Characterization of deep sea benthic megafaunal communities observed in the Gulf of California

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ABSTRACT

We characterized the deep sea benthic megafaunal communities observed in the Gulf of California (GOC) in order to understand their structure and determine any possible influence of environmental variables on density and diversity. For this purpose we analyzed benthic video transect of seven dives in the GOC conducted between 345–1,357 m depth. The organisms were identified to the lowest possible taxonomic level. Their geographic location was recorded (longitude and latitude) as well as environmental data such as depth, temperature, salinity, and oxygen. Habitat was classified by substrate type, rugosity, and bioturbation. In addition, the abundance of individual organisms was quantified and the abundance of very dense organisms was estimated. Because the depth range of individual dives was highly variable, abundance and richness were estimated within seven oxygen ranges. Density was estimated based on the length of the dive and depth range. Oxygen profiles were constructed to visualize the OMZs at these sites in the Gulf of California. The oxygen plot showed the higher values for north and the shallower OMZ for south. We observed a total of 28,979 organisms belonging to 125 species and 8 phyla. Echinodermata

was the most abundant phyla represented by Ophiuroidea and observed in all locations over entire depth and oxygen range. The highest abundance and diversity was observed at very low oxygen concentration. These are preliminary results, and final results will come after the completion of additional benthic video transects footage for these dives. To complete statistical analysis, additional work needs to be done to measure and define areal coverage (m^2) of specific oxygen concentrations levels and habitat types. For now, it is clear that many organisms in the Gulf of California are able to live at low oxygen levels.

INTRODUCTION

Benthic megafaunal communities have been studied in relation to environmental variables such depth, oxygen, temperature, salinity, and habitat structure (Gage and Tyler 1991, Levin 1991), to understand the influence that these variables may have on abundance and composition of the communities. And additional goal is to investigate how a change in these characteristics could affect the structure of the biological communities.

Oxygen Minimum Zones (OMZ) develop under highly productive surface waters associated with upwelling, where biological degradation of organic matter sinking from the surface consumes oxygen, causing an oxygen-minimum ($\leq$ 1 ml/l) at the depth where horizontal water circulation is poorest (Wyrtki 1962). In the northeastern Pacific, this depth varies with latitude (Helly and Levin 2004), starting between 500–600 m in the north of central California, and at 150 m or less in tropical regions (Gilly et al. 2012). The world's largest OMZ is found in the eastern Pacific, and is produced by the high surface production characteristic of the upwelling-driven Peru (Humboldt) and California Current systems and their equatorial convergence zone (Gilly et al. 2012). It has been documented that the structure and composition of benthic megafauna are greatly influenced by the presence of OMZs, showing a decrease in community abundance and biomass at depths associated with lowest oxygen concentrations (e.g., Peru, Rosenberg et al. 1983, California, Mullins et al. 1985, Volcano 7, Wishner et al. 1990, 1995, Levin et al. 1991). Related with the taxonomic composition, dense megafaunal assemblages of ophiuroids, asteroids, shrimp, crabs, and sponges are observed at OMZs (Smith and Hamilton 1983, Wishner et al. 1995, Smallwood et al. 1999), something different have happened with mollusks (Levin et al. 2003). A 50-

year time series of dissolved-oxygen concentration had revealed an expansion of the OMZ in the equatorial Pacific (Stramma et al. 2008).

Other physical environmental variables such as temperature, salinity, and habitat structure have been cited as factors that influence faunal zonation in deep marine communities suggesting that deep-sea species richness and abundance varies according to the type of sediment, and on the availability of food (Gage and Tyler 1991).

The Gulf of California (GOC) is known to have a high diversity, with almost 5,000 benthic species including invertebrates (4,300 species), with their highest species diversity in shallow coastal regions, particularly in the northern gulf and eastern coast, bony fishes, cartilaginous fishes and hagfishes (Brusca et al. 2005). Among invertebrates, the highest diversity occurs with Mollusca (gastropods and bivalves) and Arthropoda (Decapoda). For fish taxa, there are at least 82 species of bony fishes, but they are mostly mesopelagic. 87 cartilaginous fishes (Chondricthyes) and three species of hagfish (Myxini) (Brusca et al. 2005) occur in the GOC as well. High species richness and geographic distribution may be affected by environmental variables that change from the north to south.

Overall oxygen concentrations tend to be high throughout the northern gulf. The northern island Isla Ángel de la Guarda has registered values of 5–6 ml/l near the surface, and decrease to about 1 ml/l at 300–500 m depth (Brusca et al. 2005). In the central and southern gulf, lower oxygen concentrations are typical at intermediate depths (Álvarez Borrego 1983), reaching values of less than 0.5 ml/l below 150 m (Brusca et al. 2005). For depths between 300–3,000 m in the GOC, temperatures and salinities ranged from 2.0–12 °C and 34.56–34.90 psu (Álvarez Borrego 2010).

In order to understand deep-sea benthic megafaunal community structure in the Gulf of California my aims were (1) to characterize the species composition, diversity and community structure of the benthic megafauna; and (2) to determine the influence of environmental variables (depth, oxygen, temperature, salinity and habitat structure) on density and diversity.

METHODS

STUDY AREA

Video transects were used to quantify and identify benthic megafaunal communities and to describe their habitat during seven remotely operated vehicle (ROV) dives (Table 1). The dives were conducted between 345–1,357 m of depth, and using ROV *Doc Ricketts* in March 2015 in the Gulf of California, Mexico (Figure 1).

Table 1. Description of each dive conducted in the Gulf of California where the characterization of the benthic communities was performed.

Dive	Location	Date	Latitude (N)	Longitude (W)	Transect length (m)	Depth range (m)
735	Isla Ángel de la Guarda	25/03/2015	29° 03' 10''	113° 15' 41''	364	706–1,081
736	San Pedro Martir 2	26/03/2015	28° 23' 42''	112° 23' 30''	260	378–852
734	San Pedro Martir 1	24/03/2015	28° 21' 14''	112° 20' 52''	527	345–915
731	Isla Tortuga South 2	21/03/2015	27° 23' 53''	111° 52' 21''	781	1,042–1,357
732	Isla Tortuga South 1	22/03/2015	27° 24' 48''	111° 52' 25''	839	408–918
737	Isla Cerralvo	28/03/2015	24° 13' 00''	109° 47' 11''	283	792–959
738	Cabo Pulmo	29/03/2015	23° 25' 11''	109° 20' 53''	393	1,208–1,274

The Gulf of California (GOC) is located between 20–32° N and 105.5–114.5° W in the eastern Pacific. The gulf is a semi-enclosed sea ~1,400 km in length, ~220 km in width, and covers nearly 259 km^2 (Lavin and Marinone 2003, Brusca 2005). Topographically, the GOC is divided into a series of basins that are separated by transverse ridges (Álvarez Borrego 2010). The area around the northern Great Islands (Ángel de la Guarda and Tiburón) is shallow. Moving south, the depth and complexity of the seabed increases, presenting rocky basins, troughs, ridges, and ravines with depths of up to about 3,700 m (Bray and Robles 1991). There are seven basins with depths greater than 2,000 m and the mouth of the gulf reaches a depth of 4,200 m (Álvarez Borrego 2010).

