From Fish Spawning Aggregations to Effective Marine Protected Areas in Brazil F0248011

BRAZIL – ABROLHOS BANK – 10 APRIL 2011 TO 30 MAY 2013

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A FINAL REPORT FOR THE CONSERVATION LEADERSHIP PROGRAMME

Conservation Leadership Programme

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ACKNOWLEDGEMENTS

To execute this project we relied on people connected to the fishing industry, such as fishermen and fish markets owners, in the municipalities of Alcobaça, Caravelas and Prado, who permitted the sampling and purchase of specimens. We thank Manoel David de Souza Junior, the crew of *Boto Cinza* and Cristiane Elfes for their work during the 2012 expedition. We relied also on the support from the Conservation International of Brazil, which provided the biological sampling framework, as well as research grant for a researcher per year. This project also had the following partners Rede Abrolhos-CNPQ (Abrolhos Network-National Council for Scientific and Technological Development), which also provided funding for one research assistant for a year, Universidade Federal do Paraná, Universidade Federal do Rio de Janeiro (Dr. Rodrigo Leão de Moura), Universidade Federal da Paraíba and Universidade Estadual de Maringá, The Brazilian Biodiversity Fund (FUNBIO) and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), which provided research grants and allowance for the fish sampling.

SECTION 1

1.1 SUMMARY

This project, initiated in 2004, resulted in a substantial advance on the biology of major species of groupers and snappers, which are the largest reef fish exploited by fisheries in the Abrolhos Shelf. This follow-up initiative aimed to provide support for the expansion and adaptive co-management of the Abrolhos Bank Marine Protected Areas (MPAs) network, Brazil. Results from the initial award supported proposals for an additional MPA (first one in mangroves) and buffer zones for the two existing coral reef MPAs. As new MPAs are still required and management is needed for those that are already in place, sound scientific knowledge and broad community engagement are imperative, therefore we gathered and disseminated information from fish landing surveys, habitat mapping, and underwater assessments and incorporated local support. These major targets were achieved with a strong participation of community members in all phases of the project, from research to policy-making. The data collected also provided the basis for capacity-building activities carried out with our partners. The beneficiaries of this effort since 2005 include four undergraduate Biology students, three Masters students in Zoology and Ecology, and one Ph.D. candidate, whose projects included aspects of the ecology of several species of snappers and groupers in Abrolhos.

1.2 INTRODUCTION

The Abrolhos Bank is located in Bahia state, on the Brazilian central coast. It is delimited by the enlargement of the continental shelf that extends up to 120 nautical miles from the South American continent. The largest South Atlantic coral reefs complex is situated in Abrolhos Bank, as well as extensive rhodolith beds, mangroves, estuaries, and sandbanks (Amado-Filho et al., 2012; Moura et al., 2013) (Fig. 1). This extensive environmental variety provides habitats for a large diversity of species, and 20% of the fish species are endemic to the region (Moura & Francini-Filho, 2005). In southern Bahia, the artisanal fisheries are traditional activities. However, in recent decades they have been replaced by large-scale fisheries (Paiva & Fontelles-Filho, 1995). In that time, buyers' preference for reef fish and crustaceans has increased and lead to the opening of new Brazilian and international markets. Over the last decades, fisheries targeting reef resources have been attracting fishers from other Brazilian states, who have increased the exploitation rates of these species in the Abrolhos Bank.

To conserve fish stocks and local small-scale fisheries, protected areas have been created, such as the Abrolhos National Park and the Extractive Reserves of Cassurubá and Corumbau. Such management measures, however, have been insufficient to keep the species exploitation rates at sustainable levels. Additional management measures are needed for this, based on scientific evidence, at the species or species group level. Yet, biological and ecological knowledge for informing management is scarce =. In order to manage the region's most common fisheries—which target groupers, snappers, parrotfishes, and one species of shark (Freitas, 2009)—the gathering of biological and ethnobiological data is required, including basic information concerning the existence, location and timing of spawning aggregations. These results, when properly disseminated, could base management measures, such as gear and size restrictions or fishing constraints at particular times and places.

Additionally, when performing scientific studies that include fisher partners, it is expected that the results be better understood by the community and more likely to be incorporated in localmanagement rulesIt is also expected that those management measures be more effective and easily accepted by the fishermen who participated in the data collection and in the results dissemination process (Berkes *et al*., 2001). Also, by collaborating with local fishers, the researchers are more likely to propose questions grounded on local reality and knowledge. To perform this project, we relied on people connected to the fishing industry, such as fishermen and fish market owners, in the municipalities of Alcobaça, Caravelas and Prado, who allowed for the sampling and purchase of specimens. We relied also on the support from the Conservation International of Brazil, who provided the biological sampling framework, as well as a yearly grant for a researcher. Additional partners of this project include the Rede Abrolhos-CNPQ (Abrolhos Network-National Council for Scientific and Technological Development), who also provided funding for one research assistant for a year, Universidade Federal do Paraná, Universidade Federal da Paraíba, Universidade Estadual de Maringá, The Brazilian Biodiversity Fund (FUNBIO) and the Coordenação de

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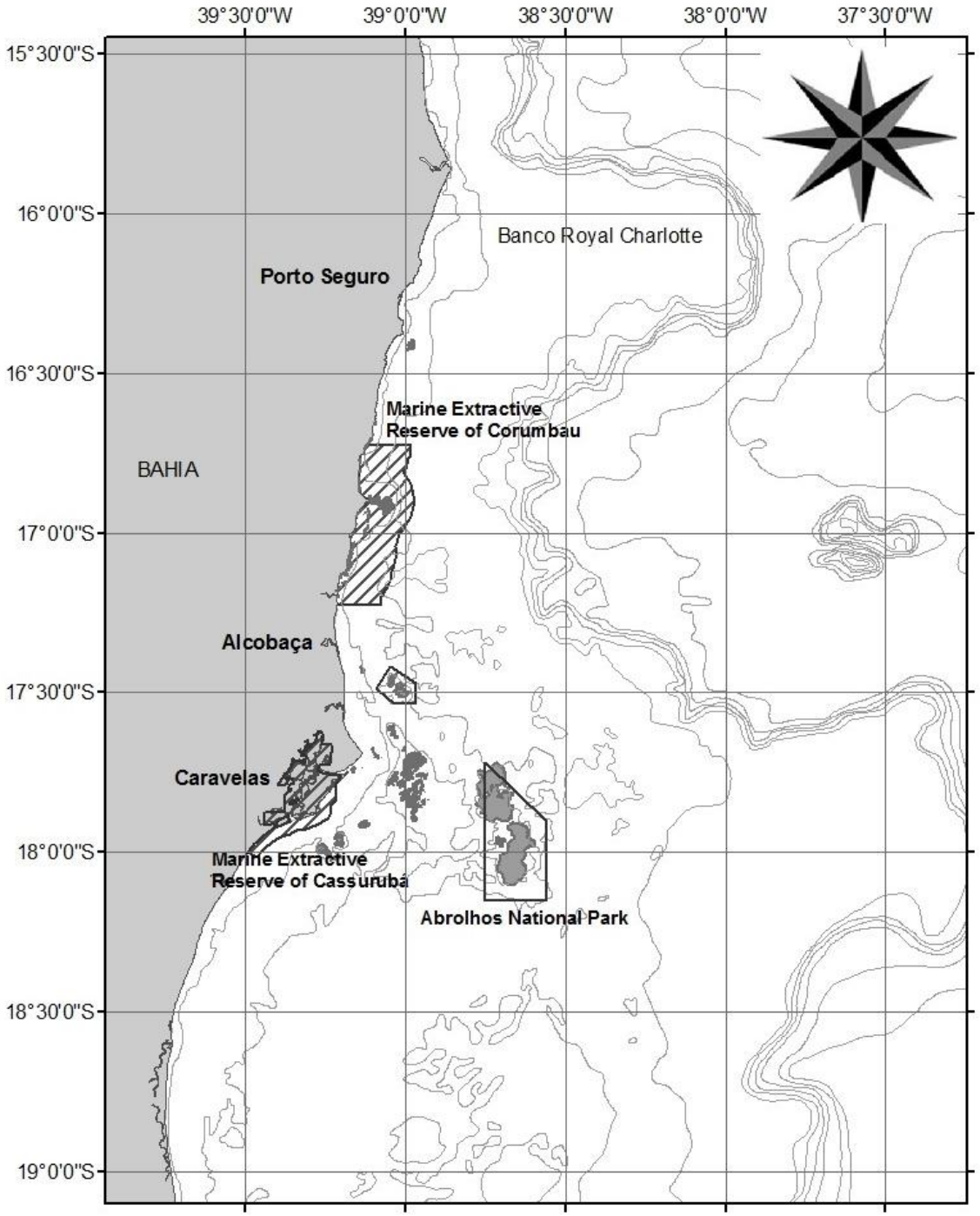

Figure 1. Abrolhos Bank location, the municipalities studied and marine protected areas.

1.3 PROJECT MEMBERS

Name: Matheus Oliveira Freitas
Occupation: Ph.D. Candidate
Project Role: Principal Investigator

I'm 33 years old, biologist and started my carrier in Marine Conservation in 2004, working with goliath groupers in south Brazil. In 2005 I started working on fisheries and ecology of endangered and commercially important reef fishes in Abrolhos, with fellowship at Marine Program - Conservation International Brazil from 2005 to 2007. I concluded my master degree with fishing and reproduction biology of lane snapper. Now I am pursuing a Ph.D. degree in Ecology and Conservation at the Federal University of Paraná - UFPR, working with groupers ecology. I am a member of the Rede Abrolhos ("Abrolhos Network"), and I also coordinate research and outreach projects sponsored by the Conservation Leadership Programme - CLP, focused on reef fish spawning aggregations and Marine Protected Areas. Currently I'm the president of Meros do Brasil Institute and coordinate the activities of fisheries biology from this project along the Brazilian coast.

Name: Marília Previero
Occupation: Master Degree Student
Project Role: Biological component

I did a degree in Biological Sciences in Universidade Estadual de Maringá, Paraná (UEM). During this course I work with fishes and fishers of the Abrolhos Bank region, when I studied the age and growth (Lutjanidae), and ethnobiology. After graduated I was scholarship from the Brazilian Biodiversity Fund, working with Conservation International of Brazil, with reef fish spawning aggregations, and biological sampling of reef fishes.
I am currently pursuing a Master's Degree in Ecology of Continental Aquatic Environments, in UEM. My dissertation project is on age and growth, and fisheries of the blue-parrotfish *Scarus trispinosus* (Scaridae). My role in this project is to interview fishers about the spawning aggregations sites and do biological sampling of this study focus species.

Name: Coral Fortunato
Occupation: Master Degree Student
Project Role: Biological component

I was graduated in Biological Sciences at the Universidade Estadual do Sudoeste da Bahia in 2010. I am currently pursuing a MSc Degree in Biodiversity and Evolutionary Biology at the Universidade Federal do Rio de Janeiro.
In my research, I try to understand the functional roles of sea urchins in Brazilian reefs, carrying out a series of experiments in the Abrolhos Reefs, off Bahia. I do manipulations of urchins in isolated patch reefs and watch their nocturnal feeding behavior with time-lapse cameras. I also collaborate with Nicole Lellys, Ronaldo Francini-Filho, Fernando Gibran, Marília Previero and Matheus Freitas in a parrotfish biology project.

