

UNIVERSIDADE FEDERAL DE SÃO CARLOS
CENTRO DE CIÊNCIAS BIOLÓGICAS E DA SAÚDE
PROGRAMA DE PÓS-GRADUAÇÃO
EM ECOLOGIA E RECURSOS NATURAIS

PEIXES DE COSTÃO ROCHOSO: RESERVA BIOLÓGICA MARINHA DO
ARVOREDO (BRASIL) E ARQUIPÉLAGO DOS AÇORES (PORTUGAL)

ÁTHILA BERTONCINI ANDRADE

SÃO CARLOS - SP

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ÁTHILA BERTONCINI ANDRADE

Tese apresentada ao Programa de Pós-Graduação em Ecologia e Recursos Naturais da Universidade Federal de São Carlos como parte dos requisitos para obtenção do Título de Doutor em Ciências na Área de Concentração em Ecologia e Recursos Naturais

Orientador: Dr. José Roberto Verani

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Aprovada em 12 de novembro de 2009


BANCA EXAMINADORA

Presidente



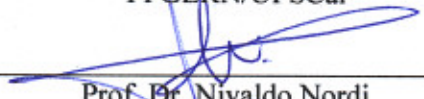
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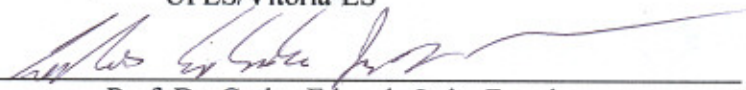
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Para minha família
A maior riqueza da minha vida

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*Overhead the albatross hangs motionless upon the air
and deep beneath the rolling waves
in labyrinths of coral caves
the echo of a distant time
comes willowing across the sand
and everything is green and submarine.*

Echoes, Pink Floyd (Meddle, 1971)

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RESUMO

O sucesso de Áreas Marinhas Protegidas depende especialmente do quão bem ela atinge seus objetivos de manejo. A Reserva Biológica Marinha do Arvoredo (RBMA) em Santa Catarina, encontra-se no limite mais ao sul de ocorrência dos peixes recifais do Atlântico Sudoeste. Apresenta-se um lista atualizada dos peixes costeiros da RBMA, com 15 novos registros a comentários sobre espécies raras e ameaçadas. Um total de 203 espécies distribuídas em 113 gêneros, 62 famílias e 17 ordens foi observado nos quatro anos de monitoramento das comunidades de peixes de costão rochoso em áreas dentro e fora da RBMA, através de censos visuais subaquáticos. As famílias mais ricas foram Carangidae, Serranidae, Labridae, Scaridae e Gobiidae. Todas as comparações favoreceram significativamente as comunidades dentro da RBMA, exceto a diversidade que não diferiu significativamente. *Haemulon aurolineatum* foi a espécie mais abundante em todos os seis locais amostrados, e *Stegastes fuscus* a mais frequente. Os comedores de invertebrados dominaram, seguidos dos onívoros em abundância relativa. A análise de como as espécies selecionadas se beneficiam do efeito de proteção não mostraram um padrão claro de aumento significativo nas abundâncias dentro da RBMA ao longo dos quatro anos amostrados. A mesma metodologia foi empregada na investigação da estrutura da comunidade de peixes de recifes rochosos rasos do Arquipélago dos Açores. Um total de 52 espécies distribuídas em 26 famílias foi observado. As categorias tróficas das espécies são comentadas quanto sua distribuição e densidades nos estratos de profundidade amostrados. Sparidae, Labridae e Carangidae foram as famílias mais ricas, sendo *Diplodus sargus*, *Pagellus acarne* e *Coris julis* as espécies mais abundantes que consequentemente apresentaram as maiores densidades. As densidades médias foram testadas quanto a sua significância nos diferentes estratos de profundidade amostrados. Interações de limpeza entre o peixe-rei *Coris julis* e o bodião azul açoriano *Centrolabrus caeruleus* labrideos são apresentadas, bem como comentários sobre a espécie exótica, *Diplodus vulgaris*, observada forrageando entre cardumes de labrídeos de pequeno porte. Para o caso da RBMA, enquanto a investigação sobre atividades de pesca ilegal, o desenvolvimento e implementação de programas educacionais de longa duração, bem como os esforços para assegurar que se cumpram as regras da RBMA não ultrapassem o mínimo executado, a RBMA continuará longe de completar seus objetivos fundamentais de proteger o rico ecossistema que abriga.

ABSTRACT

The success of a Marine Protected Area relies strongly on how well they meet their management goals. The Arvoredo Marine Biological Reserve (AMBR) lies in the southernmost limit of reef fishes occurrence in the Southwestern Atlantic. An updated checklist of shallow coastal fish species of the AMBR archipelago, with 15 new records is presented with comments on rare and threatened species. A total of 203 species belonging to 133 genera and 68 families and 17 orders was observed during the four-year monitoring the rocky reef fish in areas inside and outside the AMBR, through underwater visual censuses. The richest families were Carangidae, Serranidae, Labridae, Scaridae and Gobiidae. All comparisons significantly favoured communities inside the AMBR, except for diversity that was not significantly different. *Haemulon aurolineatum* was the most abundant species in all six sites, being *Stegastes fuscus* the most frequent. Invertebrate feeders dominated the areas, followed by omnivores in relative abundance. The analysis of how selected target species benefit from the protection effect did not show a clear pattern of significant increases in abundances along the sampled years. The same methodology was applied to investigate the community structure of shallow rocky reef fish fauna of the Azores Archipelago. A total of 52 fish species from 26 different families was observed. Trophic categories are given for observed species with comments on distribution and densities along sampled depth strata. Sparidae, Labridae and Carangidae were the most speciose families, being *Diplodus sargus*, *Pagellus acarne* and *Coris julis*, the most abundant species that consequently also accounted to the highest densities. Mean densities along sampled strata were tested for significant differences. Cleaning interactions among the rainbow wrasse *Coris julis* and the azorean blue wrasse *Centrolabrus caeruleus* are presented, as well as, comments on the exotic species *Diplodus vulgaris*, observed foraging among schools of small sized Labrids. In the case of AMBR, while surveillance of poaching, development and implementation of long-term educational programs, as well as, efforts to improve enforcement do not overcome the status of minimal, the AMBR will continue far from completing its fundamental objectives of protecting the rich ecosystem it shelters.

INTRODUÇÃO GERAL

Os recifes rochosos expõem, através da ictiofauna associada, riqueza e biodiversidade singulares. Comparativamente menos estudada que a ictiofauna dos recifes de coral, é dotada de particularidades e complexidades, dentre as quais, a coexistência de espécies de zonas tropicais e sub-tropicais.

Tendo em vista o vasto campo para descobertas, os trabalhos de pesquisa que compõem a presente tese trazem a ictiofauna de ambientes de costão rochoso como tema central de estudo. Por sua vez, o enfoque gira em torno de duas áreas dominadas pela interface costão rochoso-mar, situadas em opostos latitudinais: o litoral central de Santa Catarina, no sul do Brasil (Latitude 27°S), e o arquipélago dos Açores, Portugal (Latitude 38°N).

Os estudos desenvolvidos em Santa Catarina e Açores, apesar de compartilharem a mesma metodologia, em suma baseada na técnica de censos visuais subaquáticos, seguiram diferentes abordagens.

Os recifes rochosos de Santa Catarina, motivadores do início da pesquisa, concentraram o maior esforço e, conseqüentemente, a porção mais densa dos dados, coletados anualmente durante os verões de 2005/2006; 2006/2007; 2007/2008 e 2008/2009. A coleta e análise dos dados focaram a identificação das espécies bem como a determinação das abundâncias e das classes de comprimento que compõem as comunidades de peixes que habitam os costões rochosos da Reserva Biológica Marinha do Arvoredo (RBMA).

O **Capítulo I A (Arvoredo Marine Biological Reserve: an updated checklist of fishes)** traz a caracterização da área de estudo, comenta a riqueza das diversas formas de vida marinha e ressalta aspectos oceanográficos da dinâmica das massas d'água na região. E, como principal contribuição, atualiza a lista de espécies de peixes da RBMA apresentando a descoberta de novos registros realizados nos últimos anos. O manuscrito aborda ainda o estado de conservação das espécies presentes através dos critérios estabelecidos pela *The International Conservation Union* (IUCN); a ocorrência de espécies consideradas raras para o local; os indícios que apontam Santa Catarina como o limite Sul de ocorrência dos recifes rochosos rasos e das espécies de peixes tropicais.

Os resultados do monitoramento das áreas recifais dentro e fora dos limites da RBMA são descritos no **Capítulo I B (Arvoredo Marine Biological Reserve: Protecting rocky reef fishes on subtropical Atlantic reefs)** que apresenta o panorama geral das famílias de

maior riqueza e das espécies mais frequentes e abundantes. Também, caracteriza as comunidades de peixes, quanto à dominância de espécies, nos seis locais amostrados; apresenta e discute categorias tróficas, riqueza, equitabilidade, abundância e densidade na comparação entre áreas (dentro e fora) da RBMA.

Ainda, em análise mais aprofundada do caso, foi verificado o comportamento das densidades nas diferentes classes de comprimento de duas espécies *alvo* da pesca na região, ao longo dos quatro anos de estudo dentro e fora da RBMA, levantando-se questões fundamentais sobre a efetividade da Reserva.

Apresentando os estudos desenvolvidos nos Açores, diante dos fatores como as características do ambiente rochoso, buscou-se no **Capítulo II A (Rocky reef fish community structure in two Azorean islands (Portugal) Central North Atlantic)** conhecer as variações nas comunidades de peixes dentro de um gradiente de profundidades, variando de piscinas de maré abertas à costões de maior profundidade.

A importante interação mutualística de limpeza entre labrídeos, praticada por uma espécie recentemente descrita, foi identificada através de registros fotográficos no **Capítulo II B (Cleaning activity among Labridae in Azores: the rainbow wrasse *Coris julis* and the Azorean blue wrasse *Centrolabrus caeruleus*)**. Igualmente, a presença da espécie invasora, a qual ainda não são conhecidos os efeitos nos ambientes rochosos dos Açores é relatada no **Capítulo II C (The Common two-banded seabream (*Diplodus vulgaris*), another exotic species in Azores)** juntamente com a abordagem da temática, recorrente nos recifes brasileiros.

Por fim, no **Anexo I (Foraging activity by *Mugil curema* Valenciennes, 1836 (Perciformes, Mugilidae))** é apresentado o registro do comportamento peculiar da chamada *parati*, - espécie de tainha que habita os costões da RBMA, e mais além, como produto dos esforços pela conservação na área, é apresentada no **Anexo II (Peixes de Costão Rochoso de Santa Catarina, 2ª ed.)** a proposta para a segunda edição do livro “Peixes de Costão Rochosos de Santa Catarina - I. Arvoredo”, que contará com informações levantadas pela pesquisa em questão, além da considerável ampliação do acervo fotográfico de espécies, desde o seu lançamento em janeiro de 2006.

*In the end we will conserve only what we love;
We will love only what we understand;
We will understand only what we have been taught.*

Baba Dioum, Senegalese ecologist.

CAPÍTULO I

A. ARVOREDO MARINE BIOLOGICAL RESERVE: AN UPDATED CHECKLIST OF FISHES

*Artigo formatado para o periódico **Revista Brasileira de Zoologia***

Arvoredo Marine Biological Reserve: an updated checklist of fishes

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Abstract

The Arvoredo Marine Biological Reserve (AMBR) lies in the Brazilian Zoogeographic Province, where the southernmost limit to reef fishes seems to have its boundaries on the very last rocky reef formations South of Santa Catarina. In the present study, we provide an updated list of shallow coastal fish species of the AMBR archipelago, with 15 new records and comments on rare and threatened species. A total of 203 species belonging to 133 genera and 68 families and 17 orders was observed. The richest families were Carangidae, Serranidae, Labridae, Scaridae and Gobiidae. The most speciose genera were *Halichoeres* and *Sparisoma*. Global assessments up to date indicate the presence of 14 species assigned as threatened within AMBR. Adverse oceanographic conditions shall play a major barrier to tropical reef fish communities to spread further South, once records of a well-developed shallow reef fish assemblages beyond Santa Catarina are scarce and occasional.

Key Words: Rocky reef fish, MPA, Arvoredo, Southern Brazil, Santa Catarina.

Resumo

A Reserva Biológica Marinha do Arvoredo (RBMA) encontra-se na Província Zoogeográfica Brasileira, onde o limite mais ao sul dos peixes recifais parece ter suas fronteiras nas últimas formações rochosas ao sul em Santa Catarina. No presente estudo apresenta-se um lista atualizada dos peixes costeiros da RBMA, com 15 novos registros e comentários sobre espécies raras e ameaçadas. Um total de 203 espécies distribuídas em 133 gêneros, 62 famílias e 17 ordens foi observado. As famílias mais ricas foram Carangidae, Serranidae, Labridae, Scaridae e Gobiidae. Os gêneros mais ricos foram *Halichoeres* e *Sparisoma*. Os levantamentos globais indicam a presença de 14 espécies classificadas como ameaçadas na RBMA. As condições oceanográficas adversas devem funcionar como barreira para que comunidades de peixes tropicais expandam seus limites mais ao sul, uma vez que registros do estabelecimento de comunidades de peixes recifais em áreas rasas ao sul de Santa Catarina são escassos e ocasionais.

Palavras chave: Peixes de costão rochoso, Áreas Marinhas Protegidas, Arvoredo, Sul do Brasil, Santa Catarina.

Introduction

Reef-fishes are important members of shallow marine communities, showing great diversity and abundance in these areas. Reef fish communities are present along the Brazilian coast from Manuel Luiz Reefs (Rocha & Rosa, 2001) below the Amazon River mouth, down south to the coast of the state of Santa Catarina (Hostim-Silva et al., 2006), including the oceanic islands. This region is known as the Brazilian Zoogeographic Province (BZP), a well-established endemism area (including the oceanic islands) within the Western Atlantic (Briggs 1974, 1995).

Discussions on zoogeographical patterns of Brazilian reef fish have received considerable contributions in recent years (Floeter & Gasparini, 2000; Joyeux et al., 2001; Floeter et al. 2001; Moura, 2003; Rocha, 2003; Floeter et al. 2008; Rocha et al. 2008). This is especially due to an increased knowledge on the southwestern Atlantic reef fish fauna, provided by ichthyofaunal surveys, description, redescription and revalidation of fishes endemic to Brazilian reefs (e.g. *Elacatinus figaro* Sazima, Moura & Rosa, 1997; *Gramma brasiliensis* Sazima, Gasparini & Moura, 1998; *Haemulon squamipinna* Rocha & Rosa, 1999; *Clepticus*

brasiliensis Heiser, Moura & Robertson, 2000; *Scarus zelindae* Moura, Figueiredo & Sazima, 2001; *Labrisomus cricota* Sazima, Gasparini & Moura, 2002; *Sparisoma tuiupiranga* Gasparini, Joyeux, & Floeter, 2003; *Acyrtus pauciradiatus* Sampaio, Nunes & Mendes, 2004; *Lutjanus alexandrei* Moura & Lindeman, 2007; *Elacatinus phthirophagus* Sazima, Carvalho-Filho & Sazima, 2008; *Halichoeres sazimai* Luiz-Jr, Ferreira & Rocha, 2009).

The Arvoredo Marine Biological Reserve (AMBR) lies within the BZP, where the southernmost limit to reef fishes seems to have its boundaries on the very last rocky reef formations South of Santa Catarina (Floeter et al. 2001). Habitat constraints such as adverse oceanographic conditions (e.g. low water temperature, strong cold fronts) shall play a major barrier to tropical reef fish communities to spread further South.

In the present study, we provide an annotated checklist of shallow coastal fish species of the Arvoredo Marine Biological Reserve, with new records and comments on rare and threatened species.

Marine life forms

Dives along the rock/sand interface is rich in marine life forms. The bottom composition can be highly diverse, with rocks covered by zoanthids (*Palythoa caribaeorum*), brown algae (mainly *Sargassum* ssp. and *Padina* ssp.) and calcareous algae.

Porto Norte site (PON), a small bay on the northwest side of the Arvoredo Island, shelters the unique calcareous algae (rhodolith) bank in Southern Brazil (Plate II), important for generating complexity in the environment. The bank has approximately 100,000 m² and depths varying from 7 to 20 m; it is composed mainly by the non articulated, free living calcareous algae *Lithophyllum* sp. Other species such as *Neogoniolithon* cf. *strictum*, also occurs in the site, and serves as substrate for the zoanthid *Zoanthus* sp. (Gherardi, 2004). The area serves as a refuge and source of food for a range of organisms such as zoanthids, decapods (Koettker & Freire, 2006; Bouzon & Freire, 2007), bivalves (Wiggers, 2003), Cnidaria (Morandini et al., 2005), ophiurus, seastars (Oliveira, 1989), algae, bryozoans epifauna, ascidians (Rocha et al., 2005, 2006), sponges (Lerner, 1996; Lerner et al., 2005) and chelonian (Proietti et al., 2009).

Oceanography

The AMBR is located in the transition zone between two major oceanographic provinces (the Southern Brazilian Bight - SBB, 23-28.5°S, and the Southern Brazilian Shelf - SBS 28.5-34°S) (Castro & Miranda, 1998). This transition is accompanied by an abrupt change in the coastline orientation where the continental shelf narrows to ~70Km at Santa Marta Cape (Eichler et al., 2008).

Dominant water masses in the SBB result from the mixing of warm and salty tropical water (TW; T>20 °C, S>36.4), relatively colder and fresher South Atlantic Central Water (SACW; T<20°C, S<36.4) and the continental runoff from several small to medium size estuaries along the SBB coast (coastal water, CW) (Castro & Miranda, 1998). During spring/summer the water column is well stratified (thermocline), with temperature of about 21° C and frequent upwelling events of the SACW. During autumn/winter, the water column remains homogeneous with the advection of sub-Antarctic waters with temperatures of 17° C (Nimer, 1989). The outer SBS is under the influence of two major oceanic systems of Brazil and Malvinas Currents, which converge near 38°S and have direct influence on the formation of shelf water masses (Piola & Matano, 2001). This dual characteristic enables the existence of both tropical (warmer waters) and temperate (colder waters) species communities.

Such distinct seasonal patterns on the dynamism of the water masses produce small to meso-scale events, such as eddies, meanders, mushroom-like features, plumes, filaments, fronts and upwelling areas (see Pereira et al., 2009).

Material and Methods

The study area

The Arvoredo archipelago (27°17' S; 48°28' W) is formed by three islands (Arvoredo, Galés and Deserta) and a rocky outcrop (São Pedro), which are part of the no-take area named 'Arvoredo Marine Biological Reserve' (AMBR). This Marine Protected Area (MPA) was designated in 1990 and is the unique of its category in the South-Southeast coast of Brazil, legally protecting remnants of the Atlantic Rainforest and a rich marine biodiversity. The reserve has 17,600 ha, and is located in the central coast of the state of Santa Catarina (Figure 1), 11 km north of Santa Catarina island and 7 km off the continent. The archipelago lies over the continental platform and is characterized by the presence of pre-Cambrian crystalline

rock shorelines. The depth throughout the archipelago varies from 5 to 25 meters, rarely deeper than 30 m.

Arvoredo is the largest island (318.6 ha), with highly accident relief and steep coastlines providing sites sheltered from the dominant northern quadrant winds (e.g. PON, ENG and SAF) and from the strong southern winds (e.g. PON, PTL and SAD) (Figure 1). Along its southern rocky-shore SCUBA diving is permitted, as the shoreline in this area lies outside of the reserve limits (Figure 1). Galés island (39.7 ha), the closest to the continent, has the same rocky formation as Arvoredo island, with few scarps and two small islets divided by a 27 m deep channel from the main island. Deserta island (13.2 ha) has a well scarped shoreline which is influenced by strong waves due to its SW-NE orientation; its relief is elevated in the northern area, with a strong decline southwards (Plate I).

A few outcrops can be found in the region, such as Pedra Noceti, Parcel do Boi and Parcel da Deserta. The rocky habitat is characterized by many cavities formed by large boulders and medium-small sized pebbles covered with macro algae (Plate II).

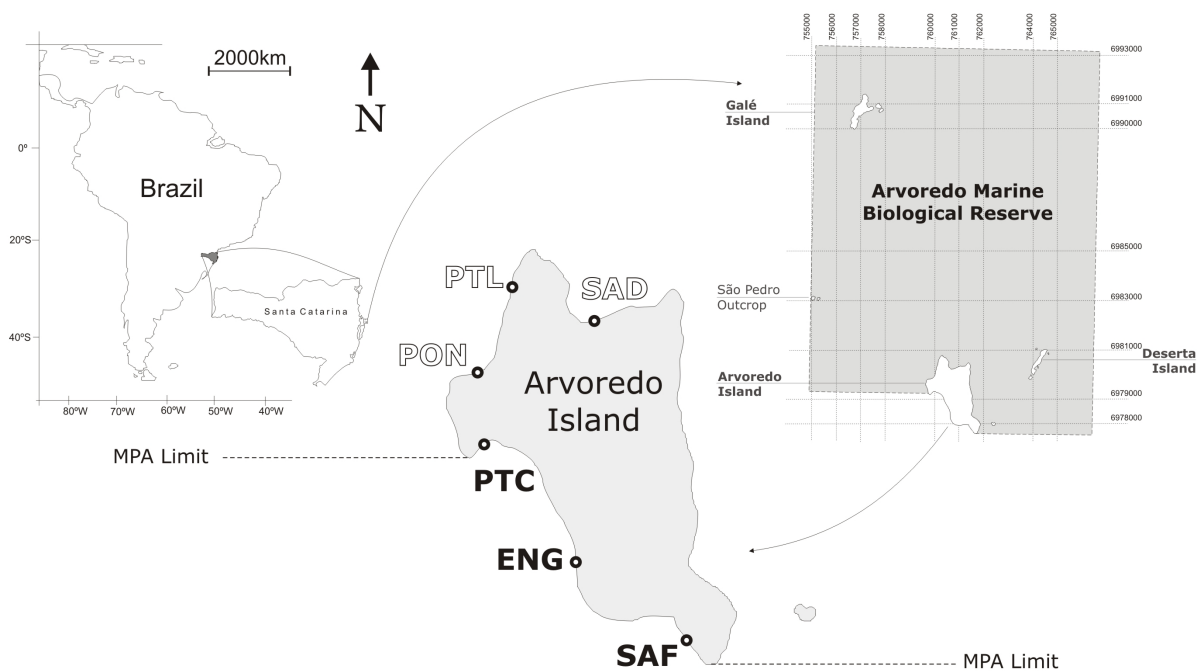


Figure 1: The Arvoredo Marine Biological Reserve (AMBR) archipelago (27°17' S; 48°28' W) formed by the islands of Arvoredo, Galés and Deserta; and São Pedro rocky outcrop. Sampled sites by underwater visual census (UVC) in the long-term monitoring program inside the AMBR are Saco D'água (SAD), Ponta do Letreiro (PTL), Porto Norte (PON), and outside are Ponta do Capim (PTC), Engenho (ENG) and Saco do Farol (SAF).

Fish Inventory

From 2005 to 2009, surveys have been conducted during summer months. Six sites have been surveyed (Figure 1): three inside the AMBR area (Saco D'água - SAD, Ponta do Letreiro - PTL and Porto Norte - PON), and three outside the AMBR area (Ponta do Capim - PTC, Engenho - ENG and Saco do Farol - SAF).

Besides the main surveying program cited above, the checklist presented here included records through different methodologies: (i) utilization of bottom trawling samples; (ii) underwater observations; (iii) verification of existent museum voucher specimens; (iv) video/photography registers and other reliable sources (researcher observations); (v) published data. Bottom trawling data was acquired from a rapid environmental assessment (February 2003) to support the elaboration of the "Arvoredo Marine Biological Reserve Management Plan", a research effort done in February of 2003 (Godoy et al., 2006).

Five samples of 5-min-trawling were carried on the islands adjacent areas, giving a total amount of 104.000 m² area (< 0,001% of the reserve's total area). Two surveys were employed aiming to species observation by Scuba (February 2002 and February 2003). Several sites around the three reserve's islands were chosen taking into account both higher and lower degrees of wave exposure (Arvoredo, Galés and Deserta) aiming to assess a higher habitat diversity (Godoy et al., 2006, 2007).

The existence of vouchers at MZUSP museum (Museu de Zoologia da Universidade de São Paulo) was verified on-line at the website of the "National System on information on Ichthyological Collections" (www.mnrj.ufrj.br/pronex). Specimens from the CIUFSC collection (Coleção Ictiológica da Universidade Federal de Santa Catarina) were included following Cannella & Frutuoso (1993). An evaluation of sources of photographs and videos that had been reliably done within the AMBR area provided the inclusion of species that were not detected through other methodologies.

The IUCN red list categories are presented for the available assessed species.

Results

The richest families were Carangidae (17 spp.), Serranidae (16 spp.), Labridae (9 spp.), Scaridae and Gobiidae (both with 8 spp.), Blenniidae and Pomacentridae (both with 7 spp.) Haemulidae, Sparidae and Labrisomidae (all with 6 spp.).

