REEF CHECK GERMANY

Annual Reef Check survey of Kalawy house reef, Safaga, Egypt

Report 2010

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with support from Magic Life GmbH & Co KG

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Content

1. Summary

Every year Reef Check is conducting surveys at the House Reef of Club Magic Life Kalawy. It has been 12 months since the last survey took place. The first surveys on fish, invertebrates, substrate, coral damage and trash, were conducted by biologists in March 2008 using the Reef Check method (Hodgson et al. 2006). This was the baseline for the following annual reports in 2009 and this one. By using a standard method and counting certain indicators, alterations to the regularly surveyed reef sites should be tracked. Further the abundances and diversity of fish species can be compared.

Starting with the fish indicators, surgeonfish (Acanthuridae) and butterflyfish (Chaetodontidae) had the greatest abundance of all the Reef Check fish indicators. Compared to results of 2009, there was a slight decrease of parrotfish > 20 cm. Unfortunately, the abundance of important predators like groupers (Epinephelinae) and trevallies (Carangidae) decreased as well. Especially these families are highly favoured food fish, therefore it is urgently recommended to observe local fishery activities and to ban it. The disappearence of these top predators can affect the ecological balance of the reef substantially.

Overall, this year´s fish census showed similar results compared to previous years. Five out of six of the most abundant species belong to the family of damselfish (Pomacentridae). This result was expected, since members of this family are mainly swarm-forming, hence they form every year the bulk of all individuals counted.

For the invertebrate indicators, a decrease of Long-spined sea urchins (Diadematidae), Trochus shells (Trochidae) and Giant clams (Tridacnidae) was observed. Further, Purple coral snails (*Coralliophila violacea*) had a decline as well. Abundance of this species, which primary feeds on the coral genus Porites, decreased considerably, the number of Porites colonies affected in 2010 was half of that recorded in 2009.

The Coral Damage Surveys showed a slight decrease of coral predation and coral breakage compared to 2009, but still clearly higher values than in 2008. The decrease was predominant at reef site A. Values of the higher frequented reef site B were more persistent with a slight decrease for coral breakage and a slight increase of coral predation. The results showed no clear increase in coral damage as in 2009

(in contrast to 2008; see report 2009). Nevertheless, coral damage values for reef site B still remained high compared to the first study.

The substrate surveys showed no distinct differences compared to the results of 2009. A significant decrease of soft corals of the family Xeniids, as was shown from 2008 to 2009 could not be observed. All results of hard coral subcategories remained within their standard deviations. The total hard coral cover was 31,4%, which is 1% below corresponding value of the 2009 study but almost identical to the result of 2008 (31,3%). Hard Coral cover pooled over sites showed a constant slightly decrease at reef area A and a constant increase at reef area B. Over all, the staghorn corals (*Acropora* spp.) were again the dominating group, followed by other branching corals (mainly raspberry corals *Pocillopora* spp.) and pore corals (*Porites* spp.). Pore corals were more abundant than “other branching corals” in sites A, compared to site B. The abundance of dead corals was persistent with 0,2 % throughout all studies. The categories Recently Killed Corals (RKC), Sand (SD) and Rubble had similar values. Algae cover was lower than last year, mainly due to the decrese in Turf Algae (TA). Contribution of Nutrient Indicator Algae (NIA) was persistingly low.

The house reef in Kalawy is still in good condition, but some aspects should be considered. First, a few modifications of the entrance area could increase sustainable usage, e.g. the descent line should be fixed more centrally and away from the coral block, the “confined area” should be marked better and a info board for snorkelling activities (How and where to snorkel, some info on tide level and weather) is recommended. Second, fishing activities on the hotel premises should be strictly banned as well as the consumption of local reef fish (Parrotfish, Napoleon, etc.) and local reef fish predators (Tunas, Trevallies) so that the fish community can recover or remain stable. Overall, the results and the development of Kalawy reef over the past years are mainly positive. We recommend a more comprehensive substrate analysis to validate or falsify the changes in coral cover in Kalawy and surely continue the regular surveys over the next years (see chapter 5.5).

2. Introduction

Coral reefs are among the most biologically diverse ecosystems. They are important producers of nutrients and thus play a significant role for many marine species. While coral reefs have adapted to numerous natural impacts over thousands of years, the human impact is actually a greater threat, against which such a vulnerable ecosystem can hardly compensate. Poorly planned tourism development, but also tourists themselves, including snorkelers and SCUBA divers, may have negative impacts on coral reefs and the organisms depending on it.

Reef Check Germany e.V. was commissioned by Club Magic Life Kalawy, to monitor coral reef health and determine the impact of tourism on their house reef. Studies were carried out in March 2008, 2 months after the opening of the club, and June 2009 by a Reef Check group of four scientists. Aims of the studies were to record the health status of the house reef at permanent observation stations and to create a basis for future surveys. The Reef Check data were sent to the Reef Check headquarters, where they were put into the global data base to be used in reports on the health status of reefs at both global and regional level. Further, data will be used as an early warning system for large scale shifts. On a local level, the results will be used as a tool for decision makers, managers of tourist activities and other responsible parties.

Main results of 2008 and 2009 studies were that the most abundant indicatorfish at the Kalawy reef were Butterflyfish and Surgeonfish. With Butterflyfish there was strong decline abundance in 2009. Higher numbers of important predators in the same year support the assumption that the hotel building and closing most of the area have led to much less local fishing activities at the house reef. Results of the fish census showed in 2009 a significant higher amount of individuals here than in 2008. The data showed further that the higher numbers are mostly due to swarm- or group-forming species of Pomacentridae. Depending on season and reproduction, surveys on such swarms may deviate by up to 100 or 1,000 individuals.

Results of the invertebrate study revealed the following results: there was a decrease of Long-spined sea urchins (Diadematidae) and an increase of Purple coral snails (*Corraliophila violacea*). Falling numbers of Sea urchins may be a matter of an increasing number of triggerfish (Balistidae) since Sea urchins belong to their

favourite food items. Purple coral snails mainly feed on Porites colonies. In 2009, there were five times more Porites colonies affected by coral snails than in 2008.

Concerning coral coverage the fringing reef of Kalawy is still a reasonably healthy and colourful reef. Results of 2009 did not show high deviations concerning the different types of hard corals. Branching Acropora were like in 2008 the most abundant hard corals, followed by Pocillopora and Porites colonies. Percentage of dead corals and rubble remained the same; just algal cover was higher, probably due to seasonal changes. In total, the reef was in 2008 and 2009 in healthy and normal condition and featured the same diversity as other fringing reefs of the surrounding area (e.g. Safaga and El Quseir).

The aim of this study was to survey exactly the same six locations at the same three depths surveyed in 2008 and 2009. The collected data had been compared and possible differences regarding abundance, diversity and composition of substrate were analyzed. Until the second survey in 2009 about 16,000 dives were made at the survey sites. Approxiamately 12,000 dives took place between the second survey and the present one. By using identical survey methods and locations, the impact of tourism on Kalawys' fringing reef should be determined in the present study.

3. Methods

3.1 Survey sites

The same survey sites were used as for the 2008 and 2009 surveys. The sites were marked using permanent markers. There were two sites, one north and one south of the jetty, where hotel guests can enter the water safely. Reef sites lay between 26°30'30.98" North / 34°4'21.44" East and 26°30'40.63" North / 34°4'18.53" East. Both sites were surveyed at three different depths (5 m, 10 m, and 15 m). For a more detailed description of the survey sites, please refer to the 2008 report.

Table 1: Terms of survey sites.

Abbreviation	Definition	Abbreviation	Definition
ML	Magic Life	B	Survey site NORTH
A	Survey site SOUTH	5/10/15	Depths of transects

3.2 Survey methods

Reef Check method

The Reef Check method was used according to Hodgson (2006), as described in the 2008 report.

Extended Reef Check method

Data was collected using an extended Reef Check protocol like 2008 and 2009. This extension was developed by scientists at the Red Sea Environmental Centre and has been successfully applied at the annual Reef Monitoring in Dahab, South Sinai. The extension comprises additional indicators for fish (Tab. 2) and invertebrates (Tab. 3), and three new subcategories for the substrate survey (Tab. 4) were added in the last twelve months. Within the coral damage surveys, population of branching corals was measured using ten 1 x 1 m quadrates, instead of five 2 x 2 m frames. Accordingly, the sampling size was 10% this year, instead of 20% of the first year. All additional materials and methods were used as stated in the 2008 report.

Table 2: Additional fish indicators of the extended Reef Check protocol. *also counted off-transect (Alter 2006)

Common name	Scientific Name	Indicator for
Grouper < 30 cm	Serranidae	Overfishing
Parrotfish <20 cm	Scaridae	Overfishing/Regeneration of the family
Surgeonfish	Acanthuridae	Algal cover
Tuna and Mackerel	Scombridae	Overfishing
Trevallies*	Carangidae	Overfishing/Predator-prey-relationship in the reef
Steephead Parrot	*Chlorurus gibbus*	Overfishing
Twinspot Snapper*	*Lutjanus bohar*	Overfishing
Spangled Emperor*	*Lethrinus nebulosus*	Overfishing
Bluestreak Cleaner Wrasse	*Labroides dimidiatus*	Key organism for diversity of reef fish
"Farmer fish"	*Stegastes* und *Plectroglyphidodon*	Algal cover
Lyretail Grouper	*Variola louti*	Overfishing
Giant Moray	*Gymnothorax javanicus*	Predator-prey-relationship in the reef

Table 3: Additional Invertebrate indicators of the extended Reef Check protocol (Alter 2006).

Common name	Scientific Name	Indicator for
Slipper lobster	*Scyllarides* spp.	Local fishery/Overfishing
Three-knobbed conch	*Strombis tricornis*	Local fishery/Curio trade
Common spider conch	*Lambis truncata sebae*	Local fishery/Curio trade
Reef octopus	*Octopus cyaneus*	Local fishery
Nudibranchs	Nudibranchia	Divers attraction
Purple coral snail	*Coralliophila violacea*	Predation on pore corals (*Porites* spp.)
Cowries	Cypraeidae	Curio trade
Horn drupe	*Drupella cornus*	Predation on branching corals (*Acropora* spp., *Pocillopora* spp.)

Table 4: 35 codes and categories used for the extended substrate surveys, modified after English et al. (1994).