Name: Fernanda Cervi
Occupation: Biologist
Project Role: Biological component

I graduated in Biological Sciences from the Universidade Estadual de Maringá (UEM), Paraná, Brazil, in early 2012, with experience in fisheries ecology in Marine Protected Areas belonging to the Abrolhos Bank.
In the same year I started living in Caravelas, Bahia, and with support from Rede Abrolhos, I began fieldwork with reef fishes of Marine Protected Areas (MPAs) in the Abrolhos Bank, collaborating with Nicole Lellys, Ronaldo Francini-Filho, Fernando Gibran, Marília Previero and Matheus Oliveira Freitas in the "Parrotfish Project", and integrating me into the Rede Abrolhos ("Network Abrolhos") and Conservation Leadership Programme (CLP). I currently hold a scholarship from Rede Abrolhos-CNPq to perform the biological sampling.

Name: Dr. Ronaldo Bastos Francini-Filho
Occupation: Professor on Universidade Federal da Paraíba
Project Role: Biological component

I have a Ph.D. degree from the Universidade de São Paulo- USP, and I am an Associate Professor at the Universidade Federal da Paraíba - UFPB in Rio Tinto, Paraíba State. I coordinate the long term underwater monitoring of the Abrolhos Network ("Rede Abrolhos"), in which several of my students are engaged.I am also an underwater photographer.

I collaborate with the CLP project in several projects in Abrolhos, oceanic islands and seamounts, deep sea, fish biology, and outreach.

Name: Dra. Carolina Viviana Minte-Vera
Occupation: Professor at Universidade Estadual de Maringá
Project Role: Biological component

I have a Ph.D. degree from the School of Fishery and Aquatic Sciences, of the University of Washington. Currently I am an assistant professor at the State University of Maringa and Senior Scientist at the Inter American Tropical Tuna Commission. I am supervising Ph.D. and master students at the Graduate Ecology Program (PEA) of the State University of Maringa, as well as undergraduate student, some of them involved with research in the Abrolhos Bank. I regularly teach graduate courses in Quantitative Ecology, have participated in several national and international working groups about fisheries management and fish conservation.

SECTION 2

2.1 AIM AND OBJECTIVES

This initiative aimed to provide support for the expansion of adaptive co-management of the Abrolhos Bank MPA network and fishing management. Results from the initial award supported proposals for an additional MPA (the first one in mangroves) and buffer zones for the two existing coral reef MPAs. As new MPAs are still required, and adaptive management must be based on sound scientific information and broad community enrolment, we gathered and disseminated data from fish landing surveys, habitat mapping, and underwater assessments. The objectives were: (1) to co-manage fisheries' resources, based on the results of some biological species and focusing on community involvement in decision making; (2) to continue the processing and collection of biological data of threatened species, including Scaridae species and large sharks caught by artisanal fishing in the region; (3) to monitor and compare the potential spawning aggregation sites of the groupers and snappers, based on data previously collected about peak capture by fleets, spawning peaks, and interviews with fishermen; and (4) to implement a major campaign for dissemination of the results obtained to all fishing communities in the Abrolhos Bank through shirts, adhesive rules and banners.

2.2 METHODOLOGY

2.2.1 Co-management of fisheries resources

By actively participating in the creation and establishment of MPAs in the region of the Abrolhos Bank, we facilitated the discussion of our research findings at regional MPA council meetings and the further incorporation of our results into the local management guidelines.

Meetings and workshops with fishermen and managers of marine protected areas in the region were carried out. At those meetings, the estimates of size at 50% maturity (L_{50}), available from the study of Freitas *et al*. (2011), were presented to stakeholders, along with information about the relevance of this knowledge as a tool for fisheries management in the region. The presentations and discussions were held in the cities of Caravelas (Cassurubá Extractive Reserve), Porto Seguro and Prado (Corumbau Marine Extractive Reserve). In each MPA, the information was discussed within management councils, which voted on the need and importance of implementing minimum catch sizes for the main species of reef fishes of the region.

2.2.2 Collection of biological data of threatened species

Between April 2011 and March 2013, data regarding commercially important reef fish and species classified as endangered by IUCN was collected and added to the biological data obtained by the project initiated in 2004 through the partnership of the CLP, Conservation International's Marine Program Brazil, FUNBIO and Abrolhos Network. Data collection was centralized in the ports of the Alcobaça and Caravelas municipalities (Fig. 1). The species *Scarus trispinosus*, *Sparisoma amplum*, *Lutjanus analis*, *Haemulum plumieri* and *Anisotremus virginicus* were sampled monthly. *Epinephelus morio*, *Mycteroperca bonaci* and *Ocyurus chrysurus* were sampled only in the months corresponding to their reproductive season, which was previously determined for the region by Freitas *et al*. (2011). The species *Dermatolepis inermis*, *Mycteroperca intertitialis* and *M*. *venenosa* were sampled whenever available, due to the high commercial value and low frequency of these species in fish landings.

To obtain samples of the Epinephelidae and Lutjanidae species, the specimens were bought and taken to the laboratory, where the biological material was removed before the specimens were resold in regional trade. For the species of the family Scaridae (*Scarus trispinosus* and *Sparisoma amplum*) samples were taken from carcasses donated by fishermen. These fish were filleted before sale, and the carcasses—containing the head, skeleton and viscera—were donated for research at no cost to the team. Some individual specimens were weighed before filleting for further correction and correlation of carcass weight to total weight. The lengths of specimens of *S. trispinosus* were measured during landings in the Alcobaça and Caravelas municipalities.

All specimens were measured to the nearest mm for total length (TL), sexed, and weighed to the nearest 0.1 g for total weight (TW) and gonad weight (Wg). Maturity was macroscopically determined from gonad size, consistency, color, vascularization, and presence of lateral

sperm sinuses, ovarian cavity, ovarian lamellae, and identifiable oocytes (Colin *et al*., 2003). Five developmental phases were used, according to Brow-Peterson *et al*. (2011) and García-Cagide *et al*. (2001).

In addition to the reproductive data, stomachs and otoliths were collected for further studies of diet, age, and growth. A collection protocol for obtaining biological samples of large sharks was also implemented—in this case, without much success, as the sharks most often arrive into port decapitated and eviscerated, which precludes the collection of biological samples.

2.2.3 Monitoring the potential spawning aggregation sites of the Epinephelidae and Lutjanidae species.

Vessel surveys expeditions and interviews with fishermen were done in three municipalities along the Abrolhos Bank (Prado, Alcobaça and Caravelas). The methodological approach followed the standard procedures developed by the Society for the Conservation of Reef Fish Aggregations, described in greater detail in the "Manual for the Study and Conservation of Reef Fish Spawning Aggregations" (Colin *et al*., 2003). Three seasonal fisheries-independent cruises (in full-moon lunar cycle) were used to sample biological data in situ and to map potential spawning aggregation sites. Interviews with fishermen considered local experts were conducted between June until August 2011. Questions about the ecology of the most important species in the fisheries of the region, as well as the reproductive behaviour of these species, were posed to the fishermen to ascertain the existence and locations of spawning aggregations. These interviews were conducted by means of semi-structured questionnaires, with spaces for additional information. Fishermen who use hook-and-line, gillnets, long lines, or harpoon were interviewed (Fig. 2).

2.2.4 COMMUNICATION CAMPAIGNS FOR DISSEMINATION OF THE RESULTS

We adapted the communication strategies according to the culture of the region and organized different educational materials, such as t-shirts and adhesive rules and drawings for printing. We held lectures in fishing communities, and also produced and maintained a website of the project.

Figure 2. Researcher makes an interview with fisherman in Abrolhos Bank.

2.3 OUTPUTS AND RESULTS

2.3.1 Co-management of fisheries resources

Between April 2011 and March 2013, a total of 494 fishermen and stakeholders attended the workshops held in the fishing communities of the Abrolhos Bank. We focused on the participation of two types of meetings: the deliberative council meetings

of the Marine Extractive Reserves (MER) and general meetings with fishermen (Table 1). In meetings with deliberative councils, we discussed the implementation of fisheries management measures proposed for Abrolhos, such as the maintenance and expansion of marine-protected areas and the establishment of minimum catch size limits for the main species of reef fish (Figure 3, 4).

Figure 3. CLP project member performing a lecture in the Corumbau ER deliberative council.

With regard to marine protected areas, we participated in the discussions of expansion and establishment of No-Take Areas in the fishing communities of Corumbau EMR. In addition, we offered information about potential sites for the occurrence of spawning aggregations and participated in the proposed extension of the Abrolhos Marine National Park and the establishment of other conservation units in the area. However, these proposals have stalled due to non-coordination and the social policy of the Brazilian government, which ran over the expansion process, which eventually hindered the proposal.

The proposal of minimum size limit based on the L_{50} in Corumbau MER was thoroughly discussed between the deliberative council and fishermen's. This measure has not been adopted as a management measure within this MER. In Cassurubá MER, the opposite occurred: in a few meetings dealing with this issue, the establishment of minimum size limit for catch was discussed and voted on as a management tool by fishermen and managers. After going through the deliberative council vote, an fishing agreement, or *Acordos de Pesca* in Portuguese, was adopted, which establishes minimum size for catches with spearfishing of *Lutjanus synagris*, *L. jocu*, *Ocyurus chrysurus*, *Epinephelus morio*, *Mycteroperca bonaci* and *Cephalopholis fulva*. Moreover, several other regulatory instruments of fishing activities were established, such as the prohibition of some fishing gears and the demarcation of fishing areas. More information about the fishing rules and regulations of the Cassuruba MER agreement are in Appendix II (only in Portuguese). Artisanal small-scale fisheries are particularly difficult to assess and manage, although they can have a strong impacts, on reef ecosystems by reducing the population size of its target species and affecting ecological processes (Roberts, 1995; Hawkins & Roberts, 2004).

Figure 4. Group photo taken during a workshop in the Cumuruxatiba fish community, at Corumbau MER.

Table 1. Number and activities conduced in Abrolhos Bank during the implementation of the project.

Activity	Quantity (No.)	Participants & Stakeholders Engaged (No.)
Extractive Reserves Deliberative Council Meetings		
Corumbau MER Deliberative Council Meetings	4	120
Cassuruba MER Deliberative Council Meetings	2	64
Workshops		
Corumbau MER	5	110
Cassurubá MER	1	40
Caravelas	12	160

2.3.2 Collection of biological data of threatened species

Tropical reef fish stocks of commercially important species are being steadily overfished worldwide (Jennings & Polunin, 1996; Pauly *et al*., 2002). Although successful strategies for managing these resources depend on the interaction between highly heterogeneous social, political, and economic factors, they cannot refrain from strong biological and ecological background to guide decision-making (McClanahan & Castilla, 2007).