A total of 203 fish species belonging to 133 genera, 68 families and 17 orders was recorded (Table I). From these, 96 species occurred inside one of the 418 40m² transects, which accounted to 29801 fish, in a surveyed area of 16720m² (Bertoncini et al., *in prep.*).

The most speciose genera were, *Halichoeres* and *Sparisoma* with five species, followed by *Epinephelus*, *Gymnothorax*, *Mycteroperca*, *Serranus*, *Lutjanus* and *Sphyræna* with four species each. Although Craig & Hasting (2007) proposed a phylogenetic review of Epinephelinae (Serranidae), only the resurrected *Hyporhamphus* is considered here.

Table I. Checklist of fishes from Arvoredo Marine Biological Reserve. Order and Families are arranged according to Nelson (2006). Vouchers at MZUSP museum are indicated when available. IUCN criteria and categories are presented for the globally assessed species (see IUCN, 2009).

Order	Family	Species	IUCN	Museu
Carcharhiniformes	Triakidae	<i>Mustelus schmitti</i> Springer, 1939	EN A2bd+3bd+4bd	
Torpediniformes	Narcinidae	<i>Narcine brasiliensis</i> (Olfers, 1831)	DD	MZUSP 55364
Rajiformes	Rhinobatidae	<i>Rhinobatos percellens</i> (Walbaum, 1792)	NT	
		<i>Zapteryx brevirostris</i> (Müller & Henle, 1841)	VU A2ab+3b+4ab	
	Rajidae	<i>Atlantoraja cyclophora</i> (Regan, 1903)	VU A3bd+4bd	
		<i>Psammobatis</i> sp.		
		<i>Rioraja agassizii</i> (Müller & Henle, 1841)	VU A4d	
		<i>Sympterygia bonapartii</i> (Müller & Henle, 1841)	DD	
Myliobatiformes	Dasyatidae	<i>Dasyatis centroura</i> (Mitchill, 1815)	LC	
		<i>Pteroplatytrygon violacea</i> (Bonaparte, 1832)		
	Gymnuridae	<i>Gymnura altavela</i> (Linnaeus, 1758)	VU A2bd+4bd	
	Myliobatidae	<i>Aetobatus narinari</i> (Euphrasen, 1790)	NT	
Anguilliformes	Muraenidae	<i>Gymnothorax ocellatus</i> Agassiz, 1831		
		<i>Gymnothorax funebris</i> Ranzani, 1840		
		<i>Gymnothorax moringa</i> (Cuvier, 1829)		
		<i>Gymnothorax vicinus</i> (Castelnau, 1855)		
		<i>Muraena retifera</i> Goode & Bean, 1882		
	Ophichthidae	<i>Myrichthys breviceps</i> (Richardson, 1848)		MZUSP 55347
		<i>Myrichthys ocellatus</i> (Lesueur, 1825)		MZUSP 55328
Clupeiformes	Engraulidae	<i>Engraulis anchoita</i> Hubbs & Marini, 1935		
	Clupeidae	<i>Harengula clupeola</i> (Cuvier, 1829)		

Clupeiformes	Clupeidae	<i>Sardinella janeiro</i> (Eigenmann, 1894)		
Aulopiformes	Synodontidae	<i>Synodus foetens</i> (Linnaeus, 1766)		
		<i>Synodus synodus</i> (Linnaeus, 1758)		
Batrachoidiformes	Batrachoididae	<i>Porichthys porosissimus</i> (Cuvier, 1829)		MZUSP 55454
Lophiiformes	Lophiidae	<i>Lophius gastrophysus</i> Miranda Ribeiro, 1915		
	Antennariidae	<i>Antennarius striatus</i> (Shaw, 1794)		
	Ogcocephalidae	<i>Ogcocephalus vespertilio</i> (Linnaeus, 1758)		MZUSP 55433
Mugiliformes	Mugilidae	<i>Mugil curema</i> (Valenciennes, 1836)		MZUSP 55387
		<i>Mugil platanus</i> Günther, 1880		
Beloniformes	Exocoetidae	<i>Exocoetus volitans</i> Linnaeus, 1758		
	Hemiramphidae	<i>Hemiramphus brasiliensis</i> (Linnaeus, 1758)		
		<i>Hyporhamphus unifasciatus</i> (Ranzani, 1842)		
Beryciformes	Holocentridae	<i>Holocentrus adscensionis</i> (Osbeck, 1765)		MZUSP 55390
		<i>Myripristis jacobus</i> Cuvier, 1829		MZUSP 55388
Gasterosteiformes	Syngnathidae	<i>Halicampus crinitus</i> (Jenyns, 1842)		
		<i>Hippocampus erectus</i> Perry, 1810	VU A4cd	MZUSP 55461
		<i>Hippocampus reidi</i> Ginsburg, 1933	DD	MZUSP 55456
	Fistularidae	<i>Fistularia petimba</i> Lacepède, 1803		
		<i>Fistularia tabacaria</i> Linnaeus, 1758		
Scorpaeniformes	Dactylopteridae	<i>Dactylopterus volitans</i> (Linnaeus, 1758)		MZUSP 55431
	Triglidae	<i>Prionotus punctatus</i> (Bloch, 1793)		
	Scorpaenidae	<i>Scorpaena brasiliensis</i> Cuvier, 1829		MZUSP 55371
		<i>Scorpaena isthmensis</i> Meek & Hildebrand, 1928		
Perciformes	Centropomidae	<i>Centropomus parallelus</i> Poey, 1860		
		<i>Centropomus undecimalis</i> (Bloch, 1792)		
	Serranidae	<i>Diplectrum radiale</i> (Quoy & Gaimard, 1824)		
		<i>Dules auriga</i> Cuvier, 1829		
		<i>Epinephelus adscensionis</i> (Osbeck, 1765)	LC	
		<i>Epinephelus itajara</i> (Lichtenstein, 1822)	CR A2d	
		<i>Epinephelus marginatus</i> (Lowe, 1834)	EN A2d	MZUSP 55399
		<i>Epinephelus morio</i> (Valenciennes, 1828)	NT	MZUSP 55352
		<i>Hyporthodus niveatus</i> (Valenciennes, 1828)	VU A2d+3d	ZUEC 5226
		<i>Mycteroperca acutirostris</i> Bean, 1882	LC	MZUSP 55325
		<i>Mycteroperca bonaci</i> (Poey, 1860)	NT	MZUSP 55423
		<i>Mycteroperca interstitialis</i> (Poey, 1860)	VU A2d+3d	MZUSP 55396
		<i>Mycteroperca microlepis</i> (Goode & Bean, 1879)	LC	ZUEC 5227
		<i>Paranthias furcifer</i> (Valenciennes, 1828)	LC	
		<i>Serranus atrobranchus</i> (Cuvier, 1829)		
		<i>Serranus baldwini</i> (Evermann & Marsh, 1889)		
		<i>Serranus flaviventris</i> (Cuvier, 1829)		MZUSP 55429
		<i>Serranus phoebe</i> Poey, 1851		MZUSP 55435
	Priacanthidae	<i>Priacanthus arenatus</i> Cuvier, 1829		
	Apogonidae	<i>Apogon pseudomaculatus</i> Longley, 1932		

Perciformes	Malacanthidae	<i>Malacanthus plumieri</i> (Bloch, 1786)		MZUSP 55430		
	Pomatomidae	<i>Pomatomus saltatrix</i> (Linnaeus, 1766)				
	Rachycentridae	<i>Rachycentron canadum</i> (Linnaeus, 1766)				
	Echeneidae	<i>Echeneis naucrates</i> (Linnaeus, 1758)				
	Carangidae	<i>Alectis ciliaris</i> (Bloch, 1787)				
		<i>Carangoides crysos</i> (Mitchill, 1815)			MZUSP 55363	
		<i>Carangoides ruber</i> (Bloch, 1793)				
		<i>Caranx bartholomaei</i> (Cuvier, 1833)				
		<i>Caranx latus</i> Agassiz, 1831				
		<i>Decapterus macarellus</i> (Cuvier, 1833)				
		<i>Oligoplites saliens</i> (Bloch, 1793)				
		<i>Pseudocaranx dentex</i> (Bloch & Scheneider, 1801)			MZUSP 55438	
		<i>Selar crumenophthalmus</i> (Bloch, 1793)				
		<i>Selene vomer</i> (Linnaeus, 1758)			MZUSP 55468	
		<i>Seriola dumerili</i> (Risso, 1810)			MZUSP 55424	
		<i>Seriola lalandi</i> Valenciennes, 1833				
		<i>Seriola rivoliana</i> Valenciennes, 1833				
		<i>Trachinotus carolinus</i> (Linnaeus, 1766)				
		<i>Trachinotus falcatus</i> (Linnaeus, 1758)				
		<i>Trachinotus goodei</i> (Jordan & Evermann, 1896)			MZUSP 55395	
		<i>Thachurus lathami</i> Nichols, 1920				
		Lutjanidae	<i>Lutjanus cyanopterus</i> (Cuvier, 1828)		VU A2d	
			<i>Lutjanus analis</i> (Cuvier, 1828)		VU A2d, B1+2e	
	<i>Lutjanus jocu</i> (Bloch & Schneider, 1801)					
	<i>Lutjanus synagris</i> (Linnaeus, 1758)					
	Gerreidae	<i>Diapterus rhombeus</i> (Cuvier, 1829)				
		<i>Eucinostomus argenteus</i> Baird & Girard, 1855				
		<i>Eucinostomus gula</i> (Quoy & Gaimard, 1855)				
	Haemulidae	<i>Anisotremus surinamensis</i> (Bloch, 1791)			MZUSP 55393	
		<i>Anisotremus virginicus</i> (Linnaeus, 1758)			MZUSP 55359	
		<i>Haemulon aurolineatum</i> (Cuvier, 1830)			MZUSP 55357	
		<i>Haemulon parra</i> (Desmarest, 1823)				
		<i>Haemulon steindachneri</i> (Jordan & Gilbert, 1882)			MZUSP 55354	
	Orthopristidae	<i>Orthopristis ruber</i> (Cuvier, 1830)				
		<i>Archosargus probatocephalus</i> (Walbaum, 1792)				
	Sparidae	<i>Archosargus rhomboidalis</i> (Linnaeus, 1758)				
<i>Calamus penna</i> (Valenciennes, 1830)						
<i>Calamus pennatula</i> Guichenot, 1868				MZUSP 55415		
<i>Diplodus argenteus</i> (Valenciennes, 1830)				MZUSP 55348		
<i>Pagrus pagrus</i> (Linnaeus, 1758)			EN A1bd+2d			
Sciaenidae	<i>Cynoscion leiarchus</i> (Cuvier, 1830)					
	<i>Micropogonias furnieri</i> (Desmarest, 1823)					
	<i>Odontoscion dentex</i> (Cuvier, 1830)			MZUSP 55345		

Perciformes	Sciaenidae	<i>Pareques acuminatus</i> (Bloch & Scheneider, 1801)	MZUSP 55386
		<i>Paralonchurus brasiliensis</i> (Steindachner, 1875)	
	Mullidae	<i>Pseudupeneus maculatus</i> (Bloch, 1793)	MZUSP 55344
		<i>Mullus argentinae</i> Hubbs & Marini, 1933	
	Pempheridae	<i>Pempheris schomburgkii</i> Müller & Troschel, 1848	
	Kyphosidae	<i>Kyphosus incisor</i> (Cuvier, 1831)	
		<i>Kyphosus sectator</i> (Linnaeus, 1758)	MZUSP 55335
	Chaetodontidae	<i>Chaetodon sedentarius</i> Poey, 1860	
		<i>Chaetodon striatus</i> Linnaeus, 1758	MZUSP 55342
	Pomacanthidae	<i>Holacanthus ciliaris</i> (Linnaeus, 1758)	MZUSP 55391
		<i>Holacanthus tricolor</i> (Bloch, 1795)	MZUSP 55392
		<i>Pomacanthus arcuatus</i> (Linnaeus, 1758)	
	Pomacanthidae	<i>Pomacanthus paru</i> (Bloch, 1787)	MZUSP 55458
	Cirrihidae	<i>Amblycirrhitus pinos</i> (Mowbray, 1927)	
	Pomacentridae	<i>Abudefduf saxatilis</i> (Linnaeus, 1758)	MZUSP 55349
		<i>Chromis</i> cf. <i>enchrysur</i> Jordan & Gilbert, 1882	
		<i>Chromis jubauna</i> Moura, 1995	MZUSP 55432
		<i>Chromis multilineata</i> (Guichenot, 1853)	MZUSP 55356
		<i>Stegastes fuscus</i> (Cuvier, 1830)	MZUSP 55343
		<i>Stegastes pictus</i> (Castelnau, 1855)	MZUSP 55346
		<i>Stegastes variabilis</i> (Castelnau, 1855)	MZUSP 55400
	Labridae	<i>Bodianus pulchellus</i> (Poey, 1860)	MZUSP 55398
		<i>Bodianus rufus</i> (Linnaeus, 1758)	MZUSP 55414
		<i>Halichoeres brasiliensis</i> (Bloch, 1791)	
		<i>Halichoeres bathyphilus</i> (Beebe & TeeVan, 1932)	
		<i>Halichoeres dimidiatus</i> (Agassiz, 1831)	
		<i>Halichoeres poeyi</i> (Steindachner, 1867)	MZUSP 55333
	<i>Halichoeres sazimai</i> Luiz Jr, Ferreira & Rocha, 2009		
	<i>Thalassoma noronhanum</i> (Boulenger, 1890)		
	<i>Xyrichtys novacula</i> (Linnaeus, 1758)		
Scaridae	<i>Cryptotomus roseus</i> Cope, 1871	MZUSP 55425	
	<i>Scarus trispinosus</i> Valenciennes, 1840		
	<i>Scarus zelindae</i> Moura, Figueiredo & Sazima, 2001		
	<i>Sparisoma amplum</i> (Ranzani, 1842)		
	<i>Sparisoma axillare</i> (Steindachner, 1878)	MZUSP 55361	
	<i>Sparisoma frondosum</i> (Agassiz, 1831)	MZUSP 55362	
	<i>Sparisoma radians</i> (Valenciennes, 1840)		
	<i>Sparisoma tuiupiranga</i> Gasparini, Joyeux & Floeter, 2003		
Blenniidae	<i>Hyleurochilus fissicornis</i> (Quoy & Gaimard, 1824)	MZUSP 55322	
	<i>Hyleurochilus pseudoaequipinnis</i> Bath, 1994	MZUSP 55320	
	<i>Hypsoblennius invemar</i> Smith-Vaniz & Acero, 1980	MZUSP 55413	
	<i>Ophioblennius trinitatis</i> (Miranda-Ribeiro, 1919)		
	<i>Parablennius marmoreus</i> (Poey, 1876)	MZUSP 55317	

Perciformes	Blenniidae	<i>Parablennius pilicornis</i> (Cuvier, 1829)	MZUSP 55324	
		<i>Scartella cristata</i> (Linnaeus, 1758)	MZUSP 55440	
	Labrisomidae	<i>Labrisomus kalisheræ</i> (Jordan, 1904)		
		<i>Labrisomus nuchipinnis</i> (Quoy & Gaimard, 1824)	MZUSP 55379	
		<i>Malacoctenus</i> cf. <i>delalandii</i> (Valenciennes, 1836)		
		<i>Paraclinus spectator</i> Guimarães & Bacelar, 2002	MNRJ 15877	
		<i>Starksia brasiliensis</i> (Gilbert, 1900)	MZUSP 55367	
		<i>Starksia</i> sp.		
	Chaenopsidae	<i>Emblemariopsis signifera</i> (Ginsburg, 1942)	MZUSP 55369	
	Gobiesocidae	<i>Gobiesox barbatulus</i> Starks, 1913		
		<i>Tomicodon fasciatus</i> (Peters, 1860)		
	Gobiidae	<i>Barbulifer ceuthoecus</i> (Jordan & Gilbert, 1884)	MZUSP 55331	
		<i>Barbulifer</i> sp.		
	Gobiidae	<i>Bathygobius soporator</i> (Valenciennes, 1837)		
		<i>Coryphopterus glaucofraenum</i> Gill, 1863	MZUSP 55332	
		<i>Ctenogobius saepepallens</i> (Gilbert & Randall, 1968)		
		<i>Gnatholepis thompsoni</i> Jordan, 1904		
		<i>Gobiosoma hemigymnum</i> (Eigenmann & Eigenmann, 1888)	MZUSP 55368	
		<i>Gobiosoma nudum</i> (Meek & Hildebrand, 1928)	MZUSP 55404	
	Ptereleotridae	<i>Ptereleotris randalli</i> Gasparini, Rocha & Floeter, 2001		
	Ephippidae	<i>Chaetodipterus faber</i> (Broussonet, 1782)		
	Acanthuridae	<i>Acanthurus bahianus</i> (Castelnau, 1855)	MZUSP 55397	
		<i>Acanthurus chirurgus</i> (Bloch, 1787)	MZUSP 55341	
	<i>Acanthurus coeruleus</i> Bloch & Schneider, 1801			
Sphyraenidae	<i>Sphyraena barracuda</i> (Walbaum, 1792)			
	<i>Sphyraena</i> cf. <i>borealis</i> DeKay, 1842			
	<i>Sphyraena</i> cf. <i>sphyraena</i> (Linnaeus, 1758)			
	<i>Sphyraena guachancho</i> Cuvier, 1830			
Gempylidae	<i>Thyrsitops lepidopoides</i> (Cuvier, 1832)			
Trichiuridae	<i>Trichiurus lepturus</i> Linnaeus, 1758	MZUSP 55420		
Stromateidae	<i>Peprilus paru</i> (Linnaeus, 1758)			
Pleuronectiformes	Paralichthyidae	<i>Etropus longimanus</i> Norman, 1933		
		<i>Cyclopsetta fimbriata</i> (Goode & Bean, 1885)		
		<i>Paralichthys brasiliensis</i> (Ranzani, 1842)		
		<i>Paralichthys orbignyana</i> (Valenciennes, 1842)		
		<i>Syacium micrurum</i> Ranzani, 1842		
	Bothidae	<i>Bothus ocellatus</i> (Agassiz, 1831)	MZUSP 55378	
		<i>Bothus robinsi</i> Topp & Hoff, 1972	MZUSP 55457	
	Achiridae	<i>Gymnachirus nudus</i> Kaup, 1858		
	Tetraodontiformes	Balistidae	<i>Balistes capriscus</i> Gmelin, 1789	
			<i>Balistes vetula</i> Linnaeus, 1758	VU A2d
Monacanthidae		<i>Aluterus monoceros</i> (Linnaeus, 1758)		
	<i>Aluterus scriptus</i> (Osbeck, 1765)			

Tetraodontiformes	Monacanthidae	<i>Stephanolepis hispidus</i> (Linnaeus, 1766)	
	Ostraciidae	<i>Acanthostracion polygonius</i> (Poey, 1876)	
		<i>Acanthostracion quadricornis</i> (Linnaeus, 1758)	
		<i>Lactophrys trigonus</i> (Linnaeus, 1758)	MZUSP 55428
	Tetraodontidae	<i>Canthigaster figueiredoi</i> Moura & Castro, 2002	
		<i>Sphoeroides greeleyi</i> (Gilbert, 1900)	
		<i>Sphoeroides spengleri</i> (Bloch, 1785)	MZUSP 55338
		<i>Sphoeroides testudineus</i> (Linnaeus, 1758)	
	Diodontidae	<i>Cyclichthys spinosus</i> Linnaeus, 1758	
		<i>Diodon hystrix</i> Linnaeus, 1758	

New records for AMBR

Fifteen new records for the ABMR are presented: *Harengula clupeola* (Cuvier, 1829), *Hemiramphus brasiliensis* (Linnaeus, 1758), *Paranthias furcifer* (Valenciennes, 1828), *Caranx bartholomaei* (Cuvier, 1833), *Caranx latus* Agassiz, 1831, *Decapterus macarellus* (Cuvier, 1833), *Seriola lalandi* Valenciennes, 1833, *Thachurus lathami* Nichols, 1920; *Pagrus pagrus* (Linnaeus, 1758), *Chromis* cf. *enchrysurus* Jordan & Gilbert, 1882, *Sphyræna* cf. *borealis* DeKay, 1842 and *Acanthurus coeruleus* Bloch & Schneider, 1801, and three elasmobranchs, *Gymnura altavela* (Linnaeus, 1758), *Rhinobatos percellens* (Walbaum, 1792) and *Dasyatis centroura* (Mitchill, 1815).

These new records, together with the observed by Barneche et al. (2009) for ABMR, provide an updated list from 174 species (Godoy et al., 2006; Hostim et al., 2006) to 203 species (Table 1), an increase of 14.3% in the number of species.

Threatened species

The IUCN Red List of Threatened Species™ provides taxonomic, conservation status and distribution information on plants and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered-CR, Endangered-EN and Vulnerable-VU). The IUCN Red List also includes information on plants and animals that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e., are Data

Deficient-DD); and on plants and animals that are either close to meeting the threatened thresholds (i.e., are Near Threatened-NT) (IUCN, 2009). The IUCN assessed species and their respective status are given (Table I) providing an updated picture of threatened fish species in the AMBR.

So far, global assessments indicate the presence of 14 species assigned as threatened within AMBR: one Critically Endangered, three Endangered, and ten Vulnerable. Five are assigned as Least Concern, three Not Threatened and three as Data Deficient (Figure 2).

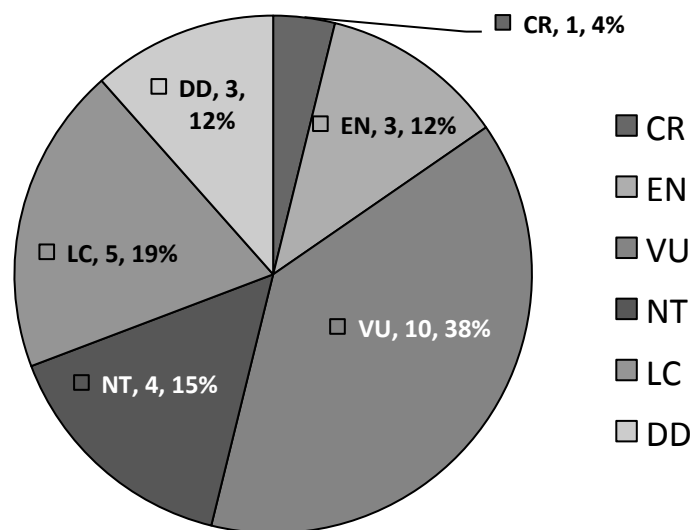


Figure 2. Percentages of species (n=26) assigned under IUCN’s categories. CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concern and DD - Data Deficient.

Discussion

Fish inventories are scarce and little representative of the reef species composition in the state of Santa Catarina (Godoy, 1987; Canella & Frutuoso, 1993; Manes, 2001; Barreiros et al., 2004; Hostim-Silva et al., 2006; Godoy et al., 2007; Dinslaken, 2008; Bernache et al., 2009; Leite, 2009). Here we provide a cohesive list to the southernmost marine sanctuary in Brazilian waters.

This check list is being constantly updated by means of underwater visual censuses adopted in the long-term monitoring program at ABMR (Bertoncini et al., *in prep.*), that started in 2005 as a subproject of “Projeto Peixes de Costão Rochoso de Santa Catarina”, which

provided the first comprehensive species list for ABMR (see Hostim-Silva et al., 2006), result of a previous decade efforts of many collaborators and partner institutions.

It is important to consider that IUCN's classifications reflect global assessments, and the Brazilian national list was not considered here once it is in a reviewing process. Furthermore the red book of Santa Catarina's Threatened species is being prepared (see IGNIS, 2009) and it will provide a more realistic picture of threatened species along this geographic region.

The geographic range of a species is determined by complex interactions among ecological factors within evolutionary processes (Holt, 2003). Range expansions are theoretically viable, when basic criteria are met, such as minimum biophysical requirements (see Figueira and Booth, 2009), adequate habitat and food to support survival, tolerance to factors affecting the physiology of the organism (temperature, oxygen, nutrients, etc.), and the aptitude of surviving within the biological community, which involves predation and competitors in the new environment (Preston et al., 2008). These factors are also valid for species invasions (see Gerhardinger et al., 2006).

Marine organisms are able to undertake rapid and dramatic range shifts due to their highly mobile larval phase, and this potential is strengthened wherever major ocean currents facilitate long-distance dispersal (Figueira and Booth, 2009). This is the case of the SE coast of Australia where Booth et al. (2007) observed the importance of the East Australian Current in driving larval settlement pulses of many species of tropical coral reef fish each summer.

The tropical water over the SBB is probably responsible in driving larval settlement pulses of many tropical warm-water species that have the coast of Santa Catarina as their southernmost distribution limit, such as *Paranthias furcifer* (Valenciennes, 1828), *Epinephelus morio* (Valenciennes, 1828), *Halichoeres brasiliensis* (Bloch, 1791), *Scarus zelindae* Moura, Figueiredo & Sazima, 2001, *Scarus trispinosus* Valenciennes, 1840 and the three species of *Acanthurus* genera, *Acanthurus bahianus* (Castelnau, 1855), *Acanthurus chirurgus* (Bloch, 1787) and *Acanthurus coeruleus* Bloch & Schneider, 1801 (Plate III). All the above species occur in naturally very low densities and especially, but not only, as juveniles in the AMBR. Up to date little information is available whether these warm-tropical-water-species survive their first winter after settlement.