Code	Category	Code	Category
AA	Algal Assemblage	MA	Macroalgae
AB	Acropora Branching	OT	Others
AD	Acropora Digitate	PC	Porites Columnar
AT	Acropora Tabulate	PM	Porites Massive
CA	Coralline Algae	RB	Rubble
CB	Coral Branching	RC	Rock
CC	Coral Columnar	RKC	Recently Killed Coral
CE	Coral Encrusting	SC	Soft Coral
CF	Coral Foliose	SCA	Soft Coral Alcyonids
CM	Coral Massive	SCN	Soft Coral Nephteids
CME	Coral Millepora	SCX	Soft Coral Xeniids
CMR	Mushroom Corals	SD	Sand
CS	Coral Sub-Massive	Si	Silt
CTU	Coral Tubipora	SP	Sponge
DC	Dead Coral	TA	Turf Algae
DCA	Dead Coral with Algae	Wa	Water
FA	Fleshy Algae	ZO	Zoanthids
HA	Halimeda Algae		

4. Results

4.1 Fish indicator

The results of the fish surveys showed that surgeonfish (Acanthuridae) were the family with the highest abundance of approximately 16 individuals per 100 m² at both reef sites. Therein they had their highest local abundance of an average of 25 individuals per 100 m² at the 5 m transects. They were followed by butterflyfish (Chaetodontidae) with an average abundance of 8 individuals per 100m². Bluestreak cleaner wrasse (*Labroides dimidiatus*) showed an abundance of 4 individuals per 100 m^2. Within Parrotfish (Scaridae) considerably more individuals bigger than 20 cm per 100 m^2 were counted (3,0) than individuals smaller 20 cm (1,8). The groupers (Serranidae) < 30 cm with around 1,5 Ind./100 m^2 was the last group of the most common indicators. While 11 additional fish indicators with less than one individual per 100 m² were present, five indicators have not been observed at all (Table 5):

Table 5: Total number and mean abundance per 100 m² and standard deviation (SD) of fish indicators pooled of all transects. *Additional indicators are marked with an asterisk.

Indicator	Total	Mean	SD
Parrotfish > 20cm (Scaridae)	73	3,0	2,2
Parrotfish < 20cm (Scaridae)*	44	1,8	1,7
Steephead parrot (*Chlorurus gibbus*)*	0	0,0	0,0
Bumphead parrotfish (*Bolbometopon muricatum*)	0	0,0	0,0
Surgeonfish (Acanthuridae)*	393	16,4	12,0
Broomtail wrasse (*Cheilinus lunulatus*)	22	0,9	1,2
Humphead wrasse (*Cheilinus undulatus*)	0	0,0	0,0
Trevallies (Carangidae)*	3	0,1	0,4
Tuna & Mackerel (Scombridae)*	0	0,0	0,0
Snapper (Lutjanidae)	5	0,2	0,5
Twinspot Snapper (*Lutjanus bohar*)*	2	0,1	0,4
Emperor (Lethrinidae)*	22	0,9	2,0
Spangled emperor (*Lethrinus nebulosus*)*	2	0,1	0,3
Butterflyfish (Chaetodontidae)	191	8,0	5,8
Sweetlips (Haemulidae)	0	0,0	0,0
Grouper <30 cm (Epinephilinae)*	33	1,4	1,3
Grouper >30 cm (Epinephilinae)	9	0,4	0,6
Lyretail grouper (*Variola louti*)*	1	0,0	0,2
Bluestreak cleaner wrasse (*Labroides dimidiatus*)*	106	4,4	2,4
"Farmer fish" (*Stegastes* spp. & *Plectroglyphidodon* spp.)*	11	0,5	1,3
Moray eels (Muraenidae)	2	0,1	0,3
Giant moray (*Gymnothorax javanicus*)*	1	0,0	0,2

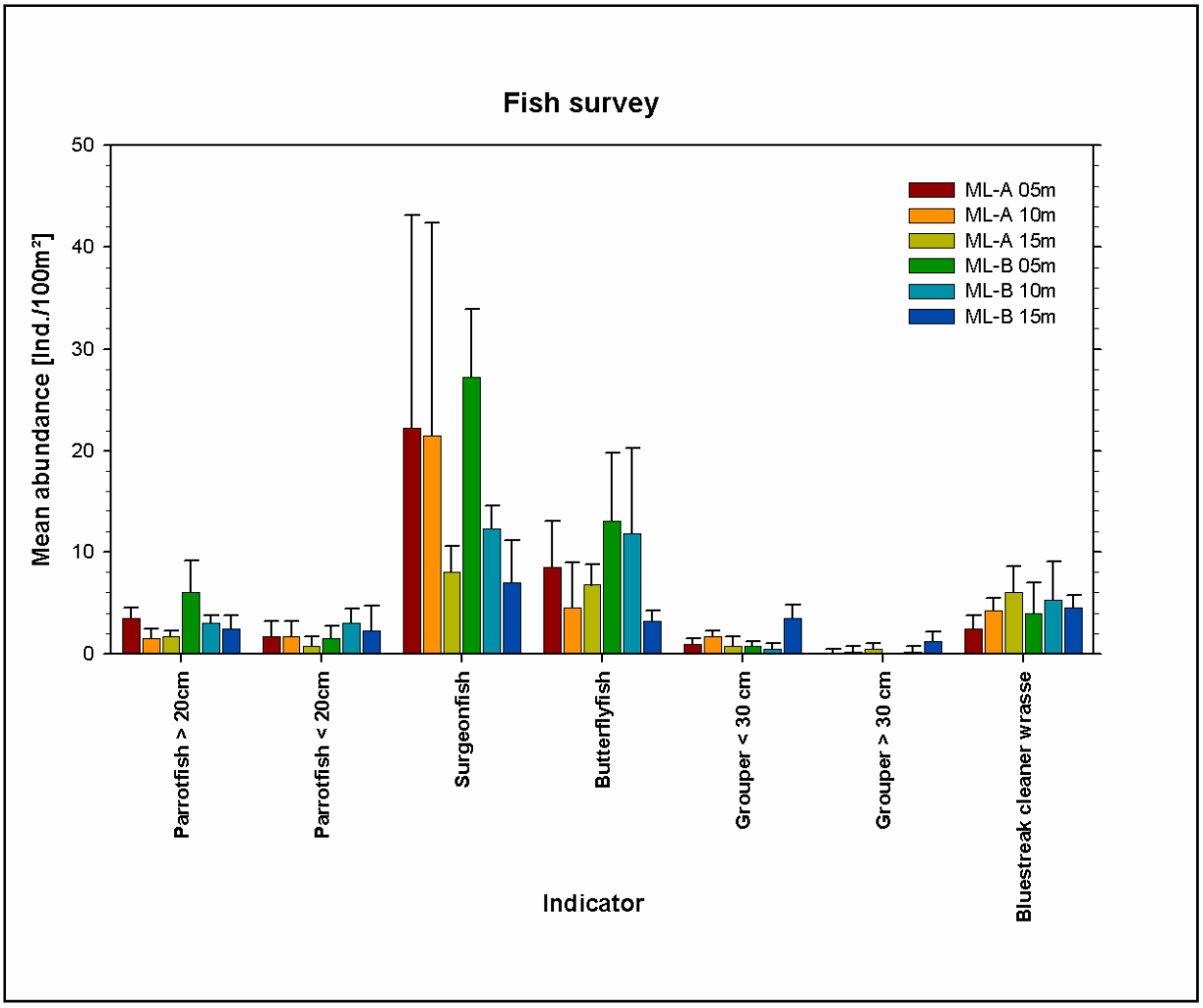

Figure 1: Results of the fish survey for all transects. Indictors with low values are not shown.

Sweetlips (Haemulidae), steephead parrotfish (*Clorurus gibbus*), bumphead parrotfish (*Bolbometopon muricatum*), humphead wrasse (*Cheilinus undulatus*) and tuna and mackerel (Scombridae) (table 5).

Top predators like moray eels and groupers > 30 cm were indeed rarely counted inside transects, though were sufficient individuals seen outside transects. “Farmer fish” feeding on benthic algae were primarily counted in the 5 m transects. One male humphead wrasse (*Cheilinus undulates*) was only observed aside from the data collection, but was not observed within the surveys.

Almost all indicators showed a lessening abundance with increasing depth, except for the Bluestreak cleaner wrasse (*L. dimidiatus*). Comparing the abundances of the northern and the southern reef area, abundances in the north (B) are slightly higher than in the south (A) (Figure 1).

4.2 Fish census

This year, 12197 fish were counted all together, consisting of 109 species within 73 genera and 29 families. The majority of the fish were Pomacentrides (53,9%) and Serranides (24,2%), although main part of the latter consisted of the subfamily Anthiinae with 23,6%. Other common families were Labridae (Wrasses, 6,6%), and Acanthuridae (Surgeonfish, 3,0%). The most frequent species in Kalawy Reef was the Half-and-half-Chromis (*Chromis dimidiata)* with a relative abundance of 36,9%. With a less, but still high abundance, there was the Jewel fairy basslet (*Pseudanthias squamipinnis)* with 23,6%. Furthermore, belonging to the 6 most frequent species were Miry's damsel (*Neopomacentrus miryae*), Paletail damsel (*Pomacentrus trichourus*), Pale damsel (*Amblyglyphidodon indicus*) and Arabian chromis (*Chromis flavaxilla*). The 6 most frequent species and their relative abundance are listed in Table 6. For a complete list of species see Table 21 on page 34.

Table 6: Total, absolute and relative abundance of the 6 most abundant fish species of Kalawy Reef.

	Abundance				
Species	**Total**	**Mean**	**SD**	**absolute [Ind./m²]**	**relative [%]**
Chromis dimidiata	4494	749	253	11,2	36,9
Pseudanthias squamipinnis	2880	480	284,9	7,2	23,6
Neopomacentrus miryae	640	106,7	152,7	1,6	5,3
Pomacentrus trichourus	428	71,3	75,4	1,1	3,5
Amblyglyphidodon indicus	387	64,5	42,1	1,0	3,2
Chromis flavaxilla	273	45,5	50,9	0,7	2,2

The 109 species of fish, counted in the Kalawy Reef could mostly be allocated to the following families: Labridae (wrasses; 19,3%; 21 species), Pomacentridae (10,1%; 11 species), Chaetodontidae (Butterflyfish; 8.3%, 9 species), Scaridae (Parrotfish; 7,3%, 8 species), Serranidae (Grouper; 6,4 %, 7 Arten) and Acanthuridae (Surgeonfish; 5.5%; 6 species). An overview of fish diversity is shown in Tabelle 22; a complete list is on page 37.