A total of 1420 fish were sampled from 32 species (Table 2). This resulted in a substantial contribution for the biological studies on age, growth, reproduction, and feeding of the species targeted by regional fisheries. A detailed list of the data collected, organized by biological species, is in Table 3. Among the species sampled are more of the *Sparisoma amplum* and *Scarus trispinosus*, which are key species for maintenance of coral reefs; yet, there was no biological information for the South Atlantic.

A total of 2354 specimens of *S. trispinosus* were measured, showing a slight difference between the municipalities. In Caravelas, sampled specimens ranged from 28 to 55 cm (Total Length TL) with mean of 39 cm, while the variation in Alcobaça was 32 to 85 cm TL with a mean of 58 cm (Fig. 5). The differences in landed sizes reflect the fishing grounds were each fleets operate. The Caravelas fleet operates in shallow reefs (depths up to 25 meter, while the Alcobaça fleet operates in remote areas (depths up to 40 meters), often with the use of illegal fishing gear such as air compressors, which allow for longer bottom time (Fig. 6).

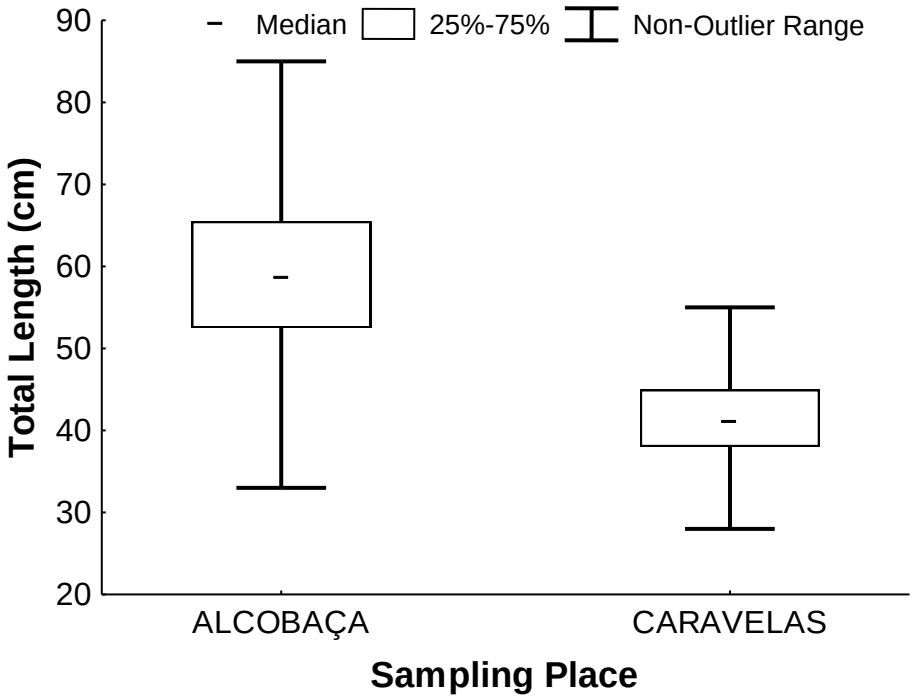

Figure 5. Box-plot of total length of *Scarus trispinosus* captured by commercial spearfishing in the municipalities of Alcobaça, Caravelas, Bahia.

Figure 6. Underwater fisherman preparing to dive with the help of air compressor. (Photo: Manoel David).

Table 3. Number of specimens per species sampled in the region of the Abrolhos Bank, Bahia.

	Sampling place				
Species	**Alcobaça**	**Caravelas**	**Prado**	**Scientific Expedition**	**Total**
Anisotremus virginicus	54	86	0	1	141
Bodianus rufus	2	0	1	0	3
Carcharhinus leucas	0	2	0	0	2
Caranx hippos	0	1	0	0	1
Caranx lattus	0	2	0	0	2
Cephalopholis fulva	2	2	0	0	4
Chaetodipterus faber	0	6	0	0	6
Dermatolepis inermis	23	0	0	0	23
Epinephelus itajara	1	0	0	0	1
Epinephelus adscensionis	0	0	1	0	1
Epinephelus morio	9	7	0	2	18
Haemulon aurolineatum	0	3	0	11	14
Haemulon parra	3	0	0	0	3
Haemulon plumieri	84	76	0	20	180
Halicheroes brasiliensis	0	2	0	0	2
Lutjanus analis	39	1	0	0	40
Lutjanus cyanopterus	0	1	1	0	2
Lutjanus jocu	1	8	0	1	10
Lutjanus synagris	0	0	0	8	8
Mycteroperca bonaci	18	14	2	0	34
Mycteroperca interstitialis	11	0	0	0	11
Mycteroperca venenosa	24	2	0	0	26
Ocyurus chrysurus	0	0	0	20	20
Priacanthus arenatus	0	0	0	3	3
Rhomboplites aurorubens	0	0	0	1	1
Scarus trispinosus	483	249	0	0	732
Scarus zelindae	0	8	0	0	8
Scomberomorus brasiliensis	0	0	0	0	0
Selene vomer	0	4	0	0	4
Sparisoma amplum	92	24	0	0	116
Sparisoma frondosum	0	3	0	0	3
Sphyraena barracuda	0	0	0	1	1
Total	846	501	5	68	1420

Table 4. Number of structures per species collected between April 2011 and March 2013 in the region of the Abrolhos Bank, Bahia.

	Collected structures				
Species	**Gonads**	**Stomach**	**Otolith**	**Spine**	**Ray**
Anisotremus virginicus	141	141	141		
Bodianus rufus	3	3	3		
Carcharhinus leucas	2	2			
Caranx hippos	1	1	1		
Caranx lattus	2	2	2		
Cephalopholis fulva	4	4	4	3	
Chaetodipterus faber	6	6	6		
Dermatolepis inermis	22	22	22	18	
Epinephelus adscensionis	1	1	1		
Epinephelus itajara	1	1	1	1	
Epinephelus morio	18	18	16	12	1
Haemulon aurolineatum	14	14	14		
Haemulon parra	3	3	3		
Haemulon plumieri	180	180	180		
Halicheroes brasiliensis	2	2	2		
Lutjanus analis	40	40	40		
Lutjanus cyanopterus	2	2	2	1	
Lutjanus jocu	10	10	10	1	
Lutjanus synagris	8	8	8		
Mycteroperca bonaci	34	34	34	23	
Mycteroperca interstitialis	10	10	10		
Mycteroperca venenosa	25	25	25	5	1
Ocyurus chrysurus	20	20	20		
Priacanthus arenatus	3	3	3		
Rhomboplites aurorubens	1	1	1		
Scarus trispinosus	732	0	699	1	
Scarus zelindae	8	0	7		
Scomberomorus brasiliensis	1	1			
Selene vomer	4	4	4		
Sparisoma amplum	116	0	103		
Sparisoma frondosum	3	0	3		
Sphyraena barracuda	1	1	1		
Total	1418	1417	1366	65	2

Regarding the collection of biological data for sharks, we had no satisfactory results. Only one sample of tiger shark (*Galeocerdo cuvier*) was obtained during the project. The common landing procedure of sharks hinders data collection about the reproductive and feeding of these species (even species identification in some cases). Unlike other species, sharks are eviscerated, decapitated, and have their fins separated from their bodies while still on deck. When a shark arrives into port, only the body, or "cigar" (*charuto* as it is popularly known), is landed (Fig. 7). Repeated attempts to convince fishermen to land the whole fish, or even the viscera, were unsuccessful.

Therefore, we believe that only research expeditions or onboard observers travelling along with the fishermen will have access to this biological material of sharks in the Abrolhos. In a recently published study by Bornatowski *et al*. (2012), the authors indicate that the abundance of humpback whale carcasses available over the Abrolhos bank, mainly during the breeding season, may be an important seasonal component of shark diets. The authors report that carcasses of the humpback whale and other species comprised 22.3% and 20.8% of the diet of large sharks, respectively. These data suggest that efforts aimed at collecting biological sharks should be prioritized between the months of May and November, which is the breeding season of humpback whales in Abrolhos.

Figure 7. Body of tiger shark, gutted and head landed on Caravelas, Abrolhos Bank (Photo: Danielle Marinho Nobre).

2.3.3 Monitoring of the potential spawning aggregation sites of the Groupers, Snappers and Scarids.

From March 12–25th, 2012 an expedition sampling directed through fishing and underwater observations over the Abrolhos Bank was held. During this period, several dives in local potential aggregation sites of large snappers were performed in order to record the presence of spawners or reproductive morphological features such as swollen abdomens or increased staining patterns. During these dives, however, no characteristic features of spawning or spawning aggregation was observed or recorded. In addition to the dives, the areas were examined with the aid of video images obtained by a Remotely Operated Vehicle (ROV) with a range of 100 m depth (Fig. 8). This expedition allowed the mapping and characterization of substrates that assisted

in the composition of the new map of Mega Habitats in Abrolhos by Moura *et al*. (2013).

Figure 8. Researcher operating the ROV to search spawning aggregations and characterization of the substrate (Photo: João Batista Teixeira).

By targeting fisheries, we collected various biological samples of commercial species (Table 05). We recorded the second important result: specimens of *Rhomboplites aurorubens* (Fig. 09) and *Ocyurus chrysurus* were recorded in an advanced stage of gonadal maturation, and histological results revealed the presence of Pós Ovulatory Follicle's (POFs), which are considered a direct indication of recent spawning (Colin *et al.,* 2003) (Fig. 10).

Figure 9. Specimen of *Rhomboplites aurorubens* collected during the expedition onboard in March 2012, in south of Abrolhos Bank.

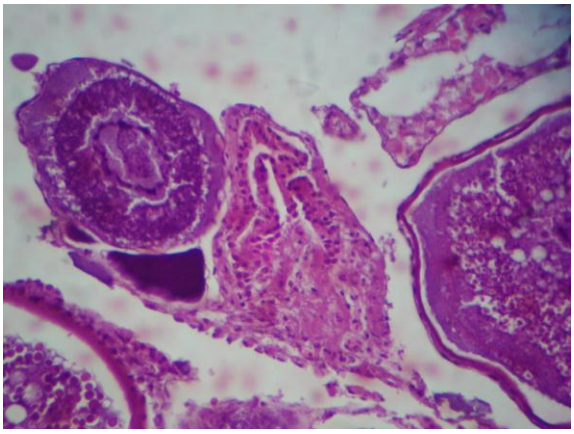

Figure 10. POF of specimen of *Rhomboplites aurorubens* collected during the expedition onboard in March 2012, in south of Abrolhos Bank.

A second expedition to search for potential sites of spawning aggregations was held between August 29 and September 8, 2012. This field campaign, conducted in two work fronts—one aboard ships (Fig. 11) and another in the ports of fish landings —collected, in partnership with local fishermen, 24 samples of large groupers and snappers over four days (Table 05) (Fig. 12). In the histological analysis samples of *Epinephelus morio*, *Mycteroperca bonaci*, and *Cephalopholis fulva* POFs were observed, which characterized the area as a spawning ground. During this expedition, oceanographic conditions prohibited dives and visual observations of fish. The locations where the samples were taken are in Figure 13. Concurrently, another strategy was established to obtain data from fishing areas via the collection of biological material in Alcobaça, the largest fishing port in the region. In this port, a total of 53 samples of large reef fish were collected. The samples collected indicated imminent spawning, by hydrated oocytes or recent POFs, for the species *C*. *fulva*, *E*. *morio*, *M*. *venenosa*, *M*. *bonaci*, and *Dermatolepis inermis*.