A good example to support the hypothesis that winter may act as a key bottleneck for survival and population establishment of some species can be demonstrated is the case of two selected genera: *Sparisoma* and *Acanthurus* (Figure 3). The harsh winter conditions in 2007 may have lead to such an abrupt fall in densities in 2008 especially for *Sparisoma*.

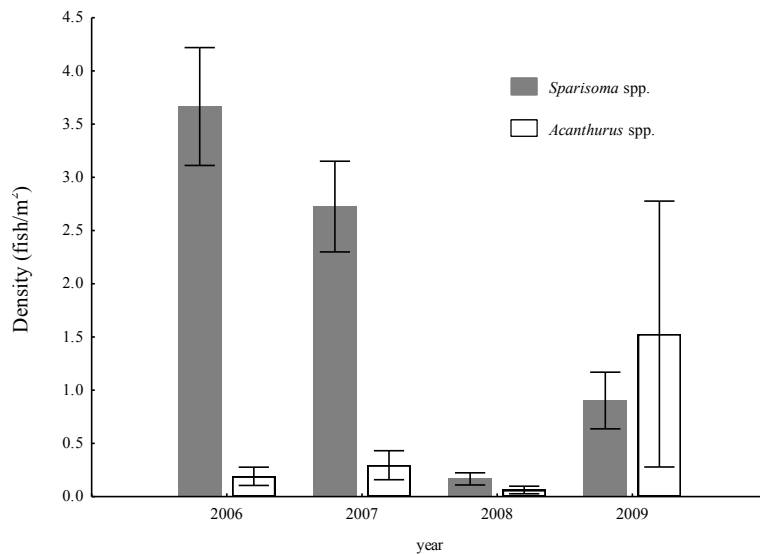


Figure 3. Densities of the genera *Sparisoma* and *Acanthurus*, at the AMBR.

Future research efforts should focus the presence and at least short-term (one season) persistence of these species not only at ABMR islands, but Southern islands along Santa Catarina, evaluating their range extensions and the suitability of biophysical environmental factors for at least the juvenile stages (see Ludsin & DeVries, 1997; Hurst & Conover, 2001; Pratt & Fox, 2002; Figueira and Booth, 2009).

Leite et al. (2009), recently registered the presence of the Azorean Chromis, *Chromis limbata* (Valenciennes, 1833) in Santa Catarina, at Campeche and Xavier islands (South AMBR), extending its known range by almost 6,400 km, being the 6th *Chromis* species to be registered in Brazil. It will not be a surprise to register this species within AMBR in a near future, as sampling efforts.

The group of elasmobranchs are, unfortunately, rarely spotted nowadays along Santa Catarina islands, but had been previously common, not to say abundant (see Souza, 2000), along the 60's and 70's. Despite this rarity on shallow coastal environments (islands and rocky shores) and excluding the hypothesis of lack of research effort where some species are likely to be found as batoids over sandy bottoms (recorded by Godoy et al., 2006), elasmobranchs continue to occur in the industrial and artisanal fisheries, such as *Rizoprionodon* spp., *Sphyrna* spp. and *Charcarhinus* spp. (see SEAP-UNIVALI online statistics at www.univali.br/gep).

Two batoid species, *G. altavela* and *D. centroura*, both previously unrecorded for the AMBR, were observed and photographed (Plate III). The former was recorded at PON, where four specimens were foraging over the rodolith bank, two smaller 1.0m, and two larger 1.8m width of disc, and the latter was observed alone at ENG, 1.5m width of disc. During late 2009 *R. percellens* was also registered by a dive group over a flat sand bottom at ENG.

Elasmobranchs have been generally rare or absent in rocky reef fish community studies (applying UVC methods) conducted in the last decade along the Southern Brazilian coastal environments. Ferreira et al. (2001) observed a single small-sized species *Narcine brasiliensis*, Floeter et al. (2007) did not censused elasmobranchs, Rangel et al. (2007), Mendonça-Neto et al. (2008), Chaves & Cassino (2009) and Leite (2009), did not report the occurrence of a single elasmobranch species. This rare profile of this group seems to be shared by the diverse Brazilian coastal environments, and probably associated to the intense years of fishing pressure and lack of management policies for this group.

None the larger, the goliath grouper, *Epinephelus itajara* (Lichtenstein, 1822), neither the smaller, the Barber Goby, *Elacatinus figaro*, Sazima, Moura & Rosa, 1997, both threatened, were observed in our samples at the AMBR. However, the former was registered in 1999 (LFM *pers. obs.*).

The AMBR and other coastal islands along Santa Catarina were once home of an abundante population of the largest Atlantic grouper (see Souza, 2000). Reaching more than 2 m in length and weighing up to 455 kg (Bullock et al., 1992). *E. itajara* is now threatened by over-fishing throughout its geographical range. Its large size, slow growth, late maturity and habit of forming spawning aggregations all contribute to its vulnerability, while habitat degradation of mangrove nursery areas (Frias-Torres, 2006) has also caused serious problems (Bullock et al., 1992). In Brazil, although protected since 2002 (expanded until 2012), research has been a challenge and needed in order to further evaluate its conservation status throughout its Brazilian range (Hostim-Silva et al., 2005; Gerhardinger et al., 2007; Craig et al., 2008; Gerhardinger et al., 2009).

On the other hand, the barber goby, *E. figaro*, a specialized cleaner which cleans throughout life and feeds almost exclusively on parasites and mucus (Sazima et al., 2000), occurred in none of our samples, although anecdotally one of its paratypes is from the nearby (7 km) Porto Belo region (MZUSP 49139). Its absence along at AMBR islands could explain the role played by the French Angelfish, *Pomacanthus paru* (Bloch, 1787), as the major cleaner at AMBR. Even playing a major role, densities of *P. paru* are low at AMBR (0.59/100m², see

Bertoncini *in prep.*) and species richness of the angelfish clients (n=8) is far lower at AMBR (*E. marginatus*, *M. acutirostris*, *A. virginicus*, *H. aurolineatum*, *D. argenteus*, *P. maculatus*, *A. saxatilis*, *S. axillare*) when compared to that recorded at Abrolhos Archipelago on Northeastern Brazil, 31 species (Sazima et al., 1999). This reduction of cleaning activity and client diversity at higher latitudes was already recognized for the Barber Goby (Sazima et al., 2000).

Despite underestimates (123 visually recorded species, against a regional list of 203 spp.) species richness estimates derived from standardized sampling units (see Bertoncini et al., *in prep.*) allow a better resolution in the assessment of small-scale patterns in species richness, provided by check lists.

Although species lists have a limited comparative value in local-scale biodiversity assessments, due to difficulties in interpreting levels and distribution of sampling efforts (Bunge & Fitzpatrick 1993, Colwell & Coddington 1994), they are a crucial tool for assessing species distribution ranges and regional-scale biodiversity patterns (Gaston & Williams, 1996). The extra 15 species recorded for the first time at AMBR since the beginning of this project reveals that the distribution of a substantial portion of Southern Brazilian rockyreef ichthyofauna is still poorly known. Finally, considering that some of the reef fish species reported herein occur in northernmost localities with coral and coralline algae bottoms, it characterizes the coast of Santa Catarina as the Southern outpost of the Brazilian Province. The existence of a well-developed shallow reef fish assemblage south of the state of Santa Catarina is unsuitable, once up to date records of reef fishes further south are scarce and occasional (e.g. Cousseau & Bastida 1976, Cousseau & Menni 1983, Figueiroa et al. 1992, Astarloa & Figueiroa 1995, Irigoyen, 2005).

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PLATE I



Overview the Southern coast of Arvoredo island. Deserta island is on the right.



Overview of the northern coast of Galés island and the two islets on the left.



Overview of Deserta island.

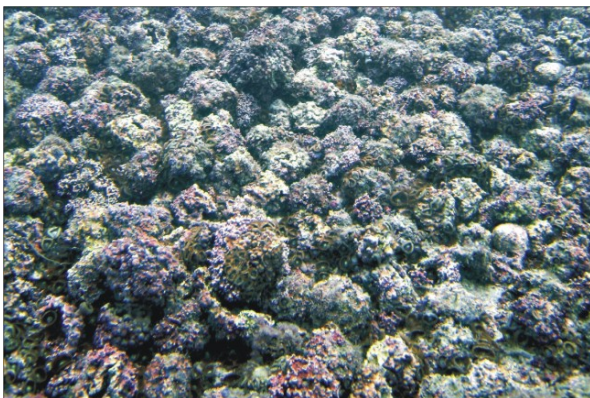
PLATE II



Steep rocky shores of Arvoredo island and the presence of boulders.



Huge and spaced boulders, with a school of *Diplodus argenteus* foraging.



Calcareous algae (rhodolith) bank at PON.



Cover of zoanthids (*Palythoa caribaeorum*)

PLATE III



Paranthias furcifer (Serranidae)



Scarus zelindae (Scaridae)



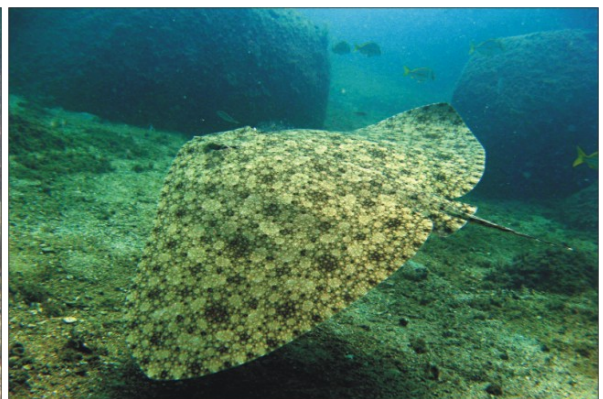
Acanthurus coeruleus (Acanthuridae)



Xyrichtys novacula (Labridae)
Foto: Leonardo Machado



Dasyatis centroura (Dasyatidae)



Gymnura altavela (Gymnuridae)
Foto: Omar Dário Gonzalvez

**B. ARVOREDO MARINE BIOLOGICAL RESERVE: PROTECTING ROCKY REEF FISHES ON
SUBTROPICAL ATLANTIC REEFS**

*Artigo formatado para o periódico **Scientia
Marina***

Arvoredo Marine Biological Reserve: Protecting rocky reef fishes on subtropical Atlantic reefs.

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Abstract

The success of a Marine Protected Area relies strongly on how well they meet their management goals. The Arvoredo Marine Biological Reserve (AMBR) has been a synonym of conflict since its creation. In the present study, we provide the results of a four-year monitoring the rocky reef fish in areas inside and outside the AMBR, comparing richness, diversity, abundances and densities among the sampled areas, as well as, the trophic structure. All comparisons significantly favoured communities inside the AMBR, except for diversity that was not significantly different. Carangidae, Serranidae and Labridae were the richest families, and *Haemulon aurolineatum* was the most abundant species in all six sites, being *Stegastes fuscus* the most frequent. Invertebrate feeders dominated the areas, followed by omnivores in relative abundance. The analysis of how selected target species benefit from the protection effect did not show a clear pattern of significant increases in abundances along the last four years inside the AMBR. While surveillance of poaching, development and implementation of long-term educational programs, as well as, efforts to improve enforcement do not overcome the status of minimal, the AMBR will continue far from completing its fundamental objectives of protecting the rich ecosystem it shelters.

Key Words: Rocky reef fish, MPA, Arvoredo, Southern Brazil, Santa Catarina.

Resumo

O sucesso de Áreas Marinhas Protetidas depende especialmente do quão bem ela atinge seus objetivos de manejo. A Reserva Biológica Marinha do Arvoredo (RBMA) tem sido sinônimo de conflito desde sua criação. No presente estudo são apresentados os resultados de quatro anos de monitoramento das comunidades de peixes de costão rochoso em áreas dentro e fora da RBMA, comparando as riquezas, diversidade, abundâncias e densidades dentro das áreas amostradas, bem como sua estrutura trófica. Todas as comparações favoreceram significativamente as comunidades dentro da RBMA, exceto a diversidade que não diferiu significativamente. Carangidae, Serranidae e Labridae foram as famílias mais ricas, sendo *Haemulon aurolineatum* a espécie mais abundante em todos os seis locais amostrados, e *Stegastes fuscus* a mais frequente. Os comedores de invertebrados dominaram os locais, seguidos dos onívoros em abundância relativa. A análise de como as espécies selecionadas se beneficiam do efeito de proteção não mostraram um padrão claro de aumento significativo nas abundâncias dentro da RBMA ao longo dos quatro anos amostrados. Enquanto a investigação sobre atividades de pesca ilegal, o desenvolvimento e implementação de programas educacionais de longa duração, bem como os esforços para assegurar que se cumpram as regras da RBMA não ultrapassarem o mínimo executado, a RBMA continuará distante de alcançar seus objetivos fundamentais de proteger o rico ecossistema que abriga.

Palavras-chave: Peixe de costão rochoso, Áreas Marinhas Protegidas, Arvoredo, Sul do Brasil, Santa Catarina.

Introduction

The success of a Marine Protected Area (MPA) in conserving fishing resources, including maintenance of biodiversity, ecosystem structure and enhanced tourism, relies strongly on how well they meet their management goals (Russ, 2002; García-Charton *et al.*, 2008). It's a worldwide consensus that MPAs represent an efficient way to conserve marine fishing resources, protecting ecosystems from human nuisances (Allison *et al.*, 1998; Roberts *et al.*, 2001, 2005; Rodrigues *et al.*, 2004; Schrope, 2001; García-Charton *et al.*, 2008) and Brazil shelters a growing number of MPA from Fernando de Noronha and Abrolhos in the Northeast to Arvoredo in the South (see Godoy *et al.*, 2007).

Since its creation, the Arvoredo Marine Biological Reserve (AMBR) has been a synonym of conflict, especially with fishermen and dive operators from the surroundings (see Wharlich, 1999; Vivacqua, 2005). The archipelago shelters one of the best scuba dive destinations of southern Brazil, which guarantees the maintenance of a significant economic activity for nearby cities. Fishermen, on the other hand, had on the reserve a source of locally important artisanal fisheries. Displaced from these fishing grounds and without alternatives, most became discredited with the elemental issues evolving the marine protected area (their discontentment is expressed by poaching, which is recurring).

The Brazilian legislation (Forest Code Law 4,771/65 and Fauna Law 5,197/67) did not clearly express the do's and don'ts among the different categories of Conservation Units (namely Biological Reserves, National Parks and Ecological Stations), which occurred only in 2000 with the approval of the SNUC - The National System of Conservation Units (Law 9,985). SNUC clearly prohibited public visitation at Biological Reserves and Ecological Stations, unless for scientific or environmental educational purposes. This law, along with the lack of interest from dive operators in continuing a program for environmental education through a "Conduct Adjustment Act" (a wasted chance to promote their presence inside the reserve boundaries), culminated in the total prohibition of tourism activities inside the AMBR in 2002, which was even "tolerated" two years after the SNUC publication.

The year of 2002 was also marked as the beginning of research projects to prepare the AMBR Management Plan, concluded and public presented on 29th July 2004. Up to date, little has been implemented of the Management Plan, due to a series of difficulties imposed by the Brazilian Governmental Agency (IBAMA), from bureaucracy to lack of personnel and resources. Although dive operators are resigned with their condition (allowed to dive outside the reserve, South of Arvoredo island), their efforts have been directed in changing the category of Biological Reserve to a Marine Park, which would allow tourism activities.

In the present study, we provide the results of a four-year monitoring the rocky reef fish in areas inside and outside (frequently visited by fishermen) the AMBR, showing the richness, diversity, abundances and densities among the sampled areas, as well as, the trophic structure observed. An analysis of how selected target species benefit from the protection effect is commented.

Material and Methods

The study area

The Arvoredo archipelago (27°17' S; 48°28' W) is formed by three islands (Arvoredo, Galés and Deserta) and a rocky outcrop (São Pedro), which are part of the no-take area named 'Arvoredo Marine Biological Reserve' (AMBR). This MPA was designated in 1990 and is up to date the unique of its category in the South-Southeast coast of Brazil, sheltering remnants of the Atlantic Rainforest on its islands and rich marine biodiversity. The reserve has 17,600 ha, and is located in the central coast of the state of Santa Catarina (Figure 1), 11 km north of Santa Catarina Island and 7 km off the continent. The archipelago lies over the continental platform and is characterized by the presence of pre-Cambrian crystalline rock shorelines. The depth throughout the archipelago varies from 5 to 25 meters, rarely deeper than 30 m.

Arvoredo is the largest island (318.6 ha), with highly accident relief and steep coastlines providing sites sheltered from the dominant northern quadrant winds (e.g. PON, ENG and SAF) and from the strong southern winds (e.g. PON, PTL and SAD) (Figure 1). Along its southern rocky-shore SCUBA diving is permitted, as the shoreline in this area lies outside the reserve limits (Figure 1). The rocky habitat is characterized by many cavities formed by large boulders and medium-small sized pebbles covered by macro algae.

The region shows distinct seasonal patterns on the dynamism of the water masses, located in an area of predominant offshore waters, with low turbidity and consequently high transparency (Chludinski and Bonetti Filho, 2002). The area is under the influence of two major oceanic systems of Brazil and Malvinas Currents, which converge near 38°S and have direct influence on the formation of shelf water masses (Piola and Matano, 2001). This dual characteristic enables the existence of both tropical (warmer waters) and temperate (colder waters) species communities.

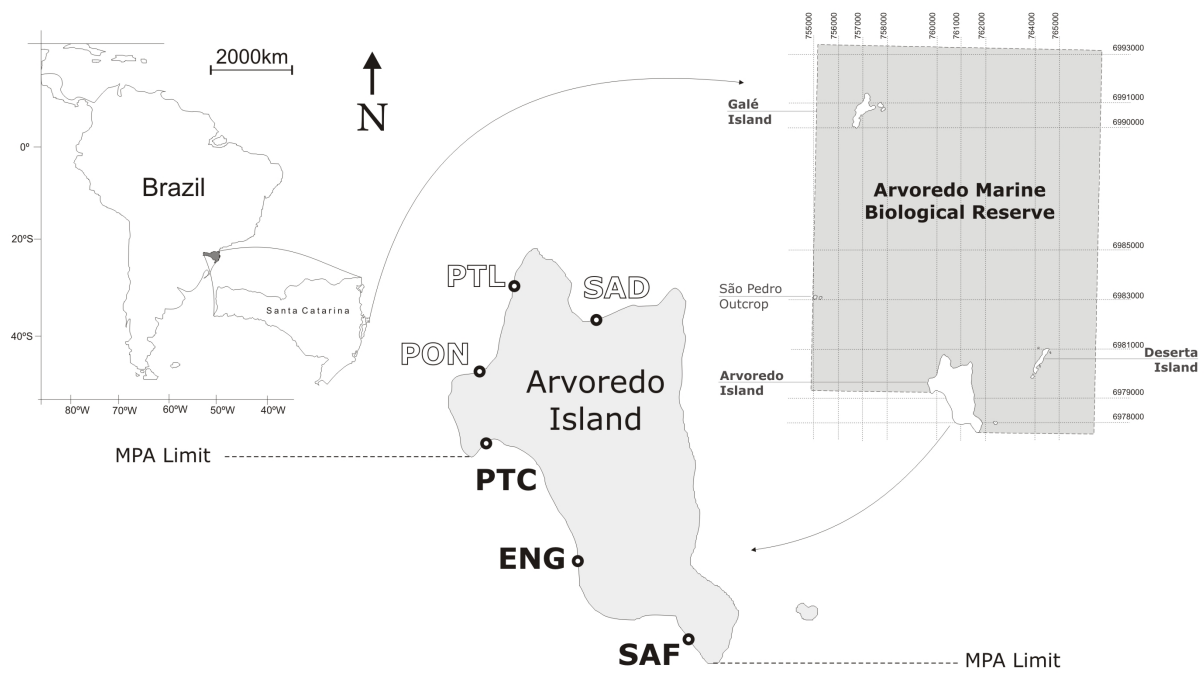


Figure 1: The Arvoredo Marine Biological Reserve (AMBR) archipelago (27°17' S; 48°28' W) formed by the islands of Arvoredo, Galés and Deserta; and São Pedro rocky outcrop. Sampled sites by underwater visual census (UVC) in the long-term monitoring program inside the AMBR are Saco D'água (SAD), Ponta do Letreiro (PTL), Porto Norte (PON), and outside are Ponta do Capim (PTC), Engenho (ENG) and Saco do Farol (SAF).

Sampling design

Surveys were conducted during summer months (late November to March) starting at 2005/2006 (considered for analyses as 2006) up to summer 2008/2009 (considered as 2009). Six sites were considered in this study (Figure 1): three inside the AMBR area (Saco D'água - SAD, Ponta do Letreiro - PTL and Porto Norte - PON), and three outside the AMBR area (Ponta do Capim - PTC, Engenho - ENG and Saco do Farol - SAF).

Reef fish community was assessed through 40 m² (20 m x 2 m) underwater strip transects, adapted from Brock (1954) at the same depth (6 m) in all sites, providing data on occurrences, abundances and size classes. Divers swam 20 m one way for 5-7 min along each transect, identifying and recording the number and size of each highly mobile fish species observed within a distance of 1 m on each side of the transect, and returned during 5-7 min accounting only for the cryptic species, reducing the underestimation of this fish group counts. Fish sizes were estimated (Total length - TL) according to four size classes (<10 cm, 11-20 cm, 21-30 cm, >31 cm) and written on PVC slates; being the total fish abundance of a

species the sum of size classes abundances. A pilot study was conducted in order to calibrate differences among divers regarding size classes estimation and no significant differences were observed among divers (ANOVA $p = 0.296$, $F = 1.216$). Transects were not conducted whenever visibility was less than 3 m. Fishes observed outside transects' boundaries were also identified to compose the checklist.

Data analyses

Variations in the composition and structure of the community were investigated using mean densities (fish/100m²). The dominance-diversity curves of all six sampling sites, based on the species' relative abundance, were compared graphically in association with indexes of diversity Shannon (H') and the evenness (J') (Magurran, 2004).

Species were also classified according to their frequency of occurrence in samples as frequent (100-70%), common (69-30%), occasional (29-5%) and rare (<5%).

Once assumptions of normality and homoscedasticity (Levene's test) were not met (Zar, 1999; Kochzius, 2002) for analysis of variance (ANOVA) the non-parametric Kruskal-Wallis test (Zar, 1999) followed by the *post-doc* Dunn test, when applicable, were applied. Mean density for selected species were compared yearly between inside and outside MPA, by *Student's t test*; alternatively the non-parametric Mann-Whitney test was applied when assumptions of the first were not met (Zar, 1999).

Trophic classifications were based on Ferreira *et al.* (2004); Floeter *et al.* (2004) and Froese & Pauly (2009) and the five major trophic categories proposed follow Rangel *et al.* (2007): Herbivores (Hb) - fishes that feed mostly on algae and include different behaviors such as territorial, browsing, and roving fishes; Invertebrate feeders (In) - feed mostly on sessile and mobile invertebrates; Carnivores (Ca) - feed mostly on fishes, but also include invertebrates on their diet; Planktivores (Pl) - includes day and night planktivores feeding on micro and macrozooplankton, and Omnivores (Om) - feed on algae, detritus and small invertebrates.

Results

A total of 121 species belonging to 84 genera and 47 families was observed (Table 1). From these, 25 species were only included in the checklist and were not considered for any

subsequent analyses, once they never occurred inside one of the 418 40m² transects, which accounted to 29801 fish, in a surveyed area of 16720m² (approx. 140h of observations).

The richest families were Carangidae (11 spp.) Serranidae (9 spp.), Labridae (5 spp.), Haemulidae and Labrisomidae (both with 6 spp). *Haemulon aurolineatum* (Cuvier, 1830) was the most abundant species in all sites pooled (Figure 2), followed by *Stegastes fuscus* (Cuvier, 1830), *Decapterus macarellus* (Cuvier, 1833), *Coryphopterus glaucofraenum* Gill, 1863 and *Abudefduf saxatilis* (Linnaeus, 1758), that together accounted to 56,8% of total number of fishes.

Stegastes fuscus was the most frequent species (Figure 3), followed by *Malacoctenus cf. delalandii* (Valenciennes, 1836), *Parablennius marmoratus* (Poey, 1876), *Abudefduf saxatilis*, and *Epinephelus marginatus* (Lowe, 1834).

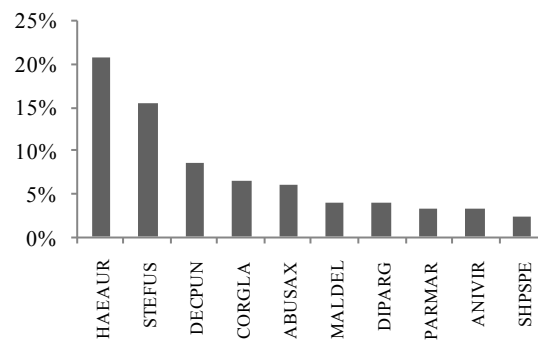


Figure 2. Percentage of the ten most relative abundant species during the study.

