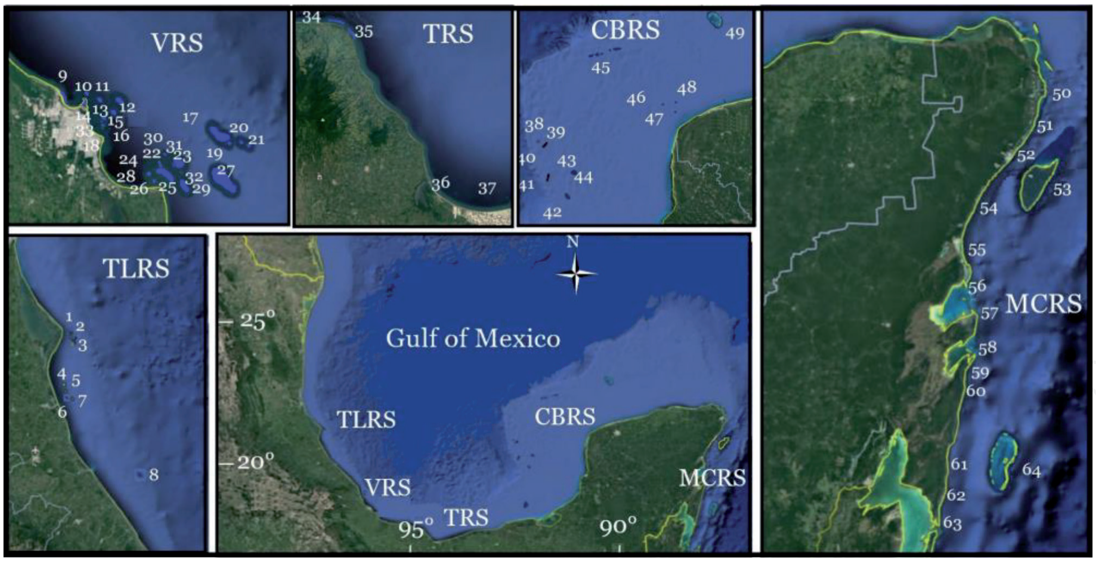

Figure 1.
Coral reefs of the south Gulf of Mexico and Mexican Caribbean. 1=Blanquilla, 2=Medio, 3=Lobos, 4=Tanhuijo, 5=Enmedio, 6=Pantepec, 7=Tuxpan, 8=Blake, 9=Punta Gorda, 10=Galleguilla, 11=Blanquilla, 12=Anegada de Adentro, 13=Verde, 14=Hornos, 15=Pájaros, 16=Sacrificios, 17=Anegada de Afuera, 18=Mocambo, 19=Topatillo, 20=Santiaguillo, 21=Anegadilla, 22=Polo, 23=Enmedio, 24=Los Bajitos, 25=Chopas, 26=Blanca, 27=Cabezo, 28=Giote, 29=Rizo, 30=La Palma, 31=Los Sargazos, 32=Periférico, 33=Terranova, 34=La Perla, 35=Zapotitlán, 36=Palo Seco, 37=Tripie, 38=Triángulos Oeste, 39=Triángulos Este, 40=Obispo Norte, 41=Obispo Sur, 42=Arcas, 43=Banco Pera, 44=Banco Nuevo, 45=Arenas, 46=Serpiente, 47=Madagascar, 48=Sisal, 49=Alacranes, 50=Punta Nizuc, 51=Puerto Morelos, 52=Punta Maroma, 53=Cozumel, 54=Akumal, 55=Boca Paila, 56=Yuyum, 57=Punta Allen, 58=Punta Herrero, 59=Tampalam, 60=El Placer, 61=Mahahual, 62=Xahuayxol, 63=Xcalak, 64=Chinchorro.

The highest part of the submerged banks is between 3 and 15 m below sea level and its maximum depth is 18 m [37, 38] and the coral cover of these reefs ranges from 5 to 25% [25]. The coral reefs located on the west shelf of the Campeche Bank, play the role of a source of biodiversity of an important coral and fish community which supply with larval stages to the coral reef ecosystem of the Veracruz shelf [39, 40].

