REEF CHECK GERMANY

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

Report 2009

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with support from Magic Life GmbH & Co KG

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Content

1. Summary 4

2. Introduction 6

3. Methods 8

3.1 Survey sites 8

3.2 Survey methods 8

4. Results 11

4.1 Fish indicator 11

4.2 Fish census 13

4.3 Invertebrate survey 14

4.4 Coral damage 16

4.4 Substrate survey 18

5. Discussion 22

5.1 Fish survey 22

5.2 Fish census 23

5.3 Invertebrate survey 25

5.4 Coral damage 26

5.5 Substrate survey 30

5.6 Conclusion 31

6. References 32

7. Appendix 33

1. Summary

It has been 16 months since the last survey on the House Reef at Magic Life Club, Kalawy, took place. A survey on fish, invertebrates, substrate, coral damage and trash, conducted by biologists in March 2008, was the foundation for the annual reports. For both surveys (2008 and 2009), Reef Check-Method (Hodgson et al. 2006) was used. By using constant methods, and observing defined indicators, changes to observed reef sites can be determined, and abundances and diversity of different species can be compared.

Starting with the Reef Check fish indicators, butterflyfish (Chaetodontidae) still have the greatest abundance of all Reef Check fish indicator, although the abundance has decreased by half. In contrast, the numbers of groupers and trevallies has increased. These species belong to the reef's top predators; an increase in abundance may cause a decrease in numbers of prey (e.g. butterflyfish). Increasing numbers of trevallies and groupers may also indicate reduction, or even ceasing of local fisheries. The presence of a hotel complex, as well as the accompanying high tourist frequency, has made access to these reef sites difficult for local fishermen. Overall, the number of fish was nearly doubled, compared to 2008. A more detailed analysis of the data shows 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.

For the invertebrate indicators, a decrease of sea urchins and an increase of *Coralliophila violacea* could be recognized. The decrease of diadem and pencil urchins may be directly linked to increasing numbers of triggerfish (Balistidae), which feed on sea urchins.

The coral damage surveys showed an increase of breakage and predation. Reef site B showed a greater increase in breakage than reef site A. This was most notable in the deeper areas (10 m and 15 m), where the first traces of 1.5 years of frequent diving activity is noticeable. However, the proportion of breakage is low compared to highly frequented dive sites. The physical damage of corals could be caused by nature (e.g. strong wave action, erosion) or anthropogenic impact. Often, the exact reason is difficult to define or cannot be ascertained with certainty.

The corals of Kalawy Reef are still healthy and colourful. The results of the actual surveys do not show large changes in coverage of hard corals and their groups. Like

last years' results, staghorn corals are dominating, followed by raspberry corals and pore corals. The amount of dead corals and recently killed corals remained at similar low values, only algae cover was higher, probably caused by seasonal changes.

Kalawy House Reef is still in good condition. The frequent diving and snorkeling activities show no excessive stress on the reef's health so far. The results show increasing fish richness and no negative influence by diving on the fish communities. In fact, the opposite seems to be the case. The building of the hotel complex and diving business seem to have affected local fisheries in a negative manner; meaning that no actual local fishing activities are at the reef and the fish community has been able to recover.

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. Furthermore, they protect coasts from erosion and storm destruction by acting as breakwaters. The aesthetic and commercial value of coral reefs provides an important income for many countries, as coral reefs are attractive sites for tourism and water sports. Simultaneously, coral reefs are characterized as "highly sensitive ecosystems" (Hughes 2002), damaged by natural and human impact in many areas. 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 Magic Life Club, Kalawy, to monitor coral reef health and determine the impact of tourism on their house reef. A study was carried out in March 2008, 2 months after the opening of the club, by a Reef Check group of four scientists. The aim of the study was 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 was sent to the Reef Check headquarters, where it was put into the global data base to be used in reports on the health status of reefs at both global and regionallevel. These reports are available to the public and can be found on the Reef Check homepage (www.reefcheck.org). On a national level, Reef Check Egypt will use the results to assess the status of coral reefs in the Red Sea. 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. The health status of the Kalawy house reef was assessed by using the Reef Check Method (Hodgson et al. 2006) and a study on the biodiversity of corals, fish and molluscs. Additionally, every study was carried out using an extended Reef Check method, allowing detailed information about the composition of substrate and the dynamics of the fish population.

The main results of the 2008 study were that the most abundant indicator fish was the butterfly fish, followed by parrotfish. No large groupers (> 30 cm) were observed. Composition and abundance of invertebrates showed similar results. Long-spined sea urchins, giant clams and trochus shells were the only indicators present at all transects. The amount of trash under water was very low and only a small number of damaged corals were counted. The impact of coral predation by *Drupella cornus* and *Coralliophila violacea* was very low. No coral diseases were observed. The percentage cover of live hard coral at Kalawy was 32.5 %. The live soft coral cover was 13.9 %. The percentage cover of recently killed corals was low, with an average of 0.7 %. Branching Acropora was the most abundant hard coral type, while soft corals of the family Xeniidae were most abundant. Overall there were no deviant results compared to Reef Check data over the last few years for this region. The reef was 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 is to survey the exact same six locations at the same three depths surveyed in 2008. Afterwards, collected data will be compared and possible differences relating to the abundance, diversity and composition of substrate will be analyzed. Prior to the first survey in 2008 about 1,000 dives were made at the survey sites. Approxiamately 15,000 dives took place between the first survey and the present one. By using these identical survey methods and locations, the impact of tourism on Kalawys' fringing reef can be determined in the present study.

3. Methods

3.1 Survey sites

The same survey sites were used as for the 2008 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

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. This extension was developed by scientists at the Red Sea Environmental Centre and has been successfully applied at Reef Monitoring in Dahab, South Sinai. The extension comprises additional indicators for fish (Tab. 2) and invertebrates (Tab. 3), and three new subcategories for 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 previous 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.)
Cauris	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 result of counting shows that surgeonfish (Acanthuridae) are the family with the highest abundance of approximately 14 individuals per 100 m² on both reef sites. Therein they had their highest local abundance of an average of 22 individuals per 100 m² at the 5 m transects. They were followed by butterfly fish (Chaetodontidae) with an average abundance of 6.5 individuals per 100m². Parrotfish (Scaridae), both larger and smaller than 20 cm, and bluestreak cleaner wrasse (*Labroides dimidiatus*) with an abundance of approximately 4 individuals per 100 m², are the last two of the five common indicators. The high percentage of juvenile bluestreak cleaner wrasse was striking. While 8 additional fish indicators with less than one individual per 100 m² were present, three indicators have not been observed at all (Table 5): Sweetlips (Haemulidae), steephead parrotfish (*Clorurus gibbus*), and tuna and mackerel (Scombridae).

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)	103	4,29	2,90
Parrotfish < 20cm (Scaridae)*	103	4,29	5,67
Steephead parrot (*Chlorurus gibbus*)*	2	0,08	0,41
Bumphead parrotfish (*Bolbometopon muricatum*)	0	0,00	0,00
Surgeonfish (Acanthuridae)*	345	14,38	6,90
Broomtail wrasse (*Cheilinus lunulatus*)	15	0,63	1,13
Humphead wrasse (*Cheilinus undulatus*)	0	0,00	0,00
Trevallies (Carangidae)*	9	0,38	0,77
Tuna & Mackarel (Scombridae)*	0	0,00	0,00
Snapper (Lutjanidae)	8	0,33	0,48
Twinspot Snapper (*Lutjanus bohar*)*	3	0,13	0,34
Emperor (Lethrinidae)*	24	1,00	1,25
Spangled emperor (*Lethrinus nebulosus*)*	0	0,00	0,00
Butterflyfish (Chaetodontidae)	155	6,46	3,43
Sweetlips (Haemulidae)	0	0,00	0,00
Grouper <30 cm (Epinephilinae)*	60	2,50	2,00
Grouper >30 cm (Epinephilinae)	13	0,54	0,83
Lyretail grouper (*Variola louti*)*	4	0,17	0,38
Bluestreak cleaner wrasse (*Labroides dimidiatus*)*	99	4,13	2,59
"Farmer fish" (*Stegastes* spp. & *Plectroglyphidodon* spp.)*	8	0,33	1,09
Moray eels (Muraenidae)	5	0,21	0,41
Giant moray (*Gymnothorax javanicus*)*	1	0,04	0,20

“Farmer fish” feeding from benthic algae were only counted in the 5 m transects. Top predators like Giant moray (*Gymnothorax javanicus*) and yellow-edged lyretail grouper (*Variola louti*) were scarcely observed within the transects. A female humphead wrasse (*Cheilinus undulates*) was only observed aside from the data collection, but was not observed within the surveys.