Analyzing, integrating, and comparing the results of biological samples collected by the team since 2004, we corroborate and strengthen the information contained in Freitas *et al*. (2011), which indicates that for Epinephelidae (*E*. *morio*, *M*. *bonaci*, *M*. *venenosa*, *D*. *inermis*, and *C*. *fulva*) the reproductive cycle occurs between the months of July to September, with a peak of spawning in August. The spawning aggregation areas, as indicated by the Local Ecological Knowledge and by direct histological and scientific evidence obtained in the specimens, are located in the Northern part of the Abrolhos Bank, at depths below 25 meters and near the continental shelf. Two spawning peaks, one from August–October and another from January–April were observed for all species, except for *R*. *aurorubens*, which has a reproductive period from January to April, peaking in February/March. The areas evaluated as potential sites for the occurrence of spawning aggregations were located in south of the Abrolhos Bank for species *O*. *chrysurus* and *R*. *aurorubens*, and the north and northeast along the continental shelf for the other species (Fig. 11).

Table 05. Number of species collected in Spawning aggregations between March 2012 and March 2013 in the region of the Abrolhos Bank, Bahia.

Spawning aggregations expedtions				
Species	On board			Landing Ports
	March 2012	August 2012	March 2013	Alcobaça port August/September 2012
Epinephelus morio	2	2	5	7
Mycteroperca bonaci		14	1	16
Mycteroperca venenosa				11
Mycteroperca interstistialis				
Dermatolepis inermis				1
Cephalopholis fulva		2		2
Lutjanus synagris	8		11	
Lutjanus analis			3	
Lutjanus jocu	1	1	13	
Lutjanus cyanopterus		1		
Ocyurus chrysurus	20		12	
Rhomboplites aurolineatum	1		0	
Haemulum plumieri	20		11	
Haemulum aurolineatum	1-1		12	
Scarus trispinosus		3	8	16
Sparisoma amplum		1	1	

Through interviews with fishermen, we obtained the names of fishes and the approximate locations of fishing. No correlations were found by comparing data from fishermen with indicative direct spawning of fishes. Only species *Epinephelus morio* showed direct correlation between the peaks of reproduction from fishers' knowledge and scientific research (Table 6). We believe that the fishermen's inability to identify the breeding seasons of fish results from the

procedure of handling and fish processing. In the early 90s, the fish export trade was established in the Abrolhos region. This trade requires that fish reach the fishing landing without scale or skin damage, and without processing and removal of the viscera on deck. For that reason, fishermen no longer process the commercial fish themselves and, consequently, no longer visually identify mature gonads, which are usually evident upon opening the fish.

Figure 11. CLP team and fishermen's aboard ships in the expedition to search spawning aggregations in Abrolhos Bank. (Photo: Carolina Minte-Vera).

Figure 12. CLP team colleting biological data in lab to spawning aggregations research in Abrolhos Bank. (Photo: Carolina Minte-Vera)

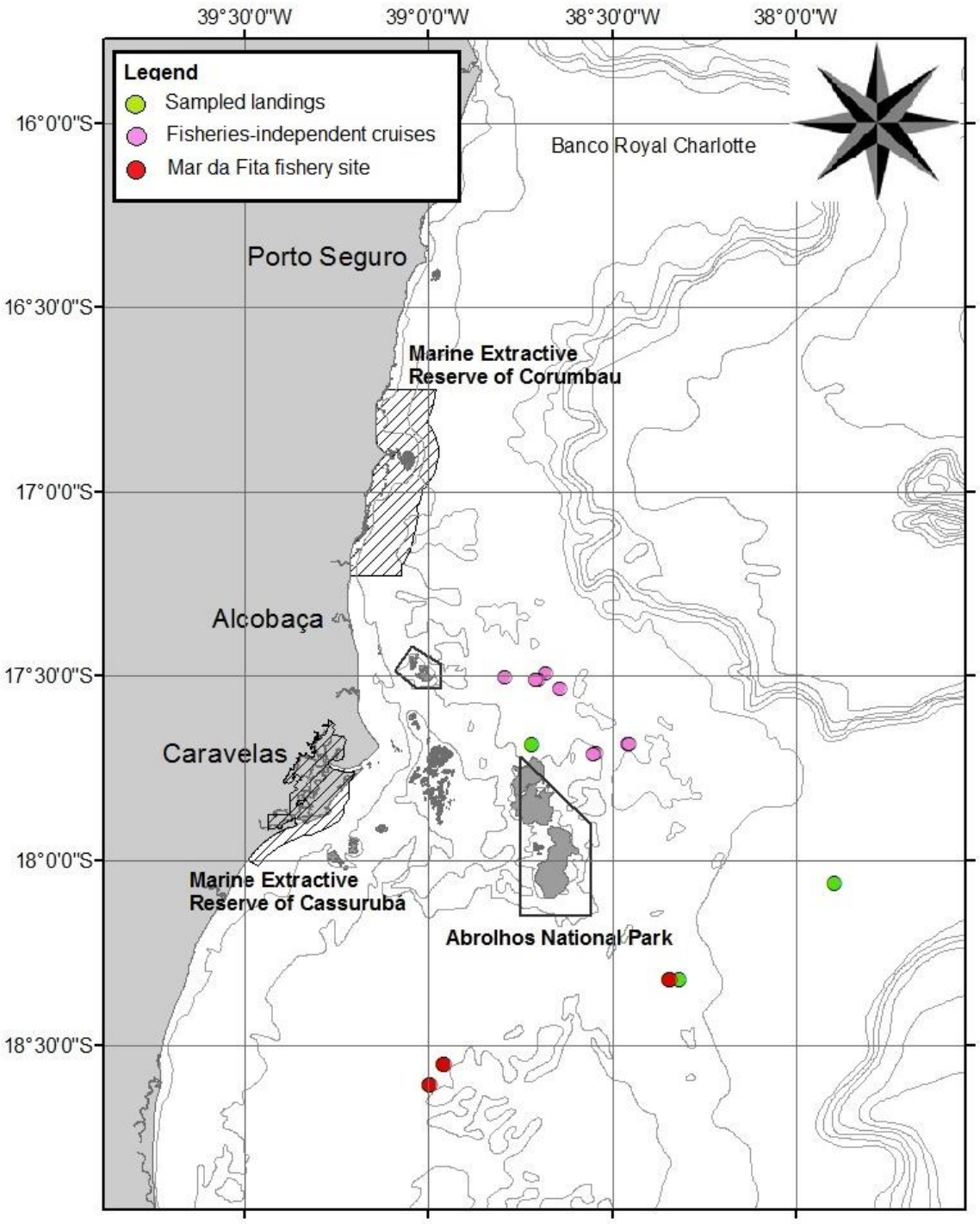

Figure 13. Locations of fish collected during sampling of fisheries landings. Fishing spots where fish were collected on a scientific expedition and fishing spots that indicate the fishing "Mar da Fita", according to the fishermen in the Abrolhos Bank , Bahia.

Table 6. Spawning seasons (X) and times easier to catch each species (in gray) according to the fishermen interviewed in the municipalities of Alcobaça, Caravelas and Prado, Bahia state.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cephalopholis fulva	X	X	X								X	X
Dermatolepis inermis	X	X	X	X	X	X	X	X				X
Epinephelus morio							X	X				
Lutjanus analis	X	X	X	X								X
Lutjanus bucanella	X	X	X									X
Lutjanus jocu	X	X	X	X	X	X	X					
Lutjanus synagris	X	X	X	X	X	X	X	X				
Lutjanus vivanus	X	X	X									X
Mycteroperca bonaci	X	X	X	X			X	X	X	X		X
Mycteroperca intertitialis											X	X
Mycteroperca venenosa											X	X
Ocyurus chrysurus	X	X			X				X	X	X	X
Paranthias furcifer	X											X
Scarus trispinosus	X	X	X									X

Another important result of this project was the professional and academic capacity building. Since 2005, several researchers have accessed and studied the biological data collected by the CLP project in partnership with other institutions. The list of researchers, master's and doctoral degrees related scientific publications are available in Appendix I.

2.3.4 Campaign to disseminate the results

Successful implementation of management arrangements in traditional communities ultimately depends on the sociocultural conditions of the communities and their understanding and adherence to the rules (Busilacchi *et al*., 2012). Management may be more difficult in traditional communities that depend on catches below the L_{50} for their survival, as is the case for many communities in the Abrolhos Bank.

Based on this, three main types of educational materials were produced during the project. Two hundredadhesive strips with drawings of a scale and indication of the the length at 50% maturity (suggested as minimum sizes) of key species of reef fish were distributed in fishing communities. The scales were made of high-strength material so that they could be fixed by fishermen in their boats where they could aid in measurement and consequently, the release of fish below the required measurement. In addition to the boats, the rulers were placed in other places of great movement of fishers.

In addition, a total of 300 T-shirts with pictures of the ruler and size at 50% maturity of the fish, along with the phrase "I respect, and you?" were widely distributed in fishing communities. This proved to be a very effective way of incorporating and building awareness, and several times fishermen were noticed

commenting on information contained in the shirts (See Appendix III).

In addition, ten banners containing information of breeding seasons and L_{50} sizes were made and used in lectures and workshops. The project page has been created and made available on the site www.peixesrecifais.org. On this website, the main activities of the project are available and summarized, as well as photos, contact and vita of the CLP team members, project partners, and the list of scientific publications generated by the project.

2.4 ACHIEVEMENTS AND IMPACTS

Abrolhos represents a highly threatened and extremely rich area in the South Atlantic. Fisheries are the central activity for thousands of people, and coastal and marine management is dependent upon a MPA network that is not yet fully designed and implemented. The current project envisages a scaled-up and innovative approach to address these challenges, being integrated with major research and conservation efforts. The project provided new information about reproductive cycles, spawning, and growth parameters of the main commercially important reef fishes found in Abrolhos. Research of the scale proposed here will provide information that may be used in concert with results of other studies to pursue conservation outcomes. Translated into everyday language, this information can also be used by local populations to inform their opinions on resource use and management. It is noteworthy that local fisheries management strategies have rarely accounted for the concentrated nature of fish spawning events. The approach that we are proposing has great potential to provide a key input to governmental decision-making and conservation-planning in Abrolhos.

The legacy of the initiative encompasses three major dimensions. The first one includes the contribution for capacity building, professional development and career advancement of several young researchers that are involved with marine research and conservation in an important and frequently neglected coastal country. Second, the project will represent a landmark in community participation in the decision-making process in Abrolhos MPAs, being capable of fostering a long-term adaptive management scheme for the entire region. Finally, as already achieved during the first award, the project's results will support new MPA establishments in Abrolhos.