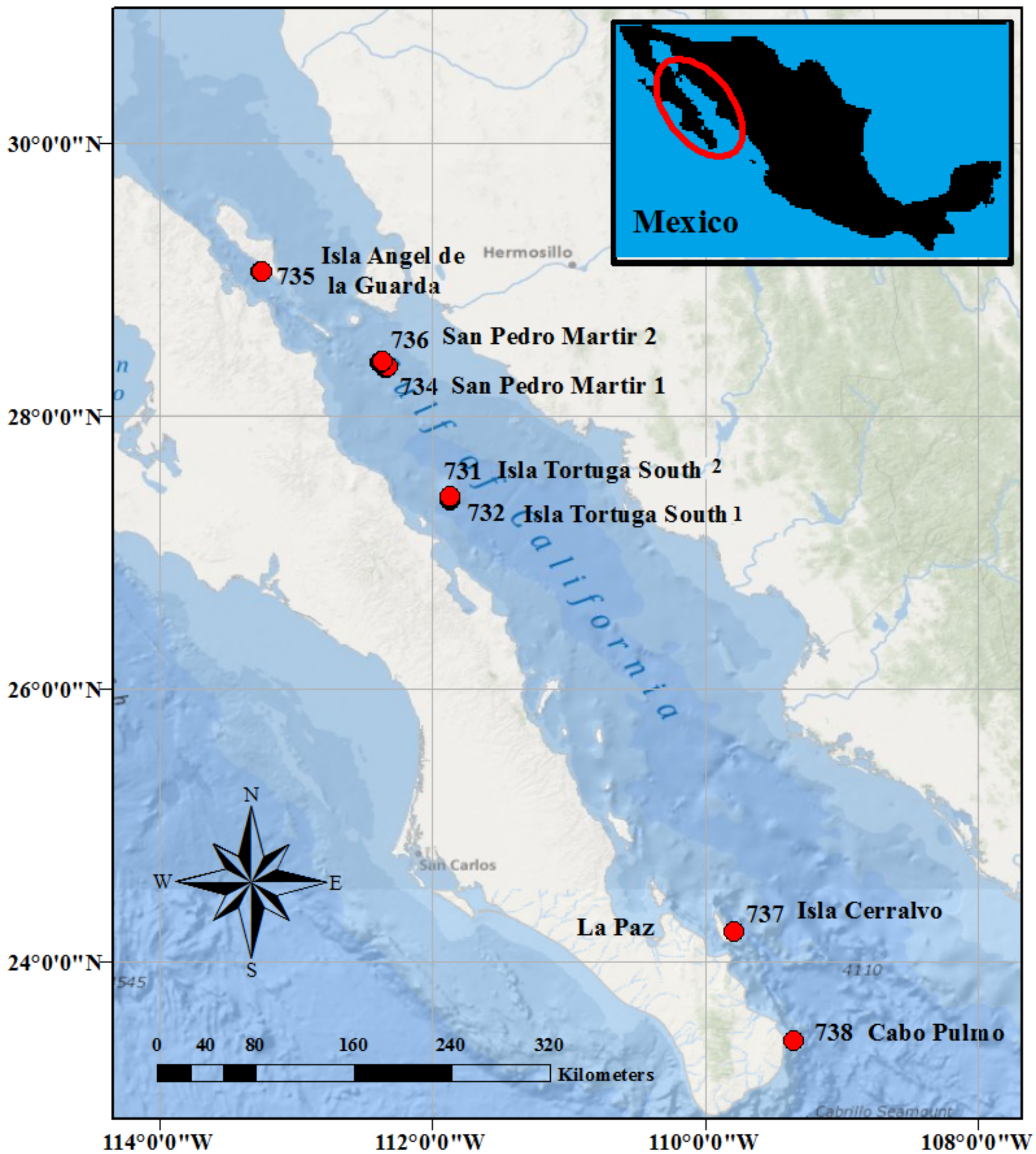

Figure 1. The Gulf of California region showing the seven dives conducted.

BENTHIC MEGAFAUNAL COMMUNITY AND HABITAT COMPOSITION

Video transects were analyzed using MBARI's Video Annotation and Reference System (VARS). The organisms were identified to the lowest possible taxonomic level, and because the identification of organisms on video can be uncertain, we were conservative in our assignment of taxonomic names. Their geographic location was recorded (longitude and latitude) as well as environmental data such as depth, temperature, salinity, and oxygen. Habitat was classified by substrate type (mud, mud with rocks, rocks, shell hash, and shell hash with rocks), rugosity (low, medium, and high), and bioturbation (none, mounds, single hole burrow, and single hole burrow with mounds).

The abundance of individual organisms was quantified; the abundance of very dense organisms (e.g. Ophiuroids, Sabellids, Porifera) was estimated. Abundance and richness were estimated by seven oxygen ranges, and by habitat categories. Initially, taxa density (m^{-2}) was estimated based on the length of the dive. Then, because dives spanned large depth ranges, taxa density (m^{-2}) was estimated based on seven depth categories of approximately 150 m each. The length of transects in both cases was measured by plotting the data in ArcGIS. The width of the area recorded in video was estimated to 1 m using two lasers mounted on the ROV, with parallel beams spaced 29 cm apart.

DATA ANALYSIS AND STATISTICS

Oxygen profiles were constructed to visualize the OMZs at these sites in the Gulf of California and to explore oxygen levels in each location and by the depth range where organisms were observed. The oxygen levels were classified in low, medium, and high.

Using data generated where animals were observed, and for each geographic location, the environmental variables oxygen, temperate and salinity were evaluated for correlation using a draftsman plot routine (PRIMER, Plymouth Marine Laboratory; Clarke 1993).

The abundance and species richness of benthic megafauna were described by each range of oxygen and each habitat category. To explore the community similarity by geographic location, we used a non-metric multidimensional scaling (MDS) analysis, based on a resemblance matrix using the Bray-Curtis similarity index after square-root transformation of the density data.

In order to evaluate diversity by depth range, we estimated ecological indices as Shannon diversity (H'; log base 2) and Pielou´s Evenness (J'), along with a dominance (Simpson) index (λ).