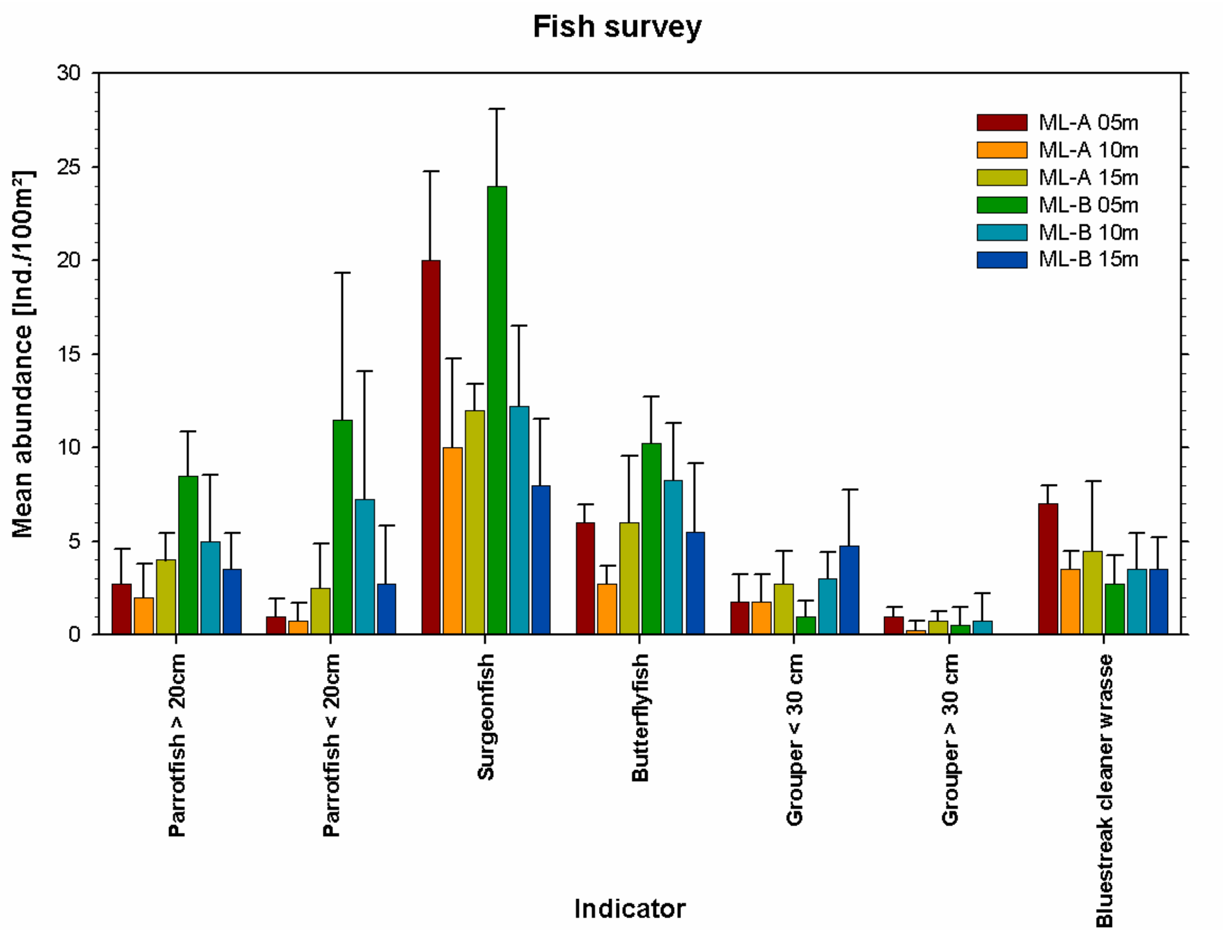

Figure 1: Results of the fish survey for all transects. Indictors with low values are not shown.

In the northern reef site, significantly more parrotfish and butterfly fish were counted. The number of bluestreak cleaner wrasse in the southern reef sites rose (Figure 1). Figure 1 clearly shows that the most frequent fish indicators were counted at the 5 m transects, regardless of northern or southern sites.

4.2 Fish census

This year, 19,045 fish were counted all together, consisting of 110 species within 74 genus and 28 families. The majority of the fish were Pomacentrides (55.6 %) and Serranides (28.9 %), although the latter was only represented by the subfamily Anthiinae. Other common families were Labridae (Wrasses, 5.4 %), and Acanthuridae (Surgeonfish, 2.0 %). The most frequent species in Kalawy Reef was the Half-and-half-Chromis (*Chromis dimidiata)* with a relative abundance of 29.8 %. With a slightly lesser abundance, there was the Jewel fairy basslet (*Pseudanthias squamipinnis)* with 8.5 %. Furthermore, belonging to the 6 most frequent species were Miry's damsel (*Neopomacentrus miryae*), Paletail damsel (*Pomacentrus trichourus*), Klunzinger's wrasse (*Thalassoma rueppellii*) and Pale damsel (*Amblyglyphidodon indicus*). The 6 most frequent species and their relative abundance are listed in Table 6. For a complete list of species see tTable 21 on page 33.

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

	Abundance				
Species	**Total**	**Mean**	**SD**	**absolute [Ind./m²]**	**relative [%]**
Chromis dimidiata	5670	945,00	370,12	2,36	29,8
Pseudanthias squamipinnis	5420	903,33	932,43	2,26	28,5
Neopomacentrus miryae	2860	476,67	426,75	1,19	15,0
Pomacentrus trichourus	822	137,00	84,66	0,34	4,3
Thalassoma rueppellii	388	64,67	87,45	0,16	2,0
Amblyglyphidodon indicus	371	61,83	25,93	0,15	1,9

The 110 species of fish, counted in the Kalawy Reef could mostly be allocated to the following families: Labridae (wrasses; 18.2 %, 20 species), Pomacentridae (12.7 %, 14 species), Chaetodontidae (Butterflyfish, 8.2 %, 9 species), Acanthuridae (Surgeonfish, 7.3 %, 8 species), Scaridae (Parrotfish, 7.3 %, 8 species) and Serranidae (Grouper, 6.4 %, 7 Arten). An overview of fish diversity is shown in Tabelle 22; a complete list is on page 36.

Table 7: Fish diversity of Kalawy Reef.

	Species		Individuals		Genera	
Family	**total**	**in percent**	**total**	**in percent**	**total**	**in percent**
Labridae	20	18,18%	1032	5,42%	14	18,92%
Pomacentridae	14	12,73%	10583	55,57%	8	10,81%
Chaetodontidae	9	8,18%	188	0,99%	2	2,70%
Acanthuridae	8	7,27%	5499	28,87%	5	6,76%
Scaridae	8	7,27%	189	0,99%	5	6,76%
Serranidae	7	6,36%	383	2,01%	4	5,41%
All families (total)	110		19045		74	

The species richness was more or less balanced in the examined depths. A comparison of both reef areas showed 7 more species in the southern area (ML-A) than in the northern (ML-B). In the transects of 5 meters depth, there were more than twice as manyindividuals counted as in 10 meters and 15 meters (Table 8).

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

Site / depth	**A**	**B**	**15 m**	**10 m**	**5 m**
Individuals	9947	9098	4834	4707	9504
Species Richness [S]	97,0	90,0	82	84	84
Shannon-Wiener Index H'	2,09	2,16	2,25	2,24	1,88
Eveness E = H'/lnS	0,50	0,51	0,54	0,53	0,44

4.3 Invertebrate survey

The 6 surveyed transects showed partial differences concerning composition and frequency of indicator-species. Long-spined sea urchins and giant clams were the only indicator-species appearing in all transects. The long-spined sea urchin appeared on average with 2.-4 individuals per 100 m². The transects in 5 meters depth showed a significant 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 examined transects. Slate-pencil sea urchins had an average appearance of 0.1 individuals per 100 m². Moreover, two Banded boxer shrimps were counted. Outside transects, one Crown-of-Thorns Starfish was counted. There were no significant differences concerning the frequency of indicators between the northern and the southern area. All in all, Giant clams (*Tridacna* spp.) and Purple coral snails (*Coralliophila violacea*) had the highest average abundance (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*)	2	0,1	0,3
Long-spined urchins (*Diadema* spp. & *Echinotrix* spp.)	58	2,4	2,8
Pencil urchin (*Heterocentrotus mammillatus*)	2	0,1	0,3
Collector urchin (*Tripneustes gratilla*)	0	0,0	0,0
Sea cucumber (Holothuroidea)	1	0,0	0,2
Crown-of-thorns (*Acanthaster planci*)	0	0,0	0,0
Giant clam (*Tridacna* spp.)	131	5,5	6,0
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)	14	0,6	1,0
Purple coral snail (*Coralliophila violacea*)	172	7,2	6,1
Horn drupe (*Drupella cornus*)	65	2,7	3,6
Cowries (Cypraeidae)	2	0,1	0,3
Nudibranchs (Nudibranchia)**	6	0,3	0,4
Reef octopus (*Octopus cyaneus*)	1	0,0	0,2

There were neither spiny lobsters nor Slipper lobsters, nor Triton’s trumpets found. This may be because they are all night active animals, which usually hide during the daytime in cracks and caves. That makes them often hard to find. There is a tendency showing that with increasing depth, there is a decreasing abundance in invertebrate-indicators. Only Nudibranchs showed a converse trend (Figure 2).