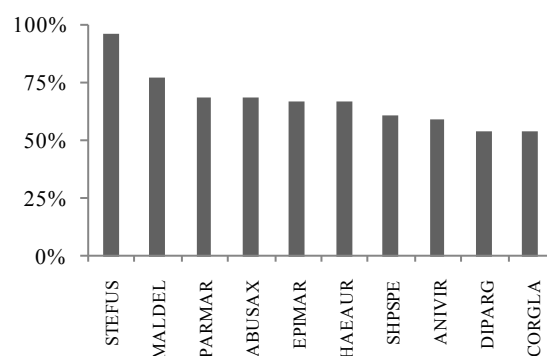


Figure 3. Frequency of occurrence of the ten most frequent species on transects during the study.

Table 1. Checklist of rocky reef fishes from Arvoredo Marine Biological Reserve. Families are arranged according to Nelson (2006). Data for trophic category (TC) follows as Ca, Carnivores; Hb, Herbivores; In, Invertivores; Om, Omnivores; Pl, Planktivores. Total number of specimens counted (n), Relative Abundance (RA), Frequency of occurrence (FO), overall Density (fish/100m²) (D); Pooled density (fish/100m²) for sites inside (Din), and outside (Dout) the AMBR; Standard error (s.e.). Bold numbers indicate the ten highest values. Asterisks at (n) indicate observed species, but not inside transects.

Family	Species	TC	n	RA	FO	D	s.e.	Din	s.e.	Dout	s.e.
Narcinidae	<i>Narcine brasiliensis</i> (Olfers, 1831)	In	*								
Dasyatidae	<i>Dasyatis centroura</i> (Mitchill, 1815)	In	*								
Gymnuridae	<i>Gymnura altavela</i> (Linnaeus, 1758)	In	*								
Muraenidae	<i>Gymnothorax funebris</i> Ranzani, 1840	Ca	3	0.01	0.72	0.02 ± 0.01		0.03 ± 0.02			
	<i>Gymnothorax moringa</i> (Cuvier, 1829)	Ca	6	0.02	1.44	0.04 ± 0.01		0.04 ± 0.02		0.03 ± 0.02	
	<i>Gymnothorax vicinus</i> (Castelnau, 1855)	Ca	3	0.01	0.72	0.02 ± 0.01		0.03 ± 0.02			
Ophichthidae	<i>Myrichthys breviceps</i> (Richardson, 1848)	In	1	<0.01	0.24	0.01 ± 0.01				0.01 ± 0.01	
	<i>Myrichthys ocellatus</i> (Lesueur, 1825)	In	19	0.06	4.55	0.11 ± 0.03		0.04 ± 0.02		0.21 ± 0.05	
Clupeidae	<i>Harengula clupeola</i> (Cuvier, 1829)	Pl	500	1.68	1.20	2.99 ± 1.33		1.05 ± 1.05		5.52 ± 2.74	
	<i>Sardinella janeiro</i> (Eigenmann, 1894)	Pl	330	1.11	0.72	1.97 ± 1.15				4.56 ± 2.64	
Synodontidae	<i>Synodus synodus</i> (Linnaeus, 1758)	Ca	3	0.01	0.72	0.02 ± 0.01		0.01 ± 0.01		0.03 ± 0.02	
Batrachoididae	<i>Porichthys porosissimus</i> (Cuvier, 1829)	Ca	*								
Ogcocephalidae	<i>Ogcocephalus vespertilio</i> (Linnaeus, 1758)	Ca	11	0.04	2.63	0.07 ± 0.02		0.11 ± 0.03		0.01 ± 0.01	
Mugilidae	<i>Mugil curema</i> (Valenciennes, 1836)	Hb	27	0.09	1.20	0.16 ± 0.09		0.28 ± 0.15			
	<i>Mugil platanus</i> Günther, 1880	Hb	3	0.01	0.24	0.02 ± 0.02				0.04 ± 0.04	
Hemiramphidae	<i>Hemiramphus brasiliensis</i> (Linnaeus, 1758)	Om	211	0.71	0.96	1.26 ± 0.74		1.48 ± 1.13		0.98 ± 0.85	
Holocentridae	<i>Holocentrus adscensionis</i> (Osbeck, 1765)	In	106	0.36	19.86	0.63 ± 0.07		0.92 ± 0.11		0.26 ± 0.07	
	<i>Myripristis jacobus</i> Cuvier, 1829	Pl	1	<0.01	0.24	0.01 ± 0.01		0.01 ± 0.01			
Syngnathidae	<i>Micrognathus crinitus</i> (Jenyns, 1842)	Pl	23	0.08	2.39	0.14 ± 0.08		0.24 ± 0.13			
	<i>Hippocampus reidi</i> Ginsburg, 1933	In	3	0.01	0.72	0.02 ± 0.01		0.02 ± 0.01		0.01 ± 0.01	
	<i>Fistularia tabacaria</i> Linnaeus, 1758	Ca	*								
Dactylopteridae	<i>Dactylopterus volitans</i> (Linnaeus, 1758)	In	*								

Scorpaenidae	<i>Scorpaena brasiliensis</i> Cuvier, 1829	Ca	2	0.01	0.48	0.01 ± 0.01		0.03 ± 0.02
Centropomidae	<i>Centropomus undecimalis</i> (Bloch, 1792)	Ca	39	0.13	1.67	0.23 ± 0.10	0.12 ± 0.07	0.39 ± 0.22
Serranidae	<i>Diplectrum radiale</i> (Quoy & Gaimard, 1824)	Ca	2	0.01	0.48	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
	<i>Dules auriga</i> Cuvier, 1829	In	*					
	<i>Epinephelus marginatus</i> (Lowe, 1834)	Ca	672	2.25	67.22	4.02 ± 0.20	5.12 ± 0.29	2.58 ± 0.23
	<i>Epinephelus morio</i> (Valenciennes, 1828)	Ca	1	<0.01	0.24	0.01 ± 0.01	0.01 ± 0.01	
	<i>Epinephelus niveatus</i> (Valenciennes, 1828)	Ca	59	0.20	11.48	0.35 ± 0.05	0.37 ± 0.07	0.33 ± 0.07
	<i>Mycteroperca acutirostris</i> Bean, 1882	Ca	403	1.35	49.04	2.41 ± 0.16	2.07 ± 0.18	2.86 ± 0.29
	<i>Mycteroperca bonaci</i> (Poey, 1860)	Ca	43	0.14	8.61	0.26 ± 0.04	0.34 ± 0.07	0.15 ± 0.04
	<i>Mycteroperca interstitialis</i> (Poey, 1860)	Ca	15	0.05	3.35	0.09 ± 0.02	0.06 ± 0.03	0.12 ± 0.04
	<i>Paranthias furcifer</i> (Valenciennes, 1828)	Pl	1	0.00	0.24	0.01 ± 0.01		0.01 ± 0.01
	<i>Serranus atrobranchus</i> (Cuvier, 1829)	In	*					
	<i>Serranus flaviventris</i> (Cuvier, 1829)	In	47	0.16	7.42	0.28 ± 0.06	0.46 ± 0.09	0.04 ± 0.03
Apogonidae	<i>Apogon pseudomaculatus</i> Longley, 1932	Pl	3	0.01	0.72	0.02 ± 0.01	0.03 ± 0.02	
Malacanthidae	<i>Malacanthus plumieri</i> (Bloch, 1786)	Ca	4	0.01	0.72	0.02 ± 0.01	0.01 ± 0.01	0.04 ± 0.03
Carangidae	<i>Alectis ciliaris</i> (Bloch, 1787)	Ca	6	0.02	0.24	0.04 ± 0.04		0.08 ± 0.08
	<i>Carangoides crysos</i> (Mitchill, 1815)	Ca	6	0.02	0.24	0.04 ± 0.04		0.08 ± 0.08
	<i>Caranx bartholomaei</i> (Cuvier, 1833)	Ca	221	0.74	2.15	1.32 ± 0.72	1.79 ± 1.16	0.70 ± 0.69
	<i>Caranx latus</i> Agassiz, 1831	Ca	*					
	<i>Decapterus macarellus</i> (Cuvier, 1833)	Pl	2544	8.54	7.42	15.22 ± 3.49	18.08 ± 4.05	11.46 ± 6.05
	<i>Oligoplites saliens</i> (Bloch, 1793)	In	*					
	<i>Pseudocaranx dentex</i> (Bloch & Schneider, 1801)	Pl	271	0.91	3.59	1.62 ± 0.65	2.71 ± 1.14	0.19 ± 0.09
	<i>Selene vomer</i> (Linnaeus, 1758)	Ca	2	0.01	0.48	0.01 ± 0.01	0.02 ± 0.01	
	<i>Seriola dumerili</i> (Risso, 1810)	Ca	10	0.03	0.48	0.06 ± 0.04	0.11 ± 0.08	
	<i>Seriola lalandi</i> Valenciennes, 1833	Ca	186	0.62	0.72	1.11 ± 0.92	1.96 ± 1.61	
	<i>Seriola rivoliana</i> Valenciennes, 1833	Ca	48	0.16	2.39	0.29 ± 0.14	0.45 ± 0.24	0.07 ± 0.07
	<i>Trachinotus falcatus</i> (Linnaeus, 1758)	Ca	1	<0.01	0.24	0.01 ± 0.01		0.01 ± 0.01
Carangidae	<i>Trachinotus goodei</i> (Jordan & Evermann, 1896)	Ca	*					

Lutjanidae	<i>Lutjanus analis</i> (Cuvier, 1828)	Ca	2	0.01	0.48	0.01 ± 0.01	0.02 ± 0.01	
Haemulidae	<i>Anisotremus surinamensis</i> (Bloch, 1791)	In	68	0.23	8.85	0.41 ± 0.10	0.62 ± 0.17	0.12 ± 0.05
	<i>Anisotremus virginicus</i> (Linnaeus, 1758)	In	950	3.19	59.33	5.68 ± 0.63	8.33 ± 1.07	2.21 ± 0.22
	<i>Haemulon aurolineatum</i> (Cuvier, 1830)	In	6131	20.57	66.99	36.67 ± 3.64	53.30 ± 5.98	14.89 ± 2.22
	<i>Haemulon parra</i> (Desmarest, 1823)	In	30	0.10	0.24	0.18 ± 0.18		0.41 ± 0.41
	<i>Haemulon steindachneri</i> (Jordan & Gilbert, 1882)	In	385	1.29	27.75	2.30 ± 0.34	3.09 ± 0.54	1.27 ± 0.31
	<i>Orthopristis ruber</i> (Cuvier, 1830)	In	18	0.06	0.24	0.11 ± 0.11		0.25 ± 0.25
Sparidae	<i>Calamus penna</i> (Valenciennes, 1830)	In	1	<0.01	0.24	0.01 ± 0.01	0.01 ± 0.01	
	<i>Diplodus argenteus</i> (Valenciennes, 1830)	Om	1131	3.80	54.31	6.76 ± 0.74	7.18 ± 1.08	6.22 ± 0.96
	<i>Pagrus pagrus</i> (Linnaeus, 1758)	In	4	0.01	0.72	0.02 ± 0.01	0.04 ± 0.03	
Sciaenidae	<i>Odontoscion dentex</i> (Cuvier, 1830)	Ca	283	0.95	26.79	1.69 ± 0.22	1.53 ± 0.24	1.91 ± 0.39
	<i>Pareques acuminatus</i> (Bloch & Scheneider, 1801)	In	324	1.09	43.78	1.94 ± 0.15	1.69 ± 0.19	2.27 ± 0.24
Mullidae	<i>Pseudupeneus maculatus</i> (Bloch, 1793)	In	337	1.13	28.71	2.02 ± 0.23	1.73 ± 0.28	2.39 ± 0.39
Pempheridae	<i>Pempheris schomburgkii</i> Müller & Troschel, 1848	Pl	26	0.09	0.48	0.16 ± 0.14	0.27 ± 0.24	
Kyphosidae	<i>Kyphosus</i> sp.	Hb	599	2.01	24.16	3.58 ± 0.48	4.92 ± 0.75	1.84 ± 0.48
Chaetodontidae	<i>Chaetodon striatus</i> Linnaeus, 1758	In	516	1.73	50.24	3.09 ± 0.21	3.22 ± 0.27	2.91 ± 0.32
Pomacanthidae	<i>Holacanthus ciliaris</i> (Linnaeus, 1758)	In	*					
	<i>Holacanthus tricolor</i> (Bloch, 1795)	In	*					
	<i>Pomacanthus arcuatus</i> (Linnaeus, 1758)	Om	2	0.01	0.24	0.01 ± 0.01	0.02 ± 0.02	
	<i>Pomacanthus paru</i> (Bloch, 1787)	Om	99	0.33	16.51	0.59 ± 0.08	0.91 ± 0.12	0.18 ± 0.05
Pomacentridae	<i>Abudefduf saxatilis</i> (Linnaeus, 1758)	Om	1767	5.93	68.66	10.57 ± 0.91	14.42 ± 1.48	5.52 ± 0.68
	<i>Chromis</i> cf. <i>enchrysur</i> Jordan & Gilbert, 1882	Pl	*					
	<i>Chromis multilineata</i> (Guichenot, 1853)	Pl	192	0.64	27.27	1.15 ± 0.11	1.78 ± 0.17	0.32 ± 0.09
	<i>Stegastes fuscus</i> (Cuvier, 1830)	Hb	4587	15.39	96.89	27.43 ± 0.99	31.34 ± 1.34	22.32 ± 1.38
	<i>Stegastes pictus</i> (Castelnau, 1855)	Hb	11	0.04	2.39	0.07 ± 0.02	0.02 ± 0.01	0.12 ± 0.04
	<i>Stegastes variabilis</i> (Castelnau, 1855)	Hb	61	0.20	11.72	0.36 ± 0.05	0.22 ± 0.06	0.55 ± 0.10
Labridae	<i>Bodianus pulchellus</i> (Poey, 1860)	In	5	0.02	0.96	0.03 ± 0.02		0.07 ± 0.04
	<i>Bodianus rufus</i> (Linnaeus, 1758)	In	45	0.15	6.22	0.27 ± 0.08	0.43 ± 0.14	0.06 ± 0.03

	<i>Halichoeres brasiliensis</i> (Bloch, 1791)	In	1	<0.01	0.24	0.01 ± 0.01	0.01 ± 0.01	
	<i>Halichoeres poeyi</i> (Steindachner, 1867)	In	105	0.35	16.99	0.63 ± 0.08	0.24 ± 0.06	1.13 ± 0.16
	<i>Xyrichtys novacula</i> (Linnaeus, 1758)	In	*					
Scaridae	<i>Cryptotomus roseus</i> Cope, 1871	Hb	40	0.13	1.91	0.24 ± 0.11	0.05 ± 0.05	0.48 ± 0.24
	<i>Scarus trispinosus</i> Valenciennes, 1840	Hb	3	0.01	0.24	0.02 ± 0.02	0.03 ± 0.03	
	<i>Scarus zelindae</i> Moura, Figueiredo & Sazima, 2001	Hb	1	<0.01	0.24	0.01 ± 0.01	0.01 ± 0.01	
	<i>Sparisoma amplum</i> (Ranzani, 1842)	Hb	16	0.05	3.83	0.10 ± 0.02	0.14 ± 0.04	0.04 ± 0.02
	<i>Sparisoma axillare</i> (Steindachner, 1878)	Hb	113	0.38	14.83	0.68 ± 0.12	0.74 ± 0.18	0.59 ± 0.14
	<i>Sparisoma frondosum</i> (Agassiz, 1831)	Hb	222	0.74	24.40	1.33 ± 0.17	1.60 ± 0.27	0.97 ± 0.18
	<i>Sparisoma radians</i> (Valenciennes, 1840)	Hb	167	0.56	16.99	1.00 ± 0.15	1.30 ± 0.24	0.61 ± 0.14
Blenniidae	<i>Sparisoma tuiupiranga</i> Gasparini, Joyeux & Floeter, 2003	Hb	2	0.01	0.24	0.01 ± 0.01	0.02 ± 0.02	
	<i>Hypseurochilus fissicornis</i> (Quoy & Gaimard, 1824)	In	25	0.08	4.07	0.15 ± 0.04	0.17 ± 0.05	0.12 ± 0.07
	<i>Hypsoblennius invemar</i> Smith-Vaniz & Acero, 1980	Om	*					
	<i>Ophioblennius trinitatis</i> (Miranda-Ribeiro, 1919)	Hb	6	0.02	1.44	0.04 ± 0.01	0.06 ± 0.03	
	<i>Parablennius marmoreus</i> (Poey, 1876)	Om	954	3.20	69.38	5.71 ± 0.32	4.27 ± 0.35	7.58 ± 0.56
	<i>Parablennius pilicornis</i> (Cuvier, 1829)	Om	100	0.34	16.03	0.60 ± 0.08	0.58 ± 0.10	0.62 ± 0.14
Labrisomidae	<i>Scartella cristata</i> (Linnaeus, 1758)	Hb	*					
	<i>Labrisomus kalisherae</i> (Jordan, 1904)	In	1	<0.01	0.24	0.01 ± 0.01		0.01 ± 0.01
	<i>Labrisomus nuchipinnis</i> (Quoy & Gaimard, 1824)	In	6	0.02	1.44	0.04 ± 0.01	0.04 ± 0.02	0.03 ± 0.02
	<i>Malacoctenus</i> cf. <i>delalandii</i> (Valenciennes, 1836)	In	1161	3.90	77.27	6.94 ± 0.39	5.63 ± 0.39	8.66 ± 0.72
	<i>Paraclinus spectator</i> Guimarães & Bacelar, 2002	In	5	0.02	1.20	0.03 ± 0.01	0.01 ± 0.01	0.06 ± 0.03
	<i>Starksia brasiliensis</i> (Gilbert, 1900)	In	32	0.11	7.18	0.19 ± 0.03	0.22 ± 0.05	0.15 ± 0.05
	<i>Starksia</i> sp.	In	1	0.00	0.24	0.01 ± 0.01		0.01 ± 0.01
Chaenopsidae	<i>Emblemariopsis signifera</i> (Ginsburg, 1942)	In	175	0.59	16.03	1.05 ± 0.17	1.52 ± 0.27	0.43 ± 0.16
	Gobiidae	<i>Coryphopterus glaucofraenum</i> Gill, 1863	Om	1913	6.42	54.07	11.44 ± 0.89	15.26 ± 1.36
Ephippidae		<i>Chaetodipterus faber</i> (Broussonet, 1782)	Om	*				
	Acanthuridae	<i>Acanthurus bahianus</i> (Castelnau, 1855)	Hb	26	0.09	1.91	0.16 ± 0.10	0.23 ± 0.17
<i>Acanthurus chirurgus</i> (Bloch, 1787)		Hb	25	0.08	4.31	0.15 ± 0.04	0.06 ± 0.03	0.26 ± 0.09

	<i>Acanthurus coeruleus</i> Bloch & Schneider, 1801	Hb	*						
Shpyraenidae	<i>Sphyraena cf. borealis</i> DeKay, 1842	Ca	485	1.63	5.74	2.90 ± 0.80	1.72 ± 0.84	4.45 ± 1.48	
Paralichthyidae	<i>Cyclosetta fimbriata</i> (Goode & Bean, 1885)	Ca	*						
	<i>Syacium micrurum</i> Ranzani, 1842	In	*						
Bothidae	<i>Bothus ocellatus</i> (Agassiz, 1831)	In	5	0.02	0.72	0.03 ± 0.02	0.05 ± 0.03		
	<i>Balistes vetula</i> Linnaeus, 1758	In	8	0.03	1.44	0.05 ± 0.02	0.08 ± 0.04		
	<i>Aluterus scriptus</i> (Osbeck, 1765)	Om	1	0.00	0.24	0.01 ± 0.01	0.01 ± 0.01		
	<i>Stephanolepis hispidus</i> (Linnaeus, 1766)	Om	61	0.20	7.42	0.36 ± 0.08	0.24 ± 0.07	0.52 ± 0.16	
Ostraciidae	<i>Acanthostracion polygonius</i> (Poey, 1876)	In	11	0.04	1.20	0.07 ± 0.04	0.12 ± 0.08		
	<i>Acanthostracion quadricornis</i> (Linnaeus, 1758)	In	*						
Tetraodontidae	<i>Canthigaster figueiredoi</i> Moura & Castro, 2002	Om	10	0.03	1.67	0.06 ± 0.03	0.09 ± 0.04	0.01 ± 0.01	
	<i>Sphoeroides greeleyi</i> (Gilbert, 1900)	In	*						
	<i>Sphoeroides spengleri</i> (Bloch, 1785)	In	710	2.38	61.48	4.25 ± 0.29	4.97 ± 0.45	3.30 ± 0.31	
	<i>Sphoeroides testudineus</i> (Linnaeus, 1758)	In	*						
Diodontidae	<i>Diodon hystrix</i> Linnaeus, 1758	In	*						

Reef-fish indexes and distribution in sampled areas

The mean species richness (\pm standard error) per census was 12.49 ± 0.17 species, with a minimum of 4 and a maximum of 22 species. The mean number of individuals per census was 71.29 ± 2.87 , with a minimum of 10 and a maximum of 446 fishes; and mean density was 1.78 ± 0.07 fish/m², with a minimum of 0.25 fish/m² and a maximum of 11.5 fish/m². Pooled sites were analyzed and results are shown in Table 2.

Table 2. Summary of fish community structure (mean \pm standard error) and Mann-Whitney results of comparisons between samples inside and outside the AMBR. Values for species richness (number of species per census); total number of fishes per census (N), evenness (J'), diversity (H') and density (fish/m²).

	inside	outside		
Richness	13.22 \pm 0.23	11.54 \pm 0.27	$p < 0.001^*$	Z=4.40
N	85.04 \pm 4.02	53.29 \pm 3.66	$p < 0.001^*$	Z=8.07
J'	0.73 \pm 0.01	0.79 \pm 0.01	$p < 0.001^*$	Z=5.43
H'	1.87 \pm 0.03	1.91 \pm 0.03	$p = 0.263$	Z=1.12
Density	2.12 \pm 0.10	1.33 \pm 0.09	$p < 0.001^*$	Z=8.07

The analysis over sampled sites, revealed that mean richness was highest at PON (13.96 ± 0.42) and lowest at PTC (9.72 ± 0.38). Diversity (H') was highest at SAF (2.23 ± 0.036) and lowest at PTC (1.63 ± 0.048), while evenness (J') was highest at SAF (0.876 ± 0.011) and lowest at PTL (0.705 ± 0.015).

Dominance-diversity curves for sites had similar patterns considering all species, which allows observing the richest sites (extremes were PON and SAF – 53 and 44 species respectively). Our analysis focused the first 15 species in order to observe dominances.

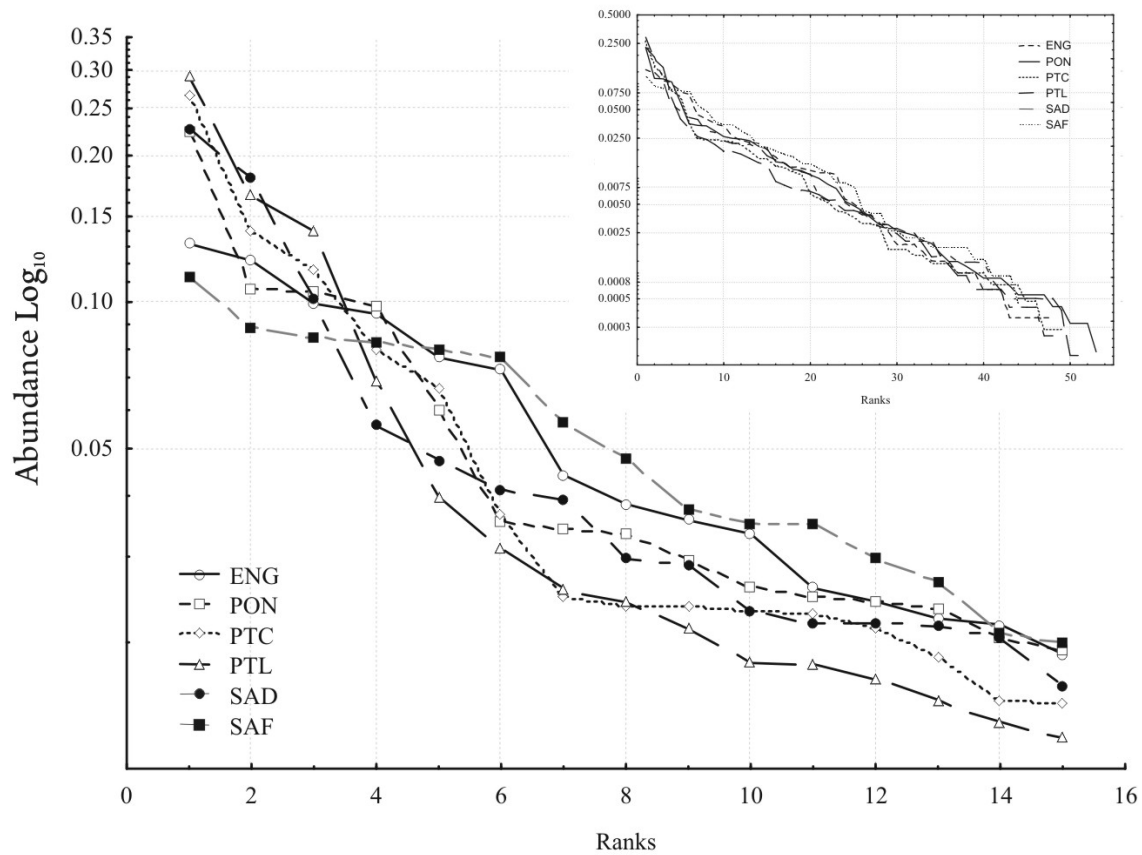


Figure 4: Dominance-diversity curves for each sampled sites inside AMBR: Saco D'água (SAD), Ponta do Letreiro (PTL), Porto Norte (PON), and outside are Ponta do Capim (PTC), Engenho (ENG) and Saco do Farol (SAF). 15 most abundant species, and in detail all the species for each site.