A distanced-based Permutational Multivariate Analysis of Variance (PERMANOVA, McArdle and Anderson 2001) was employed to test for significant differences in taxa density and diversity as a function of the range of depth. The analysis was also based on a resemblance matrix using the Bray-Curtis similarity index after square-root transformation of the density data, with 10,000 permutations and type III (partial) model (Anderson et al. 2008). For diversity analysis we used a presence–absence matrix. A non-metric multidimensional scaling (MDS) analysis, based on the same similarity resemblance matrix, was used to visualize the megafaunal patterns and to evaluate the coherence with the results provided by PERMANOVA. All the statistical analyses were run with PRIMER v.6 + PERMANOVA+ Add on (Clarke and Gorley 2006; Anderson et al. 2008).

RESULTS

WATER COLUMN OXYGEN PROFILES

The oxygen profiles in the water column showed the highest oxygen concentration in the northern gulf, decreasing south. The overall depth of the OMZ varied from broad to narrow ranges based on geographic location, and ranged from shallow as 200 m in the south and 400 m in the north to as deep as 1,000 m depth (Figure 2). In the north of the gulf, the OMZ is observed in different depths in each location explored. In Isla Ángel de la Guarda is founded to 400 m to at least 1,100 m depth; in San Pedro Martir 2 between 500–850 m depth, and in San Pedro Martir 1 between 410–920 m depth. In the center and south of the gulf, the depth ranges reached by the oxygen minimum values (OMZ) at very similar. In the center, Isla Tortuga South 2 shows the OMZ at 400–750 m and Isla Tortuga South 1 at 400–850 m depth. In the south, Isla Cerralvo and Cabo Pulmo show the OMZ at 300–800 m depth (Figure 2 and 3). Benthic megafauna occurred at varied depths within the dataset, in some cases in the OMZ, overlapping it or below it (Figure 3).

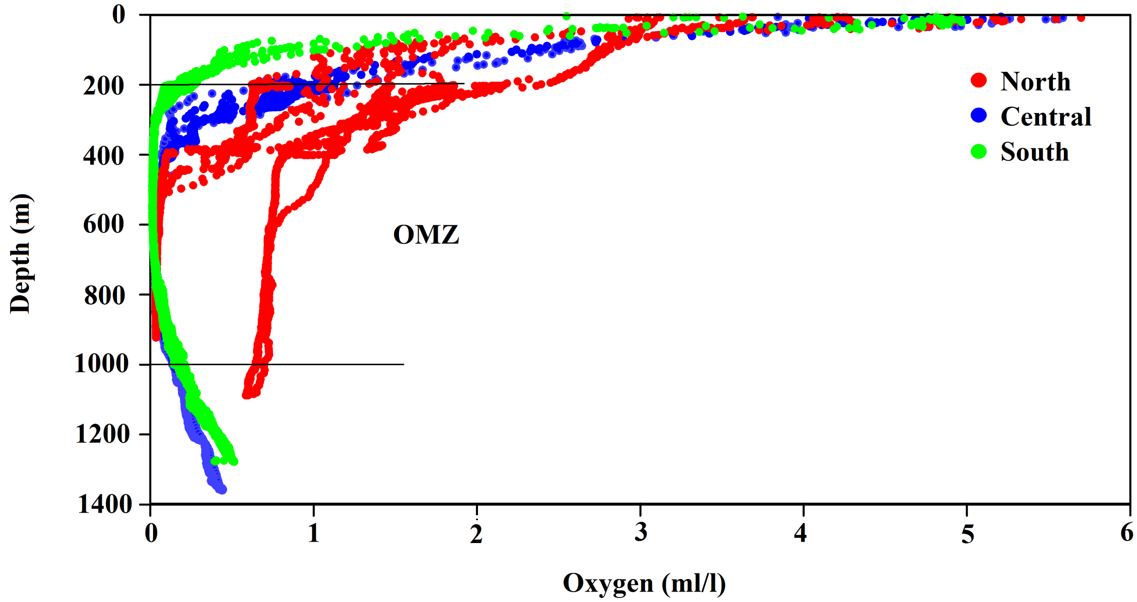

Figure 2. Vertical profiles of oxygen for the seven dives performed in the Gulf of California.

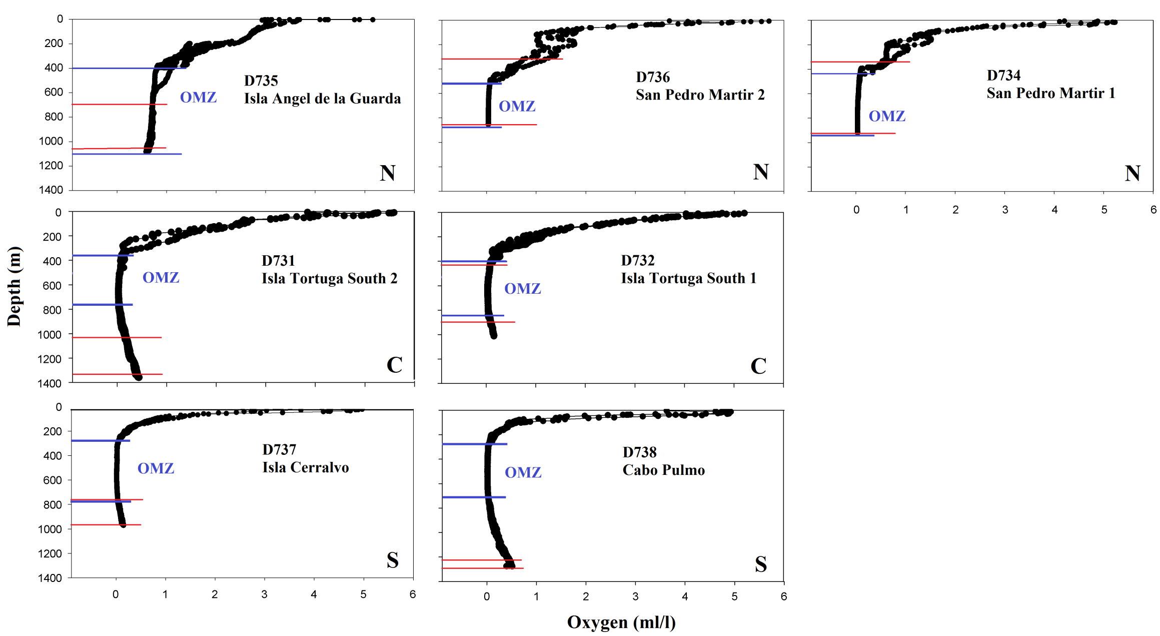

Figure 3. Vertical profiles of oxygen in the seven dives performed in the Gulf of California. Red lines represent the depth at which the seafloor was observed on each dive. Blue lines show the Oxygen Minimum Zone (OMZ) registered for each dive.