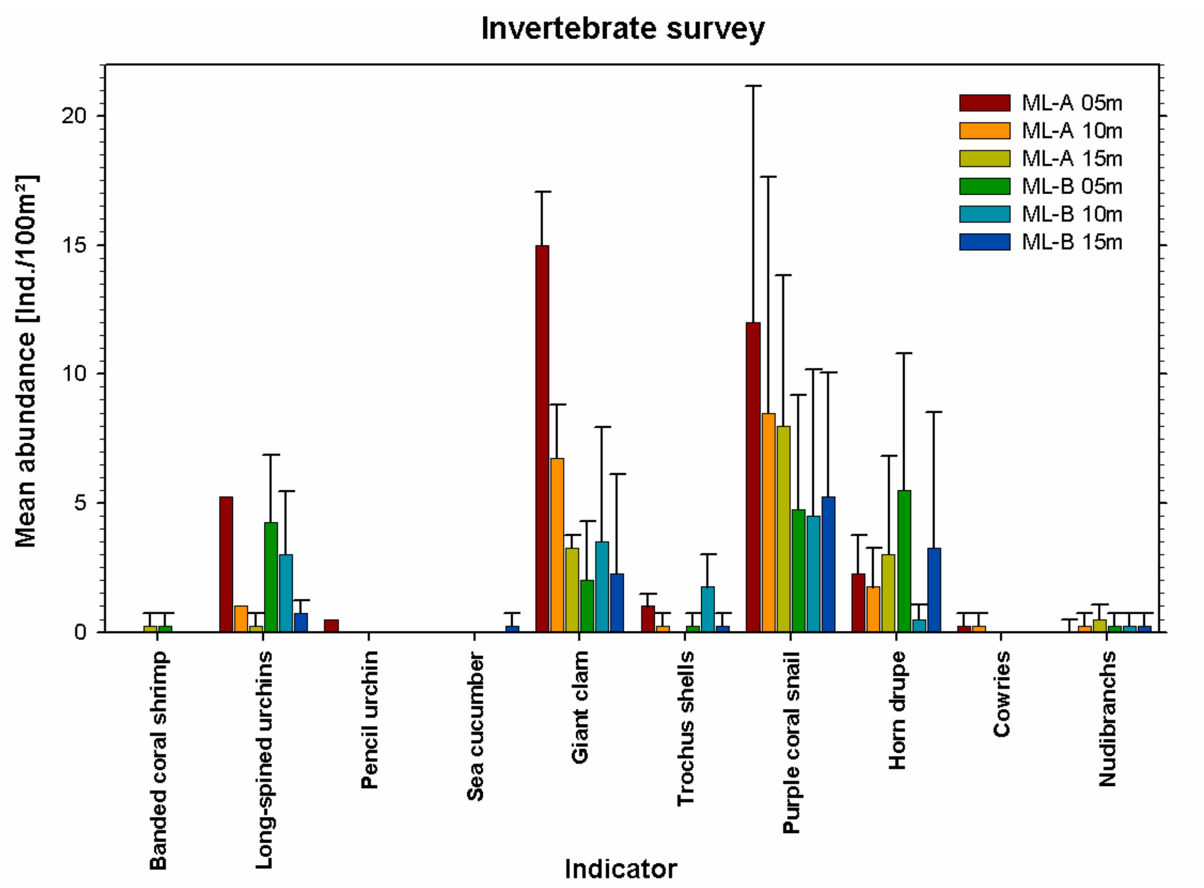

Figure 2: Results of the invertebrate surveys for all transects. Indicators with zero values are not shown.

4.4 Coral damage

The percentage of branching corals with breakage ranged between 0.69 % and 1.98 %, with an average of 1.09 % (Table 11). The results show an increase in breakage with an increase in depths in both areas. The highest number of broken corals was found on transect ML-B-15m. Most damaged coral colonies had less than 25% breakage (51 colonies) and 14 colonies could be ascribed to the 25 – 50 % breakage category (Table 10). While there were no colonies within the 50 – 75 % breakage category, two colonies could be ascribed to the 75 – 100 % breakage category. There were a total of 42 detached colonies, often lying upside down. All together, there were 115 colonies with different types of damage, while there were 291 colonies showing symptoms of coral predation. The percentage of branching corals was between 1.84 % and 3.74 %, with an average of 2.70 % (Table 11).

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

	Type	Total	Mean	SD
Coral colonies per 40 m²	*Acropora* spp.	756	31,5	13,9
	Pocillopora spp.	478	19,9	11,5
	Stylophora spp.	181	7,5	5,1
	Seriatopora spp.	14	0,6	0,9
	Millepora spp.*	206	8,6	5,6
Breakage - damaged colonies	< 25 %	51	2,1	1,7
	25 - 50 %	14	0,6	0,8
	50 - 75 %	0	0,0	0,0
	75 - 100 %	2	0,1	0,3
	Detached colonies	48	2,0	2,1
Kind of damaged colonies	*Acropora* spp.	70	2,9	2,5
	Pocillopora spp.	8	0,3	0,7
	Stylophora spp.	5	0,2	0,4
	Seriatopora spp.	1	0,0	0,2
	Millepora spp.	28	1,2	1,7
	Porites spp.	0	0,0	0,0
	Other	5	0,2	0,4
Predation (impacted colonies)	*Drupella cornus*	193	8,0	5,2
	Coralliophila violacea	59	2,5	2,0
	Acanthaster planci	0	0,0	0,0
	Parrotfish bites	39	1,6	2,0
Kind of impacted colonies (Predation)	*Acropora* spp.	71	3,0	2,2
	Pocillopora spp.	128	5,3	3,5
	Stylophora spp.	4	0,2	0,5
	Seriatopora spp.	0	0,0	0,0
	Millepora spp.	0	0,0	0,0
	Porites spp.	71	3,0	3,2
	Other	6	0,3	0,5

The distribution of coral predation with depth showed a different pattern than with breakage. The highest percentage of damage due to predation was in the 5 m transects, followed by the 15 m transects. The lowest numbers were observed in the 10 m transects (Table 11). Reef site A had 163 colonies with damage due to predation, compared to 128 colonies affected by predation at reef site B. In relation to the calculated population of branching corals the ratio was similar; reef site A had 2.83 % branching coral colonies compared to 2.57 % at reef site B. However, reef site B had the highest percentage of breakage with 1.19 %, compared to 0.99 % at reef site A.

Colonies affected by predation could be allocated to several predators, e.g. 193 colonies were affected by *Drupella cornus*, 59 colonies by *Coralliophila violacea* and a total of 39 colonies showed bite marks from parrot fish (Scaridae). If counting just the colonies where the predation damage seemed obvious and specimens of *D. cornus* could be observed simultaneously, the number of colonies decreases to 35. The abundance of coral eating snails is listed in (Table 9).

Table 11: Results of the coral damage surveys 2009, pooled for depths and sites.

Site / Depth	A	B	15 m	10 m	5 m	All
Coral Damage - Branching coral	0,99%	1,19%	1,55%	1,21%	0,67%	1,09%
Coral Predation - Branching corals	2,83%	2,57%	2,68%	1,87%	3,51%	2,70%
Predation & Damage	3,81%	3,77%	4,23%	3,08%	4,18%	3,79%
Rubble (RB)	5,21%	7,29%	10,00%	6,88%	1,88%	6,25%
Coral Damage (No. of colonies)	53	62	37	37	41	115
Coral Predation (No. of colonies)	163	128	82	74	135	291
Branching Coral Population (extrapolated)	3750	3770	1940	2730	2850	7520

No coral diseases were recorded during the surveys. Just one colony with Black-Band-Disease (BBD) was observed ouside of the survey area close to the Jetty.

4.4 Substrate survey

The coverage of living hard corals (HC) had a range between 28.1 % (ML-B-15m) and 42.5 % (ML-B-05m, table. 11) with an average of 32.4 % (Table 12). Living soft corals (SC) showed a coverage between 2.5 % (ML-A-10m) and 8.1 % (ML-B-10m, Table 14) with an average of 5,2 %. So, the average cover of all living corals (HC and SC) sum up to 37.6 %. Most of the reef consisted of coral rock (51.0 %), while sand accounted for 2.9 % (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.