SECTION 3:

3.1 CONCLUSION

In general, we believe that the original objectives have been achieved. We managed to take a significant step forward in collecting biological information of the main fish species threatened in the region, and these data will provide the basis for proposing strategies for management and conservation in Abrolhos and the Brazilian coast.

Furthermore, because of the long-term engagement that we have had with the fishermen in the region since 2005, the strategies of co-management began to bear fruits. Through biological information generated was possible to increase the

awareness of fishers and to create management mechanisms (such as establishing minimum sizes catch of fishes) in different MERs in the region. Another exciting point includes the emergence of further discussions, in other fishing communities in Abrolhos, of the need for establishing a management strategy.

The knowledge about local spawning aggregation was increased; surely this information will provide the basis for the establishment of new marine protected areas and the expansion of the existing in the Abrolhos Bank.

Based on the successes of—and mistakes made during—the execution of the project, we will draft a new proposal for the continuation of our activities. We know that changing lifestyles and habits only bear fruit when the partnership is maintained with key stakeholders in the long term.

3.2 PROBLEMS ENCOUNTERED AND LESSONS LEARNT

The only problem we encountered during the project implementation was related to the currency rates of exchange. When we made the project budget, the dollar exchange rate was around 1.75 Brazilian real. When we received the money from the CLP, the value was the lowest level in ten years, around 1.54. Because this resulted in a significant loss, we had to adapt our budget. No change was made in the project, though, in relation to the budget that was originally proposed, because the loss was compensated with the approval of other grant funds.

During project development two factors were key. One was the need to purchase the fish studied. This was the only way we found to obtain biological samples. Because the species we work are of high commercial value, we had to apply for extra funding opportunities to get enough resources for the purchase of these samples. The procedure we adopted was to buy the specimens, take biological samples and then to sell the fish.

The other problem was the relationship with the fishing communities. In many communities the fishers did not support research activities and, in many cases, omitted or made it difficult to obtain reliable data. In order to rsolve this problem, the researchers were constantly present within communities. This presence over time broke the barriers of communication between fishers and researchers, resulting in the development of friendly relationships and trust that remains today within the fishing communities.

The most important lessons learned were associated with project organization and planning. During the project these issues were well handled, and were very helpful during the project implementation and execution of correct planned activities.

3.3 IN THE FUTURE

To learning from mistakes, to improve the successes, and to not get discouraged is the motto of our team. Since the beginning of our conservation activities, spawning aggregations and ecology of reef fish Abrolhos in 2005, several lessons were

learned. One is that the work of environmental information and exchange of information with fishermen has to be constant. Therefore, we cannot stop our activities and find that somehow the problems are resolved. We have many unanswered questions, and strategies for action plans for several species need to be implemented. A greater effort must be deployed in the case of large sharks, which was a weak point during the course of the project. New methodologies and ways of approaching the fishermen must be developed, including onboard observations.

We also need to follow-up the analysis and publication of collected data regarding fish biology: reproduction, age, growth, and diet. Furthermore, we would like to propose easy-to-implement methodologies and inexpensive means of evaluating the status of fish stocks (especially endangered species). A program of fisheries data collection (catch per unit effort, production, fish size, etc.) must indeed be established in Abrolhos.

We will spare no efforts in the search for new funding resources and partners to assure that these activities are actually implemented, so that an efficient and participatory conservation program is established in Abrolhos.

SECTION 4

4.1 REFERENCES

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4.1 APPENDIX

APPENDIX I

Publications that resulted from the research funded by the CLP.

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Costa e Silva, G.H. Reprodução e alimentação de *Haemulon plumieri* no Banco dos Abrolhos, Bahia. Master degree in course Programa de Pós Graduação em Zoologia. Universidade Federal do Paraná, Brasil. Finishes on 2015.

Previero, M. A pesca do budião-azul (*Scarus trispinosus*) no Banco dos Abrolhos, Bahia. Master degree in course Ecologia de Ambientes Aquáticos Continentais) – Departamento de Biologia, Universidade Estadual de Maringá, Maringá. Finishes on 2014.

Xavier, J. Idade e crescimento de *Sparisoma amplum* (Perciformes: Scaridae) no Banco dos Abrolhos, Bahia. Master degree in course Ecologia de Ambientes Aquáticos Continentais) – Departamento de Biologia, Universidade Estadual de Maringá, Maringá. Finishes on 2015.

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APPENDIX II

Cassuruba ER Agreement Fishing", or *Acordos de Pesca*in Portuguese

Nº 71, segunda-feira, 15 de abril de 2013 Diário Oficial da União - Seção 1

Art. 11 - Fica proibida a pesca com barco motorizado numa faixa de 500 metros da linha de costa, na região compreendida entre a Ponta do Catoeiro e a Barra de Nova Viçosa.

Parágrafo único. A faixa, a que se refere o caput, é definida pelo seguinte memorial descritivo: Partindo-se do ponto P1 (Ponta do Catueiro), de coordenadas aproximadas 17°51'52,66" S, 039°15'51,47"W segue no mar por uma reta de azimute 132°57'35,93" e por uma distância aproximada de 500m até o P2, de coordenadas aproximadas 17°52'03,74"S, 039°15'39,04"W localizado no mar; deste, segue no mar por uma reta de azimute 217°33'58,25" e por uma distância aproximada de 671m até o ponto P3, de coordenadas aproximadas 17°52'21,05"S, 039°15'52,94"W, localizado no mar; deste, segue no mar por uma reta de azimute 241°37'24,73" e por uma distância aproximada de 2895m até o ponto P4 de coordenadas aproximadas 17°53'05,80"S, 039°17'19,47"W localizado no mar; deste, segue no mar por uma reta de azimute 249°20'57,79" e por uma distância aproximada de 3122m até o ponto P5 de coordenadas aproximadas 17°53'41,61"S, 039°18'58,74"W localizado no mar; deste, segue no mar por uma reta de azimute 237°41'03,39" e por uma distância aproximada de 992m até o ponto P6, de coordenadas aproximadas 17°53'58,86"S, 039°19'27,22"W localizado no mar; deste, segue no mar por uma reta de azimute 260°20'54,84" e por uma distância aproximada de 1319m até o ponto P7, de coordenadas aproximadas 17°54'06,06"S, 039°20'11,43"W, localizado no mar; deste segue no mar por uma reta de azimute 358°57'50,23" e por uma distância aproximada de 509m até o P8, de coordenadas aproximadas 17°53'49,48"S, 039°20'11,74"W, localizado na linha de costa; deste segue pela linha de costa até o P1 (ponta do Catueiro), fechando-se o polígono.

Art. 12 - Fica proibida a pesca com rede de arrasto (manual ou motorizado) nos parcéis contidos na Zona de Amortecimento da Reserva Extrativista de Cassurubá.

Art. 13 - Fica proibida a pesca com rede feiticeira nos parcéis da Zona de Amortecimento da Reserva Extrativista de Cassurubá.

Art. 14 - Ficam proibidas a captura, o desembarque, o transporte, o armazenamento, o beneficiamento e a comercialização das espécies relacionadas a seguir, que forem capturadas na pesca de mergulho, cujos comprimentos sejam inferiores a:

Nome Vulgar	Nome Científico	Tamanho mínimo (cm)
Badejo:	Mycteroperca bonaci	63 cm;
Garoupa:	Epinephelus morio	39 cm
Dentão:	Lutjanus jocu	34 cm
Guaiuba ou cioba:	Ocyurus chrysurus	22 cm;
Arioco (graco):	Lutjanus synagris	19 cm
Catua:	Cephalopholis fulva	13 cm;

Parágrafo único. Para efeito de mensuração das espécies de peixes acima referidas, define-se o comprimento como sendo a distância tomada entre a extremidade anterior da cabeça e a parte anterior (base) da nadadeira caudal.

Art. 15 - Aos infratores da presente Instrução Normativa serão aplicadas as penalidades e sanções, respectivamente, previstas na Lei nº 9.605/1998 e demais regulamentações pertinentes.

Art. 16 - Esta Portaria entra em vigor na data da sua publicação.

ROBERTO RICARDO VIZENTIN

I - DA ADMINISTRAÇÃO PÚBLICA

a) Instituto Chico Mendes de Conservação da Biodiversidade, sendo um titular e um suplente;

b) Superintendência Regional do Instituto Nacional de Colonização Agrária - INCRA no estado de Rondônia/RO, sendo um titular e um suplente;

c) Fundação Universidade Federal de Rondônia - UNIR, sendo um titular e um suplente;

d) Centrais Elétricas do Norte do Brasil S/A - ELETRONORTE, sendo titular e Centrais Elétricas de Rondônia S/A - CERON, sendo suplente;

e) Agência de Defesa Sanitária Agrosilvopastoril do Estado de Rondônia - IDARON, sendo um titular e um suplente;

f) Secretaria de Estado do Desenvolvimento Ambiental SEDAM, sendo um titular e um suplente;

g) Batalhão de Polícia Ambiental - BPA da PM do estado de Rondônia, sendo titular e, Delegacia Especializada em crimes contra o Meio Ambiente da Polícia Civil, sendo suplente;

h) Superintendência Estadual de Turismo - SETUR, sendo um titular e um suplente;

i) Prefeitura Municipal de Candeias do Jamari - RO, sendo um titular e um suplente;

j) Secretaria Municipal de Meio Ambiente do Município de Porto Velho - SEMA/RO, sendo um titular e um suplente;

II - DA SOCIEDADE CIVIL

a) Faculdade de Ciências Humanas, Exatas e Letras de Rondônia - FARO, sendo titular e Centro de Ensino São Lucas Ltda - Faculdade São Lucas, sendo suplente;

b) Instituto de Pesquisa em Defesa da Identidade Amazônica - INDIA, sendo titular e Núcleo de Apoio à População Ribeirinha da Amazônia - NAPRA, sendo suplente;

c) Centro de Pesquisas de Populações Tradicionais Cuniã - CPPT, sendo um titular e um suplente;

d) Sindicato Rural de Candeias do Jamari, sendo um titular e um suplente;

e) Colônia de Pescadores Z-1 Tenente Santana, sendo titular e Colônia de Pescadores Z-6 Candeias do Jamari, sendo suplente;

f) Ecos do Madeira - Amazônia Brasil Promoções e Ecodesenvolvimento LTDA, sendo um titular e um suplente;

g) Cooperativa de Agroextrativismo do Médio e Baixo Madeira - COOMADE, sendo um titular e um suplente;

h) Conselho das Associações e Cooperativas do Médio e Baixo Madeira - CONACOBAM, sendo um titular e um suplente;

i) Associação Rural do Rio Preto de Calama - ARCAL, sendo um titular e um suplente;

j) Associação dos Produtores Rurais de Santa Catarina, Baixo Madeira - ASSOMAR, sendo um titular e um suplente;

k) Associação Comunitária das Comunidades Pesqueiras e Extrativistas de São Carlos - ACCPESC, sendo um titular e um suplente;

l) Associação Agricultores da Localidade de Papagaios - Papagaios Rio Madeira, sendo um titular e um suplente;

m) Associação de Pequenos e Médios Produtores Rurais da LP-30 Linha Quarenta e Cinco, sendo titular e, Associação de Produtores Rurais de Itapuã do Oeste, sendo suplente;

n) Cooperativa de Produtores e Extrativistas da Bacia do Rio Madeira - COOPEBRIMA, sendo um titular e um suplente;

o) Associação de Assistência Técnica e Extensão Rural do Estado de Rondônia - EMATER, sendo um titular e um suplente.