IN SITU ENVIRONMENTAL VARIABLES

Oxygen, temperature and salinity at depth during the dives were positive highly correlated in most of locations (≥0.90). San Pedro Martir 1 (D734) showed high correlation only between temperature and salinity (0.98).

BENTHIC MEGAFAUNA COMPOSITION

We quantified 28,979 organisms belonging 125 presumptive species identified into eight animal phyla: Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, Mollusca, Porifera, and Brachiopoda, over a total area of 3.5 km^2. In terms of the total abundance of benthic megafaunal organisms, Echinodermata was the most representative phylum (59.01%), including 30 presumptive species belonging to Asteroidea, Crinoidea, Echinoidea, Holothuroidea, and Ophiuroidea groups. This was mostly due to highly dense ophiuroids (brittle stars) occurring on all locations. Annelida was the second phylum in abundance with 13.51% of the total abundance. The phylum with the lowest abundance was Brachiopoda (0.05%) (Appendix).

The high density of benthic megafauna dive 736 (69.53 org./m^2) was due to Echinoderms (52.84 org./m^2) and Annelids (9.16 org./m^2). The MDS by dive analysis did not produce any groups with at least 60% of similarity. There was 50% of similarity in a grouping composed of Isla Tortuga South 1 (D732) and the two locations in San Pedro Martir (D734 and D736) (Figure 4).

Observed megafauna were all seen in oxygen levels considered hypoxic (< 1 ml/l). The oxygen concentrations varied considerably. Most dives had relatively high (0.52–0.72 ml/l), medium (0.23–0.51 ml/l), or low (0.03–0.22 ml/l) oxygen concentrations (Figure 5).

Northern GOC

The relative abundance in the north showed variation in oxygen concentration levels; one location relatively was high, one with mixed levels and one split low and high. At Isla Ángel de la Guarda (D735), Echinoderms and Porifera were the most abundant phyla. In high oxygen levels the holothurian *Apostichopus* sp. dominated, along with and various species of Porifera. San Pedro Martir 2 (D736) was characterized by a high abundance of

Echinoderms (Ophiuroidea) in the lowest oxygen zone (0.03–0.12 ml/l), high abundance of different species of Porifera in medium oxygen levels, and high abundance of Mollusca (Pectinidae) in the highest oxygen levels. San Pedro Martir 1 (D734) showed a segregation of benthic organisms through opposite oxygen ranges, where Annelida (Sabellids) had the highest abundance in the very low oxygen level and Mollusca (Pectinidae) in highest oxygen concentration of 0.52–0.61 ml/l (Figura 5A).

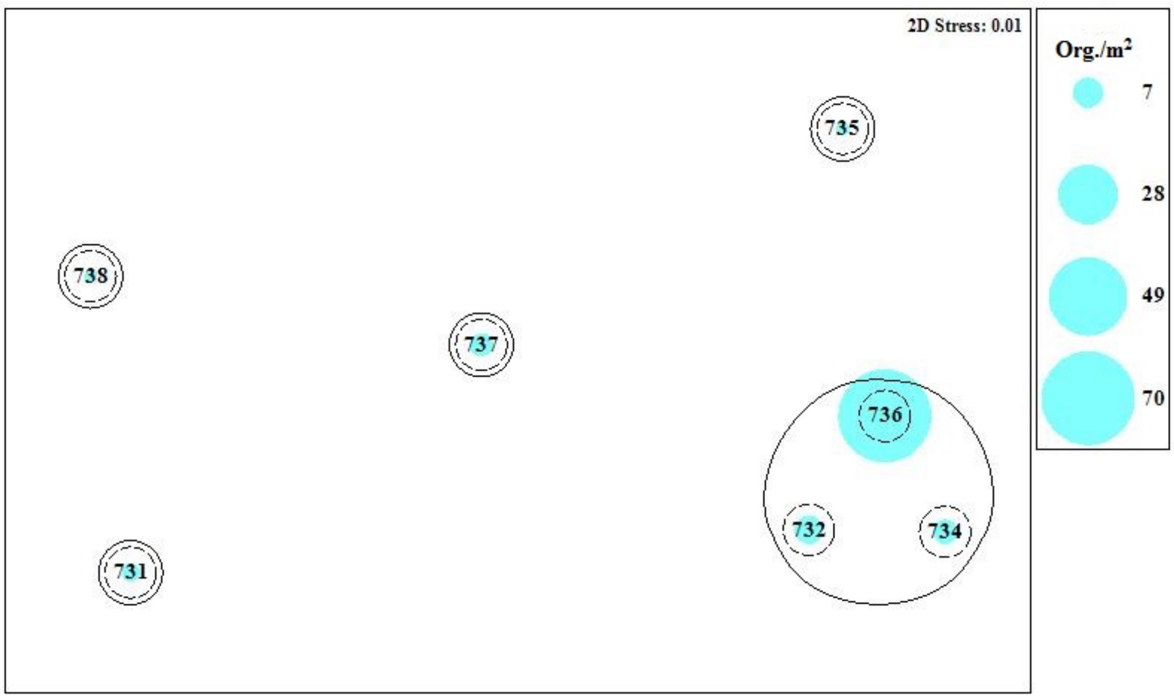

Figure 4. Benthic megafaunal density based on dives performed in the Gulf of California. We used a Multi-dimensional scaling (MDS) with the data transformed to fourth-root and measured by Bray-Curtis similarity coefficient. Continuous line represents 50% of similarity and dash line 60% of similarity.

Central GOC

In central GOC as well the relative abundance showed variation in oxygen concentration levels. Isla Tortuga South 2 (D731) was dominated by Echinodermata mostly in medium oxygen ranges (0.23–0.41 ml/l), with Ophiuroidea as the most representative group. In Isla Tortuga South 1 (D732), Arthropoda, Mollusca, and Echinodermata were observed in low oxygen concentration (0.03–0.12 ml/l) represented by the shrimp Plesionika, Gastropods Pectinidae, and ophiuroidea, respectively (Figure 5B).

Southern GOC

In the southern gulf, Isla Cerralvo (D737) showed the relative abundance in low oxygen concentration, represented by Cnidaria and Arthropoda. Cabo Pulmo (D738) was dominated by Arthropoda at medium oxygen ranges. In both locations, the most abundant species was *Plesiopenaeus armatus* (Figure 5C).