Finally, the Caribbean coast of Yucatan Peninsula almost lacks of a continental shelf, and the coast is profusely occupied by fringing reefs, from Isla Contoy to the border with Belize. This region also includes insular structures (Cozumel and Banco Chinchorro) and submerged banks (Arrowsmith) [35, 41]. The fringing formations grow parallel to the coast or are separated by a well-defined lagoon. These systems are divided into three major groups: the southern group is made up of well-developed reefs that form channel systems and massif crest reefs whose geographic limit is the 19°05′ coordinate, the central-northern group, which goes from the previous geographic limit to Contoy Island, with well-developed structures in the front, is dominated by gorgonians and algae, and the deep reefs that are located in southwest Cozumel with coral development between 10 and 50 m depth [24] (**Figure 1**, **Table 1**). The coral cover of most reefs in this region ranges from 15 to 20% [41].

Zonation of coral reefs of the Mexican Caribbean is related to environmental factors, like wave impact and light penetration [42] and include: a shallow lagoon covered with sand, seagrasses, macroalgae and scarce coral colonies; a shallow back reef covered with coral fragments and massive coral colonies; a shallow reef crest exposed to surf that is covered by branching corals (*Acropora palmata*), fire coral (*Millepora* spp) and coralline algae; a reef front with a gentle slope facing the prevailing winds, with a depth of 5 to 25 m. This zone is covered with branching and massive corals, sand and debris, and the reef slope is covered with massive and foliose corals as well as sponges and gorgonians. This zone is an extension of the reef front with a high slope at a depth of 12 to 40 m [13, 14] or more.

Reef	Geographic location	Average surface (ha)	Depth (m)
1. Blanquilla	21°32′33”N; 97°16′49”W	200.76	0.5–20
2. Medio	21°30′44”N; 97°15′09”W	118.78	0.5–20
3. Lobos	21°28′19”N; 97°13′27”W	398.26	0.5–30
4. Tanhuijo	21°08′17”N; 97°16′18”W	155.45	0.5–20
5. Enmedio	21°04′56”N; 97°15′20”W	237.05	0.5–20
6. Pantepec	21°02′40”N; 97°14′27”W	100.99	16–27
7. Tuxpan	21°01′44”N; 97°11′43”W	144.99	0.5–30
8. Blake	20°45′47”N; 96°59′24”W	124.49	9–34
9. Punta Gorda	19°15′05”N; 96°10′45”W	39.03	0–4
10. Galleguilla	19°13′49”N; 96°07′22”W	34.99	0–18
11. Blanquilla	19°13′35”N; 96°05′51”W	42.49	0–24
12. Anegada de Adentro	19°13′33”N; 96°03′19”W	75.85	0–36
13. Verde	19°12′11”N; 96°04′03”W	67.11	0–27
14. Hornos	19°11′28”N; 96°07′13”W	12.02	0–3
15. Pájaros	19°11′18”N; 96°05′21”W	113.08	0–18
16. Sacrificios	19°10′35”N; 96°05′31”W	45.18	0–14
17. Anegada de Afuera	19°09′23”N; 95°51′23”W	471.6	0–45
18. Mocambo	19°09′00”N; 96°05′25”W	43.73	0–7
19. Topatillo	19°08′30”N, 95°50′08”W	13.72	0–45
20.Santiaguillo	19°08′29”N; 95°48′30”W	17.5	0–45
21. Anegadilla	19°08′09”N; 95°47′43”W	20.62	0–45
22. Polo	19°06′29”N; 95°58′37”W	21.97	0–24
23. Enmedio	19°06′21”N; 95°56′20”W	258.62	0–24
24. Los Bajitos	19°06′06”N; 95°58′28”W	42.79	
25. Chopas	19°05′22”N; 95°58′07”W	473.63	0–24
26. Blanca	19°05′10”N; 95°59′56”W	41.33	0–18
27. Cabezo	19°04′31”N; 95°51′00”W	1037.59	0–24
28. Giote	19°04′08”N; 95°59′55”W	3.46	0–2
29. Rizo	19°03′50”N; 95°55′41”W	184.41	0–18
30. La Palma	19°07′15”N; 95°57′58”W	197.14	4–26
31. Los Sargazos	19°06′22”N; 95°56′47”W	19.22	2–22
32. Periférico	19°04′57”N; 95°56′03”W	4.59	2–16
33. Terranova	19°10′59”N; 96°05′42”W	6.53	1–15
34. La Perla	18°32′35”N; 94°49′34”W	ND	1–12
35. Zapotitlán	18°27′42”N; 94°45′44”W	ND	1–12
36. Palo Seco	18°10′33”N; 94°31′32”W	ND	11–22
37. Tripie	18°10′33”N; 94°22′03”W	ND	7–15
38. Triángulos Oeste	20°57′58”N; 92°17′56”W	ND	0–18
39. Triángulos Este	20°54′31”N; 92°12′55”W	ND	0–18
40. Obispo Norte	20°28′41”N; 92°12′21”W	ND	5–18
41. Obispo Sur	20°25′28”N; 92°13′25”W	ND	5–18