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

Category	Mean	SD
HC	32,4%	8,8%
RKC	1,4%	1,9%
SC	5,2%	4,9%
NIA	0,7%	1,4%
SP	0,1%	0,5%
RC	51,0%	12,2%
RB	6,3%	6,0%
SD	2,9%	3,4%
SI	0,0%	0,0%
OT	0,0%	0,0%

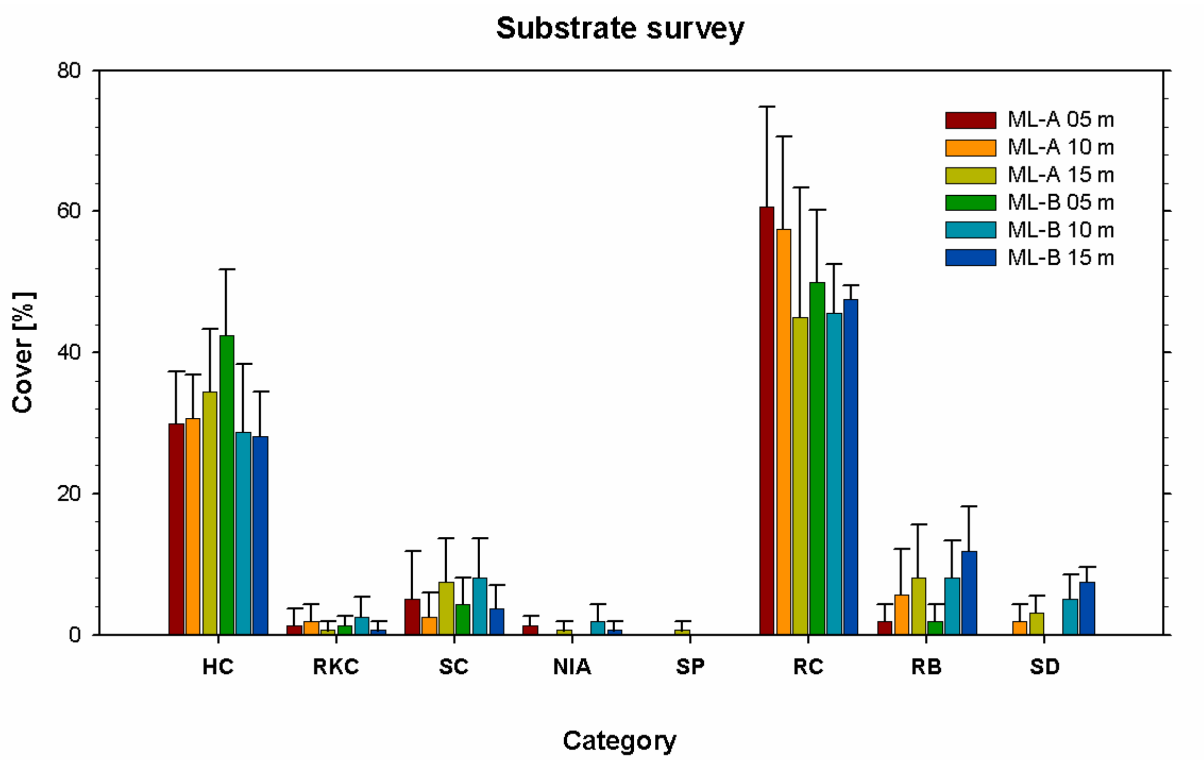

Figure 3: Results of the substrate surveys.

Within hard corals, branching staghorn corals of the category AB (Acropora branching) comprised the largest group with 11.3 % (Tab. 13), followed by other branching corals (CB), primarily *Pocillopora* spp. with 5.3 % and massive *Porites* spp. (PM) with 4.9 %. Soft corals were heavily represented by Xeniidae (SCX), which had the highest amount of coverage with an average of 3.1 %, followed by Alcyonidae (SCA) with 1.6 %. Mean values for each transect of the most common coral groups and genera are given in Table 14.

Table 13: Results of the substrate surveys 2009 with extended RC categories. Pooled data of all transects.

Category	Mean	SD	Category	Mean	SD
Corals			**Algae**		
AB	11,3%	7,30%	AA	0,4%	0,95%
AD	1,4%	1,80%	CA	3,3%	3,81%
AT	0,4%	0,95%	DCA	2,9%	3,51%
CB	5,3%	4,85%	FA	0,1%	0,51%
CC	0,4%	1,20%	HA	0,0%	0,00%
CE	2,5%	3,13%	MA	0,2%	0,71%
CF	0,2%	1,02%	TA	4,9%	4,27%
CM	1,2%	1,80%	**Abiotic / Others**		
CME	2,7%	3,03%	OT	0,0%	0,00%
CMR	0,4%	1,20%	SP	0,1%	0,51%
CS	1,4%	1,95%	ZO	0,0%	0,00%
CTU	0,0%	0,00%	DC	0,2%	0,71%
PC	0,4%	0,95%	RB	6,3%	6,03%
PM	4,9%	3,34%	RC	39,7%	10,74%
SC	0,1%	0,51%	RKC	1,4%	1,95%
SCA	1,6%	3,36%	SD	2,9%	3,35%
SCN	0,1%	0,51%	Si	0,0%	0,00%
SCX	3,4%	4,65%	WA	0,0%	0,00%

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	30,0%	30,6%	34,4%	42,5%	28,8%	28,1%
Acropora spp.	8,8%	16,3%	11,3%	15,6%	14,38%	11,9%
Other branching corals	6,3%	2,5%	3,8%	12,5%	2,50%	4,4%
Porites spp.	8,1%	3,8%	6,9%	6,9%	4,38%	1,9%
Other (sub-)massive corals	2,5%	3,1%	6,9%	0,0%	0,63%	4,4%
Millepora spp.	2,0%	4,4%	1,3%	5,0%	2,50%	0,6%
Hard corals (HC) Other	1,9%	0,6%	4,4%	2,5%	4,38%	5,0%
Soft corals (SC) Total	5,0%	2,5%	7,5%	4,4%	8,13%	3,8%
Alcyonidae	5,0%	0,6%	0,6%	2,5%	0,63%	0,0%
Nephtheidae	0,0%	0,0%	0,0%	0,0%	0,00%	0,6%
Xeniidae	0,0%	1,9%	6,3%	1,9%	7,50%	3,1%

Algae showed coverage of 11.9 % (Table 13). The most common were turf algae (TA) with 7.8 % coverage, of which 4.9 % was on rock and 2.9 % on dead corals (DCA). Coralline algae (CA), which contributes to consolidate the reef's structure, had a cover of 3.3%. The categories AA, FA and MA had very low coverage, these are included in the main category nutrient indicator algae (NIA) with 0.7 % cover (Table 12). Halimeda algae were not recorded. The percentage of recently killed corals (RKC) was 1.4 %, the sum of dead corals (DC and DCA) was 3.1 %.

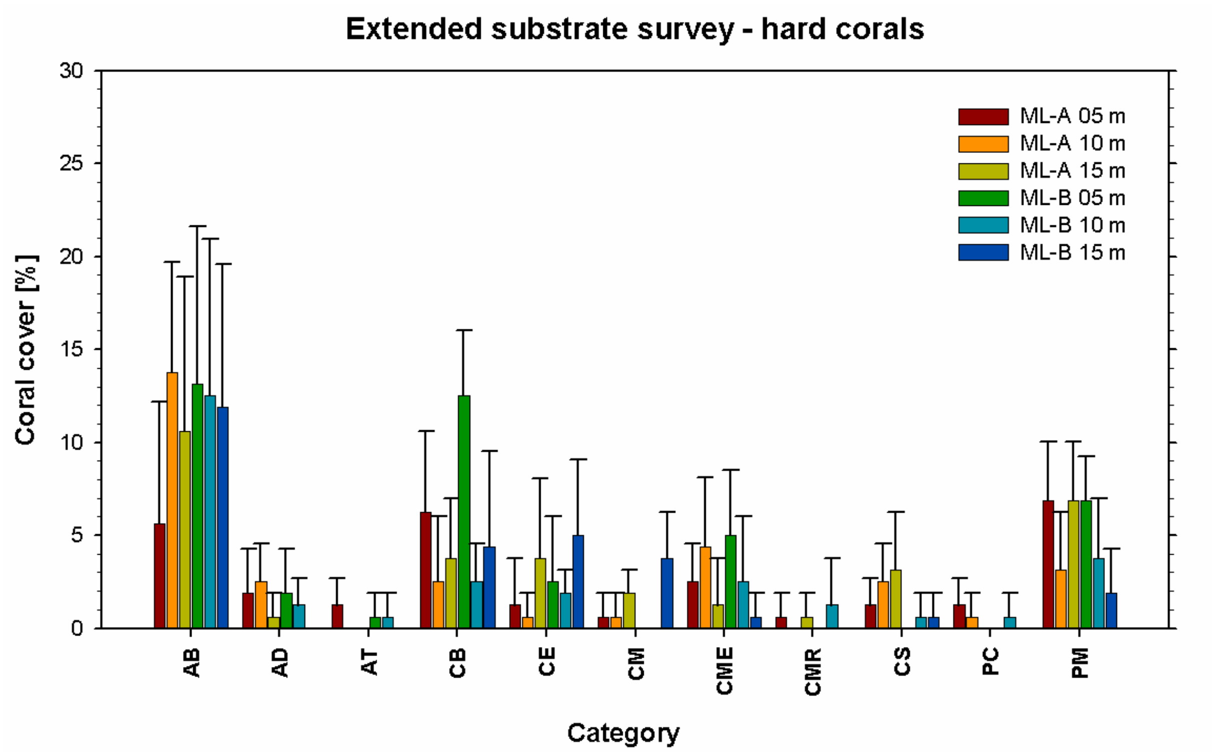

Figure 4: Cover of 11 coral categories for all transects.