Parágrafo único. O Conselho Consultivo será presidido pelo chefe ou responsável institucional da Floresta Nacional de Jacundá, a

Local newspapers with stories about the CLP project and the fishing agreements

O SAMBURÁ

BARRA DE CARAVELAS, BAHIA - ANO III - EDIÇÃO NÚMERO 35 - jornalosambura@gmail.com

Tiragem 2.000 Exemplares

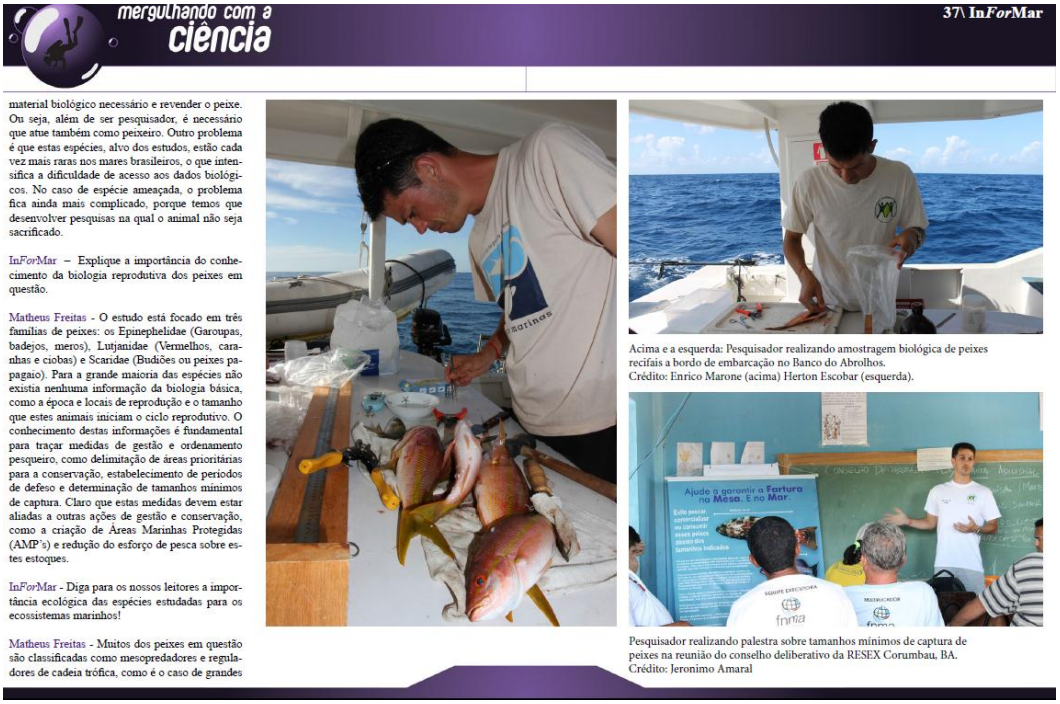
MENSAL - Período Março/Abril - 2012

Resex do Cassurubá constrói regras para Acordo de Pesca

Durante o mês de Abril foram realizados alguns encontros para criar o **Acordo de Pesca na Reserva Extrativista do Cassurubá**.

O objetivo era construir as regras da pesca junto com os pescadores, que são os principais conhecedores e envolvidos com a questão.

LEIA NAS PÁGINAS 4 e 5



mergulhando com a ciência

37\ InForMar

material biológico necessário e revender o peixe. Ou seja, além de ser pesquisador, é necessário que atue também como peixeiro. Outro problema é que estas espécies, alvo dos estudos, estão cada vez mais raras nos mares brasileiros, o que intensifica a dificuldade de acesso aos dados biológicos. No caso de espécie ameaçada, o problema fica ainda mais complicado, porque temos que desenvolver pesquisas na qual o animal não seja sacrificado.

InForMar – Explique a importância do conhecimento da biologia reprodutiva dos peixes em questão.

Matheus Freitas - O estudo está focado em três famílias de peixes: os Epinephelidae (Garoupas, badejos, meros), Lutjanidae (Vermelhos, caranhas e ciobas) e Scaridae (Budiões ou peixes papagaio). Para a grande maioria das espécies não existia nenhuma informação da biologia básica, como a época e locais de reprodução e o tamanho que estes animais iniciam o ciclo reprodutivo. O conhecimento destas informações é fundamental para traçar medidas de gestão e ordenamento pesqueiro, como delimitação de áreas prioritárias para a conservação, estabelecimento de períodos de defeso e determinação de tamanhos mínimos de captura. Claro que estas medidas devem estar aliadas a outras ações de gestão e conservação, como a criação de Áreas Marinhas Protegidas (AMP's) e redução do esforço de pesca sobre estes estoques.

InForMar - Diga para os nossos leitores a importância ecológica das espécies estudadas para os ecossistemas marinhos!

Matheus Freitas - Muitos dos peixes em questão são classificadas como mesopredadores e reguladores de cadeia trófica, como é o caso de grandes

Acima e a esquerda: Pesquisador realizando amostragem biológica de peixes recifais a bordo de embarcação no Banco do Abrolhos.
Crédito: Enrico Marone (acima) Herton Escobar (esquerda).

Pesquisador realizando palestra sobre tamanhos mínimos de captura de peixes na reunião do conselho deliberativo da RESEX Corumbau, BA.
Crédito: Jeronimo Amaral