Reef	Geographic location	Average surface (ha)	Depth (m)
42. Arcas	20°11′47”N; 91°57′58”W	ND	0–18
43. Banco Pera	20°42′55”N; 91°55′05”W	ND	16–44
44. Banco Nuevo	20°30′00”N; 91°50′44”W	ND	0–30
45. Arenas	22°06′42”N; 91°23′27”W	ND	0–30
46. Serpiente	20°57′58”N; 92°17′56”W	0.21	7–18
47. Madagascar	20°57′58”N; 92°17′56”W	0.21	4–13
48. Sisal	20°57′58”N; 92°17′56”W	0.67	3–10
49. Alacranes	22°28′43”N; 89°42′05”W	333,768	0.5–50
50. Punta Nizuc	21°19′10”N; 86°46′30”W	ND	1- > 30
51. Puerto Morelos	20°51′16”N; 86°51′40”W	9066	0.5–25
52. Punta Maroma	20°43′42”N; 86°57′37”W	ND	1- > 30
53. Cozumel	20°25′16”N; 86°55′52”W	11,987	1.5- < 40
54. Akumal	22°23′24”N; 87°18′30”W	ND	1.5–65
55. Boca Paila	20°01′11”N; 87°28′06”W	ND	1- > 30
56. Yuyum	19°54′49”N; 87°25′42”W	ND	1–45
57. Punta Allen	19°46′20”N; 87°26′52”W	ND	1- > 30
58. Punta Herrero	19°19′42”N; 87°26′43”W	ND	1- > 30
59. Tampalam	19°06′54”N; 87°32′11”W	ND	1- > 30
60. El Placer	18°53′23”N; 87°38′06”W	ND	1- > 30
61. Mahahual	18°42′49”N; 87°42′07”W	ND	1- > 30
62. Xahuayxol	18°21′15”N; 87°47′27”W	ND	1- > 30
63. Xcalak	18°15′35”N; 87°49′25”W	17,949	1–70
64. Chinchorro	18°34′24”N; 87°21′06”W	144,360	1.5–60

Table 1.
Geographic location and characteristics of the coral reefs from the South Gulf of Mexico and Mexican Caribbean. Source of data [19, 20, 25, 37, 38, 43–48].

3. Fish communities

As a consequence of habitat morphology, the study of coral reef fish is based upon visual censuses. This way, it makes not easy to compare abundance data of coral reefs with fish faunas caught with trawl and other kind of nets on soft grounds. However, quantitative data provide records of relative abundance and therefore allows to get a picture of fish communities in each habitat.

The current stream on the Mexican Caribbean is one of the factors determining the physical and chemical properties of the marine waters of the Gulf of Mexico [39] and is a decisive factor in the ichthyologic composition [12]. The current system, the rainfall regime and the continental drainage modify the environmental conditions at the regional level [49], leading to the presence of endemic species and influencing the abundance of some others. The fish community associated to the reefs of the southern Gulf of Mexico and the Mexican Caribbean is made up of 776 species belonging to 115 families. The highest species richness corresponds to the Caribbean (579 species) [4, 6, 10, 11, 50], followed by the reefs of Veracruz (509 species) [3, 9, 32, 33, 51–54] and the Campeche Bank (445 species) [2, 12, 38, 55, 56]. The differences are related in part to the sampling effort carried out and the

Family	Veracruz Coast	Campeche Bank	Mexican Caribbean	Total
Serranidae	45	39	45	63
Gobiidae	27	30	22	48
Carangidae	23	20	24	25
Labrisomidae	10	16	22	24
Haemulidae	20	15	16	21
Sciaenidae	19	8	7	19
Labridae	16	16	16	19
Pomacentridae	15	15	14	15
Scaridae	14	14	14	14

Table 2.
Species richness of the main fish fauna associated to the reefs of the South Gulf of Mexico and the Mexican Caribbean.

distance to the center of origin [57], since most of them are of Caribbean origin. On the other hand, regional conditions (turbidity, nutrient concentration, etc.) are determining factors in the fish components [27]. For example, in Veracruz, species that normally inhabit estuarine areas (e.g. *Bairdiella veraecrucis*) have been recorded in the proximity of the reefs located near the coast [54]. Published data for the reefs of the southern Gulf of Mexico and the Mexican Caribbean [2, 4, 6–13, 32, 33, 38, 50–56] reveal that the families with the highest species richness are: Serranidae, Gobiidae, Carangidae, and Labrisomidae (**Table 2**).