5. Discussion

It has been 16 months since the last biological survey of the house reef at Magic Life Club Kalawy took place. During this time, the previously pristine house reef Kalawy has established itself as a popular diving and snorkeling site for club guests. There have been approximately 15,000 dives at the survey sites, both north and south of the jetty, since the last Reef Check study. 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 2008 and 2009, showed that in both years the highest abundance of fish were butterflyfish (Chaetodontidae), with an average of 11.3 individuals *per* 100 m² (2008) and 6.5 individuals *per* 100 m² in 2009 (Table 5). The abundance of this family seemed to have decreased by half in the last 15 months. Butterflyfish are indicators for aquarium trade. Since this is not taking place at the house reef, a possible explanation could be the increasing number of top-predators, e.g. groupers. Their abundance has risen since June 2009 (Table 15). Nevertheless, censuses at different daytimes or currents can lead to deviating data in both years. Parrotfish (Scaridae) (>20 cm) reached the second highest abundance with 4.29 individuals *per* 100 m². This number has remained constant, compared to the number in 2008 (4.5 individuals *per* 100 m²). Comparing the two reef sites, there were bigger differences. The southern, more exposed reef site showed a decrease of approximately 2 individuals *per* 100 m², while the northern reef site showed an increase of around 2 individuals. The 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 counted as an additional indicator, as it is a key indicator for fish diversity in the reef (Bshary 2003). The inference drawn from this fact can be applied to the higher diversity and abundance at the survey site ML-A (south). Compared to ML-B, 7 species and 850 individuals more were counted at this site. In annual comparison, the highest increase in individual numbers is recorded for groupers (Epinephelinae) and trevallies (Carangidae). While there were no trevallies counted in 2008, in 2009 there was an average of 0.38 individuals *per* 100 m². Groupers, both larger and smaller than 30 cm, showed a 7-fold increase in abundance compared to 2008 (Table 15). Annual comparison of the surveys south of the jetty showed a decreasing abundance of parrotfish (> 20 cm), broomtail wrasse, snapper, butterflyfish, and sweetlips. In contrast, there is an increasing abundance in the south of trevallies, groupers (both larger and smaller than 30 cm), cleaner wrasse and farmer fish. North of the jetty, there is an altered scenario: increasing numbers of parrotfish, broomtail wrasse, trevallies, snappers and groupers, compared to 2008. On the other hand, the abundance of butterflyfish, sweetlips, cleaner wrasse and farmer fish had decreased.

Table 15: Mean abundance data of fish indicators of Kalawy report 2008 in comparison to actual data. Data are pooled over all and for site A and site B. Mean abundance is expressed as individuals per 100 m² *Additional indicators are marked with an asterisk. ²Data 03/2008, ³Data 06/2009

Indicator \ Site	A+B²	A+B³	A²	A³	B²	B³
Parrotfish > 20cm	4,50	4,29	5,00	2,92	4,00	5,67
Broomtail wrasse	0,54	0,63	0,67	0,33	0,42	0,92
Trevallies*	0,00	0,38	0,00	0,42	0,00	0,33
Snapper	0,21	0,33	0,42	0,25	0,00	0,42
Butterflyfish	11,33	6,46	12,58	4,92	10,08	8,00
Sweetlips	0,13	0,00	0,08	0,00	0,17	0,00
Grouper <30 cm*	0,33	2,50	0,00	2,08	0,67	2,92
Grouper >30 cm	0,04	0,54	0,00	0,67	0,08	0,42
Bluestreak cleaner wrasse*	4,38	4,13	4,17	5,00	4,58	3,25
"Farmer fish"*	0,33	0,33	0,42	0,50	0,25	0,17

5.2 Fish census

While the jewel fairy basslet (*Pseudanthias squamipinnis)* was the most frequently occurring species in 2008, the half-and-half-Chromis (*Chromis dimidiata*) appeared most frequently in 2009 with a relative abundance of 31.9*.* However, the difference to *Pseudanthias squamipinnis* (31.8) is quite small. Both species show an increase compared to 2008 (Table 16). There was a notable increase in the abundance of Klunzinger's wrasse *(Thalassoma rueppellii)*. However, there were mostly juvenile individuals counted in 2009, which leads to the conclusion that the increase of individuals is connected to the reproduction cycle. This could also be an explanation for the less abundant pale damselfish (*Amblyglyphidodon indicus)* and the bluegreen pullers *(Chromis viridis)*. In almost every transect, a clutch of pale damselfish could be observed. With carrying out the study in March 2008 and June 2009, such differences in abundances are not unusual. The fact that in 2009 more than twice as many individuals were counted is also directly correlated to *Pomacentridae* and the species *Pseudanthias squamipinnis* (Serranidae). They both have a very high reproduction rate; especially swarm- or group-forming species like *Chromis dimidiata, Neopomacentrus miryae* and *Pseudanthias squamipinnis*. This explains the phenomenon of extremely divergent seasonal abundances. The 7 most frequent fish species are shown in Table 6 (for a complete list of species, see Table 21 on page 33).

In comparison to two different sites in the Red Sea (Table 16), a significant larger number of *Chromis dimidiata* in El Quadim Bay and a significant lower number in the northern Red Sea, Jordan, can be observed. The other numbers are more or less balanced; although *Chromis viridis* in the northern Red Sea and Kalawy in 2009 are significant lower than in El Quadim Bay and Kalawy in 2008.

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]this study, [2]surveys 2008, [3]Kochzius (2007), [4]Khalaf & Kochzius (2002).* Data not available.

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

Figure 5 shows the differences in relative abundance for the surveys in 2008 and 2009 of the 7 most common fish species. Most of them are assembling in schools or groups except the Klunzinger's wrasse (*Thalassoma rueppellii*). Some of the fish indicators showed a slight decline in abundance. Lower numbers of butterflyfish may be correlated with an increased abundance of top predators (Groupers and Moray eels).

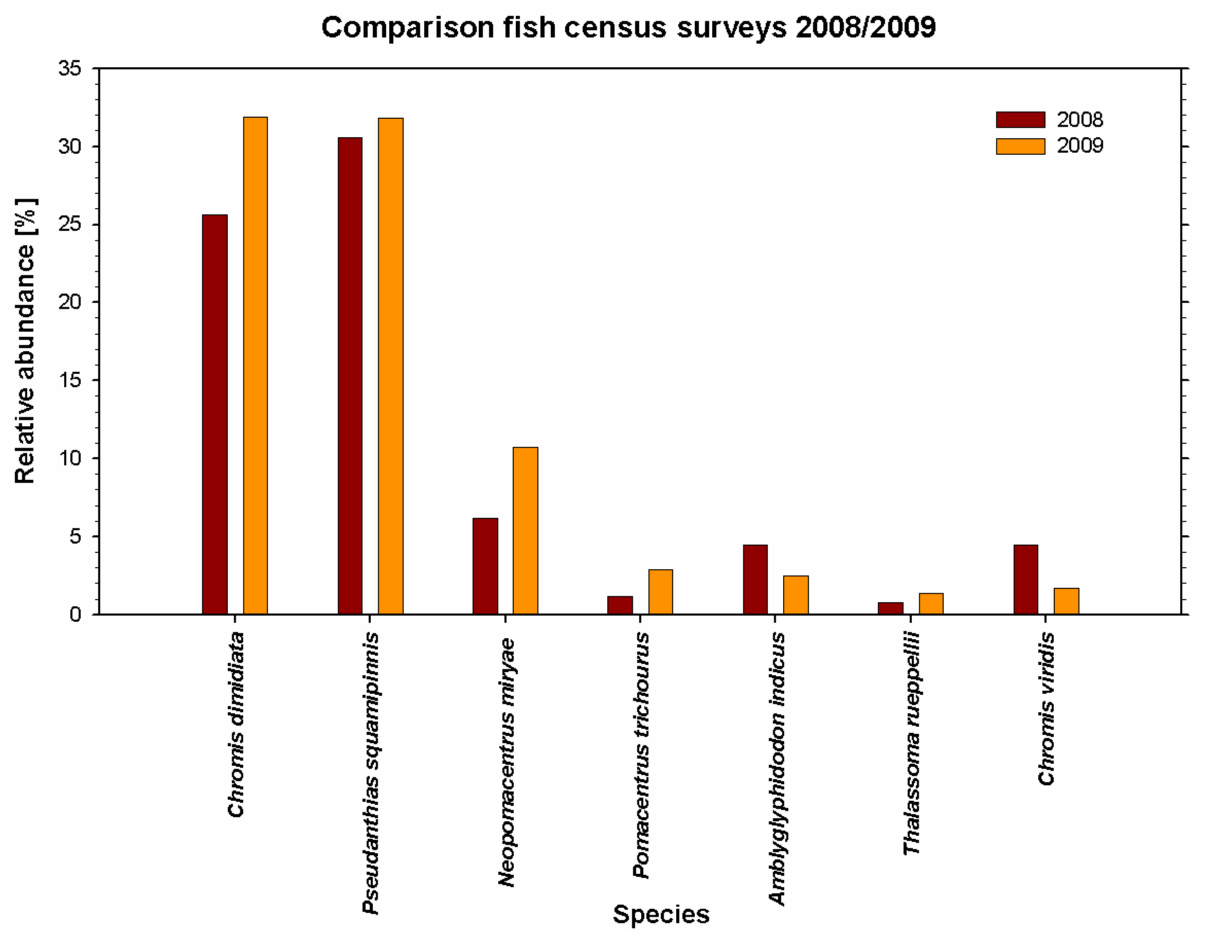

Figure 5: Relative abundance of most common fish species der sieben häufigsten Arten im Kalawy-Riff.