Trophic structure

The majority (33%) of the fish species observed were invertivores (In), including 16 families with Labrisomidae and Haemulidae (6 spp.) and Labridae (4 spp.) as the richest ones. Carnivores (Ca), accounted to 27% of species, where Carangidae (8 spp.) and Serranidae (8 spp.) were the richest, followed by Herbivores (Hb) with 18% and six families, being Scaridae the richest (8 spp). Omnivores (Om) accounted for 12% of the species and included eight families, followed by Planctivores (Pl) (10%) with ten families as well (Figure 5).

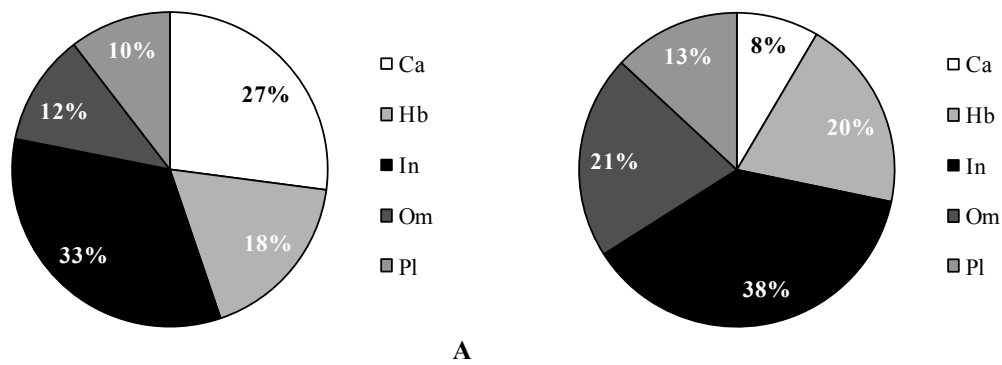


Figure 5. Trophic categories of rocky reef fishes recorded at AMBR: **A**. number of species in each category; **B**. relative abundances.

Observing the number of species and the relative abundance (RA), and species composition of each trophic category (Figure 5), the dominant group, invertivores composed by 32 species, was mostly represented by *H. aurolineatum* (that also accounted to the highest densities in all sites), followed by *A. virginicus*, *M. delalandii* and *S. spengleri*. Except for PTC and ENG (both outside AMBR), invertivores accounted to values higher than 35% of relative abundance at all sites (Figure 6).

Carnivores, the second richest trophic category with 26 species, had its highest densities inside the AMBR, represented by *E. marginatus* (5.1/100m²). The following species with high RA values were *S. borealis*, *M. acutirostris* and *O. dentex*.

Omnivores, composed by 11 species had relative abundances higher than 25% at PON, ENG and SAF, and the most representative species were *C. glaucofraenum*, *A. saxatilis*, *D. argenteus* and *P. marmoreus*, all with high frequencies of occurrence. PTC had the lowest values of relative abundance, and was dominated by *P. marmoreus*.

Among the 17 herbivore species, richness varied from 12 species at PTL to eight at PTC. A clear dominance was observed by *S. fuscus* and *Kyphosus* sp. at all sites, except for SAF, where *S. frondosum* replaced the latter. Only at PTC the relative abundance of herbivores (30.0%) was superior to invertivores (27.9%).

Planktivores, the least rich category, with ten species, had seven species present at SAD, while at SAF, only two species. The most abundant species were *D. macarellus*, *H. clupeiola* and *S. janeiro*. *P. dentex* was also responsible for high values, associated specifically to PON (8.0/100m²). Among all the planktivores, *C. multilineata* was the unique species with a frequency of occurrence superior to 8.0%.

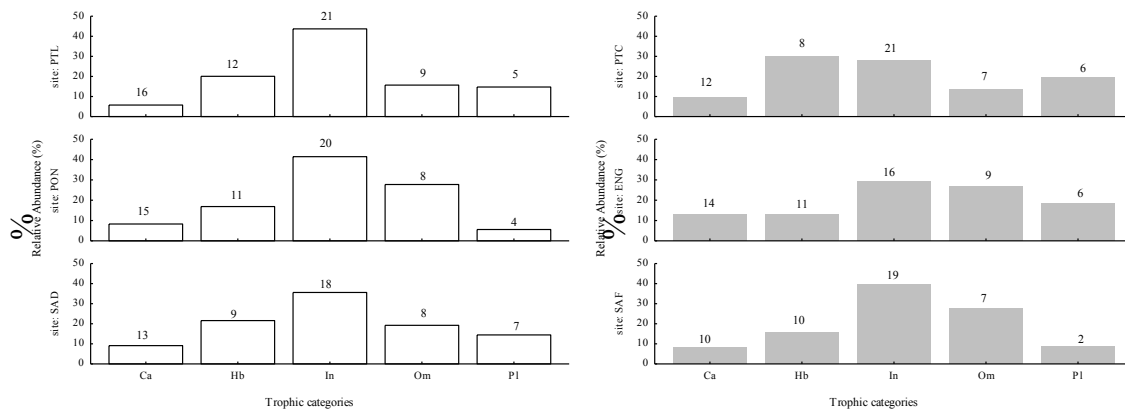


Figure 6. Relative Abundance of trophic categories among sampled sites grouped in inside (left) and outside (right) the AMBR. Numbers refer to richness.

Target species

In order to evaluate primary evidences (increase in the abundance and the proportion of larger/older individuals) of effectiveness of the AMBR, two target species in Santa Catarina were selected in order to evaluate their densities (including size classes), among years, inside and outside the AMBR. Densities (fish/100m²) of each size class of the dusky grouper, *E. marginatus* (Figure 7) and the comb grouper, *M. acutirostris* (Figure 8), are presented and compared: inside (left column) and outside (right column) the AMBR, for each sampled year. For the dusky grouper, *E. marginatus*, differences of size classes were observed for the second class (11-20 cm), between 2006 inside and 2007 inside, and for the third class (21-30 cm) between the group (2006 inside, 2008 in/outside) and 2007 outside. The first and fourth classes were homogeneous among years/areas.

Differences among size classes within area/year were mostly clear between the (< 10 cm) and the grouped second and third (11-30 cm) classes (see 2006 inside, 2008 in/outside and 2009 inside).

Comparisons between densities inside and outside the AMBR were significantly different ($Z=3.83$, $p<0.001$) only for 2006. Nonetheless, comparisons among years (inside or outside) revealed that 2006 inside and 2008 inside presented values significantly higher than 2007 inside, and on the other hand, 2008 outside was different than the previous years.

For the comb grouper, *M. acutirostris*, differences were evident just for the first size class (<10 cm), being the high density of 2008 outside equal only to 2009 inside. 2007 in/outside was marked by the lack of young comb groupers in this size class, which also turned to be the year with the lowest values, being different from 2009, when considering the area inside, and

also different from 2006 and 2008 in the outside analysis. Only 2008 showed significant differences between inside and outside ($Z=1.98, p=0.047$), but are not considered strong.

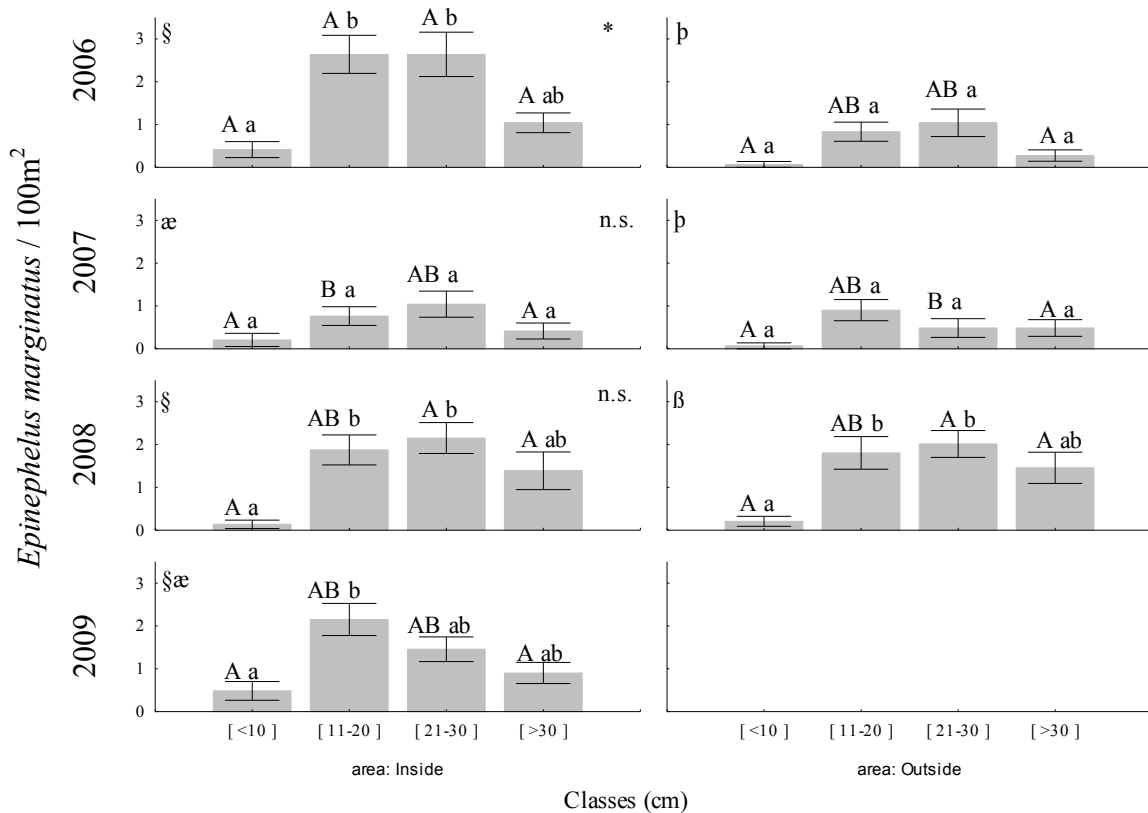


Figure 7: Mean density (fish/100m²) for each size class of *E. marginatus* inside (left column) and outside (right column) the AMBR, for each sampled year. Capital letters indicate homogeneous groups of the same size class among all years and areas; small letters indicate homogeneous groups among size classes in the same area, each year. Symbols on top-left indicate homogeneous groups for comparisons among years inside, and among years outside the AMBR. Asterisks (*) indicates significant differences between inside and outside for each year, and n.s. denotes no significant differences.

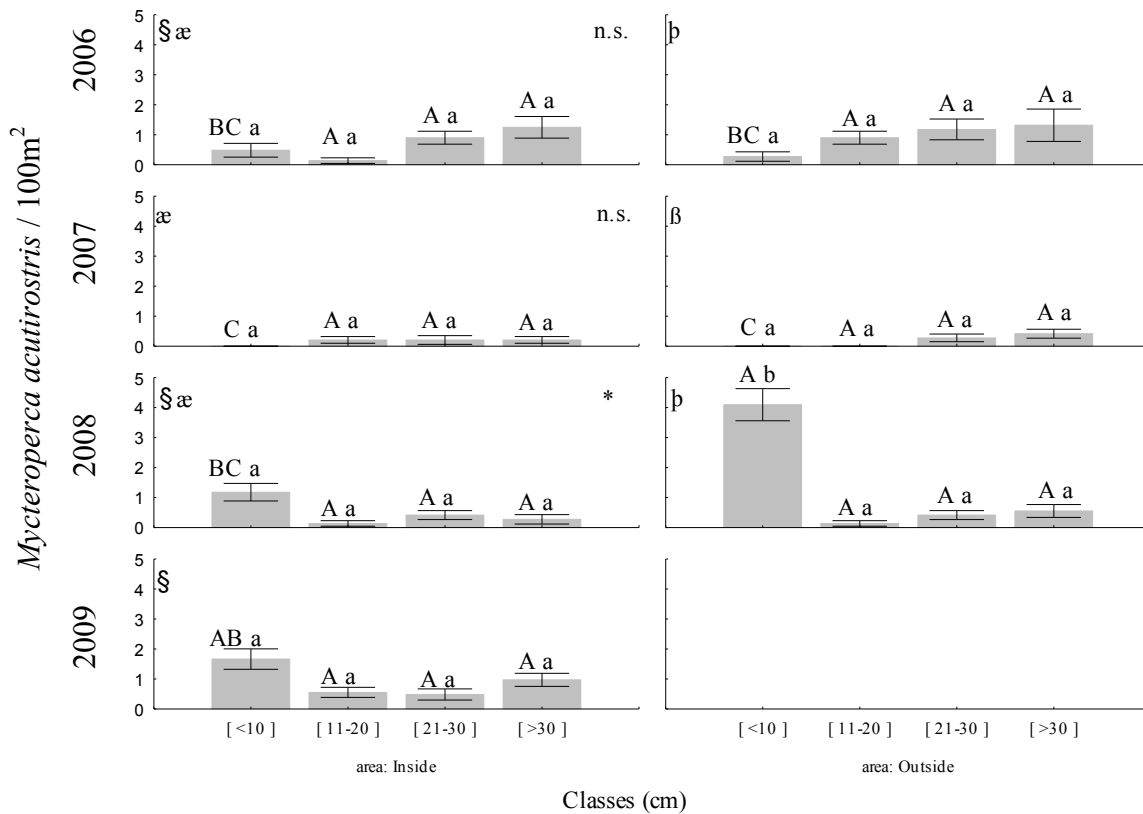


Figure 8: Mean density (fish/100m²) for each size class of *M. acutirostris* inside (left column) and outside (right column) the AMBR, for each sampled year. Capital letters indicate homogeneous groups of the same size class among all years and areas; small letters indicate homogeneous groups among size classes in the same area, each year. Symbols on top-left indicate homogeneous groups for comparisons among years inside, and among years outside the AMBR. Asterisks (*) indicates significant differences between inside and outside for each year, and n.s. denotes no significant differences.

Discussion

The dominance-diversity curves showed a clear minor dominance at SAF, being the most abundant species *A. saxatilis*, and the abundances from the second to the sixth species very close. This similar, but slightly steeper pattern was shared with ENG, where *C. glaucofraenum* and *H. aurolineatum* dominated. These were the southernmost sites, outside the reserve boundaries.

The remaining four sites presented steeper curves, where dominances were more evident. SAD and PTL, the northernmost sites within the reserve, were dominated by *H. aurolineatum*, *S. fuscus* and *D. macarellus*. PON and PTC, sites closer to the reserve limits, were dominated by *H. aurolineatum*, *A. saxatilis* and *S. fuscus* (PON), and *S. fuscus*, *D. macarellus* and *H. aurolineatum* (PTC).

The uncertainty and variability in dispersal patterns of marine organisms, such as shifts in resources abundances require proper attention in evaluating the performance of a MPA like the AMBR. Although *H. aurolineatum* was the most important invertivore observed at all sites, its dominance can be attributed to the presence of high densities of juveniles (TL<10 cm), detected in 2007 and 2009 samples. Furthermore, areas inside AMBR, sheltered the highest densities (Figure 6) of invertivores and extreme values of mean densities of *H. aurolineatum* were observed at PTL (69.4/100m²) and SAF (9.3/100m²).

The tentative conclusion of potential importance of sheltered areas as juvenile nursery habitats (e.g. for *H. aurolineatum* and *M. acutirostris*), has been proposed as a key factor establishing no-take Marine Protected Areas in Hawaiian islands (DeMartini, 2004), where spatial variations in recruitment among habitats of varying wave exposure, should be long-term evaluated. Especially considering that despite many empirical and theoretical studies and reviews (e.g., Doherty and Williams, 1988; Doherty, 1991; Caley *et al.*, 1996), recruitment and subsequent temporal variations in the abundance of fishes on coral reefs remain unclear (DeMartini, 2004).

Although grouping reef fish in trophic categories has been a problem widely discussed (Parrish, 1989), attempts have been done (Moura, 2003; Ferreira *et al.*, 2004; Rangel *et al.*, 2007) in order to evaluate the distributions of trophic categories proportions, ranging from broader (e.g. along huge latitudinal gradients) to simple (e.g. within an area) objectives.

This strong influence proportioned by *H. aurolineatum*, lead to the conclusion that invertivores are, despite differences in grouping categories, the most important trophic group in high latitudes, and not omnivores as stated by Ferreira *et al.* (2004). These differences are possibly due the presence of *M. delalandii* (Labrisomidae), a cryptic species that strongly influenced the proportions of invertivores, and this family was not considered in their analyses. A biased sample utilized by Ferreira *et al.* (2004) could have also lead to such different conclusions, possibly misinterpreting locally specific patterns as we observed. Reef fish community abundances was highly dynamic among years (see *Sparisoma* and *Acanthurus* case in Bertoncini *et al.*, *in prep.*), and trophic guilds may distinctly vary within an area leading to distinct results (Meekan and Choat, 1997; Forrester *et al.*, 2002; Moura, 2003).

Among carnivores, *S. borealis* occurred in numerous schools of small juveniles, accounting to high densities at ENG (11.1/100m²), which besides the expressive richness, it was the only site where carnivores were relatively more abundant than herbivores. Similarly, *S. lalandi*,

was represented by adults foraging along the shallow rocky shores. Both species can be considered rare, once their frequency of occurrence was inferior to 6.0%.

Important carnivores, such as *E. marginatus* and *M. acutirostris* are considered common at AMBR and are known as target species of line and hook, and spearfishing (Wharlich, 1999; *pers. obs.*).

The differences in relative abundance of omnivores among areas were driven by *C. glaucofraenum*. This small-sized species, was observed in high densities along the rock/sand interface. PON concentrated these values, once sampled depth was close to this interface. On the other hand, *C. glaucofraenum* was considered rare at PTC, the steepest rocky-shore abundant in boulders, dominated by *A. saxatilis* and *P. marmoreus* among omnivores. Moreover, this rarity of *C. glaucofraenum* at PTC, also reflected in the similar relative abundance for invertivores and herbivores (~30%), where the latter was represented by one of the highest densities of *S. fuscus* (38.9/100m²).

Among planktivores, despite their expressive contribution in the relative abundance, attention should be addressed to their frequency of occurrence, once the majority of species, excluding *C. multilineata* (72.3% FO), presented frequencies inferior to 8.0%, associated to high abundances. This was due to the presence of huge schools of small-sized species, such as *D. macarellus*, *H. clupeola* and *S. janeiro* crossing the sample units.

The analyses of size classes for *E. marginatus* clearly showed a dominance of subadults (11-30 cm) over young (>10 cm) in samples. These young are expected to occur in low densities at the sampled depth, once considering the ontogeny of this species, recruitment is known to occur in shallow environments such as tidal pools in South Brazil (see Barreiros *et al.*, 2004). Although differences were observed among years and between areas, so far there is not a clear pattern showing significant increases in abundances along the last four years among areas inside and outside the AMBR. One must consider that sampled depth (6 m) does not translate the true abundance of *E. marginatus*, once this species has clear ontogenetic shifts, in a way that larger individuals tend to inhabit deeper waters (Machado *et al.*, 2003) while these habitat changes influence its diet (Machado *et al.*, 2008), although large specimens (>80 cm) were (rarely) observed in shallow areas.

The comb grouper, *M. acutirostris*, had its differences driven by juveniles (<10 cm TL), once differences among size classes/areas/years were not much observed. These high densities of the first size class in 2008 outside AMBR, were associated to PTC and ENG (driving differences between in/outside) observed foraging over ichthyoplankton clouds, and cannot

be considered strong ($p=0.047$). Higher densities of third and fourth size classes were observed in 2006 (both inside and outside), but no significant differences were detected.

Unfortunately, this lack of differences was already observed in other studies comparing serranids abundances, like Mapstone *et al.* (1997) that used visual census to compare 10 green reefs (no fishing) with 14 blue (fished) outer-shelf reefs in the Cairns section of the Great Barrier Reef Marine Park in Australia and concluded that, after 8 years of zoning, there was virtually no difference in the density of coral trout (*Plectropomus leopardus*) between green and blue reefs.

Other similar studies report that significant increases in abundance of similar target species (groupers, snappers, porgies see García-Charton *et al.*, 2008), start to be more evident within a decade of evaluation, and of course, enforcement is crucial.

Unfortunately, poaching has been a rule, instead of an exception for the case of the AMBR since its creation, and constantly observed during our field trips. The reduction of fish standing stocks, especially among large predatory fishes was already notable worldwide (Jackson *et al.*, 2001; Pandolfi *et al.* 2003), and like in many other coastal areas, reefs have suffered from a suite of human impacts, including not only overfishing, but pollution and climate change, resulting in dramatic restructuring of the communities (Friedlander and DeMartini, 2002; Hughes *et al.*, 2003, Sandin *et al.*, 2008).

The AMBR is not an exception of malfunctioning MPA. It shares the same basic problems with MPAs worldwide, from Atol das Rocas (NE Brazil) and Abrolhos National Marine Park (Francini-Filho and Moura, 2008b) where poaching is known to occur, to the huge Great Barrier Reef Marine Park in Australia (Kelleher *et al.*, 1995; Mapstone *et al.*; 1997). Nonetheless, it is important to keep in mind that Brazilians attempts to evaluate MPAs efficiency without data previous to the establishment of the MPA have failed to conduct unequivocal analyses (see Floeter *et al.*, 2006; Francini-Filho and Moura, 2008a), but results tend to be positive in favor of MPA (see Ferreira and Maida, 2001; Floeter *et al.*, 2006).

The success of the AMBR relies heavily on community participation and understanding of the ultimate goal, as well as how an individual's actions directly impact the marine communities that surround the reserve along the rocky coasts.

The good side of the history is that the AMBR already has its Council (CORBIO), and although the process is slow, CORBIO meets periodically aggregating institutions to formulate proposals that focus on the AMBR's management, implementation and revision of the Management Plan, and also proposals to work with interested parties such as the

surrounding population, which include fishermen, dive operators, schools, tour operators (Scunas), NGOs and government agencies.

The number and size of marine protected areas in Brazil are insufficient, and some still lack management plans or have yet to receive the appropriate measures and infrastructure to make them effective (Amaral and Jablonski, 2005).

Considering historical conflicts at the AMBR since its creation, our data clearly reflect that we must consider that fishing mortality (F) is somewhat lower inside AMBR, at an unknown amount, but surely far from levels significantly lower than fished areas. While surveillance of poaching activity, the development and implementation of long-term educational programs, as well as, efforts to improve enforcement do not overcome the status of minimal (anecdotally IBAMA is aware of such needs), the AMBR will continue far from completing its objectives of protecting the rich ecosystem it shelters.

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*One hour from now,
Another species of life form
Will disappear off the face of the planet
Forever...and the rate is accelerating*

Countdown to Extinction, Megadeath (Countdown to Extinction, 1992)

CAPÍTULO II

A. ROCKY REEF FISH COMMUNITY STRUCTURE IN TWO AZOREAN ISLANDS (PORTUGAL) CENTRAL NORTH ATLANTIC

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Rocky reef fish community structure in two Azorean islands (Portugal) Central North Atlantic

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Abstract

The community structure of shallow rocky reef fish fauna of the Azores Archipelago is described from underwater visual censuses carried at eight areas (Terceira and Corvo islands). A total of 52 fish species from 26 different families was observed, and the ten most abundant fishes corresponded to 82.7% of all fishes. Trophic categories are given for observed species with comments on distribution and densities along sampled depth strata. Sparidae, Labridae and Carangidae were the most speciose families, being *Diplodus sargus*, *Pagellus acarne*, *Coris julis*, *Thalassoma pavo* and *Tripterygion delaisi* the most abundant species that consequently also accounted to the highest densities. Mean densities along sampled strata were tested for significant differences.

Key words: Shallow rocky reefs, fish communities, trophic structure.