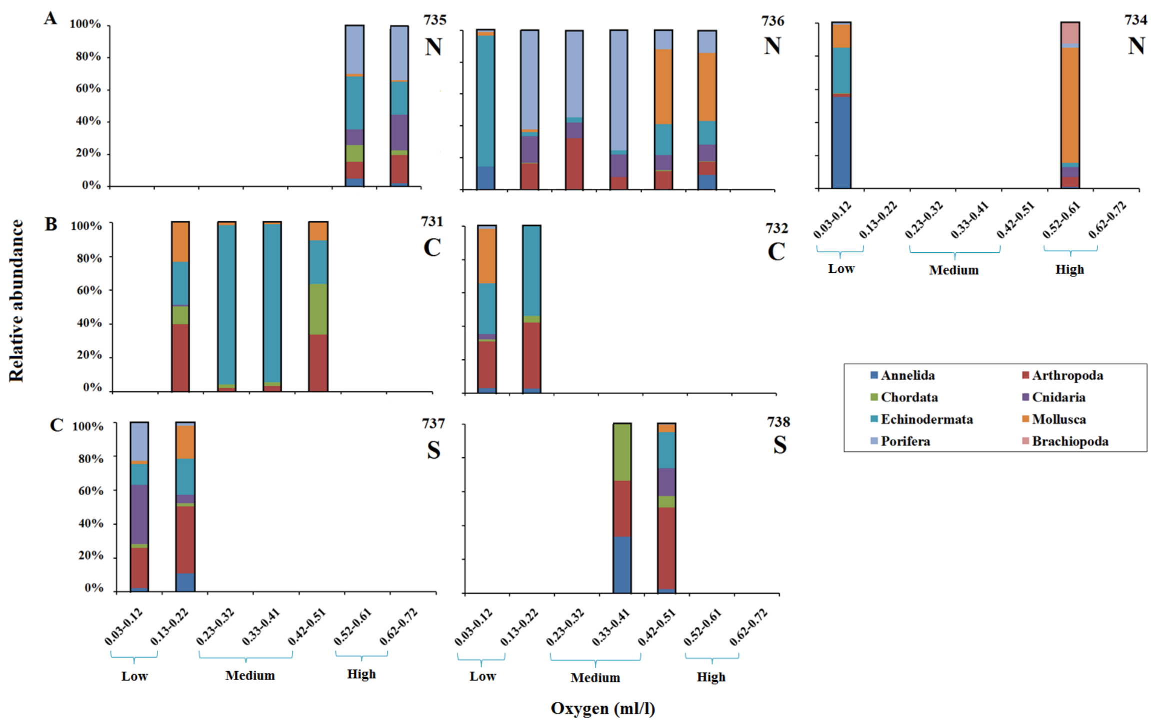

Figure 5. Percentage of benthic megafauna by phylum within each oxygen range for the locations observed in the Gulf of California.

The highest abundances were observed at very low oxygen concentrations (0.03–0.12 ml/l), with the groups Ophiuroidea, Gastropoda, and Sabellidae present in highest abundance (Figure 6A). Species diversity was also the highest (71 species of 125 species identified) at very low oxygen concentrations; high diversity (65) was also observed at medium oxygen concentrations (Figure 6B).

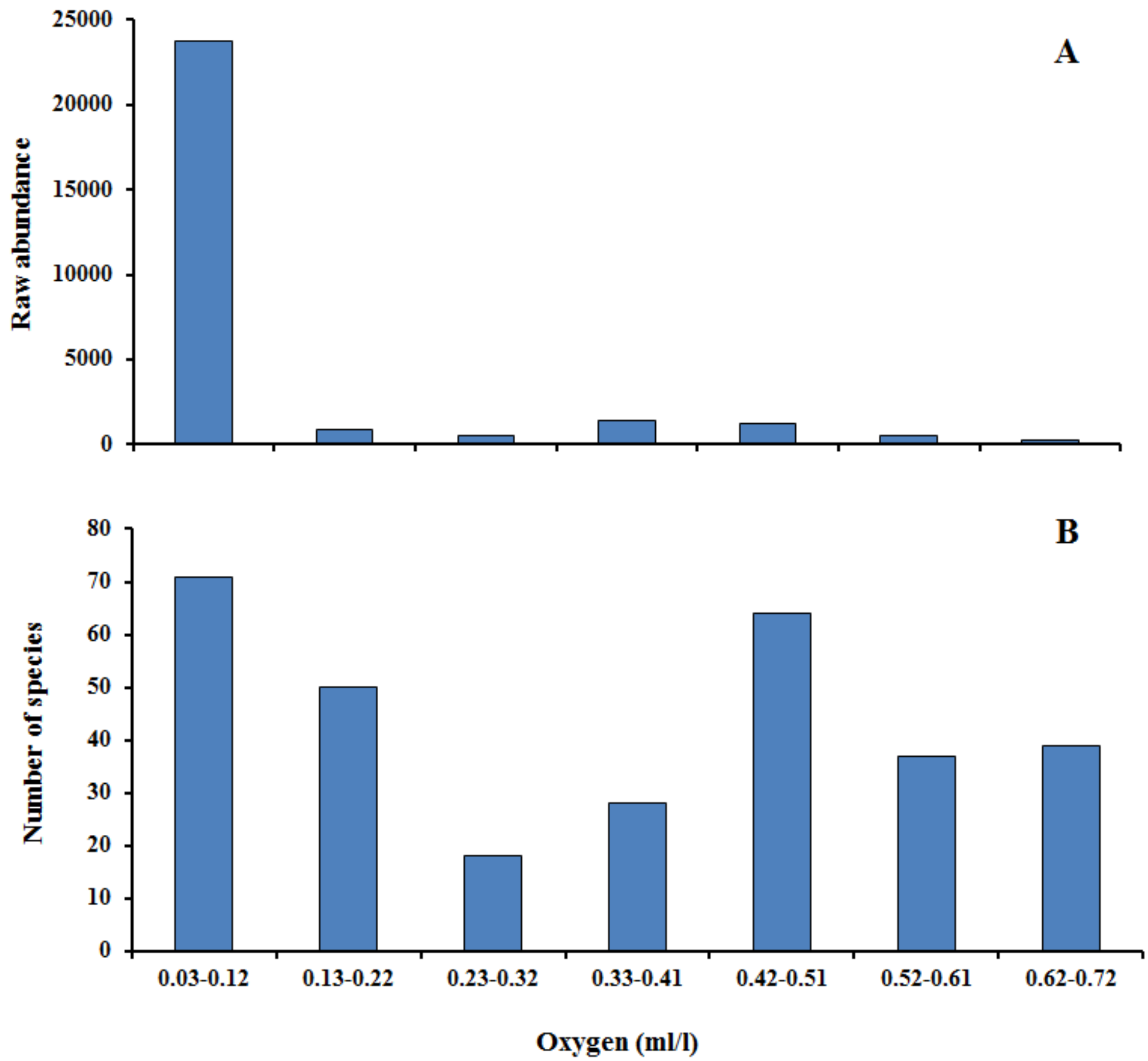

Figure 6. Raw abundance and number of species described by oxygen concentration levels measured in benthic transects in seven locations in the Gulf of California.