5.3 Invertebrate survey

The abundance of most invertebrate indicators remained relatively balanced compared to the first survey 15 months ago. The sea urchins showed a decline in numbers (table 17). There may be several explanations for this decline. One is the doubled number of Triggerfish (Balistidae) since the first study (Sea urchins are a favorite food of this fish family, Fricke 1971). Especially in the northern reef site, the abundance of sea urchins declined (table 17). Although the abundance of giant clams as a whole remained stable, the relative abundance in the south decreased by one individual *per* 100 m², while the north's abundance increased by one individual *per* 100 m² (table 17). The same result can also be seen at Trochidae. In contrast to 2008, a Crown-of-thorns Starfish (*Acanthaster planci*) outside of transect could be observed. The crown-of-thorns and their trails were located in the northern reef site at a depth of 10 – 20 m. While the average abundance *per* 100 m² of coral-eating snails (*Drupella cornus*) remained almost unchanged, the abundance of Purple coral snails

(*Coralliophila violacea*) was more than doubled. The primary source of food for the *Coralliophila* is the coral genus Porites, whereas the genus *Acropora* is preferred by *Drupella* snails (Fujioka & Yamazato 1983, Chen et. al 2004). This result is reflected clearly in the infected coral colonies. There were a total of 12 colonies of the genus Porites, infested with Purple coral snails in 2008, but the number has risen to 59 colonies this year. The number of *Drupella* infested, *Acropora* colonies increased from 116 to 193 in the past 16 months.

Table 17: Mean abundance data of invertebrate indicators of Kalawy report 2008 in comparison to actual data. Data are pooled over all and for site A and site B. Mean abundance is expressed as individuals per 100 m² *Additional indicators are marked with an asterisk. ²Data 03/2008, ³Data 06/2009

Indicator \ Site	A+B²	A+B³	A²	A³	B²	B³
Banded coral shrimp	0,04	0,08	0,00	0,08	0,08	0,08
Long-spined urchins	4,75	2,42	2,83	2,17	6,67	2,67
Pencil urchin	0,33	0,08	0,58	0,17	0,08	0,00
Sea cucumber	0,00	0,04	0,00	0,00	0,00	0,08
Crown-of-thorns	0,54	0,58	0,17	0,42	0,92	0,75
Giant clam	5,63	5,46	7,75	8,33	3,50	2,58
	3,0	7,17	3,6	9,50	2,6	4,83

In conclusion, the current study shows no abberant results regarding the invertebrate indicators.However, the sighting of a crown of thorns, even outside of the survey transects, is reason for further observations. As long as there is no outbreak of the species, an individual is a relatively manageable enemy of corals.

5.4 Coral damage

In comparison to the survey of March 2008, an increase of coral breakage and coral predation could be observed in all transects. The overall number of colonies with breakage had more than doubled (

Table 18). Within branching colonies, the amount of broken corals had doubled. Reef site B (north) showed a higher increase with 0.6 %, compared to reef site A (south) with 0.4 % (Table 19). Possibly, there is a correlation between the probable higher number of dives at reef site B. Unfortunately, exact numbers are not available, only qualitative statements of local dive base personnel and guests, as well as our own observations, which are that reef site B is more popular amongst both divers and snorkelers. Highest numbers were recorded in transects B-15m (2.0 %) and B-10m (1.3 %).

Table 18: Total numbers of damaged corals and according genera of Kalawy report 2008 in comparison to actual data. Data are pooled over all and for site A and site B. ²Data 03/2008, ³Data 06/2009.

		A+B²	A+B³	A²	A³	B²	B³
Breakage - damaged colonies	< 25 %	33	51	21	23	12	28
	25 - 50 %	6	14	5	7	1	7
	50 - 75 %	1	0	1	0	0	0
	75 - 100 %	2	2	2	1	0	1
	Detached colony	10	48	3	22	7	26
Kind of damaged colonies	*Acropora* spp.	26	70	15	27	11	43
	Pocillopora spp.	10	8	4	6	6	2
	Stylophora spp.	3	5	3	3	0	2
	Seriatopora spp.	0	1	0	1	0	0
	Millepora spp.	12	28	8	14	4	14
	Porites spp.	0	0	0	0	0	0
	Other	0	5	0	2	0	3
Predation (impacted colonies)	*Drupella* spp.	116	193	58	103	58	90
	Coralliophila spp.	12	59	11	40	1	19
	Acanthaster planci	0	0	0	0	0	0
	Parrotfish	16	39	6	20	10	19
Kind of impacted colonies (Predation)	*Acropora* spp.	87	71	43	43	44	28
	Pocillopora spp.	22	128	10	60	12	68
	Stylophora spp.	4	4	3	3	1	1
	Seriatopora spp.	0	0	0	0	0	0
	Millepora spp.	0	0	0	0	0	0
	Porites spp.	27	71	16	55	11	16
	Other	2	6	2	2	0	4

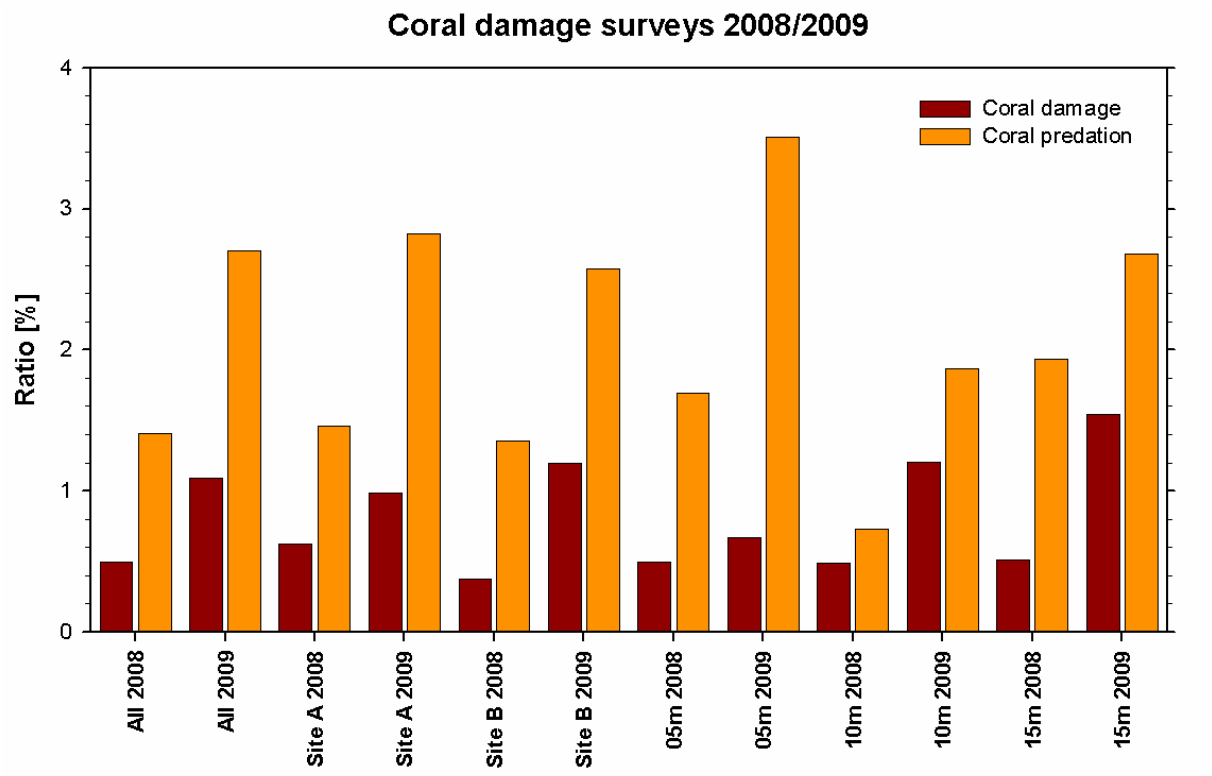

Figure 6: Comparison of coral damage results of surveys 2008 and 2009.