Resumo

A estrutura da comunidade de peixes de recifes rochosos rasos do Arquipélago dos Açores é descrita a partir de censos visuais subaquáticos em oito áreas (Ilha Terceira e Ilha do Corvo). Um total de 52 espécies distribuídas em 26 famílias foi observado, sendo que as dez

mais abundantes corresponderam a 82,7% de todos os peixes. São apresentadas as categorias tróficas das espécies, com comentários sobre sua distribuição e densidades nos estratos de profundidade amostrados. Sparidae, Labridae e Carangidae foram as famílias mais ricas, sendo *Diplodus sargus*, *Pagellus acarne*, *Coris julis*, *Thalassoma pavo* e *Tripterygion delaisi* as espécies mais abundantes que consequentemente apresentaram as maiores densidades. As densidades médias foram testadas quanto a sua significância nos diferentes estratos de profundidade amostrados.

Palavras chave: Recifes rochosos rasos, comunidade de peixes, estrutura trófica.

Introduction

The Archipelago of Azores (Figure 1), the most isolated islands in the North Atlantic, is composed by nine volcanic islands, geologically recent, located close to the Mid-Atlantic Ridge (França *et al.*, 2003) and spread over 600 km separated from the nearest continental coasts by at least 1,300 km (Morton *et al.*, 1998), forming the Macaronesian archipelagos with Madeira, Canary and Cape Verde islands.

Terceira island is one of the five islands that form the central group of Azores, being also the third largest (385 Km²). With 29 Km of length and 18 Km width, it is located 150 Km from São Miguel island (where the Azores' capital, Ponta Delgada is located) and 55 Km from São Jorge island.

Corvo is the smallest island in the archipelago, located on the North American Plate along the Mid-Atlantic Ridge between the European and the American Plates. With only 17 Km², semi-circular form, 6.5 km long by 4 km wide, it is the most isolated island in Europe, along with the island of Flores forms the Occidental group.

The Azorean ichthyofauna started to be studied along the scientific expeditions to the Archipelago, specially at the end of XIXth century, but up to the 80's research basically produced species checklists and taxonomic reviews (Afonso, 2002).

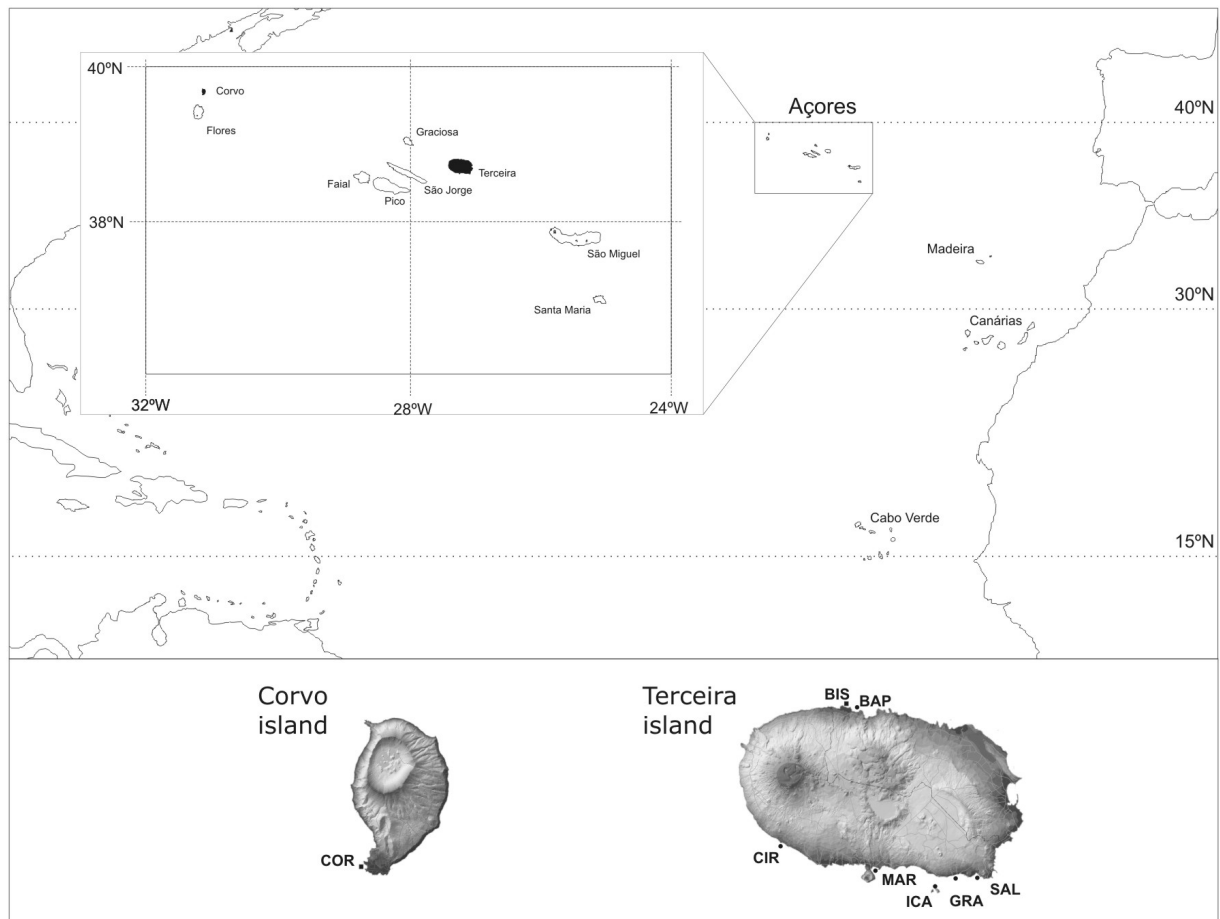


Figure 1: Azores Archipelago. Sampled islands in detail: Terceira and Corvo with respective sampled sites: Shallow tide pools: COR – Corvo, BIS – Biscoitos; Rocky reef shores: BAP – Baía das Pombas, CIR – Cinco Ribeiras, MAR – Marina, ICA – Ilhéu das Cabras, GRA – Gruta das Agulhas, SAL – Salgueiros.

Along the last two decades, the Archipelago has received significant contributions to the shore fish studies, on biology (e.g. Nash & Santos, 1993; Barreiros, 1995, Santos *et al.*, 1997, Morato *et al.*, 2000, 2001, Souza *et al.*, 2003), behaviour ecology (e.g. Santos, 1995; Barreiros & Santos, 1998; Azevedo *et al.*, 1999, Barreiros *et al.*, 2002, Soares *et al.*, 2002, Figueiredo *et al.*, 2005, Barreiros *et al.*, 2008; Bertoncini *et al.*, 2009), habitat use (Afonso *et al.*, 2009), community ecology (Ré, 1990; Patzner *et al.*, 1992, Patzner & Santos, 1993, Azevedo, 1997, Porteiro *et al.*, 1996; Porteiro *et al.*, 1998, Harmelin-Vivien *et al.*, 2001, Afonso, 2002, 2007), and intertidal ecology (e.g. Santos *et al.*, 1994, Azevedo *et al.*, 1995). These studies represent a reasonable knowledge on Azorean fish communities regarding their qualitative composition, biogeographical affinities and seasonal variations.

Despite major oceanographic current flow from west to east, the Azorean marine ichthyofauna fauna has stronger biogeographic affinities with the Eastern Atlantic than the West mainly with the archipelagos of Madeira and the Canaries, and to a lesser extent with

continental coasts of Northwest Africa, Southern Europe, and the Mediterranean (Santos *et al.*, 1995).

In the present study, we give an annotated list of the shallow coastal fish communities of the Azores archipelago, analyzing community structure parameters, trophic structure, with comments on their abundances at distinct areas and depths.

Material and Methods

Surveys were conducted from June to October 2007. Eight areas were considered in this study (Figure 1): one shallow open tidal pool at Corvo island; another shallow open tidal pool, five rocky shores and one rocky bottom within a marina at Terceira island. Samples covered four depth strata according to the rocky shore characteristics (2, 6, 9 and 14 m).

Reef fish community was assessed through 40 m² (20 m x 2 m) underwater strip transects, adapted from Brock (1954). Divers swam 20 m one way for 5-7 min along each transect, identifying and recording the number and size of each highly mobile fish species observed within a distance of 1 m on each side of the transect, and returned during 5-7 min accounting only for the cryptic species, reducing the underestimation of this fish group counts. Fish sizes were estimated according to four size classes (<10 cm, 11-20 cm, 21-30 cm, >31 cm) and written on PVC slates; being the total fish abundance of a species the sum of size classes abundances. Sampling methodology and divers remained the same during the whole period to minimize biases inherent in UVC (Kulbicki, 1998; Edgar *et al.*, 2004).

Variations in the composition and structure of the community were investigated using mean densities (fish/m²) (Magurran, 2004). The dominance-diversity curves of all eight sampling areas, based on the species' relative abundance, were compared graphically (Magurran, 2004). For the Marina (MAR) fish assemblages' differences between jetties and channels were determined by *Student's t test* (Zar, 1998).

Species were also classified according to their frequency of occurrence in samples as frequent (100-70%), common (69-30%), occasional (29-5%) and rare (<5%).

When assumptions of normality and homoscedasticity (teste by Levene's test) were met (Zar, 1998; Kochzius, 2002), analysis of variance (ANOVA) was used to evaluate spatial variations in fish densities at depth strata for 15-randomly-chosen censuses at each depth stratum. Tukey (HSD) test was performed as a *post-hoc* test (ZAR, 1998), when significant

differences were observed. Even when ANOVA assumptions were not met, the non-parametric Kruskal-Wallis test (Zar, 1998) followed by the *post-doc* Dunn test, when applicable, were applied.

The comparative analysis of fish community among sampled areas included a cluster analysis (UPGMA) using the Bray-Curtis similarity coefficient for density values (fish/m²). The matrix included all the species that contributed with a minimum mean value of 0.02 fish/m² in at least one area. Data were square root transformed to reduce the influence of the most abundant species.

Trophic classifications were based on Azevedo (1995), Harmelin-Vivien *et al.* (2001), Ferreira *et al.* (2004) and Froese & Pauly (2009) and are proposed: Herbivores (Hb) - fishes that feed mostly on algae and include different behaviours such as territorial, browsing, and roving fishes; Invertebrates feeders (In) - feed mostly on sessile and mobile invertebrates; Carnivores (Ca) - feed mostly on fishes, but also include invertebrates on their diet; Planktivores (Pl) - includes day and night planktivores feeding on micro and macrozooplankton, and Omnivores (Om) - feed on algae, detritus and small invertebrates.

Results

A total of 52 species belonging to 45 genera and 26 families was observed (Table 1). From these, ten species were only included in the checklist and were not considered for any subsequent analyses, once they never occurred inside one of the 103 40m² transects, which accounted to 7209 fish. Common names can be assessed at the Department of Oceanography and Fisheries from the University of Azores (www.horta.uac.pt).

Table 1. Checklist of rocky reef fishes from Azores Archipelago. Data for trophic category (TC) follows as Ca, Carnivores; Hb, Herbivores; In, Invertivores; Om, omnivores; Pl, Planktivores. Families are arranged according to Nelson (2006). Mean density values over 0.1 fish/m² are in boldface.

Family	Species	TC	RA	FO	MD	± St.Er.
Dasyatidae	<i>Dasyatis pastinaca</i> (Linnaeus, 1758)	Ca	0,01	0,98	0,000	0,02
Myliobatidae	<i>Myliobatis aquila</i> (Linnaeus, 1758)	Ca				
Congridae	<i>Conger conger</i> (Linnaeus, 1758)	Ca				
Muraenidae	<i>Gymnothorax unicolor</i> (Delaroche, 1809)	Ca	0,04	2,94	0,001	0,02
	<i>Muraena augusti</i> (Kaup, 1856)	Ca	0,08	5,88	0,001	0,02
	<i>Muraena helena</i> Linnaeus, 1758	Ca	0,06	2,94	0,001	0,02
Synodontidae	<i>Synodus saurus</i> (Linnaeus, 1758)	Ca	0,42	5,88	0,007	0,06
Phycidae	<i>Phycis phycis</i> (Linnaeus, 1766)	Ca	0,01	0,98	0,000	0,02
	<i>Gaidropsarus guttatus</i> (Collett, 1890)	Ca				
Scorpaenidae	<i>Scorpaena maderensis</i> Valenciennes, 1833	Ca	3,88	62,75	0,069	0,03
	<i>Scorpaena notata</i> Rafinesque, 1810	Ca				
Serranidae	<i>Epinephelus marginatus</i> (Lowe, 1834)	Ca	1,00	28,43	0,018	0,03
	<i>Mycteroperca fusca</i> (Lowe, 1838)	Ca	0,01	0,98	0,000	0,02
	<i>Serranus atricauda</i> Günther, 1874	Ca	0,94	36,27	0,017	0,02
	<i>Serranus cabrilla</i> (Linnaeus, 1758)	Ca				
Apogonidae	<i>Apogon imberbis</i> (Linnaeus, 1758)	Ca	0,07	3,92	0,001	0,02
Pomatomidae	<i>Pomatomus saltatrix</i> (Linnaeus, 1766)	Ca				
Mugilidae	<i>Chelon labrosus</i> (Risso, 1827)	Om	6,78	24,51	0,120	0,11
Atherinidae	<i>Atherina presbyter</i> Cuvier, 1829	Pl				
Carangidae	<i>Pseudocaranx dentex</i> (Bloch & Schneider, 1801)	In	0,33	5,88	0,006	0,04
	<i>Seriola rivoliana</i> Valenciennes, 1833	Ca	0,03	0,98	0,000	0,02
	<i>Trachinotus ovatus</i> (Linnaeus, 1758)	Ca	0,31	6,86	0,005	0,03
	<i>Trachurus picturatus</i> (Bowdich, 1825)	Pl	0,03	0,98	0,000	0,02
Sparidae	<i>Boops boops</i> (Linnaeus, 1758)	Om	1,58	16,67	0,028	0,06
	<i>Diplodus sargus</i> (Linnaeus, 1758)	Om	16,92	77,45	0,299	0,07
	<i>Diplodus vulgaris</i> (Geoffroy Saint-Hilaire, 1817)	Om	0,12	3,92	0,002	0,02
	<i>Pagellus acarne</i> (Risso, 1827)	In	13,04	32,35	0,230	0,12
	<i>Pagrus pagrus</i> (Linnaeus, 1758)	Ca	1,04	18,63	0,018	0,04
	<i>Sarpa salpa</i> (Linnaeus, 1758)	Hb	2,39	24,51	0,042	0,05
Mullidae	<i>Mullus surmuletus</i> Linnaeus, 1758	In	2,83	42,16	0,050	0,05
Kyphosidae	<i>Kyphosus sectator</i> (Linnaeus, 1758)	Om	0,47	8,82	0,008	0,03
Pomacentridae	<i>Abudefduf luridus</i> (Cuvier, 1830)	Om	1,90	45,10	0,034	0,03
	<i>Chromis limbata</i> (Valenciennes, 1833)	Pl	3,62	21,57	0,064	0,11
Labridae	<i>Centrolabrus caeruleus</i> Azevedo, 1999	In	4,01	76,47	0,071	0,04
	<i>Coris julis</i> (Linnaeus, 1758)	In	12,43	88,24	0,220	0,05
	<i>Labrus bergylta</i> Ascanius, 1767	Ca	0,25	16,67	0,004	0,02
	<i>Symphodus mediterraneus</i> (Linnaeus, 1758)	In	0,17	5,88	0,003	0,02
	<i>Thalassoma pavo</i> (Linnaeus, 1758)	In	11,89	91,18	0,210	0,04
	<i>Xyrichtys novacula</i> (Linnaeus, 1758)	In				
Scaridae	<i>Sparisoma cretense</i> (Linnaeus, 1758)	Hb	1,73	28,43	0,031	0,07
Tripterygiidae	<i>Tripterygion delaisi</i> Cadenat & Blache, 1970	In	7,30	66,67	0,129	0,06
Blenniidae	<i>Lipophrys pholis</i> (Linnaeus, 1758)	Om				
	<i>Ophioblennius atlanticus</i> (Valenciennes, 1836)	Hb	0,33	7,84	0,006	0,03
	<i>Parablennius incognitus</i> (Bath, 1968)	Om				
	<i>Parablennius parvicornis</i> (Valenciennes, 1836)	Om	0,32	2,94	0,006	0,05
	<i>Parablennius ruber</i> (Valenciennes, 1836)	Om	0,37	18,63	0,007	0,02
Gobiidae	<i>Gobius paganellus</i> Linnaeus, 1758	In	0,80	30,39	0,014	0,02
	<i>Pomatoschistus pictus</i> (Malm, 1865)	In	0,10	2,94	0,002	0,03
Sphyraenidae	<i>Sphyraena viridensis</i> Cuvier, 1829	Ca	0,08	2,94	0,001	0,02
Bothidae	<i>Bothus podas</i> (Delaroche, 1809)	Ca	0,17	5,88	0,003	0,03
Balistidae	<i>Balistes capricus</i> Gmelin, 1789	In	0,11	6,86	0,002	0,02
Tetraodontidae	<i>Sphoeroides marmoratus</i> (Lowe, 1838)	Om	2,01	58,82	0,036	0,02

RA, Relative abundance; FO, Frequency of occurrence; MD, Mean density (fish/m²); ±St.Er., Standard error.

The richest families were Sparidae (6 spp.), Labridae (5 spp.) and Carangidae (4 spp.), being the most speciose genera *Parablennius*, *Muraena* and *Diplodus*, with two species each. The ten most abundant species that consequently accounted to the highest densities were *Diplodus sargus* (Linnaeus, 1758), *Pagellus acarne* (Risso, 1827), *Coris julis* (Linnaeus, 1758), *Thalassoma pavo* (Linnaeus, 1758), *Tripterygion delaisi* Cadenat & Blache, 1970, *Chelon labrosus* (Risso, 1827), *Centrolabrus caeruleus* Azevedo, 1999, *Scorpaena maderensis* Valenciennes, 1833, *Chromis limbata* (Valenciennes, 1833) and *Mullus surmuletus* Linnaeus, 1758 (Figure 2). Indeed, the ten most abundant fishes corresponded to 82.7% of all fishes counted during this study.

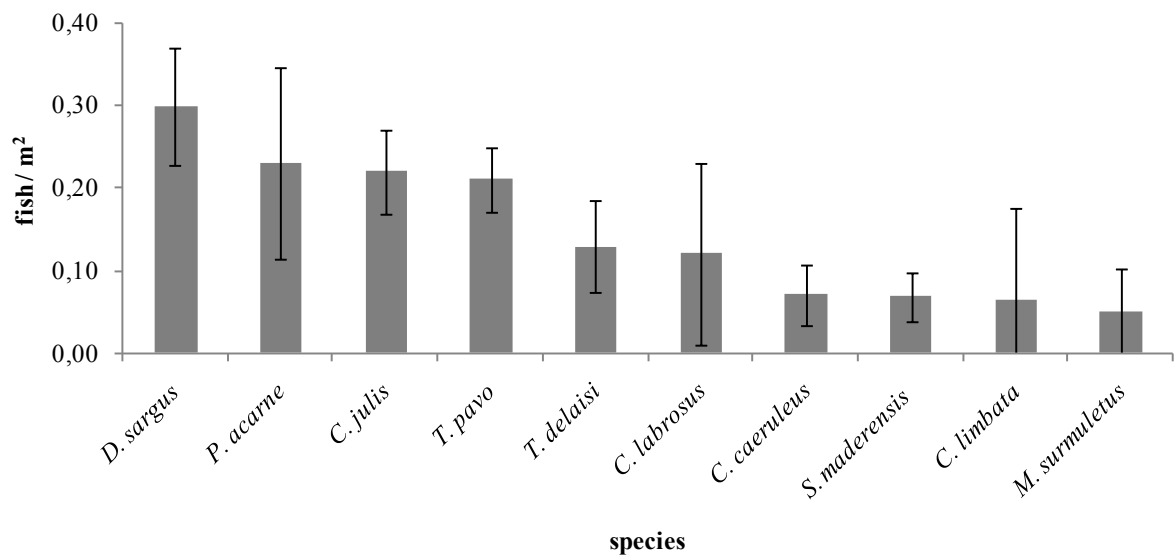


Figure 2. Mean densities (fish/m²) with respective standard error bars of the ten most abundant species.

From the 42 species, 12% are epipelagic (*Pseudocaranx dentex* (Bloch & Schneider, 1801); *Seriola rivoliana* Valenciennes, 1833; *Trachinotus ovatus* (Linnaeus, 1758); *Trachurus picturatus* (Bowdich, 1825) and *Sphyraena viridensis* Cuvier, 1829). The remaining 37 species are divided in demersal (57%) and benthic (31%), strongly associated to the bottom.

Trophic structure

The majority (40%) of the fishes observed were carnivores (Ca), including 12 families with Serranidae and Muraenidae both with three species each and Carangidae with two species, as the richest ones. Invertebrate feeders (In), accounted to 26% of species, followed by Omnivores (Om) with 21%. The former included seven families, where Labridae was the richest (4 spp.) and the latter four families, being Sparidae (3 spp.) the richest one. Herbivores (Hb) accounted for 7% of the species and included three families, followed by Planctivores (Pl) (5%) with two families (Figure 3).

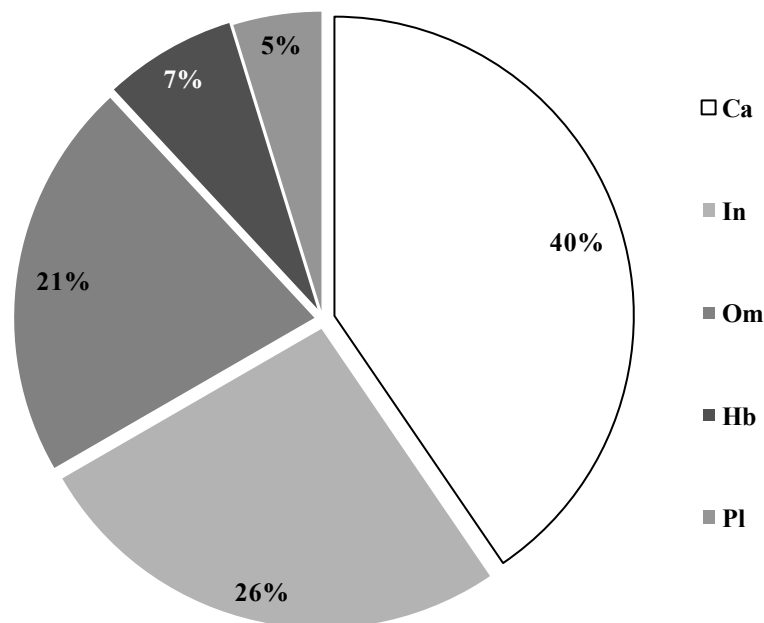


Figure 3. Percentage of species in each trophic category of rocky reef fish recorded in Azores.

Observing the proportion of each trophic categories at depth strata (Figure 4), the most abundant carnivore species at 2m, were *Epinephelus marginatus* (Lowe, 1834) and *S. madeirensis* (mean densities of 0.06 and 0.05/m²), while at 6m *S. madeirensis* and *Serranus atricauda* Günther, 1874 (mean densities of 0.06 and 0.02/m²), being 9m and 14m dominated by *S. madeirensis* among carnivores (mean densities of 0.12 and 0.18/m² respectively).

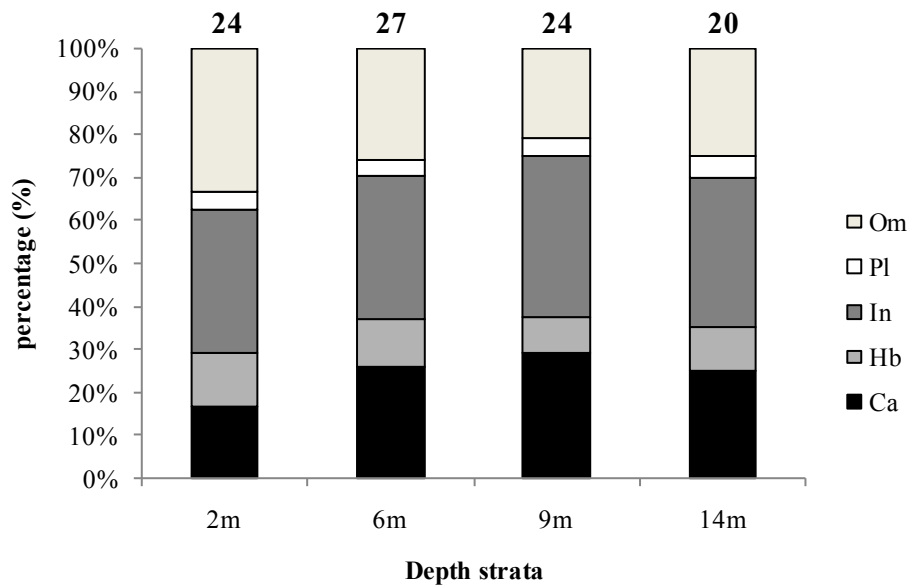


Figure 4. Proportion of trophic categories among sampled depth strata. Bold numbers refer to richness.

Among herbivores, although represented by only three species, the 6m stratum concentrated the highest values of density for *Sparisoma cretense* (Linnaeus, 1758) ($0.11/m^2$) and *Sarpa salpa* (Linnaeus, 1758) ($0.09/m^2$), both present in all surveyed depth strata. *Ophioblennius atlanticus* (Valenciennes, 1836), occurred at the two shallowest strata, being the most abundant at 2m ($0.03/m^2$).