Regional conditions of salinity, temperature, concentration of nutrients, among others, as well as the heterogeneity of the reef environment, create patterns of differential abundance among the three regions. Thus, the proportions estimated from published [11–13, 32, 58, 59] and unpublished data show that, Blue tang (*Acanthurus coeruleus*), Blue chromis (*Chromis cyanea*), Yellowhead wrasse (*Halichoeres garnoti*) and Bluehead (*Thalassoma bifasciatum*) are higher in the Caribbean, while Glass goby/Masked goby (*Coryphopterus hyalinus-personatus),* Mardi Gras wrasse (*Halichoeres burekae*), Doctorfish (*Acanthurus chirurgus*) and Brown chromis (*Chromis multilineata*) show a higher relative abundance in the reefs of the Gulf of Mexico (**Table 3**).

	Veracruz Coast	Campeche Bank	Mexican Caribbean
Abudefduf saxatilis	2–5%	<1%	2–5%
Acanthurus chirurgus	<1%	<1%	1–2%
Acanthurus coeruleus	<1%	<1%	2–5%
Acanthurus tractus	<1%	<1%	2–5%
Bodianus rufus	2–5%	<1%	
Chromis cyanea	<1%	<1%	10–20%
Chromis multilineata	10–20%	1–2%	1–2%
Chromis scotti	2–5%	2–5%	
Clepticus parrae	<1%	<1%	5–10%
Coryphopterus hyalinus-personatus	20–30%	20–30%	<5%
Elacatinus jarocho	2–5%		
Gramma loreto		1–2%	1–2%
Haemulon aurolineatum	5–10%	1–2%	<1%

	Veracruz Coast	Campeche Bank	Mexican Caribbean
Haemulon flavolineatum	<1%	2–5%	2–5%
Haemulon sciurus			2–5%
Halichoeres bivittatus	2–5%	5–10%	1–2%
Halichoeres burekae	>30%	2–5%	<1%
Halichoeres garnoti	<1%	1–2%	2–5%
Lujanus apodus			1–2%
Microspathodon chrysurus	<1%	<1%	1–2%
Ocyurus chrysurus	<1%	1–2%	
Scarus iseri	2–5%	10–20%	2–5%
Scarus taeniopterus			1–2%
Sparisoma aurofrenatum	<1%	2–5%	2–5%
Sparisoma viride	<1%	1–2%	2–5%
Stegastes adustus	2–5%	1–2%	1–2%
Stegastes partitus	1–2%	5–10%	5–10%
Stegastes planifrons	1–2%	2–5%	1–2%
Stegastes xanthurus	2–5%	1–2%	<1%
Thalassoma bifasciatum	2–5%	2–5%	10–20%

Table 3.
Relative abundance of the most abundant fish species of coral reefs of the South Gulf of Mexico and the Mexican Caribbean.

Environmental heterogeneity has been referred to as a cause of ichthyofaunal diversity [60, 61] and this heterogeneity can be analyzed at various scales: region, reef and reef zone. At the region level, oceanographic processes (currents, gyres, etc.) determine the flow of nutrients and larvae to the reefs [62]. This, together with the availability of physical spaces for recruitment and settlement of larvae as well as the availability of food, participate in the composition and abundance of fish. The conditions of higher environmental stability in the Mexican Caribbean seem to be related to its greater richness. However, the flow of fresh water and sediments on the reefs of Veracruz promotes a mixing of estuarine and marine fishes.