Though there is an increase of coral breakage, the ratio still had an acceptable dimension. Jameson et al. (1999) set a border of 4 % for their Coral Damage Index (CDI) and received values of 7-8 % damaged colonies for popular dive sites like Small Giftun in Hurghada. The results are not directly comparable, because of different methods used for the surveys. Jameson at al. (1999) expressed the breakage in relation to the entire transect. We counted all damaged colonies, though the damage might have impacted just a small part of the colony. The method used by us has different advantages. One of those is the ascribing in different damage categories. A smaller amount of damage is possibly caused by a careless diver, whilst a bigger, broken colony is likely caused by erosion. We transformed our results for a better comparability to the results to Jameson et al. (1999). With a damage of less than 25 %, you should theoretically take at least four colonies to comprise an entirely damaged colony. Since the damage is in most cases is not exactly 25 %, ratherwe decided four colonies would be the maximum amount of data to amalgamate. .In this manner we transformed partly damaged colonies to full damage colonies. This makes the results easier to compare with Jameson et al. (1999). But there is still the difference that our results picture the proportion of colonies with breakage to the complete population, whereas Jameson et al. (1999) shows the breakage proportional to the whole transect. With this transformation, the values turn to 0.30 % measured for 2008 and 0.93% for the recent survey as maximum values. The increase in coral damage is significant, even though the values are still much lower than the comparable results figured by Jameson et al. (1999), the so called “hot spots”. The increased damage could to be correlatedto an increased number of dives. The breakage of 1.1 % is low compared to most of the values for Dahab that are around 2 or 3 % for popular dive sites (unpublished data). We recommend reconsidering the independent dives and setting stronger requirements for independent divers to avoid a continuing increase.

Table 19: Mean values for data of fish indicators of Kalawy report 2008 in comparison to actual data. Data are pooled over all and for site A and site B. Mean abundance is expressed as individuals per 100 m² *Additional indicators are marked with an asterisk. ²Data 03/2008, ³Data 06/2009

Indicator \ Site	A+B²	A+B³	A²	A³	B²	B³
Coral Damage - Branching corals	0,5%	1,1%	0,6%	1,0%	0,4%	1,2%
Coral Predation - Branching corals	1,4%	2,7%	1,5%	2,8%	1,4%	2,6%
Predation & Damage	1,9%	3,8%	2,1%	3,8%	1,7%	3,8%
Rubble (RB)	6,5%	6,3%	6,3%	5,2%	6,7%	7,3%
Coral Damage (No. of colonies)	52	115	32	53	20	62
Coral Damage (Branching corals)	40	82	24	37	16	45
Coral Predation (No. of colonies)	144	291	75	163	69	128
Branching coral Population (extrap.)	8045	7520	3835	3750	3420	3770

Coral predation showed a similar increase. The ratio of counted colonies with predation increased from 1.4 % to 2.7 % (Table 19). The increase of affected colonies was unlike the breakage in the south (ML-A) more distinctive than in the north (ML-B). In particular, the colonies affected by coral feeding snails had values more than twice the values of 2008. The higher values could reflect seasonal differences due to the reproduction cycle of both snail species. Unfortunately, there is no more information available for the life cycle of these snails. Another explanation could be that natural predators of the slugs may be reduced in numbers. In this case, the apparently affected colonies were counted due to the typical appearance of the damage on the coral colonies, even though the snails could not always be observed. Specimens of *Drupella cornus* were not observed in 148 out of 193 counted colonies.

The dead white branches of the remaining 148 colonies could have had different triggers, e.g. infections, overgrowing by dominant algae or coral disease without clear signs and, through with our means, unidentifiable.

5.5 Substrate survey

Concerning coral cover, Kalawy Reef is still healthy and colorful. The results of the actual surveys do not show large changes in coverage of hard corals and their groups (

Table 20). Staghorn corals of the category AB (Acropora branching) are dominating further on, followed by other branching corals (mainly raspberry corals *Pocillopora* spp.) and pore corals (*Porites* spp.). The share of recently killed corals and dead corals remained similar, only algae cover was higher, probably because of seasonal changes.

Table 20: Mean cover [%] for several coral groupings of Kalawy report 2008 in comparison to actual data. Data are pooled over all and for site A and site B. Mean abundance is expressed as individuals per 100 m² *Additional indicators are marked with an asterisk. ²Data 03/2008, ³Data 06/2009

Gruppe \ Stelle	A+B²	A+B³	A²	A³	B²	B³
Hard corals (HC) Total	**31,3%**	**32,4%**	**32,5%**	**31,7%**	**30,0%**	**33,1%**
Acropora spp.	13,9%	13,0%	16,5%	12,1%	11,3%	14,0%
Other branching corals	5,6%	5,3%	4,6%	4,2%	6,7%	6,5%
Porites spp.	4,5%	5,3%	4,6%	6,3%	4,4%	4,4%
Other (sub-)massive corals	2,2%	2,9%	2,1%	4,2%	2,3%	1,7%
Millepora spp.	2,7%	2,7%	3,1%	2,7%	2,3%	2,7%
Hard corals (HC) Other	2,4%	3,1%	1,7%	2,3%	3,1%	4,0%
Soft corals (SC) Total	**14,1%**	**5,2%**	**13,1%**	**5,0%**	**14,8%**	**5,4%**
Xeniidae	11,0%	3,4%	9,6%	2,7%	12,5%	4,2%
Soft corals (SC) other	3,0%	1,7%	3,5%	2,1%	2,3%	1,3%

With regard to soft coral cover, inconsistent results were shown. The Reef Check survey showed a decrease from 14.1 % to 5.2 % on average for soft coral (SC) cover. Decrease in coverage is mainly due to the family Xeniidae (SCX). The 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. Controlling the overview pictures, a handful of spots tightly covered with Xeniidae could be recognised next to the one-dimensional transect line.They were counted in the surveys 2008 leading to high coverage values there. To which extent decreasing numbers are an actual fact will be verified in the next survey.

Comparing results for algae coverage, the significant increase of actual surveys is prominent, although it is largely due to turf algae (TA). On one hand, dead corals covered with turf algae were included in the DCA category this year; on the other hand, algae' growing has seasonal alterations. Seasonal turf algae coverage was more dense and visible in this survey, resulting in increasing recognition. The coverage of nutrient indicator algae remained at a very low level, giving no cause for concern..

5.6 Conclusion

Kalawy House Reef is still in solid condition. The frequent diving and snorkeling activities show no excessive stress on the reef's health so far. The results show increasing fish richness and no negative influence of diving on the fish communities. In fact, the opposite seems to be the case. The building of the hotel complex and establishment of the diving business seems to have affected local fisheries in a negative manner; meaning that no actual local fishing activities are carried out at the reef and the fish community was able to recover. However, these are only assumptions on our behalf and not proven facts.

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7. Appendix

Table 21: Results of the fish census surveys 2009 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.

Species	Total	Mean	SD	relative [%]	Abundance [Ind./ 100 m²]
Chromis dimidiata	5670	945,00	370,12	29,77	236,25
Pseudanthias squamipinnis	5420	903,33	932,43	28,46	225,83
Neopomacentrus miryae	2860	476,67	426,75	15,02	119,17
Pomacentrus trichourus	822	137,00	84,66	4,32	34,25
Thalassoma rueppellii	388	64,67	87,45	2,04	16,17
Amblyglyphidodon indicus	371	61,83	25,93	1,95	15,46
Chromis viridis	274	45,67	34,56	1,44	11,42
Chromis flavaxilla	254	42,33	52,79	1,33	10,58
Pomacentrus sulfureus	217	36,17	33,65	1,14	9,04
Caesio striata	206	34,33	81,20	1,08	8,58
Gomphosus caeruleus	198	33,00	46,54	1,04	8,25
Pseudochromis fridmani	172	28,67	18,97	0,90	7,17
Zebrasoma desjadinii	140	23,33	23,31	0,74	5,83
Labroides dimidiatus	140	23,33	15,79	0,74	5,83
Paracheilinus octotaenia	133	22,17	3,87	0,70	5,54
Siganus rivulatus	99	16,50	40,42	0,52	4,13
Acanthurus nigrofuscus	87	14,50	6,66	0,46	3,63
Siganus luridus	81	13,50	4,85	0,43	3,38
Myripristis murdjan	76	12,67	12,61	0,40	3,17
Chaetodon austriacus	74	12,33	4,89	0,39	3,08
Priacanthus hamrur	69	11,50	12,55	0,36	2,88
Neoniphon sammara	66	11,00	15,07	0,35	2,75
Ctenochaetus striatus	64	10,67	4,18	0,34	2,67
Zebrasoma xanthurum	62	10,33	5,24	0,33	2,58
Paracirrhites forsteri	62	10,33	2,80	0,33	2,58
Chlorurus sordidus	62	10,33	8,87	0,33	2,58
Abudefduf vaigensis	53	8,83	21,64	0,28	2,21
Caesio suevica	51	8,50	14,00	0,27	2,13
Chaetodon paucifasciatus	45	7,50	1,38	0,24	1,88
Scarus niger	43	7,17	4,12	0,23	1,79
Calotomus viridescens	34	5,67	9,14	0,18	1,42
Oxycheilinus digramma	30	5,00	1,67	0,16	1,25
Chromis weberi	28	4,67	11,43	0,15	1,17
Cephalopholis hemistiktos	27	4,50	3,39	0,14	1,13
Siganus argenteus	25	4,17	10,21	0,13	1,04