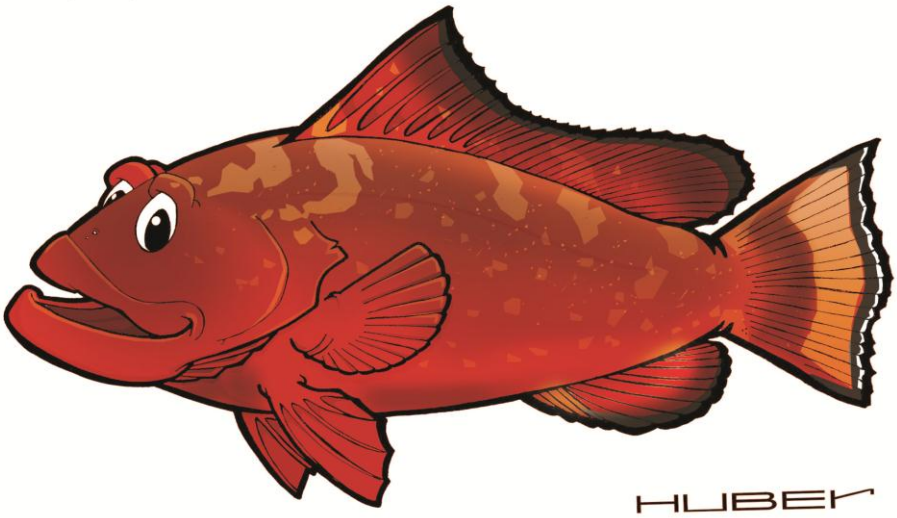
APPENDIX III

Educational Material - Banner

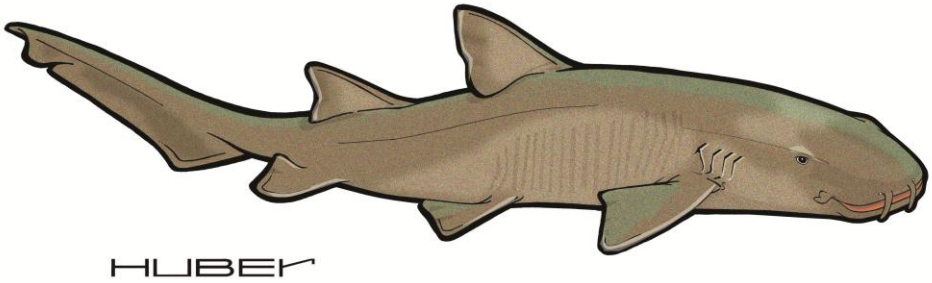
Educational Material - T-shirt

Educational Material - Adhesive scale

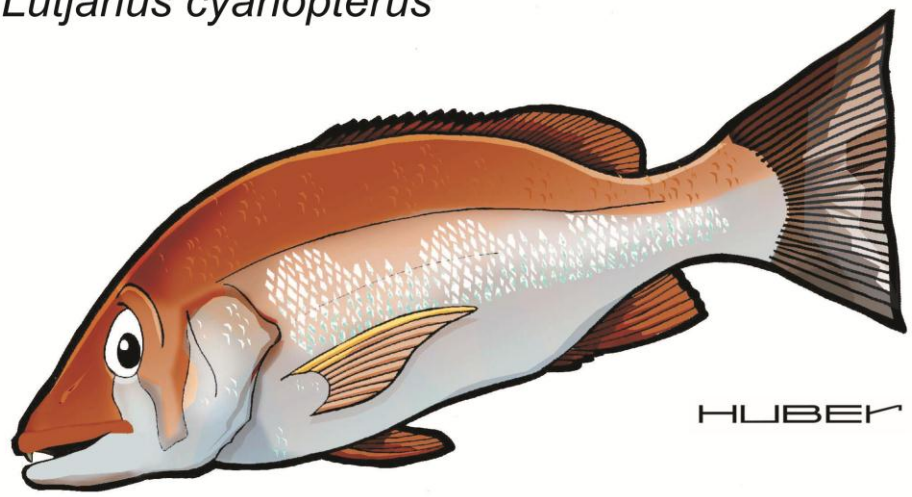
Epinephelus morio



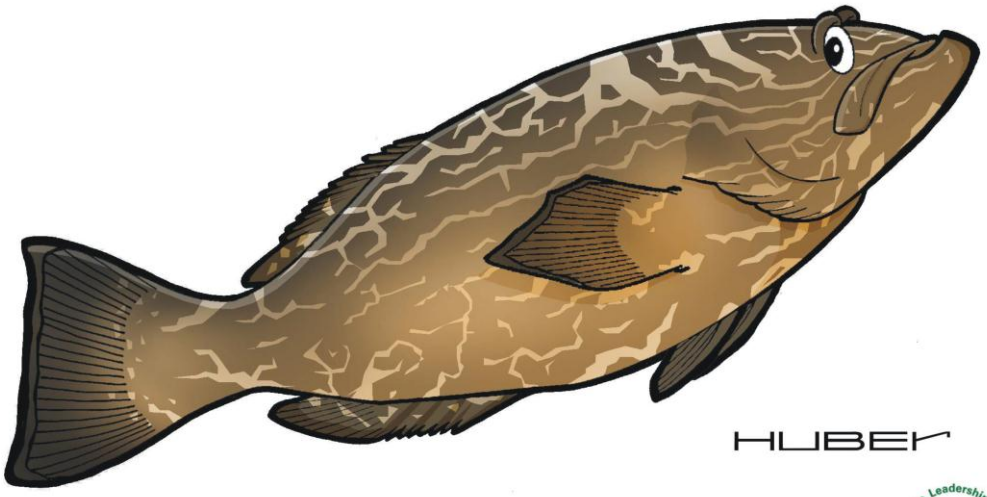
Ginglymostoma cirratum



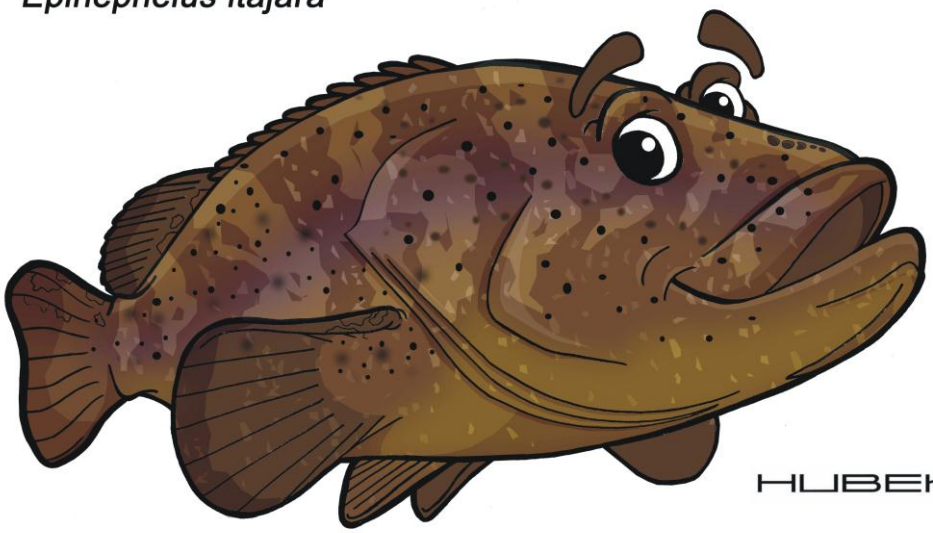
Lutjanus cyanopterus



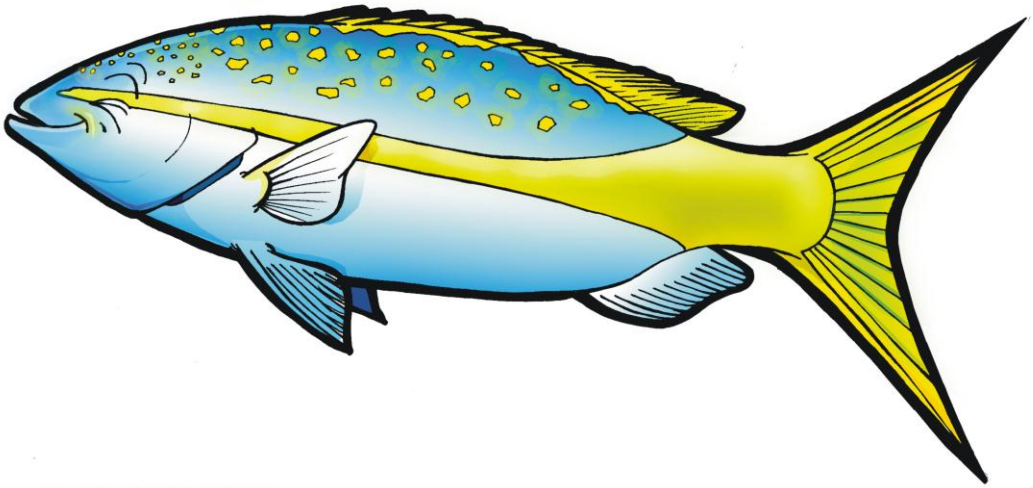
Mycteroperca bonaci



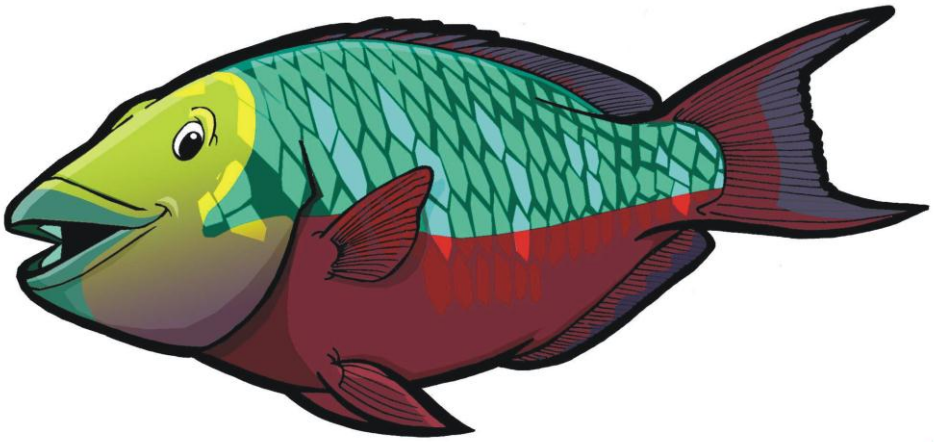
Epinephelus itajara



Ocyurus chrysurus



Sparisoma amplum



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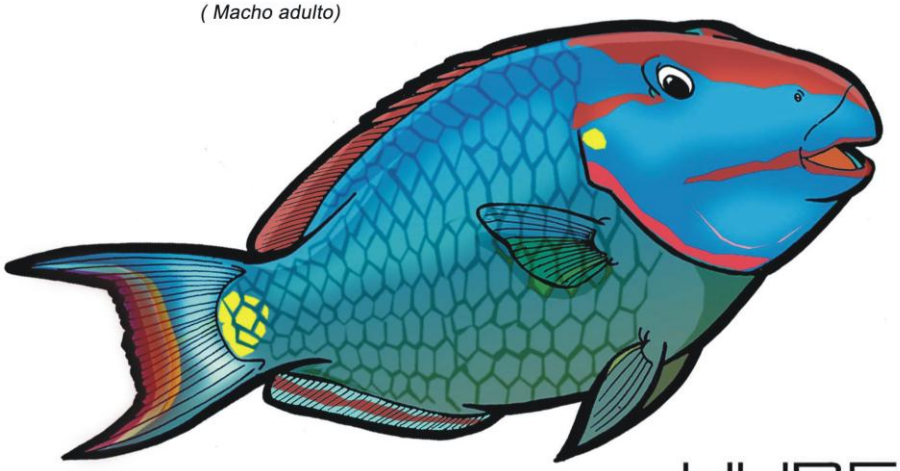
Sparisoma amplum

(Macho adulto)



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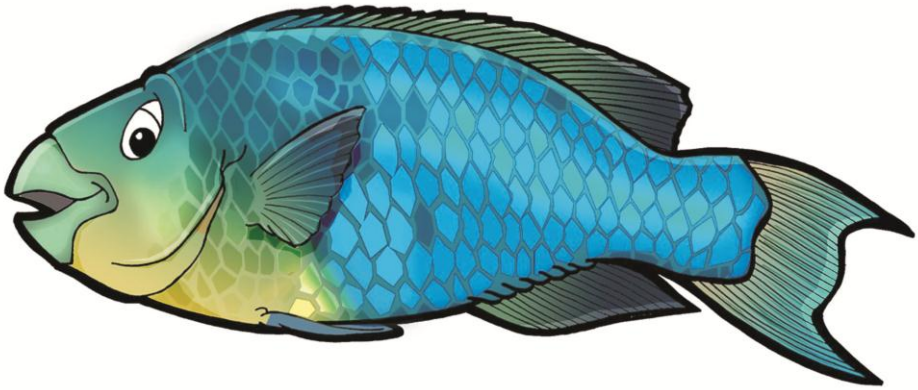
Scarus trispinosus



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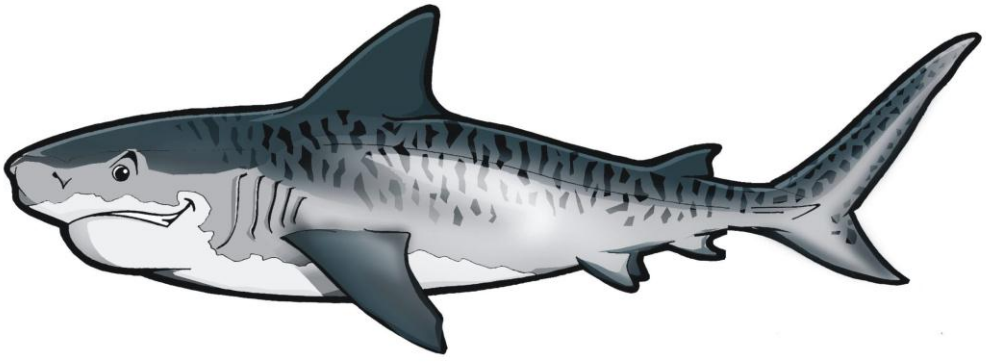
Conservation Leadership Programme