In terms of habitat, the highest abundance of benthic organisms was observed in mud (65%) with low rugosity (43%) and no bioturbation (95%), mostly represented in San Pedro Martir 2 (D736). Isla Ángel de la Guarda (D735) and Isla Cerralvo (D737) had the more abundance in mud with rocks without any bioturbation, and showed the only first one high rugosity. Both, San Pedro Martir 2 (D736) and Isla Tortuga south 2 (D731) showed their highest abundance in mud, with low rugosity and no bioturbation. The only location that presented the highest abundance in the shell hash substrate type was San Pedro Martir 1 (D734) (Table 2).

Table 2. Raw abundance by habitat categories described by the benthic video transect analyzed in the seven locations in the Gulf of California.

Dive/ Susbstrate type	735	736	734	731	732	737	738	Total	%
Mud		13402	455	1839	2811	520	319	19346	65.38
Mud with rocks	269	4048	893		2397	657	122	8386	28.34
Rocks		649						649	2.19
Shell hash			8	41				49	0.17
Shell hash with rocks	115		1047					1162	3.93
Rugosity									
high	269	4697	490		2397	456		8309	28.08
low		9334	463	1825	297	361	319	12599	42.58
medium	115	4068	1450	55	2514	360	122	8684	29.35
Bioturbation									
Mounds					275			275	0.93
None	384	18099	2403	1825	4699	626		28036	94.74
Single hole burrow				55	234	190	122	601	2.03
Single hole burrow with mounds						361	319	680	2.30

ENVIRONMENTAL VARIABLES BY RANGES OF DEPTH

The shallow range of depth show the highest mean temperature (9.16 °C ± 0.76), while the deeper range present the lowest mean temperatures (3.69 °C ± 0.18). The mean value of salinity keeps very similar among all ranges. The minimum mean value of oxygen concentration can be observed from 490-663 (0.05 $ml \cdot l^{-1}$ ± 0.01)) and 634-778 (0.05 $ml \cdot l^{-1}$ ± 0.10) m depth, being the maximum mean value at 1,212-1,357 m depth (0.44 $ml \cdot l^{-1}$ ± 0.05). From 490-633 m depth and 923-1,211 m depth, the substrate type does not present shell hash; in the shallow range the rugosity of the habitat is high, and from 345-633 m depth there is not bioturbation (Table 3).

BENTHIC MEGAFAUNA COMPOSITION BY RANGE OF DEPTH

In the depth ranged from 345–1,357 m, the mean density of benthic megafauna was highest in the 634–922 m depth category; the mean highest densities were between 634–778 m of depth (46 org./m^2) where Echinodermata (Ophiuroidea) and Annelida (Sabellidae) had the highest contribution. The depth ranged 923–1,345 m showed the mean lowest densities (1–

2 org./m^2) represented mostly by Echinodermata, Arthropoda, and Porifera. The highest species richness was found between 779–922 m depth with 75 presumptive species with the lowest diversity (H'=1.56) and lowest evenness (J'= 0.25) and high dominance (**λ** = 0.63) only by Ophiuroidea (Table 4, Figure 7).

Table 3. Description of each range of depth in the Gulf of California where the characterization of the benthic megafauna communities was performed. We show temperature (T), salinity (S), oxygen (O), and three habitat categories: Substrate type: mud (M), mud with rocks (MR), rocks (R), shell hash (SH), and shell hash with rocks (SHR); Rugosity: low (L), medium (Md), and high (H); Bioturbation: none (N), mounds (MO), single hole burrow (SHB), and single hole burrow with mounds (SHBM).

Depths (m)	T (°C)		S (psu)		O ($ml \cdot l^{-1}$)		Substrate type	Rugosity	Bioturba-tion
	Range	Average	Range	Average	Range	Average			
345-489	7.02-11.10	9.16±0.76	34.56-34.77	34.66±0.04	0.04-0.57	0.26±0.20	MR, R, SHR	H	N
490-633	6.67-8.81	7.85±0.77	34.55-34.63	34.59±0.03	0.03-0.07	0.05±0.01	M, MR	L, Md, H	N
634-778	6.08-11.81	6.60±0.86	34.54-34.83	34.56±0.04	0.03-0.72	0.05±0.10	M, MR, SHR	L, Md, H	N, MO
779-922	4.84-11.66	6.24±1.67	34.49-34.82	34.56±0.07	0.03-0.70	0.11±0.17	M, MR, SH, SHR	L, Md, H	N, SHB, SHBM
923-1067	4.28-11.63	7.41±3.35	34.53-34.81	34.64±0.13	0.13-0.67	0.33±0.24	M, MR	L, Md, H	N, SHB, SHBM
1068-1211	3.67-11.57	4.93±2.38	34.55-34.80	34.59±0.08	0.19-0.60	0.30±0.12	M, MR	L, Md, H	N, SHB
1212-1357	3.31-3.90	3.69±0.18	34.55-34.59	34.57±0.01	0.34-0.51	0.44±0.05	M, MR, SH	L, Md	N, SHB, SHBM

Table 4. Ecological characterization of benthic megafauna density by ranges of depth. Ranges of depth with number of dives in parenthesis, are presented with their number of organisms (org.), area (m^2), mean density (org./m^2), diversity (S), Shannon-Wiener diversity (H'), Pielou´s Evenness (J'), and Dominance Simpson index (λ).

Ranges of depths (m)	Org.	m^2	org./m^2	S	H'(log_2)	J'	λ
345-489 (3)	3,388	213	13	52	3.41	0.60	0.15
490-633 (1)	1,156	161	7	17	2.23	0.55	0.31
634-778 (4)	7,389	298	46	35	2.08	0.41	0.35
779-922 (5)	14,870	806	24	75	1.56	0.25	0.63
923-1,067 (3)	473	325	1	53	4.71	0.82	0.06
1,068-1,211 (3)	631	289	2	31	2.92	0.59	0.26
1,212-1,357 (2)	1,685	792	2	46	2.15	0.39	0.47