4. Heterogeneity and fish richness

At the coral reef scale, the geomorphology, the dimensions of the reef, the depth and its distance to the coast, as well as local current patterns, temperature regime, and salinity, are some of the factors defining the structure of fish communities [8, 28, 63]. At this scale, heterogeneity is related to the dimensions of each reef [25] which diversifies the niches and enhancing specific diversity, for example, in Alacranes reef (Gulf of Mexico) and Chinchorro Bank (Caribbean). The fish richness of the fringing reefs of the Caribbean, is higher in the southern reefs (Mahahual, Yuyum, and Boca Paila) compared to the northern reefs (Punta Nizuc, Puerto Morelos, and Punta Maroma) [15], perhaps because deep fore reefs tend to be smaller and less developed in the north [41], while in the center and southern, the massive coral species appear to determine the structure and diversity of the coral assemblages, influencing fish aggregations [15]. The **Figure 2** show the fish richness in some reefs of the south Gulf of Mexico and the Mexican Caribbean [2, 4, 6–13, 32, 33, 38, 50–59].

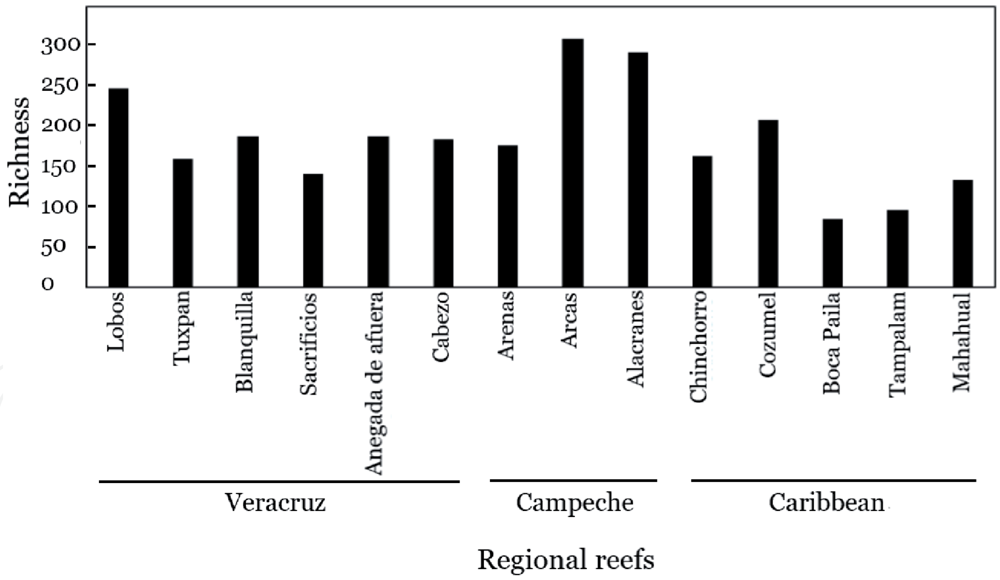

Figure 2.
Ichthyologic species richness recorded at some reefs of the southern Gulf of Mexico and the Mexican Caribbean.

The ichthyofaunal components of near-shore reef structures may be influenced by the fauna that inhabit freshwater or estuarine systems. Reefs of central Veracruz that are very close to the mouths of the Jamapa and La Antigua rivers have typically estuarine species, such as: *B. veraecrucis* [54]. This connection is also observed in Tamiahua Lagoon, Veracruz and Términos Lagoon, Campeche, where typical reef fish species like *Aluterus schoepfii* and *Stephanolepis hispidus* have been detected respectively [64, 65]. This proximity provides nutrients to reef areas and limits light penetration due to suspended sediments, which modifies the abundance of some species, such as *T. bifasciatum* [66].

In the Caribbean, reefs connected to rivers running underground, have components cataloged as freshwater, such as *Mayaheros urophthalmus* [67] or estuarine species, such as *Mugil* sp. [68]. On fringing reefs, some fishes (e.g. Lutjanidae, and Haemulidae) move from the reef to the mangrove in search of food or for breeding [69, 70], explaining their high abundance values recorded in the Caribbean reefs especially in shallow areas [13, 68].

At reef zone level, exposure to dominant winds, water transparency, depth and benthic coverage define fish richness and distribution [28, 66]. In the platform-type reefs of Veracruz and Campeche, the greater coral coverage in the leeward slope favors the richness and abundance of fish, particularly those that live closely associated with coral structures. In this reef zone are common *Halichoeres burekae*, *Coryphopterus hyalinus*, *Haemulon aurolineatum*, *Stegastes planifrons*, *Chromis multilineata*, *Chromis scotti*, *Scarus iseri*, and *Sparisoma aurofrenatum*. On the windward slope, structural complexity as well as currents concentrate plankton are determinant in the fish community structure. In the deep areas, are frecuent *H. burekae*, *C. multilineata*, *C. hyalinus,* and *Abudefduf saxatilis*. In the shallow areas of leeward, *Stegastes adustus*, *Ophioblennius macclurei*, *T. bifasciatum*, and *Microspathodon chrysurus* are the most abundant. In the crest, the fish species adapted to swell like *S. adustus, A. saxatilis*, *O. macclurei*, *T. bifasciatum,* and *M. chrysurus* dominate. Finally, in the lagoon reef, species like *Halichoeres bivittatus*, *S. adustus*, *Stegastes leucostictus* and *Sparisoma radians* are common. **Figure 3** shows the fish richness by reef zone, estimated from unpublished data on reefs from northern Veracruz, the average richness is higher on the slopes.