Table 7: Fish diversity of Kalawy Reef.

	Species		Individuals		Genera	
Family	**total**	**in percent**	**total**	**in percent**	**total**	**in percent**
Labridae	21	19,3%	806	6,6%	15	20,5%
Pomacentridae	11	10,1%	6576	53,9%	8	11,0%
Chaetodontidae	9	8,3%	177	1,5%	2	2,7%
Scaridae	8	7,3%	144	1,2%	4	5,5%
Serranidae	7	6,4%	2954	24,2%	4	5,5%
Acanthuridae	6	5,5%	366	3,0%	4	5,5%
All families (total)	109		12197		73	

The species richness was relatively balanced at all depths. A comparison of both reef areas showed 7 species more in the northern area (ML-B) than in the southern (ML-A). In the transects of 5 and 15 meters depth, there were around 1000 individuals more counted than in 10 m transects (Table 8).

Table 8: Diversity indices for fish assemblages of Kalawy Reef.

Site / depth	**A**	**B**	**15 m**	**10 m**	**5 m**
Individuals	5285	6912	4261	3344	4592
Species Richness [S]	90,0	97,0	76	74	84
Shannon-Wiener Index H'	2,48	2,38	2,31	2,34	2,25
Eveness E = H'/lnS	0,55	0,52	0,53	0,54	0,51

4.3 Invertebrate survey

The 6 surveyed transects showed partial differences concerning composition and frequency of indicator species. Long-spined sea urchins, Giant clams, Purple coral snails and Horn drupes were the only indicator species appearing in all transects (Figure 2). The Long-spined sea urchin appeared on average with 2,1 individuals per 100 m² (Table 9). The transects in 5 meters depth showed a five times higher abundance of these sea urchins than the ones in 10 and 15 meters. Collector urchins (*Tripneustes gratilla*) were not registered in any of the checked transects. Pencil urchins had with 2 counted individuals an extremely low abundance. Moreover, one

Banded coral shrimp was counted. Although during data collection no Crown-of-Thorns-Starfish has been seen, there were several feeding scars of it in the southern reef area. In the northern area were clearly more Giant clams and approximately double the number of Long-spined sea urchins than in the southern area. In total Giant clams (*Tridacna* spp.) and Purple coral snails (*Coralliophila violacea*) had the highest average abundances (Table 9).

Table 9: Pooled total number, mean abundance per 100 m² plus standard deviation (SD) of invertebrate indicators of all transects. *Additional indicators are marked with an asterisk.

Indicator	Total	Mean	SD
Lobster (*Panulirus* spp.)	0	0,0	0,0
Slipper Lobster (*Scyllarides* spp.)	0	0,0	0,0
Banded coral shrimp (*Stenopus hispidus*)	1	0,0	0,2
Long-spined urchins (*Diadema* spp. & *Echinotrix* spp.)	50	2,1	2,9
Pencil urchin (*Heterocentrotus mammillatus*)	2	0,1	0,4
Collector urchin (*Tripneustes gratilla*)	0	0,0	0,0
Sea cucumber (Holothuroidea)	0	0,0	0,0
Crown-of-thorns (*Acanthaster planci*)	0	0,0	0,0
Giant clam (*Tridacna* spp.)	97	4,0	5,0
Triton (*Charonia tritonis*)	0	0,0	0,0
Three-knobbed conch (*Strombis tricornis*)	0	0,0	0,0
Common spider conch (*Lambis truncata sebae*)	1	0,0	0,2
Trochus shells (Trochidae)	7	0,3	0,5
Purple coral snail (*Coralliophila violacea*)	107	4,5	4,8
Horn drupe (*Drupella cornus*)	56	2,3	3,3
Cowries (Cypraeidae)	0	0,0	0,0
Nudibranchs (Nudibranchia)*	10	0,4	0,7
Reef octopus (*Octopus cyaneus*)	1	0,0	0,2

There were neither Spiny lobsters nor Slipper lobsters, nor Triton's trumpets found. Except for Purple coral snails, the abundance of invertebrate indicators tend to decrease with increaing depth. Except the Purple coral snails showed the opposite (Figure 2).

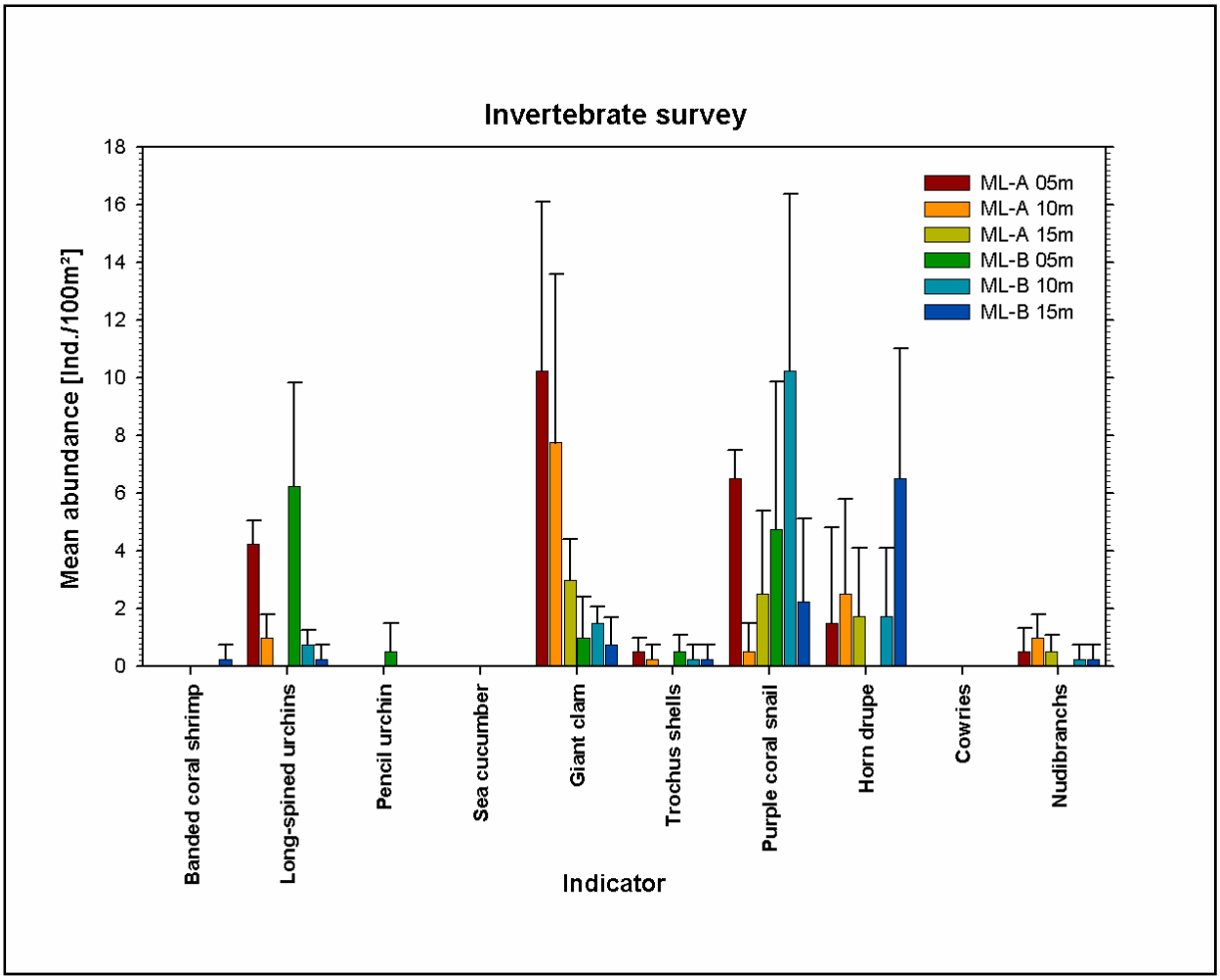

Figure 2: Results of the invertebrate surveys for all transects. Indicators with zero values are not shown.

4.4 Coral damage

In total, 0,9% of all surveyed branching corals had a breakage (Table 11). The highest breakage was found in reef area B with 1,8% (10 m) and 1,5% (15 m). The lowest number of broken corals was found in area A with 0,2% (15 m) and 0,3% (5 m). Most colonies (52) could be ascribed to the 25% breakage category (26) and detached colonies (26) (Table 10). 4 colonies could be classified in category 25-50% and 5 colonies in category 50-75% breakage. All together, there were 61 colonies with different types of damage, while 242 colonies were showing symptoms of coral predation (possibly with hard to identify coral deseases with similar appearance). These results give a percentage of 2,9% to the extrapolated total amount of branching corals (Table 11). The highest value for coral predation was measured in area A-15m with 4,1% and lowest value in area A-5m with 1,7%.

Table 10: Pooled coral damage data for all transects. **Millepora* was not counted as branching corals.

	Type	Total	Mean	SD
Coral colonies per 240 m² (6 Transects of 40m² each)	*Acropora* spp.	746	31,1	10,8
	Pocillopora spp.	393	16,4	10,7
	Stylophora spp.	104	4,3	2,8
	Seriatopora spp.	22	0,9	1,7
	Millepora spp.*	188	7,8	5,9
Breakage - damaged colonies	< 25 %	26	1,1	1,1
	25 - 50 %	4	0,2	0,4
	50 - 75 %	5	0,2	0,7
	75 - 100 %	0	0,0	0,0
	Detached colonies	26	1,1	1,3
Kind of damaged colonies	*Acropora* spp.	51	2,1	1,9
	Pocillopora spp.	3	0,1	0,3
	Stylophora spp.	2	0,1	0,3
	Seriatopora spp.	0	0,0	0,0
	Millepora spp.	4	0,2	0,5
	Porites spp.	0	0,0	0,0
	Other	0	0,0	0,0
Predation (impacted colonies)	*Drupella cornus*	191	8,0	3,0
	Coralliophila violacea	31	1,3	1,4
	Acanthaster planci	1	0,0	0,2
	Parrotfish bites	19	0,8	0,9
Kind of impacted colonies (Predation)	*Acropora* spp.	86	3,6	2,2
	Pocillopora spp.	95	4,0	2,5
	Stylophora spp.	10	0,4	0,9
	Seriatopora spp.	0	0,0	0,0
	Millepora spp.	0	0,0	0,0
	Porites spp.	43	1,8	1,4
	Other	7	0,3	0,6

112 colonies in reef area A and 130 colonies in reef area B showed signs of predation. Most of the coral predatedion was caused by Horn drupes (*Drupella cornus*, 191 colonies); followed by Purple coral snails (*Coralliophila violacea*, 31 colonies) and bite marks from parrot fish (Scaridae, 19). Off- transect (reef area A) at around 15 meter, colonies with clear feeding scars of a Crown-of-thorns starfish (*Acanthaster planci*) were observed. The starfish itself had been seen by one of the local dive instructors later on. Amount of colonies which were affected by feeding scars and Horn drupes (*D. cornus*) was 35. Amount of all counted Horn drupes is shown in Table 9.