Galeocerdo cuvier



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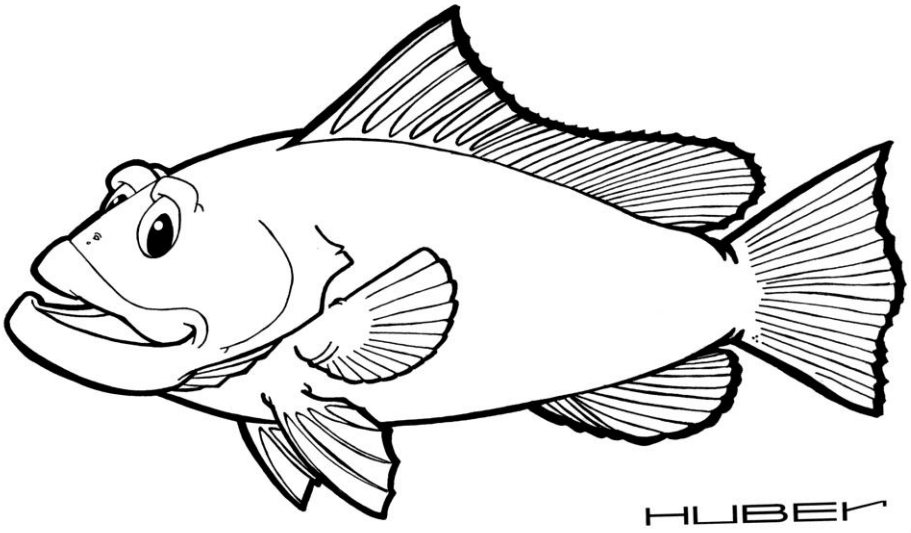
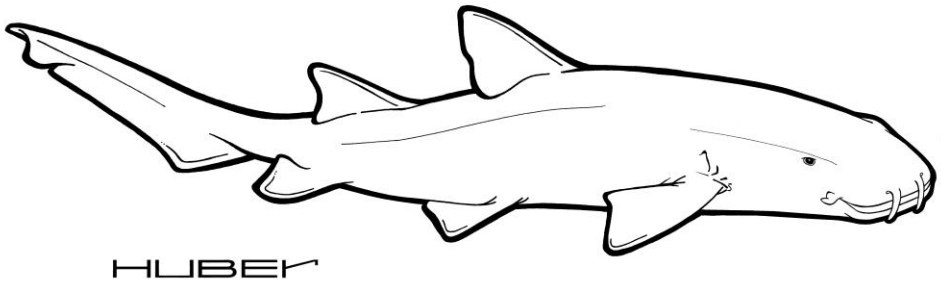
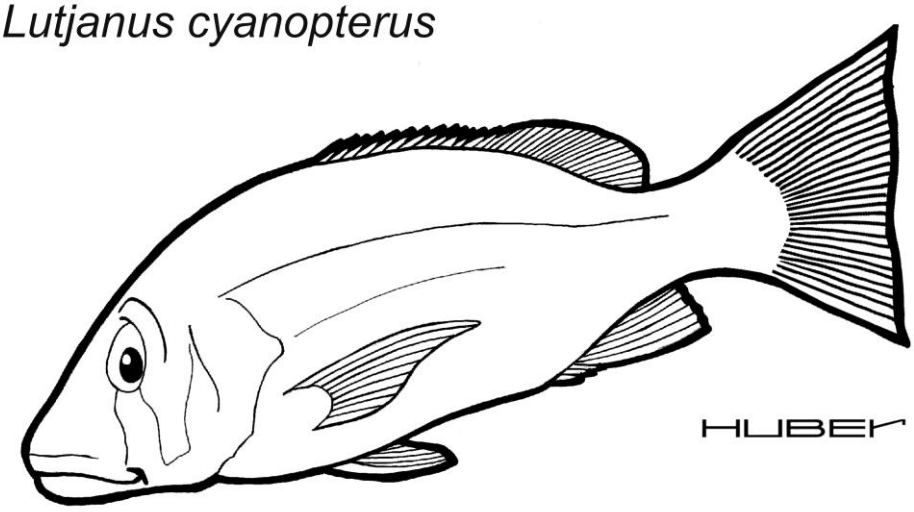
Epinephelus morio



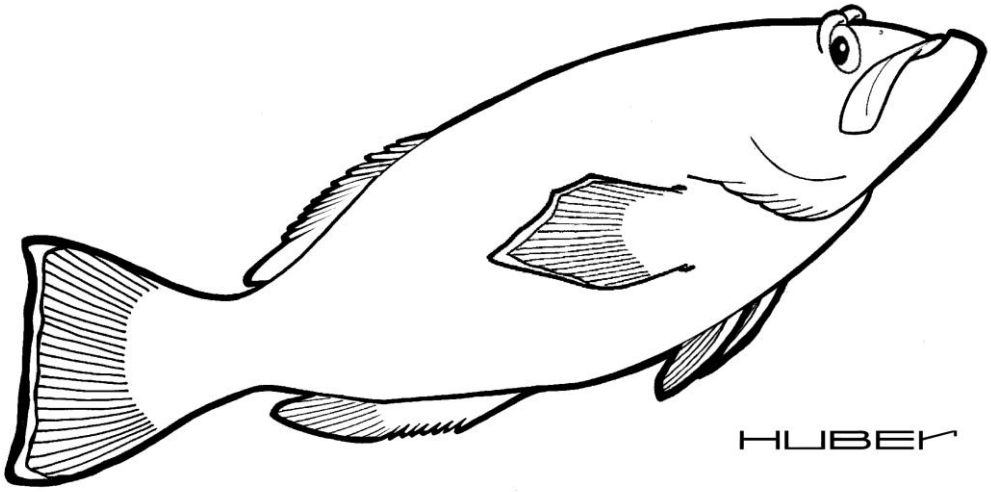
Ginglymostoma cirratum



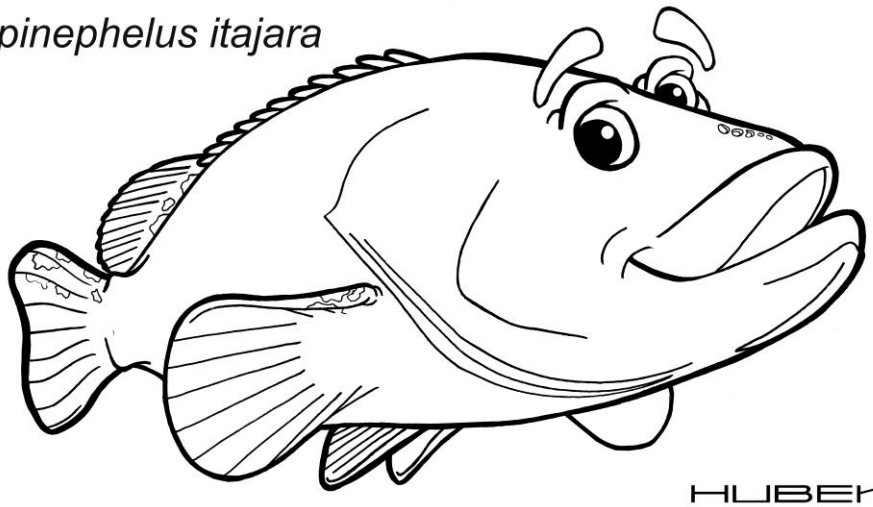
Lutjanus cyanopterus



Mycteroperca bonaci



Epinephelus itajara



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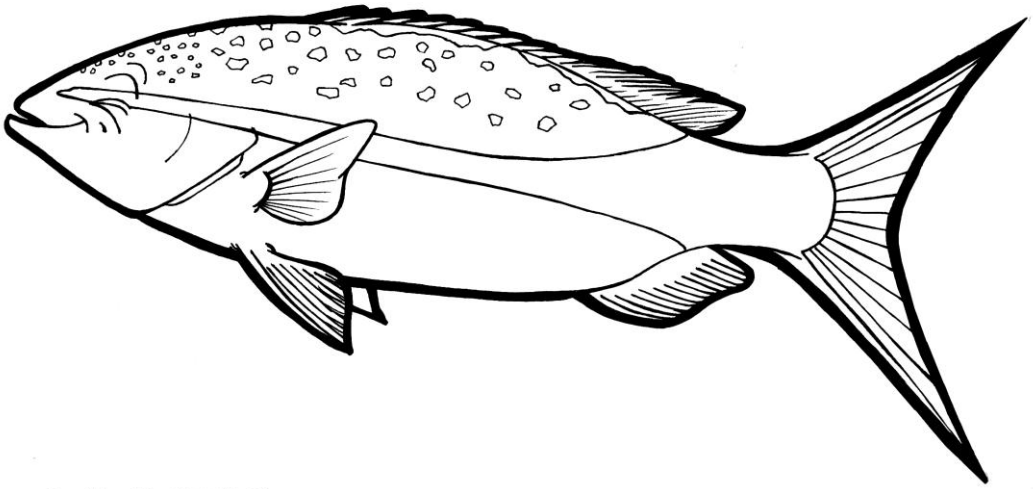
Ocyurus chrysurus

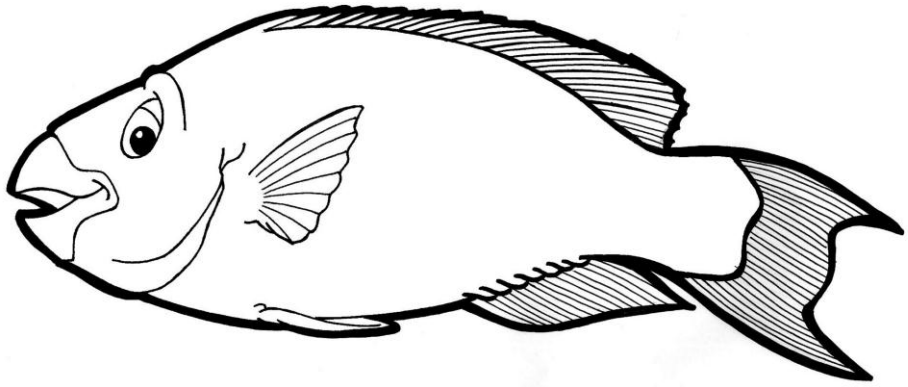


HUBER

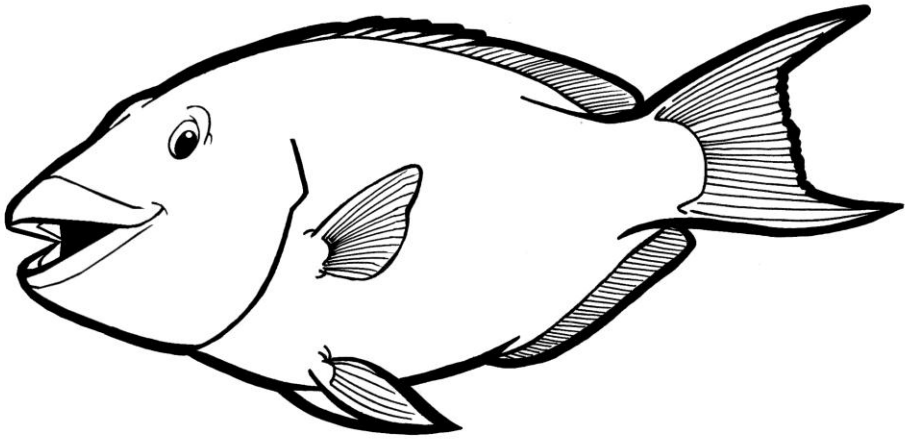
REDE ABROLHOS

Conservation Leadership Programme

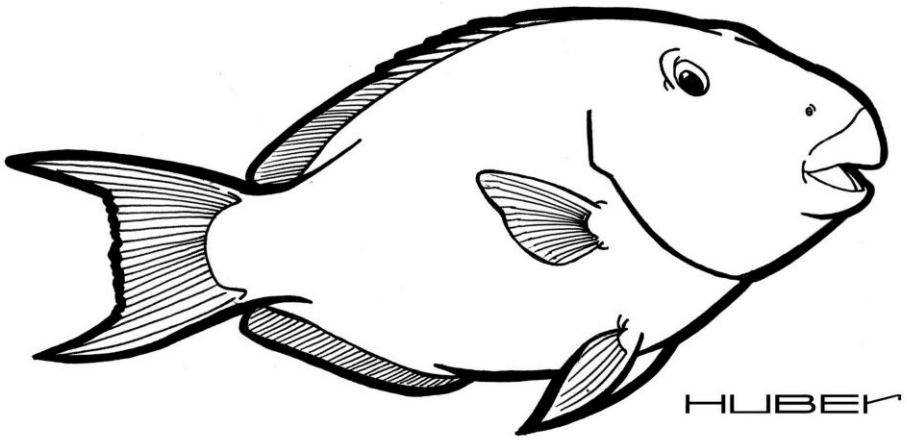
Scarus trispinosus



Sparisoma amplum fëmea



Sparisoma amplum macho



Galeocerdo cuvier