In the Mexican Caribbean, the average ichthyologic species richness is higher in the areas exposed to the waves (slope and terraces) in comparison to the lagoon

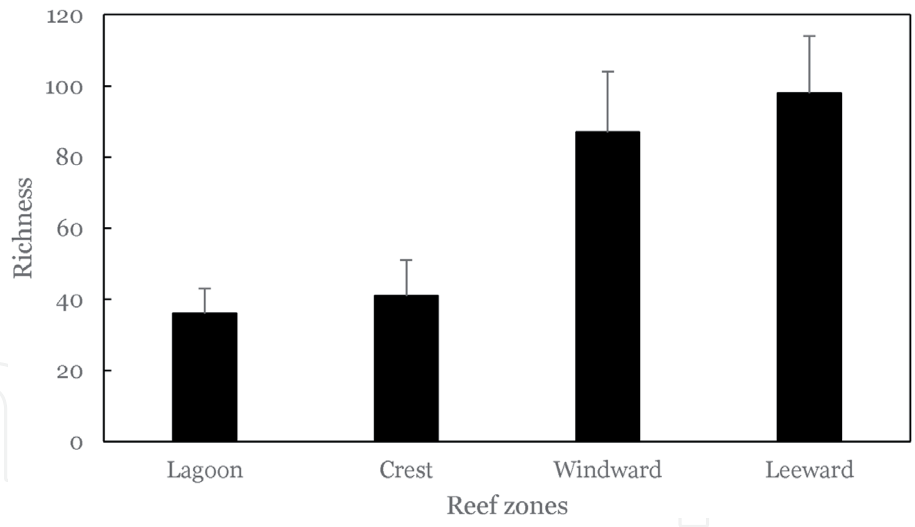

Figure 3.
Mean fish species richness by reef zone at coral reefs of northern Veracruz, Mexico.

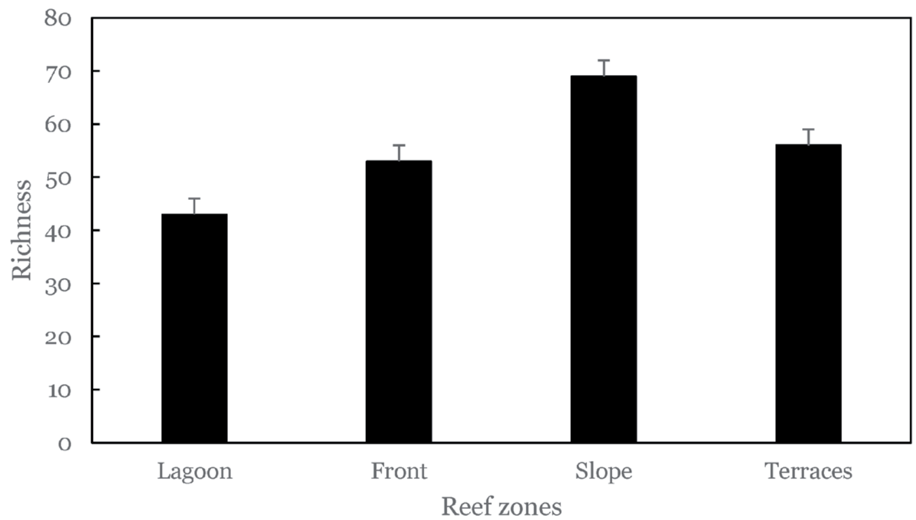

Figure 4.
Mean ichthyologic richness by reef zone in Mexican Caribbean reefs. Data sources [13, 15].