Table 11: Results of the coral damage surveys 2010, pooled for depths and sites.

Site / Depth	A	B	15 m	10 m	5 m	All
Coral Damage - Branching coral	0,5%	1,2%	0,9%	1,3%	0,5%	0,9%
Coral Predation - Branching corals	2,8%	3,1%	3,6%	3,1%	2,3%	2,9%
Predation & Damage	3,3%	4,3%	4,5%	4,5%	2,8%	3,8%
Rubble (RB)	4,2%	7,9%	6,6%	9,1%	2,5%	6,0%
Coral Damage (No. of colonies)	19	42	17	30	14	61
Coral Predation (No. of colonies)	112	130	82	86	74	242
Branching Coral Population (extrapolated)	3240	3250	1940	2090	2460	6490

Three coral colonies showed skeletal anomalies (SKA). There were no coral diseases with clear symptoms, like black-band-desease (BBD) or dark-spot-desease (DSD).

4.4 Substrate survey

The coverage of living hard corals (HC) had a range between 24,4% (ML-A-10m) and 38,8% (ML-B-05m, Table 14) with an average of 31.4% (Table 12). Living soft corals (SC) showed a coverage between 2,5% (ML-A-05m) and 6,3% (ML-B-10m, Table 14) with an average of 3,6 %. So, the mean cover of all living corals (HC and SC) summed up to 35%. Most of the reef consisted of coral rock (54,8%), while sand accounted for 2,7% (Table 12). Mean values and standard deviation for each category are shown in Table 12 (ten main categories, Reef Check) and Table 13 (35 categories, extended Reef Check). Figure 3 shows the results of the ten main categories for the six different reef sites.

Within hard corals, branching staghorn corals of the category AB (Acropora branching) comprised the largest group with 9,3% (Tab. 13), followed by other branching corals (CB), primarily *Pocillopora* spp. with 6,1% and massive *Porites* spp. (PM) with 4,4%. Soft corals were predominantly represented by Xeniidae (SCX), which had an average of 3,1%, followed by Alcyonidae (SCA) with 1,4% (Table 13). Mean values for each transect of the most common coral groups and genera are given in Table 14.

Table 12: Results of the substrate surveys with standard RC categories. Pooled data of all transects.

Category	Mean	SD
HC	31,4%	8,7%
RKC	0,6%	1,3%
SC	3,6%	3,1%
NIA	0,5%	1,0%
SP	0,2%	0,7%
RC	54,8%	11,2%
RB	6,0%	5,7%
SD	2,7%	3,4%
SI	0,0%	0,0%
OT	0,1%	0,5%

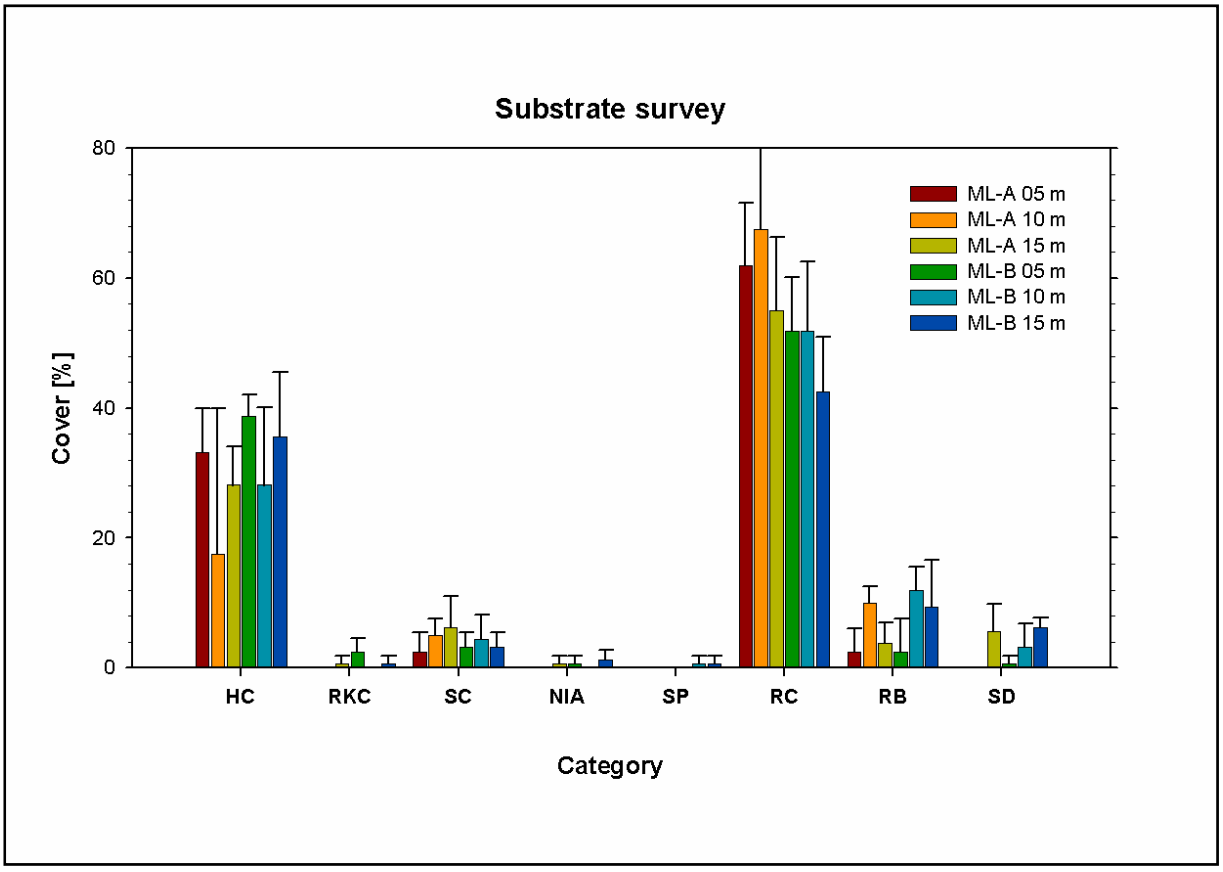

Figure 3: Results of the substrate surveys.

Table 13: Results of the substrate surveys 2010 with extended RC categories. Pooled data of all transects.

Category	Mean	SD	Category	Mean	SD
Corals			**Algae**		
AB	9,7%	6,8%	AA	0,1%	0,5%
AD	1,5%	2,1%	CA	1,7%	2,7%
AT	0,3%	1,1%	DCA	0,5%	1,5%
CB	6,1%	5,8%	FA	0,0%	0,0%
CC	0,2%	1,0%	HA	0,1%	0,5%
CE	3,2%	2,9%	MA	0,4%	1,0%
CF	0,0%	0,0%	TA	1,7%	2,4%
CM	1,7%	2,4%	**Abiotic / Others**		
CME	2,7%	2,3%	OT	0,0%	0,0%
CMR	0,3%	0,8%	SP	0,2%	0,7%
CS	0,2%	0,7%	ZO	0,0%	0,0%
CTU	0,0%	0,0%	DC	0,2%	0,7%
PC	1,0%	1,8%	RB	6,0%	5,7%
PM	4,4%	3,4%	RC	50,7%	10,4%
SC	0,0%	0,0%	RKC	0,6%	1,3%
SCA	1,4%	1,9%	SD	2,7%	3,4%
SCN	0,2%	0,7%	Si	0,0%	0,0%
SCX	2,1%	2,9%	WA	0,0%	0,0%

Table 14: Coral cover of common coral groups for all transects.

	Coral cover [%]					
	A 05m	**A 10m**	**A 15m**	**B 05m**	**B 10m**	**B 15m**
Hard corals (HC) Total	33,1%	24,4%	28,1%	38,8%	28,1%	35,6%
Acropora spp.	13,8%	14,4%	10,0%	9,4%	9,4%	11,9%
Other branching corals	8,1%	3,1%	0,6%	15,6%	5,0%	4,4%
Porites spp.	3,8%	3,1%	9,4%	2,5%	7,5%	6,3%
Other (sub-)massive corals	1,3%	0,6%	1,9%	4,4%	1,3%	3,1%
Millepora spp.	4,4%	1,3%	1,3%	4,4%	1,3%	3,8%
Hard corals (HC) Other	1,9%	1,9%	5,0%	2,5%	3,8%	6,3%
Soft corals (SC) Total	2,5%	2,5%	6,3%	3,1%	4,4%	3,1%
Alcyonidae	1,9%	0,0%	0,6%	2,5%	0,6%	0,0%
Nephtheidae	0,6%	0,0%	0,0%	0,0%	0,0%	0,6%
Xeniidae	0,0%	2,5%	5,6%	0,6%	3,8%	2,5%

In total, Algae showed a coverage of 4,5% (Table 13). The most common were turf algae (TA) with 2,2% coverage, of which 1,7% was on rock and 0,5% on dead corals (DCA). Coralline algae (CA), which contributes to consolidate the reef's structure, made up for 1,7% coverage. The categories AA, FA and MA had very low coverage; these are included in the main category nutrient indicator algae (NIA) with 0,5% cover (Table 12). The percentage of recently killed corals (RKC) was 0,6%, the sum of dead corals (DC and DCA) was 0,7%.