Despite all omnivore species (except for *Kyphosus sectator* (Linnaeus, 1758), exclusively at 6m) were observed at the shallowest stratum ($n=8$), where *D. sargus* ($0.36/m^2$) and *C. labrosus* ($0.35/m^2$) accounted for the highest mean densities, only five species were observed at the deepest stratum and with low densities, *D. sargus* ($0.09/m^2$) and *Abudefduf luridus* (Cuvier, 1830) ($0.08/m^2$).

The invertivores *C. julis* and *T. pavo* presented both the highest mean densities ($0.31/m^2$ and $0.26/m^2$) considering all sampled depths. *T. delaisi* also presented important values ($0.13/m^2$) at the shallowest stratum.

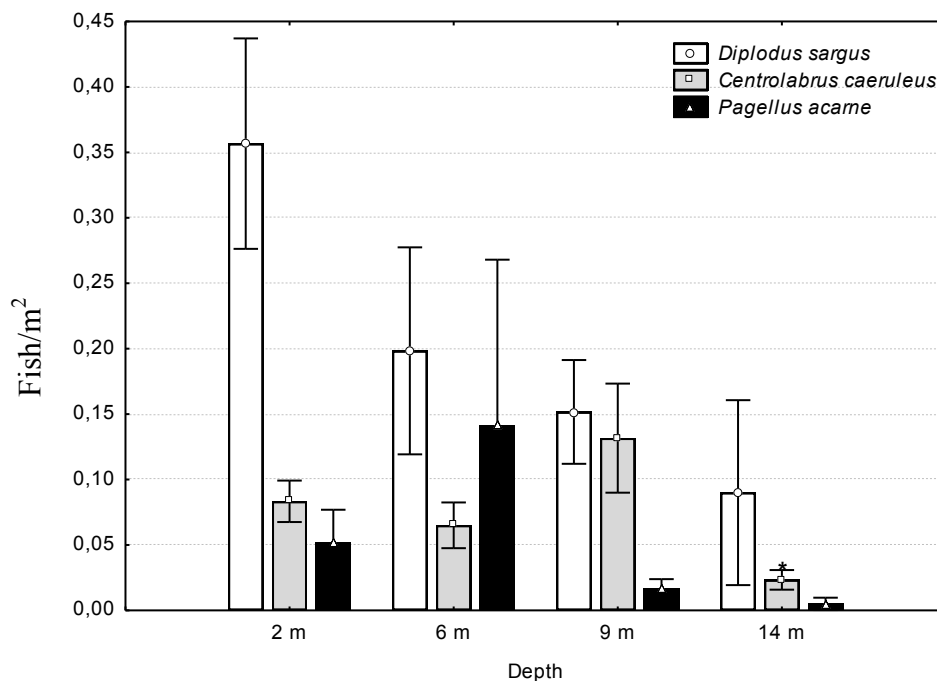
Plankivores were mostly represented by *C. limbata* ($0.36/m^2$ at 14m), which was not observed only at the shallowest stratum, where *T. picturatus* was observed, although in very low densities ($0.003/m^2$).

Reef-fish frequency, abundance and distribution along depth strata

Regarding species frequency of occurrence, four species (the invertebrate feeders *T. pavo*, *C. julis* and *C. caeruleus* and the omnivorous *D. sargus*) were considered frequent, eight common (three carnivorous, three invertebrate feeders and two omnivorous), 18 occasional (29-5%) and 12 rare (<5%) (Table 1).

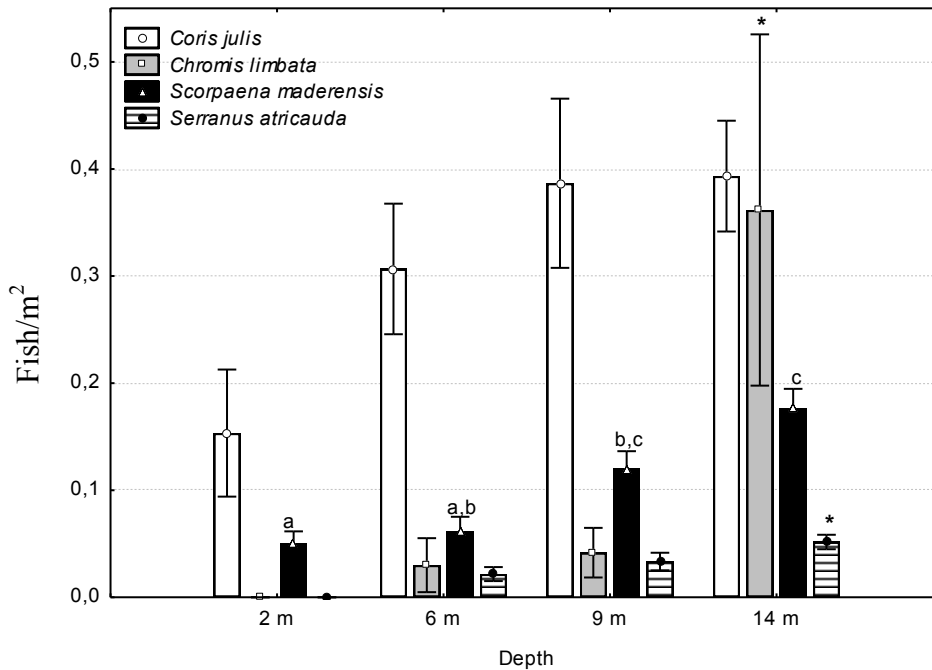
Abundant species presented a wide variation in densities regarding the sampled depths, and three groups were observed: group (A) of species that had a preference for shallower areas; group (B) of species that had a preference for deeper areas; and group (C) of species that had no clear preference for any depth strata.

Group (A) (Figure 5) was formed by three species: *C. caeruleus* (Figure 11a), did not show a clear distribution pattern, but data suggest a preference for shallower areas (2, 6 and 9 m depth concentrates 92.3% of observations) significant differences on densities were observed only for the 14 m ($F_{(3, 56)}=3.096$ $p<0.05$). On the other, although no significant differences were observed for *D. sargus* (Figure 11d) ($F_{(3, 56)}=2.438$ $p=0.074$) and *P. acarne* (Figure 11e) ($H_{(3, 60)}=5.209$ $p=0.157$), they had a tendency to be negatively distributed along depth strata.



Figures 5: Densities (Mean \pm SE) of group A: *D. Sargus*, *C. caeruleus* and *P. Acarne* among depth strata. * denotes significant differences for species within strata.

Group (B) (Figure 6) was formed by four species: *S. maderensis* (Figure 11b), presented a positive relationship for density regarding depth strata. Significant differences formed three groups ($F_{(3, 56)}=13.516$ $p<0.01$), but both shallower strata differed from the deepest, and since no significant differences were detected between 9 and 14 m (that represents more than 70% of observations), *S. maderensis* shows a clear preference for deeper areas on rocky reefs, as *C. limbata* (Figure 11i) does. This species was not even observed in the shallowest stratum, and concentrated 83% of observations in the deepest strata ($H_{(2, 45)}=22.99$ $p<0.01$).

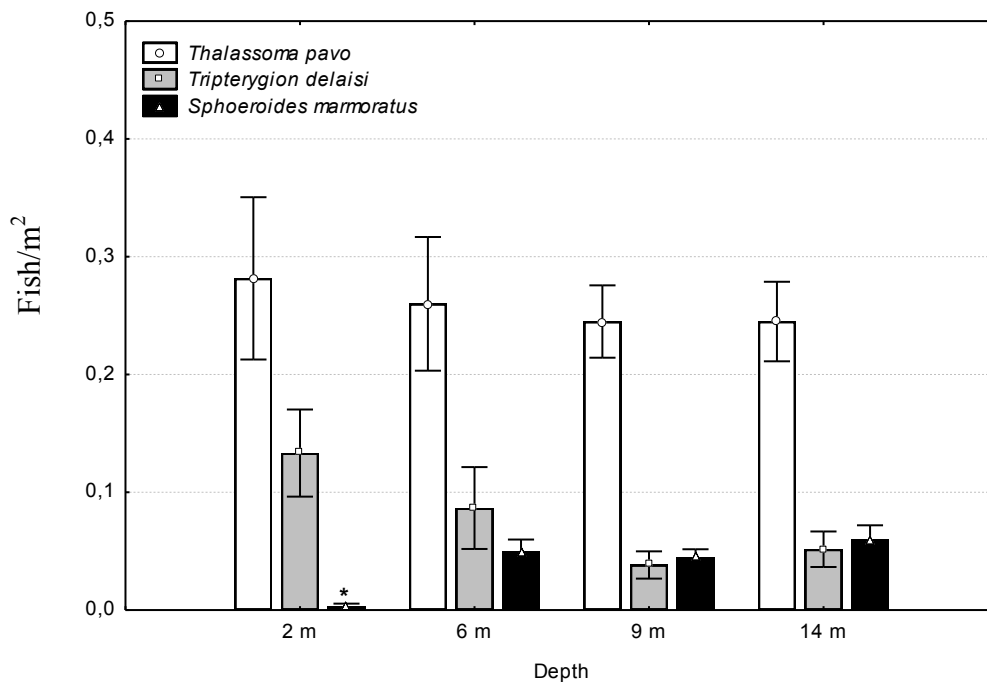


Figures 6: Densities (Mean \pm SE) of group B: *C. Julis*, *C. Limbata*, *S. maderensis* and *S. atricauda* among depth strata. * denotes significant differences for species within strata. Letters show groups detected by post-doc tests.

A very similar distribution was observed for the small grouper *S. atricauda* (Figure 11c), which presented the same tendency, but in this case, where no specimens were observed in the shallowest stratum, significant differences at $p<0.05$ level ($F_{(2, 42)}=3.79$) were detected between the group formed by 6 and 9 m, and the deepest stratum, that concentrated almost half (48%) of observations. Although this carnivorous species was not abundant, it was frequent in more than one-third of the samples.

The wrasse *C. julis* (Figure 11k and 11l), almost showed significant differences ($F_{(3, 56)}=2.7819$ $p=0.0429$) among depth strata, but no differences were observed in the *post-hoc* test. Anyway, a clear preference for deeper areas is evident.

Group (C) (Figure 7) was formed by three species: *T. pavo* (Figure 11f) was the most evenly distributed species ($F_{(3, 56)}=0.108$ $p=0.955$); followed by *T. delaisi* (Figure 11h) ($H_{(3, 60)}=3.92$ $p=0.27$). Although not so abundant, *S. marmoratus* (Figure 11g) was a common species, present in 58% of the samples, but it was rarely observed at the shallowest stratum, which differed significantly from the others ($H_{(3, 60)}=22.84$ $p<0.01$).



Figures 7: Densities (Mean \pm SE) of group C: *T. pavo*, *T. delaisi* and *S. marmoratus* among depth strata. * denotes significant differences for species within strata.

Although no significant differences were observed among depth strata for the indexes calculated (Table 2), the highest value of mean density (1.8 fish/m²) and mean richness (10.07) were associated to the shallowest stratum (2m), and the lowest (1.3 fish/m² and 9.73) to the 9m depth. The highest diversity values, as well as evenness, were associated to the deeper strata (9 and 14m).

Table 2. ANOVA results of comparisons among depth strata.

	$F_{(3,56)}$	p
S	0.06	0.9805
Density	1.01	0.3927
Diversity (H')	0.84	0.4737
Evenness (J')	1.33	0.2719

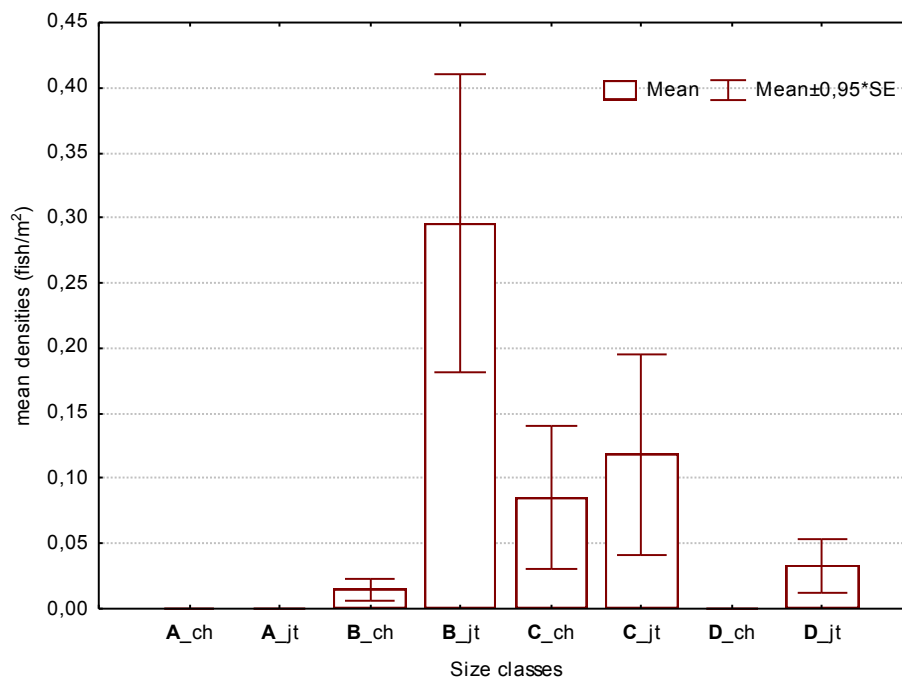
S, richness; Density, (fish/40m²); H', Shannon-Wiener; J', Pielou.

Reef-fish indexes and distribution in sampled areas

Mean richness was quite similar among areas, with an overall mean value of 9.8 species, being the lowest value associated to SAL (4) and the highest to GRA (16). Mean abundances had a great variation, from 45.4 fish/40m² at SAL to 86.9 fish/40m² at MAR, and mean overall value of 68.2 fish/40m². Diversity index ranged from 1.6 at SAL to 1.9 at BAP and 1.87 as a mean value. On the other hand, evenness ranged from 0.72 at MAR to 0.83 at ICA, with mean values of 0.79.

The total absolute number of fish/40m² also had a great variation, from 17 at SAL to 207 at MAR. These extreme values at MAR were due to the presence of huge schools of young *P. acarne*, *D. sargus* and *C. labrosus*, that alone accounted to 69.5% of total abundance.

Once the Marina (MAR) was the unique area with highly anthropogenic influence, samplings were obtained under the jetties and channels (between jetties). Comparisons of communities between the two sampled areas, showed that no significant differences were observed ($df=46$; $t=0.0363$, $p=0.971$). Mean densities for the five-most abundant species also did not show significant differences, except for the thicklip grey mullet, *C. labrosus* (Figure 11j), which was observed in significantly higher densities under the jetties ($df=22$; $t=2.406$, $p<0.05$) (Figure 8).



Figures 8: Densities (Mean \pm SE) of *C. labrosus* sampled on channels (ch) and jetties (jt) at the Marina, with respective standard error bars (SE). Size classes: **A** (<10 cm), **B** (11-20 cm), **C** (21-30 cm), **D** (>31 cm).

The representative Cluster of mean densities (Figure 9) showed two main groups (a) composed by MAR, COR and BIS areas; and (b) composed by ICA, CIR, GRA and BAP; being SAL in a single isolated link. The dominance-diversity curves are presented in Figure 10.

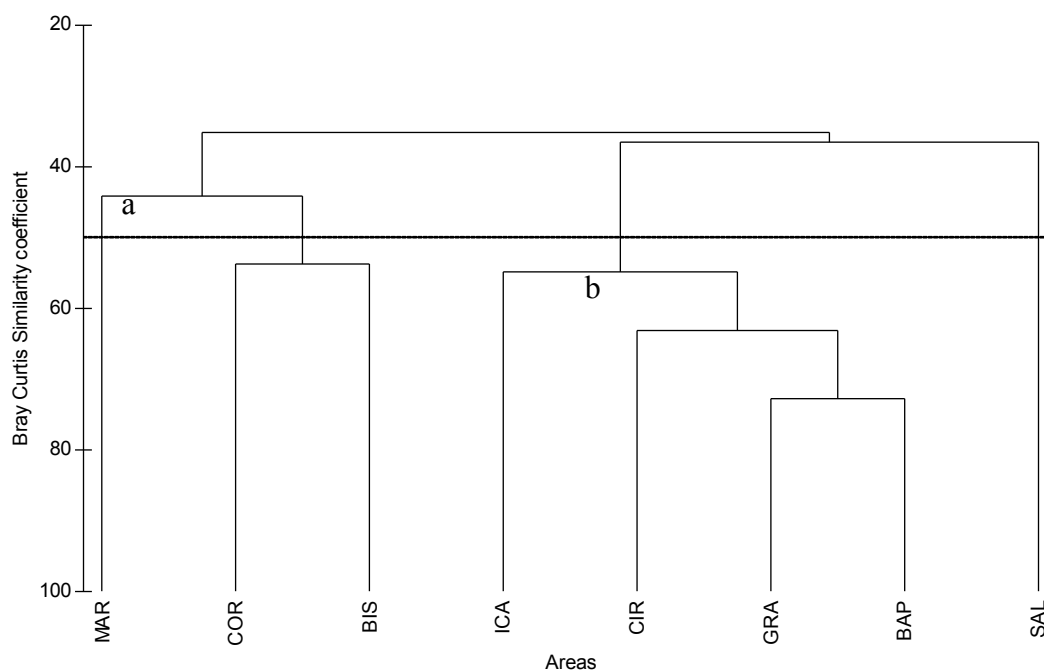


Figure 9: Cluster analysis (Bray-Curtis similarity coefficient – UPGMA for density values (fish/m²)). COR – Corvo, BIS – Biscoitos; BAP – Baía das Pombas, CIR – Cinco Ribeiras, MAR – Marina, ICA – Ilhéu das Cabras, GRA – Gruta das Agulhas, SAL – Salgueiros.

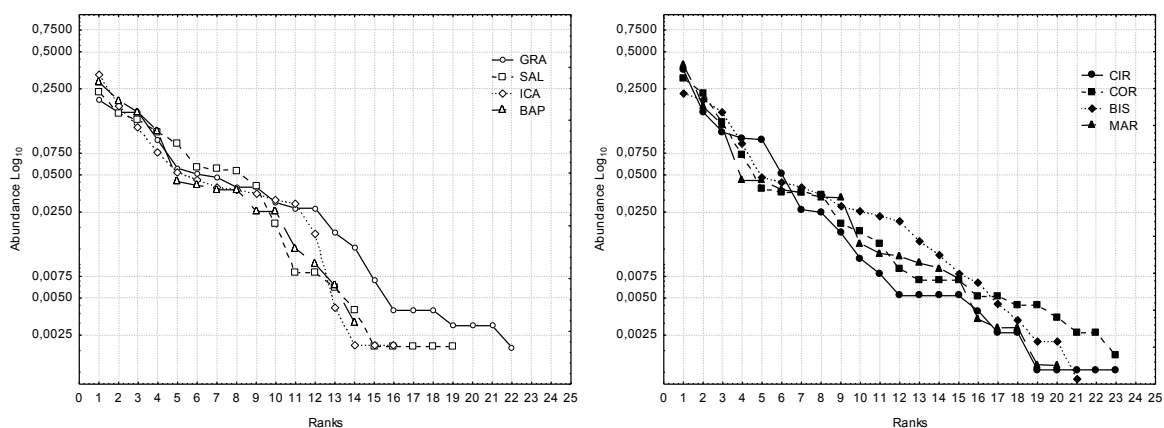


Figure 10: Dominance-diversity curves for each area. GRA – Gruta das Agulhas, SAL – Salgueiros, ICA – Ilhéu das Cabras, BAP – Baía das Pombas; CIR – Cinco Ribeiras, COR – Corvo, BIS – Biscoitos, MAR – Marina.

Discussion

Communities of fish sampled had a dominance of few species, being *T. pavo*, *C. julis*, *D. sargus* and *C. caeruleus* the most frequent, and a high percentage of rare species (Table I) was observed. The five epipelagic species were commonly observed in a strong association within the rocky bottom areas sampled.

Similarly to our results, Bortone *et al.* (1994), employing stationary census methodology identified 37 species along the rocky shores of Canary islands, and Hajagos & Van Tessell (2004), also reported similar results: 48 species, grouped in 29 families in 211 stationary census in Canary islands. On the other hand, Harmelin-Vivien *et al.* (2001), in one of the first attempts of underwater visual censuses in Azores, surveyed five Azorean islands (which did not include Terceira neither Corvo) during the Bio-Oceanographic survey in 1979, identifying 57 species, in depths up to 25m, employing the circular point method (Harmelin-Vivien *et al.*, 1985).

Our study showed Sparidae and Labridae families as the ones with most abundant species, but Harmelin-Vivien *et al.* (2001) also included Carangidae and Pomacentridae in their study. Blenniids have been considered the most conspicuous species from shallow intertidal rocky environments (see references in Santos *et al.*, 1997), but although *P. ruber* and *O. atlanticus* were considered occasional in our samples, shallow environments were clearly dominated by labrids (*T. pavo* and *C. julis*), sparids (*D. sargus*) and tripterygids (*T. delaisi*). On the other hand, deeper strata were represented by the same labrids, and the pomacentrid *C. limbata*.

Among carnivores, the scorpaenid *S. madeirensis* was the most abundant and frequent species, with densities increasing with depth. Although the majority (40%) of the fishes observed were carnivores, the proportion of trophic categories remained similar between the depth strata (Figure 4) (very similar to results of Harmelin-Vivien *et al.*, 2001). These substantial differences revealed that at each depth stratum trophic categories were represented by different species of the same trophic group, especially for the carnivores ones, which accounted for 66.6% of rare species. Among them, *T. ovatus* and *Muraena helena* Linnaeus, 1758 occurred only at 2m stratum; *Bothus podas* (Delaroche, 1809) and *Synodus saurus* (Linnaeus, 1758), were exclusively present at the 6m, being the latter known as a shallow-water predator of post-larval and juvenile of *S. viridensis* (Barreiros *et al.*, 2008). On the other hand, *Dasyatis pastinaca* (Linnaeus, 1758) and *Phycis phycis* (Linnaeus, 1766) were

exclusively observed at the 9m stratum. All invertivores, except for *P. dentex* (restricted to 6m stratum), were present at 9m, and although 2m and 6m presented the same proportion of invertivores, *Symphodus mediterraneus* (Linnaeus, 1758) at 2m, was substituted by *M. surmuletus* at 6m, especially common along rocky-sand interface at SAL.

The hovering herbivore *S. cretense*, the unique Scaridae species in Azores, and the sparid *S. salpa* revealed the highest mean densities at 6m ($0.11/m^2$ and $0.09/m^2$) among herbivores. *S. salpa* was commonly observed in small schools of up to 25 individuals, and scarids sampled in small groups of up to five individuals, but once summer is the breeding season for *S. cretense*, this value was biased due to a single sample where a mating school of 51 individuals crossed the transect line. Scarids are generally shy and get easily scared in the presence of divers, being easily underestimated (although often observed nearby transects, frequency of occurrence was less than 30% inside transects), when methodologies do not focus this fish group (wider transects would be more applicable).

Large individuals of the dusky grouper *E. marginatus* were not observed in any depth strata, differently as observed by Harmelin-Vivien *et al.* (2001) in 1979 in deeper strata on other Azorean islands. Inversely, juveniles of *E. marginatus* were observed in shallow habitat, as tidal pools, from post-larvae until reaching approximately 45cm total length (see Azevedo *et al.*, 1995; Machado *et al.*, *in prep.*). The dominance-diversity curves (Figure 10) emphasizes that species were not evenly distributed within sampled rocky shore areas and a dominance can be observed, especially in MAR and CIR, which presented a steeper slope shape, despite an elevated richness for both areas (more than half the total number of species). MAR was dominated by numerous schools of *P. acarne* of small size, which were far responsible for the highest values of density in this study ($2.0/m^2$) and represented 38.9% of relative abundance, followed by *D. sargus* (17.9%) and *C. labrosus* (12.6%). CIR was dominated by *C. julis* (35.7%), *T. pavo* (16.2%) and *P. acarne* (11.1%). Although *M. surmuletus* and *C. julis* were the most abundant species at SAL, no clear dominance was observed. However, *C. julis*, was the dominant species not only at CIR (37.5%), but BAP (28.4%) and GRA (20.3%), in all the cases followed by *T. pavo*.

Among the species which occupied a position in the first three ranks considering the eight areas, *T. pavo* had six occurrences, but never the most abundant, *C. julis* five and *D. sargus* four occurrences. *D. sargus* dominated only at COR, followed by *T. delaisi*; BIS was dominated by *C. labrosus*, and ICA by *C. limbata*.

The lower values associated to SAL for richness, mean abundance and diversity were probably due to the fact that this was the steepest rocky shore, shallow (8 m) and sandy bottom was close, which contributed to the high densities of *M. surmuletus*. Although SAL was sampled only at 6 m stratum, we discard any influence of depth, since an overall analyses of mean species number at the four sampled depth strata (2, 6, 9 and 14m) showed an incredible similarity of mean richness of 9.8 species at each strata.