and the reef front (**Figure 4**). Distribution of fish species is fitted to the availability of microhabitats as well as to the environmental preferences of each species. In the lagoons, the juvenile stages of *Haemulon sciurus*, *Haemulon flavolineatum*, *Lutjanus apodus*, *Ocyurus chrysurus*, and *Acanthurus chirurgus*, among others, are frequent. In addition, species linked to sea grasses and sand (*S. radians*, *Eucinostomus lefroyi*, *Gerres cinereus*, and *H. bivittatus*) are common too. On the reef crest, where the substrate is covered by branched corals, calcareous algae and turf algae, are common the species adapted to intense wave action as *S. adustus*, *M. chrysurus,* and *A. saxatilis*. In addition, schools of *Kyphosus vaigiensis*, *Acanthurus tractus*, *A. chirurgus*, and *S. iseri* are transient through this area. On the reef slope, schools of fish that take advantage of the concentration of zooplankton generated by the currents can be observed. Among these species, stand out for their abundance *C. scotti*, *Chromis cyanea*, and *Clepticus parrae*. In the interspaces produced by the coral development, fish species that use the spaces between corals to protect themselves from predators (*Haemulon melanorum*, *Haemulon macrostomum*) and species that use these spaces to go unnoticed by the prey (*Epinephelus morio*) are often seen. Also common are species that transit the water column in search of food (*Caranx ruber*, and *Lutjanus cyanopterus*). In the terraces characterized by the presence of gorgonids, *Cephalopholis fulva*, *Epinephelus guttatus*, and *Stegastes partitus* [13] are common.

The structure of coral reef fish communities could be influenced by natural and anthropogenic sources. The climate change may affect small sedentary fish more than large species [71]. However, the former might allow faster adaptation to new environmental conditions [72]. Given the general deterioration of reefs, a lower abundance is expected, not only of large carnivores but also of small specialist fishes [50].

The fishing pressure over fishes in coral reefs of the Gulf of Mexico and the Mexican Caribbean has produced changes in the richness and abundance of fishes [16, 50, 73]. For example, the fishing of groupers in the Mexican Caribbean caused the disappearance of the aggregation of Nassau grouper off Mahahual [74]. On the other hand, the scarcity of commercial fish species (e.g. snappers and groupers), become the parrotfish as a target group of spear-gun fishing as a result of the increasing of tourism along this area [73]. In the southern Mexican Caribbean there are a decreasing of coral reef fishes that is more evident in the large piscivores [50].

The anthropogenic disturbances, the tourism and river discharges are related to high nutrient levels on reef systems [21, 75], and could be linked to observed seagrass and hard coral cover loss over the last decades as in the Gulf of Mexico [21, 76] as in the Mexican Caribbean [77, 78]. The sediments and nutrients in coral reefs increase the turbidity and modify the richness and abundance of herbivorous fishes [66, 79].

5. The fisheries

An examination of exploited fish stocks of the southern Mexico and the Mexican Caribbean suggests that the main fisheries are composed by transient species, whose distribution extends to the warm-temperate region of the East and South Eastern USA; on the south side, fish fauna share components of Caribbean species whose distribution range up to the Brazilian coast in many cases. The main components of the exploited stocks are species dwelling the shelf grounds, and a smaller component is based on coral reef dwelling species. The general perception is that overfishing is a major concern for many reef-fish populations, and this activity may be one of the most important activities contributing to degradation of coral reefs in the southern Gulf of Mexico [17] and the Mexican Caribbean [16]. In the reefs of Veracruz, around 50 out of the 550 reef-fish recorded, are often used for fisheries. Some of them are caught directly on the coral reefs using hooks and harpoons [80, 81].

An overview of the fisheries of the Gulf of México [82] allows to conclude that the fisheries of the south and north Gulf display rather independent trends, being the Gulf menhaden (*Brevoortia patronus*) on the northern Gulf, the species ruling this trend, and representing more than 90% of the whole catch. In the southern Gulf the whole catch is more stable over time than the one of the northern Gulf and the Gulf menhaden does not appear in catch records, whose volume ranges between 50,000 and 100,000 t in the northern Gulf. On both sides, at the north and south Gulf, mullets became more abundant over the recent years, which together with shrimp and crabs as scavengers, suggest a probable increase of debris, caused by the intensity of fisheries trawling of the shrimp grounds. Other important exploited stocks deserving to be mentioned are the Spanish mackerel (*Scomberomorus maculatus*) and the King mackerel (*Scomberomorus cavalla*), two migratory species up in the food web as predators, running along the coasts of the state of Veracruz, with catch volumes of +5200 and 2300 t per year respectively. These two species also are important for fisheries on the north Gulf.