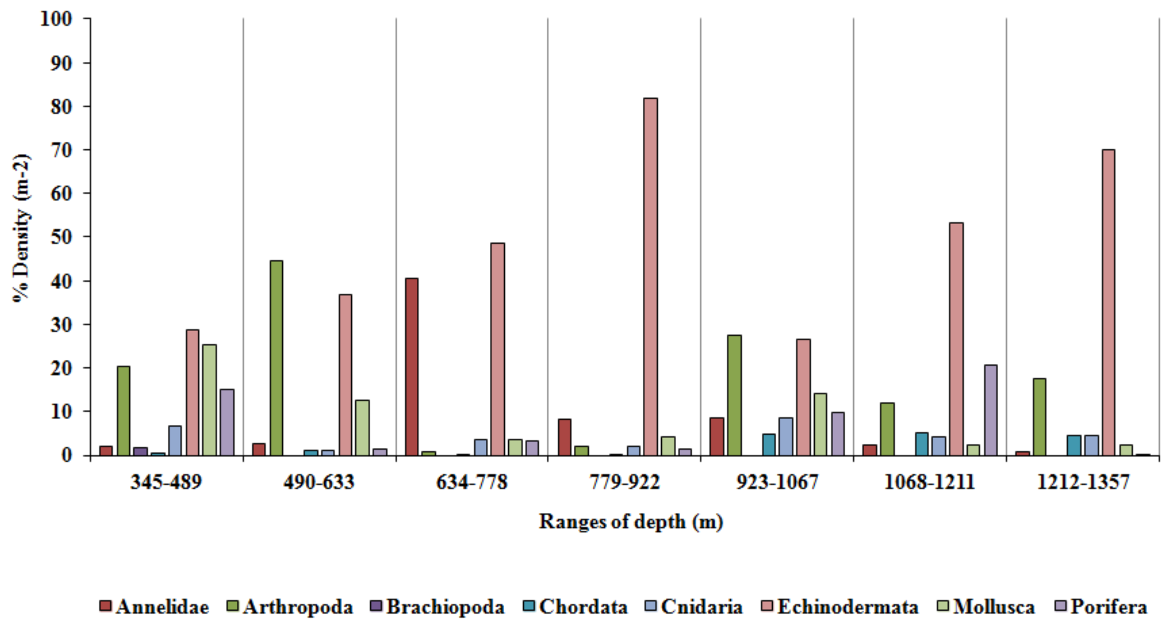

Figure 7. Phylum density in each range of depth observed in the Gulf of California.

The PERMANOVA results indicate no significant differences in density (P-F=1.27; P>0.05) and diversity (P-F=1.42; P=0.07) of organisms belonging to the benthic megafaunal community evaluated within each ranges of depth. Depth ranges MDS analysis produce one group with a 60% of similarity, formed by depth ranges 634–778 and 779–922, which have the higher mean density. The difference between shallow depth ranges and deeper depth ranges is visible (Figure 8).

DISCUSSION

Benthic organisms inhabiting the deep sea present low metabolic rates, slow growth and high longevity (Lauerman et al. 1996), however, they have developed adaptations that allow them to survive at different environmental conditions which define its composition and usually limit its abundance. The benthic megafaunal community inhabiting the areas explored in the Gulf of California with hypoxic conditions between 345–1,357 m is formed mostly by Echinodermata (Ophiuroidea), with also high representation of Annelida (Sabellidae). In other areas in northeastern pacific, Annelida (polychaeta), Arthropods

(Crustaceans), and mollusca (Bivalvia) have been reported as the most representative phyla (Grassle and Maciolek 1992).

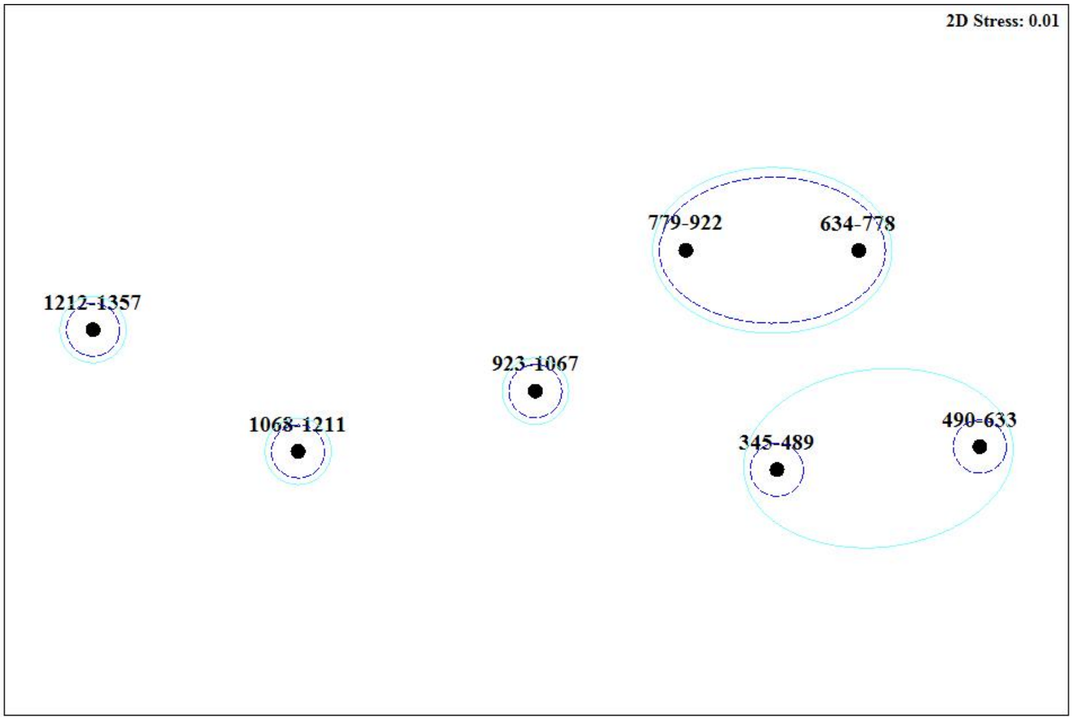

Figure 8. Benthic megafauna density based on ranges of depth determined in the Gulf of California. We used a Multi-dimensional scaling (MDS) with the data transformed to fourth-root and measured by Bray-Curtis similarity coefficient. Continuous line represents 50% of similarity and dash line 60% of similarity.

So far, the highest abundance of benthic community in the Gulf of California is observed in very low oxygen concentrations (0.03–0.12 ml/l), best represented by ophiuroids, gastropods, and sabellids. Dense megafaunal assemblages of ophiuroids, asteroids, shrimp, crabs, and sponges at OMZ boundaries have been observed in other regions of the northeastern Pacific such the Eastern Tropical Pacific west of Acapulco (Wishner et al. 1995), and off central California (Smith and Hamilton 1983). The dominance of these groups may be explained either by their tolerance for low oxygen conditions or their ability to increase in density rapidly in response to increased food (Grassle 1989). Additionally, our results show the highest species diversity (71 species of 125 species identified) in very low oxygen concentrations, but high diversity (65) also in medium oxygen concentrations. Although, differences in diversity have been explained for other places by the change of oxygen concentrations (Grassle 1989), in our results it is not clear any pattern (Figure 6) that give us a clue that the distribution of organisms in the gulf is being influenced by oxygen. However, it is important to complete the observations in all locations to cover all water columns, and to analyze the data based on density.