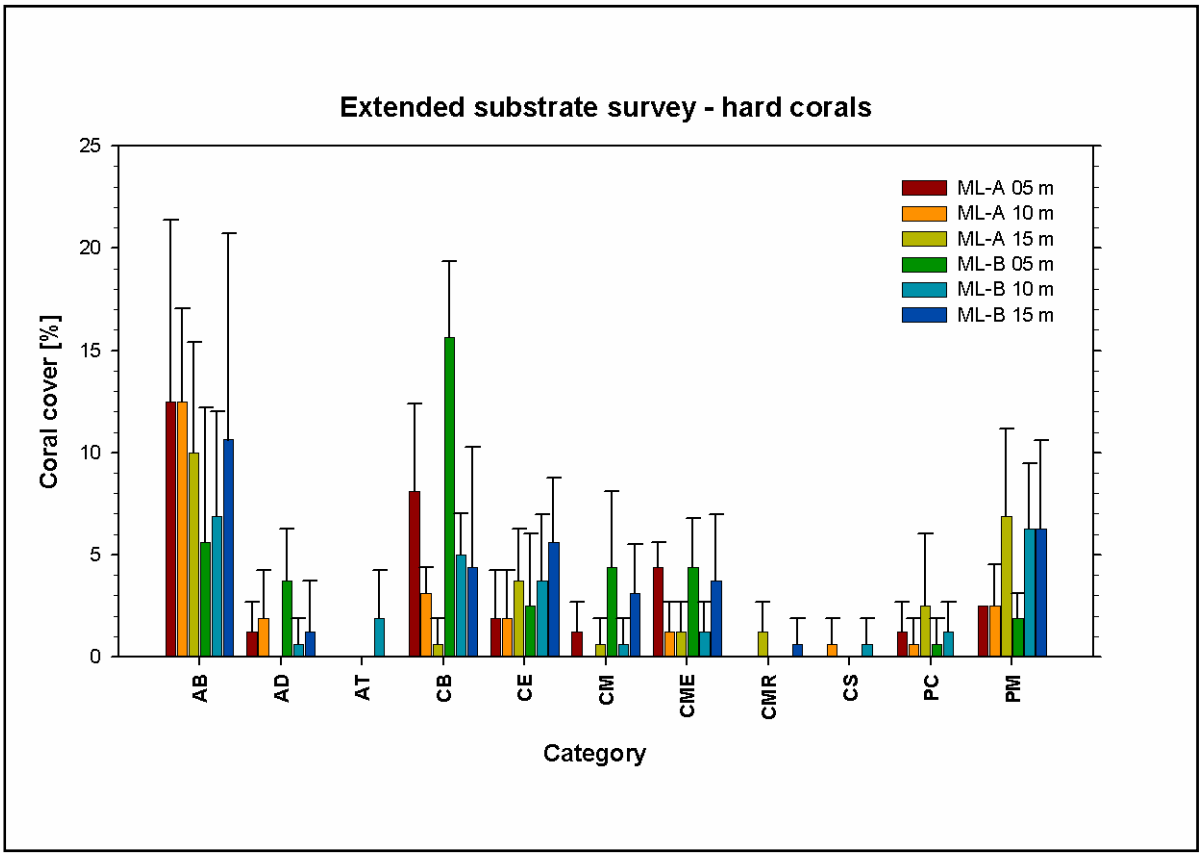

Figure 4: Cover of 11 coral categories for all transects.

5. Discussion

It has been 12 months since the last survey of the house reef at Magic Life Club Kalawy took place. Since then, there have been approximately 11,700 dives at the survey sites, both north and south of the jetty. The annual surveys at the Kalawy house reef are meant to show how far anthropogenic impacts influence the reef's ecosystem.

5.1 Fish survey

A comparison of Reef Check indicator species in 2010 showed: The highest abundance of fish were surgeonfish (Acanthuridae) with 16,4 individuals *per* 100 m^2 (Table 5). This family was newly added in 2009; therefore just countings of 2009 and 2010 can be compared. Butterflyfish (Chaetodontidae) had the second highest abundance with an average of 8 individuals *per* 100 m². After the decrease of this family in 2009, there is a slight increase this year. Butterflyfish are listed as indicators for the high fishing quote in some regions for aquarium trade, which has not been reported from the Red Sea yet. Therefore the decrease of the family in 2009 can be ascribed to the absence of individuals inside transects. Parrotfish (Scaridae) >20 cm had also a slight decrease compared to 2008 and 2009. Parrotfish seem to belong to the most favourite food fish for the local population (pers. observ.). However, the present decrease of around 1 individual/100 m^2 was so low that also a general deviation of counting could be the reason. As a new indicator in 2009 and 2010 parrotfish smaller than 20 cm were added. Due to the extremely high popularity of parrotfish as food fish, all individuals of this family are recorded for ensuring a gapless documentation. Within parrotfish smaller than 20 cm there is an apparent decline, while there were 4,4 ind./100 m^2 counted in 2009, in 2010 only 1.8 ind./100 m^2 were counted (Table 15). This decrease was restricted to the northern reef area; here around 5 individuals less per 100 m^2 were recorded than in 2009. Like in previous years abundance of the Bluestreak cleaner wrasse (*Labroides dimidiatus*) remained stable, in annual comparison as well as in the comparison of north and south. This species is an additional indicator, since it is a key indicator for fish diversity in the reef (Bshary 2003). In 2009, there was a higher amount of Bluestreak cleaner wrasses in the southern reef area which was matching with more species and more individuals counted there within the fish census. This correlation could be

seen in these results as well; just that the higher numbers of cleaner wrasse and abundance and diversity within the fish census (6 species and 1627 specimens) was not in the southern but in the northern reef area. The abundances of the two top predators, Groupers (Epinephelinae) and Trevallies (Carangidae) increased in 2009 but unfortunately decreased in 2010. A cutback of the local fishery may have been the reason for the increase in 2009, but could not be confirmed. Both families are popular food fish, so it might be assumed that at the house reef or at least at the closer surroundings fishery is still taking place. A comparison of the surveys south of the jetty showed a decrease of abundance of Parrotfish > 20 cm, Trevallies, Groupers bigger and smaller 30 cm, Bluestreak cleaner wrasse and “Farmerfish”. Numbers of Broomtail wrasse, Surgeonfish and Butterflyfish inclined. Within these species/families abundance also increased in the northern part and additionally within Groupers > 30 cm, Bluestreak cleaner wrasse and Butterflyfish. In contrast, abundance of Parrotfish larger and smaller than 20 cm, Trevallies, Snapper and Groupers < 30 cm decreased in the north (Figure 5). These observed fluctuations probably depend on different abiotic factors and are therefore not necessarily linked to anthropogenic influences.

Table 15: Mean abundance data of fish indicators of Kalawy of 2008 and 2009 in comparison to actual data. Data are pooled over for site A and site B. Mean abundance is expressed as individuals per 100 m² *Additional indicators are marked with an asterisk.

	A	A	A	B	B	B
Indicator↓ Site / Year →	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Parrotfish > 20cm	5,0	2,9	2,3	4,0	5,7	3,8
Broomtail wrasse	0,7	0,3	0,8	0,4	0,9	1,1
Trevallies*	0,0	0,4	0,0	0,0	0,3	0,3
Snapper	0,4	0,3	0,3	0,0	0,4	0,2
Butterflyfish	12,6	4,9	6,6	10,1	8,0	9,3
Sweetlips	0,1	0,0	0,0	0,2	0,0	0,0
Grouper <30 cm*	0,0	2,1	1,2	0,7	2,9	1,6
Grouper >30 cm	0,0	0,7	0,3	0,1	0,4	0,5
Bluestreak cleaner wrasse*	4,2	5,0	4,3	4,6	3,3	4,6
"Farmer fish"*	0,4	0,5	0,3	0,3	0,2	0,7

5.2 Fish census

Five out of the six of the most frequently encountered species at the Kalawy reef in 2010 belonged to the family damselfish (Pomacentridae) (Table 16). Only one species belonged to the family Serranidae (sea basses) with the subfamily Anthiinae (fairy basslets). Like in 2009 the Half-and-half-Chromis (*Chromis dimidiata*) appeared in the present study most frequently with a relative abundance of 36,9**.** Furthermore, this species shows an increase of 5% in the last 12 months. The jewel fairy basslet (*Pseudanthias squamipinnis*) was the most frequently occurring species in 2008, but shows a decrease in 2010 of around 8% to an abundance of 23,6. This year Klunzinger's wrasse (*Thalassoma rueppellii*) was not among the six most common species, but most individuals of this species counted in 2009 were juvenile. Thus, high difference in numbers is probably due to a higher or earlier reproduction cycle during the survey 2009. Much less individuals of Miry´s demoiselle (*Neopomacentrus miryae*) were counted this year, but an increase of abundance of Paletail damsel (*Pomacentrus trichrourus*) in the last two years. Pale damselfish (*Amblyglyphidodon indicus*) remained stable with 3,2 and a balanced abundance through all three years. Like in previous years, in almost every transect, a clutch of pale damselfish could be observed. There was one more swarm-forming species in the top 6 this year, the Arabian chromis (*Chromis flavaxilla*). On average 13600 individuals were counted every year inside transects, in which separate countings can show a high variation. Variations like this are mostly connected to the swarm- and group-forming species. Every year swarm-forming damselfish belong to the six most frequently species, where one swarm consist of dozens or hundreds of individuals. When there are also juveniles present this amount can easily dublicate or triplicate. High variations between the survey data of different years can also result from the random distribution of the swarms. Sometimes many swarms are inside of a transect and sometimes, just by chance, they are not - however, the actual fish population probably stays the same.The 6 most frequent fish species of all three surveys are shown in Table 6, for a complete list of species, see Table 21 on page 34.

In comparison to two different sites in the Red Sea (Table 16), abundance of *Chromis dimidiata* at Kalawy reef approaches the values from El Quadim Bay. In contrast, number of *P. squamipinnis* clearly decreased and approaches therefore values of the Marine Science Station Jordan/Red Sea. Pale damselfish had eyery year the highst

abundance at Kalawy reef compared to the other sites. For this comparison only data of 5 and 10 m transects were used.

Table 16: Relative Abundances of the most common species of Kalawy reef compared with other sites of the Northern Red Sea. To increase comparability, data from the 15 m transects is not included. [1]present study, [2]surveys 2009, [3]surveys 2008, [4]Kochzius (2007), [5]Khalaf & Kochzius (2002).* Data not available.