The fish species associated with reef and rocky areas (Gulf of Mexico and Mexican Caribbean) are usually reported in a group called "escama (scale fish)". They include groupers (e.g. *Epinephelus morio*), snappers (e.g. *Lutjanus jocu*), porgies (e.g. *Calamus bajonado*), grunts (e.g. *Haemulon plumierii*), hogfish (*Lachnolaimus maximus*), and tilefish (*Lopholatilus chamaeleonticeps*) among others [83].

In the 1970s, large predatory fishes such as sharks, and groupers were among the most important catches at the Mexican Caribbean reefs. The reduction of their populations led to new target species, such as Parrotfish, Whitefish, Spotted snapper, Tilefish and Creolefish [83]. Some of these fish species have been overfished [84]. Data by Arias-González [16] revealed that the biomass of large, predatory fish (Serranidae, Lutjanidae, Carangidae, and Sphyraenidae) was lesser in non-protected areas of the Mexican Caribbean.

In regard to the impact of climate of fish stocks, there is evidence [85] of a strong influence of climate indices, in particular the Southern Oscillation Index and the North Atlantic Oscillation Index on the catch of 66 species over historical records, finding that climate plays a significant role, in particular short-lived species. Some species respond with positive and others with negative sign respecting to the variability of these signs. This indicates the strong influence of climate. In some cases, trends help suggesting the most likely expectations of the catch in the near future, whilst others with declining trends make it difficult to forecast the effects of fishing intensity or other human impacts.

6. Conclusions

Species diversity of the Gulf of Mexico despite it does not show any evidence of being limiting for the Caribbean species, it somehow constrains the entrance to all typical Caribbean forms and in many zoological groups there are some species that are not found inside the Gulf and is known that some of these penetrate a far as the Campeche Bank reefs, or as occurs in some cases, they display very low abundances, like the Red grouper (*E. morio*), the Nassau grouper (*Epinephelus striatus*), the Gag (*Mycteroperca microlepis*). By contrast, there are a few fish species which are endemic to the Gulf of Mexico, like the Black snook (*Centropomus poeyi*), and Jarocho goby (*Elacatinus jarocho*), to just mention a few. After these examples, we can state that the Gulf of México contains some characteristics restricting the penetration of some Caribbean forms. It is pertinent to mention that in this chapter, mixohaline species associated to the brackish-waters are not considered.

In regard to the exploited fish stocks, two explanations are given respecting to significant changes of their biomasses, one is attributable to fishing intensity, and the other is to climatic variability. We consider that under certain circumstances, both factors may be responsible for these changes, especially if we look into particular fish stocks. Environmental variability is responsible of sudden changes in the biomass of short-lived species like sardine and related life forms, enhancing sudden increase or dramatic reductions [86] affecting productivity and the carrying capacity of the habitat. In contrast, long-lived stocks usually are able to support the effects of north winds occurring in winter, excepting those cases causing mass mortalities, and their biomasses are more related to their life spans and carrying capacity. The catch in the south Gulf of Mexico is estimated in 0.11 t/km^2 [87], and it was found a positive correlation of one year delay between yield and Chlorophyll *a* concentration.

Coral reefs of the Mexican Caribbean as well as those of the south of Gulf of Mexico have drastically changed over the last decades [41]. Recent studies showed an increase of macroalgae coverage and a decrease of coral cover [88] impacting coralline assemblages like herbivorous fish [73] by the lost of habitats and fishing pressure [16, 84]. The effects of fishing were detected in individual fish size and there were more evident on the unprotected reefs [16], where the commercially important species belonging to Serranidae, Lutjanidae, Carangidae, and Sphyraenidae were recorded by these authors in small quantities.

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Conflict of interest

The authors declare no conflict of interest.

Author details

Carlos González-Gándara[1*] and Ernesto A. Chávez[2]

1 Coral Reef Laboratory, Faculty of Biological and Agricultural Sciences, Veracruz University, Tuxpan Tampico Highway Km 7.5. ZIP 92860, Tuxpan, Veracruz, México

2 Interdisciplinary Center of Marine Sciences, IPN. Av. IPN s/n Playa Palo de Sta. Rita, El Conchalito, La Paz, BCS ZIP 23096, Mexico

*Address all correspondence to: cggandara@hotmail.com

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