On the other hand, environmental variables by depth are observed with a width range (Table 3), which makes it very difficult to analyze the density and diversity. For example, we found the highest diversity between 779–922 m depth, where the oxygen concentration ranged from 0.03–0.70 ml/l. This show how the highest diversity in this depth range could be associated with low, medium, and high oxygen concentration levels. And this is due to the benthic observation were made at different depth range in each location. Because of that, for now, it is advisable to carefully analyze these results.

CONCLUSIONS/RECOMMENDATIONS

In conclusion, for now, it is clear that many organisms in the Gulf of California are able to live in low oxygen levels. Ophiuroids were the most cosmopolitan organisms, being observed in high abundance in all dives analyzed in the gulf, in width depth and oxygen ranges.

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Appendix. Taxonomic list and raw abundance of all presumptive taxa founded in seven locations explored with a ROV in the Gulf of California in March 2015. Isla Ángel de la Guarda (D735), San Pedro Martir 2 (D736), San Pedro Martir 1 (D734), Isla Tortuga South 2 (D731), Isla Tortuga South 1 (D732), Isla Cerralvo (D737), Cabo Pulmo (D738).

Phylum	Group	Presumptive Taxa	731	732	734	735	736	737	738
Annelida	Onuphidae	Onuphidae							11
	Polychaeta	Polychaeta		2					1
	Polynoidae	Polynoidae					8	1	
	Sabellidae	Sabellidae	1	67	1148	7	1810	2	
	Terebellidae	Biremis		1		1			
		Terebellidae		65	122	3	563	51	
Arthropoda	Decapoda	Cancridae sp. 1		23	1				
		Caridea	5	13		4		4	39
		Caridea sp. 1		10	5	22	47		
		Decapoda							1
		Glyphocrangon	62	7				8	5
		Pandalopsis ampla							2
		Paralomis cf. papillata							2
		Plesionika		844	8	3	3	38	3
		Plesiopenaeus armatus	45					80	154
		Polychelidae 2							1
	Galatheoidea	Galatheoidea	1			5	66		
		Gastroptychus perarmatus				2	2		
		Janetogalathea californiensis		72	1	9	9	186	
		Munida bapensis		175	35	14	73		
		Munida sp. 1	2	37				10	3
		Munidopsidae	1						
		Munidopsis							1
	Isopoda	Isopoda	4					3	1
Brachiopoda	Brachiopoda	Brachiopoda			14				
Chordata	Actinopteri	Actinopteri						1	3
	Batrachoididae	Batrachoididae sp. 1		3					
	Bythitidae	Cataetyx							1
	Congridae	Congridae sp. 1		1					
	Cynoglossidae	Symphurus				2			
	Ipnopidae	Bathypterois pectinatus	25					3	9
	Liparidae	Liparidae		2					
	Macrouridae	Macrouridae	17	9				5	4

		Nezumia	1						
	Myxinidae	Eptatretus				14	1		
	Nettastomatidae	Nettastomatidae							1
	Octacnemidae	Megalodicopia	19					1	
	Ogcocephalidae	Dibranchus nudivomer		8				4	
		Dibranchus sp. A	2	1					5
		Dibranchus spongiosa							2
	Ophidiidae	Ophidiidae						6	
		Ophidiidae sp. 1						5	
		Ophidiidae sp. 2		19	4		5		
	Scyliorhinidae	Cephalurus cephalus		2	2				
		Parmaturus xaniurus			1	1	1		
		Scyliorhinidae			2		1		
	Sebastidae	Sebastes					2		
		Sebastes diploproa				1			
		Sebastes rufus				1			
	Tunicata	Tunicata		6	1	2	1		
	Zoarcidae	Lycenchelys sp. 1	1					1	2
		Lycenchelys sp. 2	5	1					3
		Lycodapus	1						
		Zoarcidae	1						1
Cnidaria	Actiniaria	Actiniaria		63		4	84	31	9
		Hormathiidae							2
		Iosactis					1		7
		Liponema brevicorne							3
		Stomphia didemon					1		
	Anthomedusae	Branchiocerianthus imperator		33					
	Anthozoa	Alcyonacea		38	1	6	11		
		Alcyonacea white				3			
		Calyptrophora						1	
		Heteropolypus ritteri				17	74	57	
		Isididae					1		
		Lepidisis				20	11		
		Octocorallia					34		1
	Antipatharia	Bathypathes						2	2
	Ceriantharia	Ceriantharia	1	1		1			
		Ceriantharia sp. 1							38
		Ceriantharia sp. 2							1
	Pennatulacea	Distichoptilum						13	3
		Pennatulacea				1		2	5

		Pennatulidae			7				
	Scleractinia	Scleractinia				17		207	1
	Siphonophorae	Dromalia alexandri		4				1	
Echinodermata	Asteroidea	Asteroidea		5	10		17	5	
		Asteroidea sp. 2			1				
		Asteroidea sp. 3		13	3	1	20		
		Asteroidea sp. 6		7	3	4	63	1	
		Asteroidea sp. 8				5	2	2	
		Asteroidea sp. 9		2	115	2	67	1	
		Dipsacaster					1		
		Goniasteridae		7			5		
		Hippasteria				2	2		
		Pedicellasteridae			5		1		
		Pedicellasteridae sp. 2		12	181		44		
	Crinoidea	Crinoidea				8	10	42	
	Echinoidea	Brisaster						18	
		Brisaster townsendi	19						
		Cidaridae			1				
		Euechinoidea				8			
		Strongylocentrotus cf. fragilis				1	3		
	Holothuroidea	Apostichopus sp. 1				32			
		Holothuroidea				1			
		Holothuroidea B	32				1	4	
		Holothuroidea P				24			
		Holothuroidea sp. 3						30	
		Holothuroidea sp. 7	1				2		
		Holothuroidea T		53		1			
		Holothuroidea W	4				24		
		Holothuroidea WR					6		
		Pannychia moseleyi						9	
		Psolidae			157		6	3	
		Psolus squamatus							27
	Ophiuroidea	Ophiuroidea	1579	1194	151	5	13469	59	67
Mollusca	Bivalvia	Acesta mori						6	1
		Acesta sphoni						5	
		Bivalvia	6						
		Pectinidae		582	180		444	10	
	Cephalopoda	Octopoda				2			
	Gastropoda	Calliostoma	11	1			15	1	
		Doridacea				1			

		Fissurellidae		201	69	1	60		
		Gastropoda		563	151	1	322	2	
		Nudibranchia		1					
	Mollusca	Mollusca	1						
	Polyplacophora	Neoloricata					2	1	
	Scaphopoda	Scaphopoda	33					55	18
Porifera	Porifera	Asbestopluma				4			
		Asbestopluma sp. A				2			
		Farrea					2	74	1
		Heterochone						1	
		Porifera		71	24	119	702	122	
		Sclerothamnopsis						3	