Species	Total	Mean	SD	relative [%]	Abundance [Ind./ 100 m²]
Arothron diadematus	25	4,17	1,72	0,13	1,04
Cephalopholis argus	24	4,00	1,26	0,13	1,00
Pygoplites diacanthus	23	3,83	0,75	0,12	0,96
Ptereleotris evides	21	3,50	5,65	0,11	0,88
Cheilinus lunulatus	20	3,33	3,78	0,11	0,83
Fistularia commersonii	20	3,33	2,34	0,11	0,83
Lethrinus borbonicus	19	3,17	3,06	0,10	0,79
Centropyge multispinis	19	3,17	2,99	0,10	0,79
Heniochus intermedius	18	3,00	1,67	0,09	0,75
Scarus fuscopurpureus	18	3,00	1,90	0,09	0,75
Scarus ferrugineus	17	2,83	1,94	0,09	0,71
Anampses twistii	16	2,67	1,37	0,08	0,67
Halichoeres hortulanus	16	2,67	1,03	0,08	0,67
Pseudocheilinus evanides	16	2,67	5,57	0,08	0,67
Parupeneus forsskali	16	2,67	1,51	0,08	0,67
Acanthurus sohal	15	2,50	3,73	0,08	0,63
Chaetodon auriga	15	2,50	2,07	0,08	0,63
Bodianus anthioides	15	2,50	3,51	0,08	0,63
Naso elegans	14	2,33	3,01	0,07	0,58
Cirripectes castaneus	13	2,17	2,23	0,07	0,54
Cephalopholis miniata	13	2,17	1,60	0,07	0,54
Rhinecanthus assasi	13	2,17	0,75	0,07	0,54
Chaetodon lineolatus	12	2,00	2,90	0,06	0,50
Larabicus quadrilineatus	12	2,00	2,28	0,06	0,50
Ecsenius gravieri	11	1,83	2,23	0,06	0,46
Chaetodon fasciatus	11	1,83	1,72	0,06	0,46
Plectroglyphidodon lacrymatus	11	1,83	3,60	0,06	0,46
Plagiotremus rhinorhynchus	10	1,67	1,37	0,05	0,42
Macolor niger	10	1,67	1,51	0,05	0,42
Chromis pembae	10	1,67	4,08	0,05	0,42
Cantherhines pardalis	9	1,50	1,38	0,05	0,38
Bodianus axillaris	8	1,33	1,51	0,04	0,33
Cheilinus abudjubbe	8	1,33	1,21	0,04	0,33
Coris aygula	8	1,33	1,03	0,04	0,33
Epibulus insidiator	8	1,33	1,03	0,04	0,33
Chaetodon semilarvatus	7	1,17	0,98	0,04	0,29
Amblyglyphidodon flavilatus	7	1,17	2,86	0,04	0,29
Pterois miles	7	1,17	1,60	0,04	0,29
Hipposcarus harid	6	1,00	0,89	0,03	0,25

					Abundance
Species	**Total**	**Mean**	**SD**	**relative [%]**	**[Ind./ 100 m²]**
Diploprion drachi	6	1,00	0,89	0,03	0,25
Synodus dermatogenys	5	0,83	1,17	0,03	0,21
Chaetodon trifascialis	5	0,83	0,41	0,03	0,21
Pseudodax moluccanus	5	0,83	0,75	0,03	0,21
Pomacanthus imperator	5	0,83	0,98	0,03	0,21
Dascyllus trimaculatus	5	0,83	2,04	0,03	0,21
Cetoscarus bicolor	5	0,83	1,60	0,03	0,21
Epinephelus tauvina	5	0,83	1,17	0,03	0,21
Pterois radiata	5	0,83	0,98	0,03	0,21
Sufflamen albicaudatus	5	0,83	0,75	0,03	0,21
Carangoides bajad	4	0,67	0,82	0,02	0,17
Bodianus diana	4	0,67	1,21	0,02	0,17
Chlorurus gibbus	4	0,67	0,82	0,02	0,17
Amanses scopas	4	0,67	1,03	0,02	0,17
Gymnothorax flavimarginatus	3	0,50	0,84	0,02	0,13
Coris caudimacula	3	0,50	1,22	0,02	0,13
Coris cuvieri	3	0,50	0,84	0,02	0,13
Epinephelus fasciatus	3	0,50	0,55	0,02	0,13
Monotaxis grandoculis	2	0,33	0,52	0,01	0,08
Lutjanus monostigma	2	0,33	0,82	0,01	0,08
Balistapus undulatus	2	0,33	0,82	0,01	0,08
Aluterus scriptus	2	0,33	0,82	0,01	0,08
Gymnothorax griseus	1	0,17	0,41	0,01	0,04
Naso unicornis	1	0,17	0,41	0,01	0,04
Chaetodon melannotus	1	0,17	0,41	0,01	0,04
Thalassoma lunare	1	0,17	0,41	0,01	0,04
Lutjanus bohar	1	0,17	0,41	0,01	0,04
Parupeneus cyclostomus	1	0,17	0,41	0,01	0,04
Amphiprion bicinctus	1	0,17	0,41	0,01	0,04
Variola louti	1	0,17	0,41	0,01	0,04
Scorpaenopsis diabolus	1	0,17	0,41	0,01	0,04
Balistoides viridescens	1	0,17	0,41	0,01	0,04
Pseudobalistes fuscus	1	0,17	0,41	0,01	0,04
Diodon hystrix	1	0,17	0,41	0,01	0,04
Ostracion cyanurus	1	0,17	0,41	0,01	0,04
Arothron stellatus	1	0,17	0,41	0,01	0,04

Tabelle 22: Fish diversity 2009 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	specie	percent	genera	percent	ind.	percent	100 m²	RA
Labridae	20	18,18%	14	18,92%	1032	5,42%	441,0	0,05
Pomacentridae	14	12,73%	8	10,81%	10582	55,57%	229,1	0,56
Chaetodontidae	9	8,18%	2	2,70%	188	0,99%	43,0	0,01
Serranidae	8	7,27%	5	6,76%	5499	28,87%	16,0	0,29
Scaridae	8	7,27%	5	6,76%	189	0,99%	10,7	0,01
Acanthuridae	7	6,36%	4	5,41%	383	2,01%	8,5	0,02
Balistidae	5	4,55%	5	6,76%	22	0,12%	7,9	0,00
Siganidae	3	2,73%	1	1,35%	205	1,08%	7,8	0,01
Pomacanthidae	3	2,73%	3	4,05%	47	0,25%	7,2	0,00
Blenniidae	3	2,73%	3	4,05%	34	0,18%	5,9	0,00
Monacanthidae	3	2,73%	3	4,05%	15	0,08%	2,9	0,00
Lutjanidae	3	2,73%	2	2,70%	13	0,07%	2,6	0,00
Scorpaenidae	3	2,73%	2	2,70%	13	0,07%	2,0	0,00
Caesionidae	2	1,82%	1	1,35%	257	1,35%	1,4	0,01
Holocentridae	2	1,82%	2	2,70%	142	0,75%	1,1	0,01
Tetraodontidae	2	1,82%	1	1,35%	26	0,14%	0,9	0,00
Lethrinidae	2	1,82%	2	2,70%	21	0,11%	0,9	0,00
Mullidae	2	1,82%	1	1,35%	17	0,09%	0,9	0,00
Muraenidae	2	1,82%	1	1,35%	4	0,02%	0,8	0,00
Pseudochromidae	1	0,91%	1	1,35%	172	0,90%	0,7	0,01
Priacanthidae	1	0,91%	1	1,35%	69	0,36%	0,6	0,00
Cirrhitidae	1	0,91%	1	1,35%	62	0,33%	0,5	0,00
Ptereleotridae	1	0,91%	1	1,35%	21	0,11%	0,5	0,00
Fistulariidae	1	0,91%	1	1,35%	20	0,11%	0,2	0,00
Synodontidae	1	0,91%	1	1,35%	5	0,03%	0,2	0,00
Carangidae	1	0,91%	1	1,35%	4	0,02%	0,2	0,00
Diodontidae	1	0,91%	1	1,35%	1	0,01%	0,0	0,00
Ostraciidae	1	0,91%	1	1,35%	1	0,01%	0,0	0,00
Diversity	**110**	**Species**	**74**	**Generea**	**1904**	**Invididuals**		