Species	Kalawy[1]	Kalawy[2]	Kalawy[3]	El Quadim Bay[4]	Marine Science Station[5] (Jordan)
Chromis dimidiata	36,8	31,9	25,6	44,9	5,6
Pseudanthias squamipinnis	23,6	31,8	30,6	32,5	24,1
Neopomacentrus miryae	5,2	10,7	6,2	*	6,2
Pomacentrus trichourus	3,5	2,9	1,2	*	*
Amblyglyphidodon indicus	3,2	2,5	4,5	*	0,5
Thalassoma rueppellii	1,4	1,4	0,8	*	*
Chromis viridis	1,1	1,7	4,5	3,6	1,6

Figure 5 shows the differences in relative abundance for the surveys in 2008, 2009 and 2010 of the 7 most common fish species. Most of them are assembling in schools or groups except for the Klunzinger's wrasse (*Thalassoma rueppellii*).

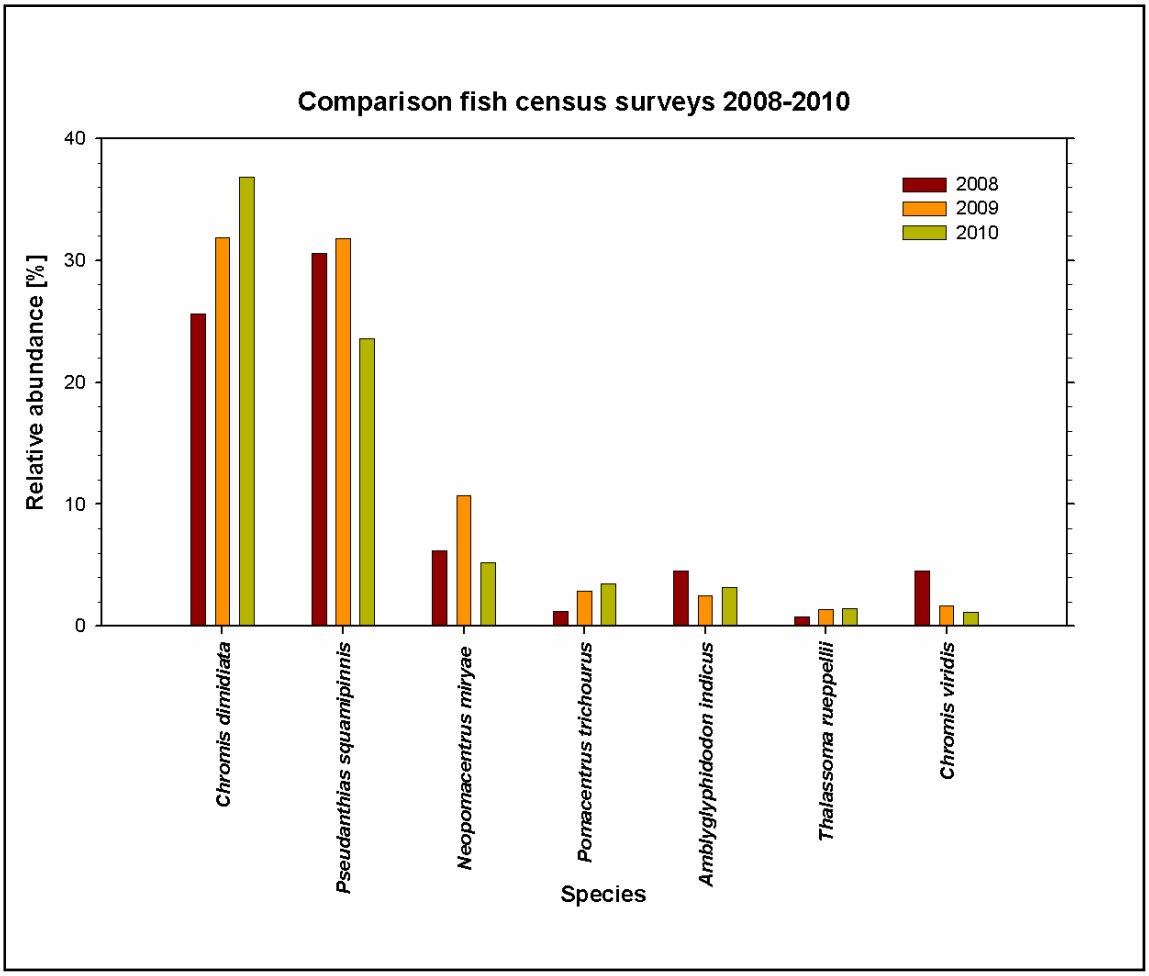

Figure 5: Relative abundance of the seven most common fish species at Kalawy-Riff.

30 months after the club opening, a slightly negative anthropogenic influence may exist concerning diversity and abundance of fish at the Kalawy reef. Indeed some indicators confirm a decrease of abundance, but with Parrotfish (Scaridae) for example it is that low that fishery as causing reason can probably be ruled out. A decline of butterflyfish (Chaetodontidae) like in 2009 did not proceed. Although just a few top predators were present inside transects, several giant morays (*Gymnothorax javanicus*) and grouper larger than 40 cm could be observed outside transects. This shows that Kalawy reef is in an ecological balanced condition.

Like in previous years cryptical species and individuals were not recorded. Also juveniles of the most species live sheltered between corals and rocks and are therefore difficult to see. Thus, this has to be considered regarding all results of the fish census.

5.3 Invertebrate survey

Results of Invertebrate indicators show a slight decrease compared to previous years. There were less Long-spined sea urchins (Diadematidae), Trochus shells (Trochidae) and Giant clams (Tridacnidae) counted than in 2008 and 2009 (Table 17). Both Long-spined sea urchins and Trochus shells graze on algae cavering the substrate, thus, a decrease of these families depends on algal cover. Algal cover at Kalawy reef decreased in the last 12 months with from than 7% to 4,5%. So this could be an explanation for the decrease of these algae-feeding species. Sea urchins and trochus shells are nocturnal species, during daytime they hide in crevices and are therefore difficult to count; thus a decrease is only restricted to visible individuals. A slight decrease of Giant clams is primarily observed in the northern reef area. In 2009 one individual of Crown-of-thorns-Starfish (*Acanthaster planci*) was seen outside transect in the northern reef area. In 2010 there were several feeding scars at around 10 coral colonies at a depth of around 15 to 20 m. In 2009 an enormous increase of abundance of Purple coral snails (*Coralliophila violacea*) was observed (Table 17). This species is primary feeding on the coral genus porites, therefore number of affected porites colonies drastically move up from 2008 to 2009. In 2010 values of abundance of Purple coral snails declined again and approached the values of 2008. In 2010 there were only half as much affected porites colonies than in 2009.

Table 17: Mean abundance data of invertebrate indicators of Kalawy of 2008 and 2009 in comparison to actual data. Data are pooled for site A and site B. Mean abundance is expressed as individuals per 100 m² *Additional indicators are marked with an asterisk.

	A	A	A	B	B	B
Indicator↓ Site / Year →	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Banded coral shrimp	0,0	0,1	0,0	0,1	0,1	0,1
Long-spined urchins	2,8	2,2	1,8	6,7	2,7	2,4
Pencil urchin	0,6	0,2	0,0	0,1	0,0	0,2
Sea cucumber	0,0	0,0	0,0	0,0	0,1	0,0
Trochus shell	0,0	0,0	0,0	0,0	0,0	0,0
Giant clam	7,8	8,3	7,0	3,5	2,6	1,1
Purple coral snail*	0,0	0,1	0,0	0,1	0,1	0,1

Present results of 2010 of invertebrate indicators have to be regarded positive, since a decrease of Sea urchins and Trochus shells indicates a reduced algal cover compared to previous years. Also the decrease of purple coral snails supports an optimistic prognosis for a healthy local reef. The predator-prey-relationship seems to be quite balanced as well, which is really important for the reef ecology. There were several octopuses (top-predators) seen outside transects.

5.4 Coral damage

In comparison to the surveys of 2008 and 2009, there is a slight decrease of coral predation and coral damage compared to 2009, but still clearly higher values than in 2008 (Figure 6). The percentage ratio of coral damage and coral predation was newly calibrated to mean values of extrapolated branching coral population (pooled data for 2008, 2009 and 2010). This calibration is based on the assumption that the branching coral population has not changed significantly over the past 3 years within the fixed transects.This minimizes the deviation caused by divergent extrapolated population numbers. The recalculated ratios are given in Table 19 and shown in Figure 6.

The newly calibrated values showed an overall decrease from 1,1 % to 0,8 % for coral breakage and from 2,8 % to 2,6 % for coral predation in contrast to the survey in 2009 (Figure 6, Table 18). The decrease was predominant in reef site A. Values of the higher frequented reef site B were more persistent with a slight decrease from 1,2 % to 1,1 % for coral breakage and a slight increase from 2,6 % to 2,7 % for coral predation. A comparison of absolute numbers of impacted colonies for all three studies is given in Table 18. Considering the total numbers of colonies with breakage the decline was from 62 to 42 colonies. Taking up just the branching corals, the decline was from 45 to 40 colonies. Thus, fire corals were the group where much less colonies were counted this year. Reef site a showed a reduced number of colonies with predation whereas site B persisted (Figure 6, Table 19).

The results of this study showed no clear increase in coral damage as in 2009 (in contrast to 2008; see report 2009). Nevertheless, coral damage values for reef site B still remained distinctly high compared to the first study, while the decrease for site A seems to be a positive sign.

Table 18: Total numbers of damaged corals of Kalawy for 2008 and 2009 in comparison to actual data. Data are pooled for site A and site B.

		A	A	A	B	B	B
		2008	**2009**	**2010**	**2008**	**2009**	**2010**
Breakage - damaged colonies	< 25%	21	23	8	12	28	18
	25 - 50%	5	7	2	1	7	2
	50 - 75%	1	0	0	0	0	5
	75 - 100%	2	1	0	0	1	0
	Detached colony	3	22	9	7	26	17
Kind of damaged colonies	*Acropora* spp.	15	27	15	11	43	36
	Pocillopora spp.	4	6	1	6	2	2
	Stylophora spp.	3	3	0	0	2	2
	Seriatopora spp.	0	1	0	0	0	0
	Millepora spp.	8	14	2	4	14	2
	Porites spp.	0	0	0	0	0	0
	Other	0	2	0	0	3	0
Predation (impacted colonies)	*Drupella* spp.	58	103	90	58	90	101
	Coralliophila spp.	11	40	10	1	19	21
	Acanthaster planci	0	0	0	0	0	1
	Parrotfish	6	20	12	10	19	7
Kind of impacted colonies (Predation)	*Acropora* spp.	43	43	44	44	28	42
	Pocillopora spp.	10	60	37	12	68	58
	Stylophora spp.	3	3	9	1	1	1
	Seriatopora spp.	0	0	0	0	0	0
	Millepora spp.	0	0	0	0	0	0
	Porites spp.	16	55	17	11	16	26
	Other	2	2	4	0	4	3

Table 19: Coral damage and predation in Kalawy. Total number of colonies and newly calibrated ratios (first 3 rows) in comparison for 2008, 2009 and 2010. Data are pooled for site A and site B.