Figure 8 shows how juveniles (11-20cm size class) of thicklip grey mullet contributed for the highest mean densities of *C. labrosus* under the jetties. Two main factors contributed for differences: first, densities were composed mostly by juveniles, and second, floating jetties provide shadow, which is used by *C. labrosus* schools to hide.

Cluster analyses grouped MAR, COR and BIS, which were not only the shallowest areas, but enclosed and protected from waves' action. BAP, GRA, COR and ICA, had the highest values for diversity, which was accompanied by high values of evenness and expressive richness. On the other hand, MAR, CIR and BIS, had low values for evenness, as a result of the dominance of *P. acarne*, *D. sargus* and *C. labrosus* at MAR, *C. julis* and *T. pavo* at CIR, and *C. labrosus*, *D. sargus* and *T. pavo* at BIS.

This assessment shows that the azorean ichthyofauna of shallow rocky reefs is relatively rich and diverse when compared to other oceanic archipelagos, such as Canary. Ecological interactions are still poorly studied. Despite our sampling limitations, results show patterns of abundance, diversity and distribution along studied depth gradients. Long-term studies should also be conducted to investigate ecological relationships, refine patterns observed inside and outside tidal pools, explore deeper areas, as well as monitor exotic species presence, such as *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) on shallow rocky reefs.

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Figure 11: (a) *Centrolabrus caeruleus*, (b) *Scorpaena maderensis*, (c) *Serranus atricauda*, (d) *Diplodus sargus*, (e) *Pagellus acarne*, (f) *Thalassoma pavo*, (g) *Sphoeroides marmoratus*, (h) *Tripterygion delaisi* (i) *Chromis limbata*, (j) *Chelon labrosus*, (k) *Coris julis* – initial female, (l) *C. julis* – terminal male. Photos by A.A. Bertoincini.

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B. CLEANING ACTIVITY AMONG LABRIDAE IN AZORES: THE RAINBOW WRASSE *CORIS JULIS* AND THE AZOREAN BLUE WRASSE *CENTROLABRUS CAERULEUS*

*Artigo submetido para o periódico **Marine Biological Association of the United Kingdom**, em 04 de dezembro de 2008, aceito em 13 de janeiro de 2009, publicado on line em 15 de maio de 2009.*

Cleaning activity among Labridae in Azores: the rainbow wrasse *Coris julis* and the Azorean blue wrasse *Centrolabrus caeruleus*

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Abstract

Cleaning interactions among the rainbow wrasse *Coris julis* and the azorean blue wrasse *Centrolabrus caeruleus* are presented with photographic registers, as well as the first record of the latter cleaning conspecifics from Azorean shallow rocky reefs.

Resumo

Interações de limpeza entre o peixe-rei *Coris julis* e o bodião azul açoriano *Centrolabrus caeruleus* labrideos são apresentadas através de registros fotográficos, bem como o primeiro registro deste limpando conspecíficos em recifes rochosos rasos açorianos.

Cleaning interactions involve small fish (the cleaners) which remove ectoparasites and other items from the body of (generally) larger, cooperating fish clients (Feder, 1966). Such interactions usually occur at traditional sites (Youngbluth, 1968), thus facilitating the repeated location of cleaners by clients, and may even act as “safe havens” in which

predatory interactions are diminished as observed by Cheney *et al.* (2008). Cleaners are also thought to share common colour patterns, which may help clients to recognize them.

Most of the important cleaning activities developed by fish and ecological studies of this mutualism relationship on reefs are reported to shallow tropical waters (Feitoza *et al.*, 2002; Feitosa *et al.*, 2003; Sazima *et al.*, 2005; Coni *et al.*, 2007; Gasparini *et al.*, 2007; Sikkell *et al.*, 2008; Soares *et al.*, 2008) and little is known on temperate waters (see Van Tassell *et al.*, 1994; Henriques & Almada, 1997; Côté, 2000), which is attributed to the lack of efforts on temperate waters.

The rainbow wrasse, *Coris julis* (Linnaeus, 1758) is a small rocky shore fish that inhabits shallow waters and is site-attached throughout its adult life. Moreover, this protogynous hermaphroditic species (with diandry) is distributed in a very large and heterogeneous geographical area (Mediterranean Sea, southern Black Sea, Northeastern Atlantic from Sweden to south of Cape Lopez, Gabon, including the Azores, Madeira and the Canary Islands) (Porteiro *et al.*, 1996) and presents conspicuous morphological variations between populations.

The Azorean blue wrasse, *Centrolabrus caeruleus* Azevedo, 1999, an endemic rocky shore fish that inhabits shallow waters in Azores, was recently distinguished from *C. trutta*, a species that inhabits Madeira and presumably Canary and Cape Verde (Azevedo, 1999; Azevedo *et al.*, 1999;).

Our diurnal observations took place at Corvo Island (39°40'N, 31°04'W), during a free diving in an open tidal pool area, in August 19th, from 1400 to 1530 hours, where two cleaning stations were detected, 50 m apart, exposed to depths from 2 to 4 m.

The cleaning processes observed always started by the client, *C. caeruleus*, positioning close to 90° head-up (Figure 1) 30 cm from the bottom, near a bolder (1 m high) over a dark brown sand bottom. All fins were fully extended and no colour change was displayed by the client. It was noticed that the great majority of *C. caeruleus* observed in this pool had different degrees of damaged tissue (Figure 2), but no parasites were evident. One or two *C. julis* were involved in the cleaning stations and 1-5 clients were observed posing simultaneously. Clients (10-15 cm TL) were not much larger than the cleaners (8-10 cm TL).



Fig. 1. Cleaning activity involving the Azorean endemic *Centrolabrus caeruleus*, posing head-up and the rainbow wrasse *Coris julis*. Photo: A.A. Bertoncini.



Fig. 2. *Centrolabrus caeruleus* commonly found in the pools of Corvo Island, with damaged tissue along the flanks and head. Photo: A.A. Bertoncini.

In a single opportunity, five *C. caeruleus* (10-15 cm TL) were posing, and as no *C. julis* approached, a single *C. caeruleus* (7 cm TL) started cleaning the conspecifics. Such bout lasted less than 15 seconds. Although no photo registers were possible, the present study is the first record of this endemic and poorly known wrasse performing cleaning activities.

Centrolabrus caeruleus are particularly shy, and by the time *C. julis* stopped cleaning, they went to the algae turfs of *Asparagopsis armata* Harvey, 1855, where especially juveniles are commonly observed swimming around (Figure 3).

Although *C. julis* juveniles (3-5 cm) were present in the cleaning station (Figure 4), none attempted to clean the posing clients.

Among the alternative short-distance signals to attract clients, which may include colour, other visual signals such as cleanerfish dances, or physical contact between cleaner and client, Stummer *et al.* (2004), tested interspecific visual communication and concluded that body size and lateral stripes both affect the recognition of cleanerfish by their fish clients.



Fig. 3. *Centrolabrus caeruleus* hiding among the algae turfs of *Asparagopsis armata*, after a cleaning event. Photo: A.A. Bertoncini.



Fig. 4. Juvenile of *Coris julis*, (4 cm) in the area of the cleaning station. Photo: A.A. Bertoncini.

Coris julis inspected and cleaned the clients' body for short intervals of 5 seconds, swimming around and then returning. The flanks were the most explored area of the clients' bodies, where damaged tissue was evident. A similar behaviour is described for wrasses in Brazilian waters: *H. dimidiatus* (Sazima *et al.*, 1998), *H. bivittatus* (Feitoza *et al.*, 2002), *H. penrosei* (Coni *et al.*, 2007) and *Thalassoma noronhanum* (Francini-Filho *et al.*, 2000).

We believe that the cleaning activity of *C. caeruleus* is rare and opportunistic, since it is abundant in Azores, but never seen as a cleaner before. On the other hand, *C. julis* was already observed cleaning *Boops boops* (Linnaeus, 1785), *Sarpa salpa* (Linnaeus, 1785) and *Sparisoma cretense* (Linnaeus, 1785), and it seemed that no fixed cleaning station were established outside tide pools, which remains to be studied.

Although *C. caeruleus* can be considered as a facultative cleaner such as *Centrolabrus exoletus* (Linnaeus, 1785), in which picking material from the body surface of other fish is not the dominant form of feeding behaviour (see Henriques & Almada, 1997), more observations in natural conditions and detailed experiments on the ontogeny of cleaning behaviour are needed.

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**C. The Common two-banded seabream (*Diplodus vulgaris*), another exotic species in
Azores**

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The Common two-banded seabream (*Diplodus vulgaris*), another exotic species in Azores.

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Abstract

The azorean ichthyofauna of shallow rocky reefs is relatively rich and diverse. Recently efforts on assessing fish communities in Azores revealed not only new species, but exotic ones such the sparid, *Diplodus vulgaris*. Although considered rare, juveniles are observed foraging among schools of small sized Labrids (*Thalassoma pavo* and *Coris julis*).

Resumo

A ictiofauna Açoriana de recifes rochosos rasos é relativamente rica e diversa. Esforços recentes no levantamento das comunidades de peixes dos Açores revelaram não apenas novas espécies, mas também a existência de espécies exóticas, como o sparídeo, *Diplodus vulgaris*. Apesar de ser considerada rara, jovens desta espécie são observados forrageando entre cardumes de labrídeos de pequeno porte (*Thalassoma pavo* e *Coris julis*).

The total number of marine species in Azores has risen recently. Crustaceans species are periodically registered (e.g. Vieira & Morato, 2001; Udekem D'Acoz et al., 2001),

confirmation of cetaceans occurrences by stranding (Barreiros et al., 2006) and recently genetic studies confirmed a new seabird winter population, Monteiro's Storm-petrel (*Oceanodroma monteiroi*) (Bolton et al., 2008). Other important research efforts focus on shallow water hydrothermal-vents, such as D. João de Casto Bank (e.g. Ávila et al. (2004), report 33 mollusk species new from this bank), Princess Alice Bank and Dollabarat Bank.

Regarding fish species, the description of a new fish species, previously unrecognized *C. caeruleus* (Azevedo, 1999); and the list of new records is vast: four records by Afonso (2002), *Liza aurata* (Risso, 1810), *Diplodus vulgaris* (Geoffrey Saint-Hilarie, 1817), *Gymnammodytes cicereus* (Rafinesque, 1810) and *Diodon holacanthus* Linnaeus, 1758; five new occurrences for the Archipelago by Azevedo et al. (2004), (*Fistularia petimba* Lacepède, 1803; *Priacanthus arenatus* Cuvier, 1829; *Decapterus macarellus* (Cuvier, 1833); *Centracanthus cirrus* Rafinesque, 1810; *Diodon eydouxi* Brisout de Barneville, 1846), Morato et al. (2004) reports *Mycteroperca phenax* Jordan & Swain, 1884; Wirtz (2005) and Pedro Afonso (pers. comm.) report *Canthigaster capistrata* (Lowe, 1839), *Scorpaena canariensis* (Sauvage, 1878) *Chaetodon sedentarius* Poey, 1870, and *Aluterus monoceros* (Linnaeus, 1758); and lately *Seriola fasciata* (Bloch, 1793) (Machado & Barreiros, 2006) and the bull head shark, *Carcharhinus leucas* (Valenciennes, 1839) (Gadid, et al. 2006).

So far 460 fish species were reported for Azores by Santos et al. (1997). This rise in new discovers and descriptions reflects the increased effort of collecting and identifying by several research projects and qualified diving observers.

An effort of 103 40m² underwater visual transects resulted in 7209 fish counted, of 52 species belonging to 38 genera and 22 families (Bertoncini et al., in press.), one species that might receive attention is the common two-banded seabream *Diplodus vulgaris* (Fig. 1). Its original distribution is in the Eastern Atlantic from Bay of Biscay to Cape Verde and the Canary Islands including the Mediterranean and Black Sea (off Bulgaria) and also from Angola to South Africa (Froese & Pauly, 2008).

This species inhabits rocky and sometimes sandy bottoms to depths of 160 m, but more commonly in less than 50 m. It was observed for the first time in 1997, at the channel between Pico and Faial islands, and nowadays it can be observed in many shallow areas of Terceira and along the central group (see Afonso, 2002), solitary or associated to other foraging species, such as *T. pavo* and *C. julis* (Fig. 2).



Fig. 1. Young *Diplodus vulgaris* (approximately 10 cm total length), over a shallow rock-reef environment at Salgueiros, Terceira Island (Azores). Photo: A.A. Bertoncini.



Fig. 2. *Diplodus vulgaris*, feeding over a shallow rock-reef environment among mixed schools of *Thalassoma pavo* (in the picture) and *Coris julis*. Photo: A.A. Bertoncini.

D. vulgaris, as well as the species reported by Azevedo et al. (2004), are species with affinities to tropical and subtropical zones, present at the Azorean temperate waters. Such records of unusual components of the marine fauna, as well as, the monitoring of their abundances, are approaches more relevant than ever in the present discussion of climate change, and may represent a possible case of range expansion, as supposed for other species (see Wirtz, 2005), once no direct human vector seems to be associated to their occurrences.

Although all the exotic fish species listed above are considered to occur occasionally in the Azores, while no stable populations seem to be established, when considering benthic invertebrates and sessile organisms, little is known on marine species introductions and invasions to the Azores (see Cardigos et al., 2006). Given the isolated position of this archipelago, as the most isolated islands in the North Atlantic, Cardigos et al. (2006) collated 51 exotic taxa for Azores and consider the potential for introductions as high, as transatlantic leisure boat-traffic stopping over at the islands has significantly increased over the last years. One of the recent alien species listed for Azores, possibly introduced by maritime traffic, belongs to a genus with high invasive potential: *Caulerpa webbiana*, first detected in 2002 near the main yachting harbour of the Azores, Horta (Faial Island) and rapidly spreading its colonized areas (Amat et al., 2008).

The importance of the continuous observations by researchers at oceanic islands can be exemplified by Alves & Alves (2002), which reported two new species for Madeira

Archipelago, coincidentally Sparids (*Lithognathus mormyrus* (Linnaeus, 1785) and *Sparus aurata* Linnaeus, 1785) at extensively studied areas.

The azorean ichthyofauna of shallow rocky reefs is relatively diverse when compared to other oceanic archipelagos (Bertoncini et al., in press.), and rich in ecological interactions still poorly studied (Bertoncini et al., 2009). Long-term studies should be conducted to monitor these exotic species on shallow rocky reefs and detect the establishment of populations to better understand their role and possible impacts on this environment.

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ANEXO I

FORAGING ACTIVITY BY *MUGIL CUREMA* VALENCIENNES, 1836 (PERCIFORMES, MUGILIDAE)

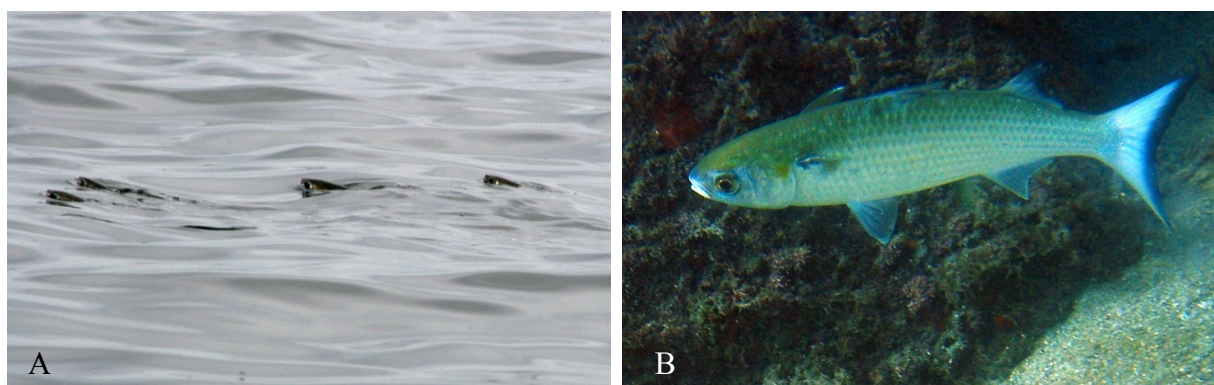
Submetido ao periódico Pan-American Journal of Aquatic Sciences, na sessão Original scientific photographs, publicado on line em 29 de janeiro de 2008.

Pan-American Journal of Aquatic Sciences (2008), 3 (1): II

Foraging activity by *Mugil curema* Valenciennes, 1836 (Perciformes, Mugilidae)

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Mulletts are ubiquitous fish species that are found in tropical and semi-tropical regions of the globe. The white mullet, *Mugil curema* Valenciennes, 1836, is a catadromous fish, inhabiting sandy coasts and littoral pools but also occurs in muddy bottoms of brackish lagoons and estuaries being widely distributed along the Atlantic and Eastern Pacific (Froese & Pauly 2007). At Patos Lagoon in southern Brazil, juvenile mullets change their diet from zooplankton to iliophagous (a combination of benthic microorganism, detrital material and inorganic sediment), their most important food items are diatoms, dinoflagellates and mineral particles (accidentally ingested) (Vieira 1991). Although it is a common bottom feeder (on microscopic or filamentous algae) it can be an actively planktonic feeder, as observed on FEB 2006, from 8:30 to 9:00 a.m., where a small school of white mullets were intensively foraging on planktonic organisms on the air-water interface, over a rhodolith bank at Arvoredo Marine Biological Reserve, Santa Catarina, Brazil. Schools and swimming patterns of juvenile forms of this species were already studied (Carvalho *et al.* 2001) and it was also observed associated to the striped mullet (*Mugil cephalus*) by Odum (1968) feeding heavily upon a bloom of the dinoflagellate *Kryptoperidinium* in an estuarine river near Sapelo Island

(USA); which were obtained near the airwater interface. It is also reported that after the four-day-bloom the mullet returned to a "normal" benthic diet of *Spartina* detritus particles, benthic diatoms and sediment particles, which conducted to the conclusion the *Mugil* presents a low efficiency in assimilating this energy source. Morphology studies of gill arches revealed that the species do not select food chemically but obtain it mechanically with the rakers and aggregate it with mucus (Eiras-Stofella *et al.* 2001). Picture Characteristics: A. Canon 20D; resolution of 8 megapixels (300 dpi), Speed ISO-400, diaphragm aperture F/9, time of exposition 1/640, Canon 75-300 mm lenses; B. Canon PowerShot S70, resolution of 7 megapixels (180 dpi), autofocus mode, Speed ISO-50, diaphragm aperture F/2.8, time of exposition 1/250.

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ANEXO II

PEIXES DE COSTÃO ROCHOSO DE SANTA CATARINA, I. ARVOREDO, 2ED.

Proposta de Livro



Peixes de Costão Rochoso de Santa Catarina, I. Arvoredo, 2ed.

The first edition of this book was released in January, 2006. Authors were Maurício Hostim-Silva, Áthila Bertoncini Andrade, Leonardo Francisco Machado, Leopoldo Cavaleri Gerhardinger, Felipe Alexandre Daros, João Pedro Barreiros and Eduardo Aires de Souza Godoy. UNIVALI edition with VIDAMAR NGO support, Itajaí, SC, Brazil. ISBN 85-7696-009-5 (Portuguese edition). 135 p.

This 2nd edition will focus on the fish biodiversity of Arvoredo Biological Marine Reserve (ABMR), presenting new and important knowledge over the rich South Brazilian marine ichthyofauna. It is intended to be published in two languages, yet to be defined (English or Spanish).

The 2nd edition will be timely, as it will provide meaningful support to regional management strategies, where the coastal zone is in demonstrable irregular overgrowth.

The book will synthesize a 15-year research effort, and will be organized in several topics, which includes updated information about the Arvoredo Marine Biological Reserve, a synopsis on reef fish ecology, biological adaptations of reef fish, systematics and rocky-shore habitat occupation.

Although it will not specifically focus management applications, the check list presented along with the ecological information on subtidal rocky reef fish communities, and the photo-drawing guide, already proved to be of great utility for many ecology/community studies.

The project intends to not only update the color underwater photos (Plate I), but also to include at least 50 new species (Plate II), registering color changes throughout life of some species (Plate III), and report distinct life phases, such as young and adults (Plate IV). All accompanied with common names (given in Portuguese, Spanish and English) and a detailed description of the most important distinctive features, pointed in schematic drawings of each species; behavior, feeding habits, reaction to divers and distribution.

The book is a strong tool to accurately identifying the most common observed fish species when diving along South Brazil. This guide-book can surely be widely used in Brazil, especially to introduce young scientists and the general public in the rocky-shore fish ecology. Scuba divers will also benefit from this tool, which provides a practical way for further studying and identifying fishes.

PLATE I



Mycteroperca bonaci (Serranidae)



Malacoctenus cf. *delalandii* (Labrisomidae)



Pomacanthus paru (Pomacanthidae)



Serranus atrobranchus (Serranidae)



Sparisoma axillare (Scaridae)



Hippocampus reidi (Syngnathidae)

PLATE II



Trachinotus goodei (Carangidae)



Pagrus pagrus (Sparidae)



Syacium micrurum (Paralichthyidae)



Dules auriga (Serranidae)



Lutjanus analis (Lutjanidae)

Foto: Daniel Lewis



Shpyraena cf. *Borealis* (Sphyraenidae)

PLATE III



Pareques acuminatus (young phase)



Anisotremus virginicus (young phase)



Pareques acuminatus (intermediate phase)



Anisotremus virginicus (intermediate phase)



Pareques acuminatus (adult phase)

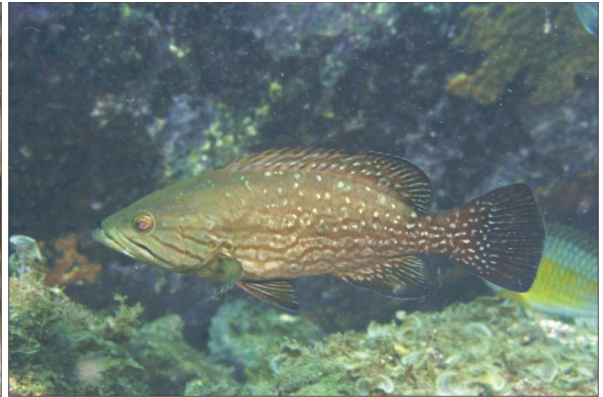


Anisotremus virginicus (adult phase)

PLATE IV



Mycteroperca acutirostris (young phase)



Mycteroperca acutirostris (adult phase)



Mycteroperca interstitialis (young phase)



Mycteroperca interstitialis (adult phase)



Epinephelus marginatus (young phase)



Epinephelus marginatus (subadult phase)

CONSIDERAÇÕES FINAIS

- Como fechamento do trabalho se reafirma o fato de que os recifes, conhecidos como rochosos, têm associados a si uma significativa riqueza de espécies e sustentam grande diversidade de relações ecológicas, muitas ainda por serem estudadas e compreendidas.
- O fato das áreas estudadas estarem em zonas de transição climática, sofrendo forte influência de massas d'água de características distintas, provoca, por vezes, homogeneidade nas comunidades de peixes, inviabilizando a detecção de padrões distintivos claros, em especial, considerando-se pequenas escalas espaciais.
- As flutuações dos índices observados nos estudos deixaram claro o dinamismo dos ambientes. Assim, apesar das dificuldades inerentes às condições de trabalho (visibilidade, condição de mar, correnteza, etc.), a observação do comportamento das comunidades de peixes, associados à eventos oceanográficos pontuais, deve ser investigada com maior profundidade.
- De um modo geral, seja pelo aumento do esforço de pesquisa, seja por possíveis mudanças climáticas, o aparecimento de espécies invasoras tem se mostrado cada vez mais corriqueiro, demandando avaliação dos impactos na ictiofauna marinha brasileira.
- A opção por desenvolver estudos que contemplem amostragens sistemáticas nos ambientes rochosos é primordial para a visualização e entendimento de padrões das comunidades em determinada área. Portanto, é necessário conferir especial atenção aos pulsos reprodutivos, objetivando a criação de parâmetros regionais para detectar os períodos de ocorrência, bem como estimativas de intensidades que possibilitem comparações futuras.
- Mais além, a detecção e o registro de 13 novas espécies no monitoramento em Santa Catarina é um claro indício de que novas áreas deverão ser contempladas na

continuidade do monitoramento, com especial atenção à investigação de pontos mais profundos e adjacentes ao ambiente de costão rochoso.

- A ampliação das amostragens para os ambientes insulares mais ao Sul de Santa Catarina deverá elucidar os limites de distribuição das espécies, uma vez que muitos desses limites de distribuição são atribuídos ao arquipélago do Arvoredo.
- Por fim, nota-se ainda que apesar dos esforços governamentais para que haja uma expressiva ampliação das áreas marinhas protegidas na costa brasileira até o ano de 2012, pouco tem sido investido em estudos nas áreas, e menos ainda em atividades que assegurem o funcionamento adequado das reservas já existentes.
- A segunda edição do livro “Peixes de Costão Rochoso de Santa Catarina”, pretende ao trazer a ictiofauna como tema, sensibilizar e alertar o público para questões sobre a importância do estabelecimento e respeito às áreas marinhas protegidas, informando ainda sobre a riqueza e beleza abrigadas nos ecossistemas marinhos.