	A	A	A	B	B	B
Indicator \ Site	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Coral Damage - Branching corals	0,7%	1,0%	0,5%	0,4%	1,2%	1,1%
Coral Predation - Branching corals	1,6%	2,9%	2,5%	1,5%	2,6%	2,7%
Predation & Damage	2,2%	4,0%	3,0%	2,0%	3,8%	3,8%
Rubble (RB)	6,3%	5,2%	4,2%	6,7%	7,3%	7,9%
Coral Damage (No. of colonies)	32	53	19	20	62	42
Coral Predation (No. of colonies)	75	163	112	69	128	130
Branching coral Population (extrap.)	3835	3750	3240	3420	3770	3250

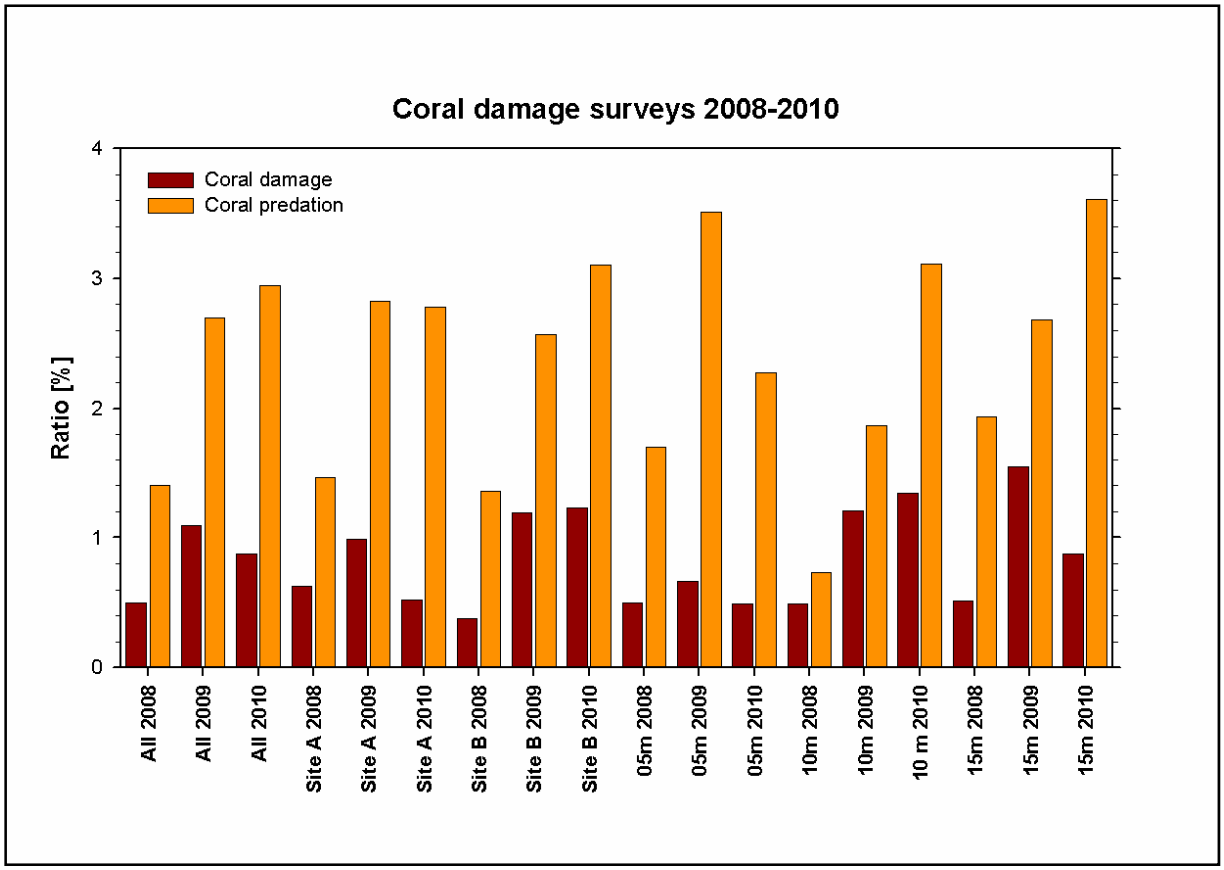

Figure 6: Comparison of coral damage results of surveys 2008, 2009 and 2010.

5.5 Substrate survey

There were no distinct divergences compared to the results of 2009. A significant decrease of soft corals of the family xeniids like in 2009 could not be observed either. All results of hard coral subcategories remained within their standard deviations. The total hard coral cover was with 31,4% below corresponding value of previous study but almost identical to the result of 2008 (31,3%). On the opposite, the share of Sand was higher in the years with lower values of Hard Coral cover. So the deviation is based on the transect deployment, which enclosed more sandy areas in 2008 and 2010 in 15m transects. It does not necessarily implements a deviation in coral cover. Hard Coral cover pooled over sites showed a constant slight decrease at reef area A and in opposite a constant increase at reef area B (Table 20). If this is a true trend or just an incident (deviation of data, more sandy patches), should or could be analyzed by a comprehensive substrate analysis based on transect images of the former studies. The decrease could originate from the construction building of the jetty (see first report for jetty construction and its potential impact at the entrance area). The row of surge breakers along the jetty could have changed physical conditions and

caused a higher sedimentation rate at the entrance area and adjacent fringing reef (south part with prevailing currents). An additional source could be the increased siltation in the lagoon which coincides with the water sport activities there and run-off with the tides.

Over all, the staghorn corals (*Acropora* spp.) were again the dominating group, followed by other branching corals (mainly raspberry corals *Pocillopora* spp.) and Pore corals (*Porites* spp.). Pore corals were more abundant than "other branching corals" in sites A, in contrast to site B. Regarding the overall soft coral cover, the results showed a further decline from 5,2% in 2009 to 3,6%. Again this was mainly due to the family Xeniidae (SCX) falling from 3,4 % to 2,1 %. A rapid qualitative inspection of the transect images of all studies implicates a significant decline in cover of these soft corals. This could be verified with a comprehensive substrate analysis based on transect images of the former studies. These fast growing, often white soft corals are pioneers of settling newly free areas (Reinicke 1995). Benayahu (1991) reports annual reproductive cycles of 7 months for *Xenia umbellata*, a widely distributed representative species of the Xeniidae. Thus, differences may be also due to annual alterations of these soft corals. The share of dead corals was persistent with 0,2% throughout all studies. The categories Recently Killed Corals (RKC), Sand (SD) and Rubble had similar values. Algae cover was lower than last year, mainly due to the Turf Algae (TA). Contribution of Nutrient Indicator Algae (NIA) was persistingly low.

Table 20: Mean cover [%] for several coral groupings of Kalawy report 2008, 2009 and actual data. Data are pooled for site A and site B.

	A	A	A	B	B	B
Gruppe \ Stelle	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Hard corals (HC) Total	**32,5%**	**31,7%**	**28,5%**	**30,0%**	**33,1%**	**34,2%**
Acropora spp.	16,5%	12,1%	12,7%	11,3%	14,0%	10,2%
Other branching corals	4,6%	4,2%	4,0%	6,7%	6,5%	8,3%
Porites spp.	4,6%	6,3%	5,4%	4,4%	4,4%	5,4%
Other (sub-)massive corals	2,1%	4,2%	1,3%	2,3%	1,7%	2,9%
Millepora spp.	3,1%	2,7%	2,3%	2,3%	2,7%	3,1%
Hard corals (HC) Other	1,7%	2,3%	2,9%	3,1%	4,0%	4,2%
Soft corals (SC) Total	**13,1%**	**5,0%**	**3,8%**	**14,8%**	**5,4%**	**3,5%**
Xeniidae	9,6%	2,7%	1,7%	12,5%	4,2%	1,0%
Soft corals (SC) other	3,5%	2,1%	2,1%	2,3%	1,3%	2,5%

5.6 Conclusion

The house reef in Kalawy is still in good condition, but some aspects should be considered. First, a few modifications of the entrance area could increase sustainable usage, e.g. the descent line should be fixed more centrally and away from the coral block, the “confined area” should be marked better and a info board for snorkelling activities (How and where to snorkel, some info on tide level and weather) is recommended. Second, fishing activities on the hotel premises should be strictly banned as well as the consumption of local reef fish (parrotfish, napoleon, etc.) and local reef fish predators (Tunas, Trevallies) so that the fish community can recover or remain stable. The results and the development of Kalawy reef over the past years are mainly positive. As mentioned above (chapter 5.5.), we recommend a more comprehensive substrate analysis to validate or falsify the changes in coral cover in Kalawy and surely continue the regular surveys over the next years.

6. References

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7. Appendix

Table 21: Results of the fish census surveys 2001 in Kalawy, Safaga, Egypt. Data are sorted by Abundance and given as total abundance with mean values and standard deviation (SD) per transect (400 m²), relative abundance and abundance as individuals per 100 m².

					Abundance
Species	**Total**	**Mean**	**SD**	**relative [%]**	**[Ind./ 100 m²]**
Chromis dimidiata	4494	749,00	253,02	36,85	187,25
Pseudanthias squamipinnis	2880	480,00	284,89	23,61	120,00
Neopomacentrus miryae	640	106,67	152,67	5,25	26,67
Pomacentrus trichourus	428	71,33	75,44	3,51	17,83
Amblyglyphidodon indicus	387	64,50	42,05	3,17	16,13
Chromis flavaxilla	273	45,50	50,90	2,24	11,38
Pseudochromis fridmani	222	37,00	34,64	1,82	9,25
Pomacentrus sulfureus	197	32,83	23,89	1,62	8,21
Thalassoma rueppellii	175	29,17	43,22	1,43	7,29
Pseudocheilinus hexataenia	172	28,67	14,31	1,41	7,17
Neoniphon sammara	159	26,50	32,30	1,30	6,63
Labroides dimidiatus	151	25,17	7,39	1,24	6,29
Zebrasoma desjadinii	148	24,67	24,64	1,21	6,17
Chromis viridis	136	22,67	12,68	1,12	5,67
Gomphosus caeruleus	131	21,83	26,31	1,07	5,46
Myripristis murdjan	119	19,83	18,90	0,98	4,96
Priacanthus hamrur	113	18,83	23,28	0,93	4,71
Mulloidichthys vanicolensis	110	18,33	40,21	0,90	4,58
Ctenochaetus striatus	91	15,17	4,62	0,75	3,79
Caesio suevica	74	12,33	21,69	0,61	3,08
Paracirrhites forsteri	72	12,00	3,22	0,59	3,00
Siganus luridus	71	11,83	11,58	0,58	2,96
Chlorurus sordidus	63	10,50	7,01	0,52	2,63
Chaetodon austriacus	60	10,00	4,34	0,49	2,50
Acanthurus nigrofuscus	55	9,17	4,40	0,45	2,29
Pseudocheilinus evanides	48	8,00	11,06	0,39	2,00
Scarus niger	47	7,83	4,22	0,39	1,96
Zebrasoma xanthurum	43	7,17	3,49	0,35	1,79
Chaetodon paucifasciatus	31	5,17	2,14	0,25	1,29
Anampses twistii	31	5,17	2,04	0,25	1,29
Chaetodon auriga	30	5,00	4,86	0,25	1,25
Acanthurus sohal	28	4,67	5,05	0,23	1,17
Cephalopholis argus	25	4,17	1,83	0,20	1,04
Cephalopholis hemistiktos	25	4,17	2,99	0,20	1,04
Oxycheilinus digramma	22	3,67	2,94	0,18	0,92

					Abundance
Species	**Total**	**Mean**	**SD**	**relative [%]**	**[Ind./ 100 m²]**
Siganus rivulatus	22	3,67	8,98	0,18	0,92
Chaetodon semilarvatus	19	3,17	2,99	0,16	0,79
Chaetodon fasciatus	18	3,00	3,29	0,15	0,75
Amanses scopas	17	2,83	1,17	0,14	0,71
Cheilinus lunulatus	16	2,67	2,25	0,13	0,67
Diploprion drachi	16	2,67	1,63	0,13	0,67
Centropyge multispinis	15	2,50	1,64	0,12	0,63
Hipposcarus harid	15	2,50	1,76	0,12	0,63
Rhinecanthus assasi	15	2,50	2,51	0,12	0,63
Sargocentron caudimaculatum	14	2,33	4,80	0,11	0,58
Pygoplites diacanthus	14	2,33	1,21	0,11	0,58
Plagiotremus tapeinosoma	13	2,17	2,40	0,11	0,54
Halichoeres hortulanus	13	2,17	1,83	0,11	0,54
Bodianus anthioides	12	2,00	3,35	0,10	0,50
Parupeneus forsskali	12	2,00	1,26	0,10	0,50
Heniochus intermedius	11	1,83	1,83	0,09	0,46
Fistularia commersonii	11	1,83	2,23	0,09	0,46
Plectroglyphidodon lacrymatus	10	1,67	3,20	0,08	0,42
Plagiotremus townsendi	9	1,50	1,22	0,07	0,38
Arothron diadematus	9	1,50	1,22	0,07	0,38
Cirripectes castaneus	8	1,33	2,80	0,07	0,33
Carangoides bajad	8	1,33	2,80	0,07	0,33
Plagiotremus rhinorhynchus	7	1,17	1,17	0,06	0,29
Amblyglyphidodon flavilatus	7	1,17	2,40	0,06	0,29
Bodianus axillaris	6	1,00	1,10	0,05	0,25
Parupeneus cyclostomus	6	1,00	1,55	0,05	0,25
Scarus fuscopurpureus	6	1,00	2,45	0,05	0,25
Cephalopholis miniata	6	1,00	1,26	0,05	0,25
Sufflamen albicaudatus	6	1,00	0,89	0,05	0,25
Bodianus diana	5	0,83	1,60	0,04	0,21
Larabicus quadrilineatus	5	0,83	1,33	0,04	0,21
Scarus ferrugineus	5	0,83	1,33	0,04	0,21
Pterois radiata	5	0,83	0,75	0,04	0,21
Chaetodon trifascialis	4	0,67	0,82	0,03	0,17
Cheilio inermis	4	0,67	0,52	0,03	0,17
Pseudodax moluccanus	4	0,67	1,03	0,03	0,17
Macolor niger	4	0,67	0,82	0,03	0,17
Chlorurus gibbus	4	0,67	1,21	0,03	0,17
Gymnothorax flavimarginatus	3	0,50	0,55	0,02	0,13

					Abundance
Species	**Total**	**Mean**	**SD**	**relative [%]**	**[Ind./ 100 m²]**
Ecsenius dentex	3	0,50	0,55	0,02	0,13
Caesio striata	3	0,50	0,84	0,02	0,13
Chaetodon melannotus	3	0,50	0,84	0,02	0,13
Anampses meleagrides	3	0,50	0,84	0,02	0,13
Epibulus insidiator	3	0,50	0,84	0,02	0,13
Lethrinus borbonicus	3	0,50	0,84	0,02	0,13
Monotaxis grandoculis	3	0,50	0,84	0,02	0,13
Pseudobalistes fuscus	3	0,50	0,84	0,02	0,13
Ostracion cyanurus	3	0,50	0,84	0,02	0,13
Cheilodipterus quinqelineatus	2	0,33	0,82	0,02	0,08
Coris aygula	2	0,33	0,52	0,02	0,08
Parupeneus macronema	2	0,33	0,82	0,02	0,08
Dascyllus trimaculatus	2	0,33	0,82	0,02	0,08
Calotomus viridescens	2	0,33	0,82	0,02	0,08
Scarus frenatus	2	0,33	0,82	0,02	0,08
Pterois miles	2	0,33	0,52	0,02	0,08
Balistapus undulatus	2	0,33	0,52	0,02	0,08
Gymnothorax javanicus	1	0,17	0,41	0,01	0,04
Saurida gracilis	1	0,17	0,41	0,01	0,04
Synodus variegatus	1	0,17	0,41	0,01	0,04
Naso elegans	1	0,17	0,41	0,01	0,04
Chaetodon lineolatus	1	0,17	0,41	0,01	0,04
Cheilinus quinquecinctus	1	0,17	0,41	0,01	0,04
Hologymnosus annulatus	1	0,17	0,41	0,01	0,04
Oxycheilinus mentalis	1	0,17	0,41	0,01	0,04
Abudefduf vaigensis	1	0,17	0,41	0,01	0,04
Aetaloperca rogaa	1	0,17	0,41	0,01	0,04
Epinephelus fasciatus	1	0,17	0,41	0,01	0,04
Acanthopagrus bifasciatus	1	0,17	0,41	0,01	0,04
Scorpaenopsis diabolus	1	0,17	0,41	0,01	0,04
Diodon hystrix	1	0,17	0,41	0,01	0,04
Cantherhines pardalis	1	0,17	0,41	0,01	0,04
Ostracion cubicus	1	0,17	0,41	0,01	0,04
Arothron hispidus	1	0,17	0,41	0,01	0,04
Arothron stellatus	1	0,17	0,41	0,01	0,04
Plectroglyphidodon lacrymatus	1	0,17	0,41	0,01	0,04

Tabelle 22: Fish diversity 2010 of Kalawy, Safaga, Egypt. Number of species and genera (total and in percent) for recorded fish families, as well as abundance (total number of individuals), abundance per 100 m² (100 m²) and relative abundance (RA).

Family	species	percent	genera	percent	ind.	percent	100	RA
Labridae	21	0,19	15	0,21	806	0,07	33,6	0,07
Pomacentridae	11	0,10	8	0,11	6576	0,54	274,0	0,54
Chaetodontidae	9	0,08	2	0,03	177	0,01	7,4	0,01
Scaridae	8	0,07	4	0,05	144	0,01	6,0	0,01
Serranidae	7	0,06	4	0,05	2954	0,24	123,1	0,24
Acanthuridae	6	0,06	4	0,05	366	0,03	15,3	0,03
Blenniidae	5	0,05	3	0,04	40	0,00	1,7	0,00
Balistidae	4	0,04	4	0,05	26	0,00	1,1	0,00
Mullidae	4	0,04	2	0,03	130	0,01	5,4	0,01
Holocentridae	3	0,03	3	0,04	292	0,02	12,2	0,02
Scorpaenidae	3	0,03	2	0,03	8	0,00	0,3	0,00
Tetraodontidae	3	0,03	1	0,01	11	0,00	0,5	0,00
Muraenidae	2	0,02	1	0,01	4	0,00	0,2	0,00
Synodontidae	2	0,02	2	0,03	2	0,00	0,1	0,00
Lethrinidae	2	0,02	2	0,03	6	0,00	0,3	0,00
Ostraciidae	2	0,02	1	0,01	4	0,00	0,2	0,00
Caesionidae	2	0,02	1	0,01	77	0,01	3,2	0,01
Siganidae	2	0,02	1	0,01	93	0,01	3,9	0,01
Pomacanthidae	2	0,02	2	0,03	29	0,00	1,2	0,00
Monacanthidae	2	0,02	2	0,03	18	0,00	0,8	0,00
Pseudochromida	1	0,01	1	0,01	222	0,02	9,3	0,02
Priacanthidae	1	0,01	1	0,01	113	0,01	4,7	0,01
Sparidae	1	0,01	1	0,01	1	0,00	0,0	0,00
Diodontidae	1	0,01	1	0,01	1	0,00	0,0	0,00
Lutjanidae	1	0,01	1	0,01	4	0,00	0,2	0,00
Carangidae	1	0,01	1	0,01	8	0,00	0,3	0,00
Fistulariidae	1	0,01	1	0,01	11	0,00	0,5	0,00
Cirrhitidae	1	0,01	1	0,01	72	0,01	3,0	0,01
Diversity	**109**	**Species**	**73**	**Genera**	**12197**	**Individuals**		