2009

Reef Check Australia
Moreton Bay Oil Spill Monitoring Report
Prepared for: SEQ Catchments Ltd

REEF CHECK AUSTRALIA

Reef Check Foundation Ltd

Geoffrey M. Cook, statistical analysis

Jody Kreuger, editor

Jennifer Loder, author

Reef Check Australia was pleased to contribute to the monitoring and recovery efforts after the March 2009 oil spill in Moreton Bay by surveying marine environments potentially impacted by the spill event. We would like to thank the SEQ Catchments Moreton Bay Oil Spill Environmental Restoration Program for project funding and Sunshine Coast Regional Council for including us in their regional grant application. Sites not funded by SEQ Catchments Ltd were generously funded by the Australian Government.

The RCA dive operator partners listed below also facilitated RCA survey teams reaching monitoring sites. Thank you to all Reef Check Australia volunteers, who collected this valuable data. Many thanks also to Geoffrey M. Cook for providing statistical analysis for site comparisons as well as expert advice.

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Table of Contents

REEF CHECK AUSTRALIA

South East Queensland Moreton Bay Oil Spill Monitoring Report 2009-2010

Overview

Reef Check Australia's (RCA) monitoring program acts as an early warning system for changes in the health of coral habitats. Replicated annual surveys provide long-term data sets that can reveal important patterns and trends over time.RCA surveys record quantitative data including substrate cover, abundance of key invertebrate species and target fish species. RCA also documents natural and anthropogenic impacts that affect coral habitats.

Summary findings for surveys conducted in South East Queensland (SEQ) before and after the March 2009 Moreton Bay oil spill event are presented in this report. Teams of trained volunteers monitored a total of 14 sites in areas of potential impact between July 5, 2009 and December 20, 2009. These sites included four existing survey sites with baseline data before the spill event as well as 10 new sites. Survey locations ranged from Jew Shoal off the coast of Noosa south to the Marietta Dal, closest to the spill site.

South East Queensland

SEQ represents the marginal edge of coral growth (Perry & Larcombe, 2003) and a transitional area where tropical, sub-tropical and temperate species mix. Although coral communities in this area are generally limited from accreting reef structures (Fellegara & Harrison, 2008 and Kleypas, McManus & Menez 1999) there are numerous coral communities with diverse and extensive coral growth. This includes offshore sites like Flinders Reef, with 119 recorded coral species (Harrison, Harriot, Banks, & Holmes, 1998).

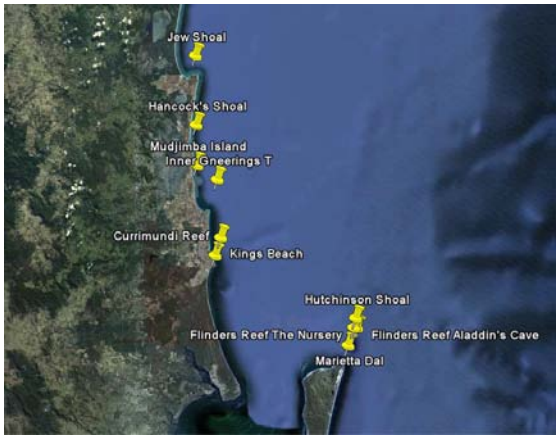

Figure 1. Google Earth map of the 14 Reef Check Australia South East Queensland survey sites within the oil spill zone

Moreton Bay is an area with ecological, cultural, recreational and economical importance. It is home to numerous threatened species and habitats and is considered one of Australia's most important marine resources (QT & GBRMPA 2000). The area also has long-standing heritage and environmental significance to local Traditional Owners. The marine environment encompasses the Moreton Bay Marine Park and the Moreton Bay Ramsar Wetlands. For these reasons, long-term monitoring of major environmental events, such as the 2009 oil spill, is essential to document and manage potential impacts. During the 2009 SEQ season, 14 sites were monitored within the area of potential oil exposure (Table 1) and four of these were within Marine National Park (MNP) zones.

Table 1. Information about RCA SEQ monitoring locations within the 2009 oil spill zone, including site number, location, depth, year of initial survey and site designation including three zones within the Moreton Bay Marine Park: Marine National Park (MNP), Habitat Protection (HP) or General Use (GU) zones

Site	#	Location	Depth (m)	1st Survey	Site Designation
Currimundi Reef*	1	Sunshine Coast	9	2009	n/a
Currimundi Reef*	2	Sunshine Coast	9	2009	n/a
Flinders Reef—Aladdin's Cave	1	Outer Moreton Bay	10	2008	MNP
Flinders Reef—The Nursery	1	Outer Moreton Bay	6	2007	MNP
Flinders Reef—The Nursery	2	Outer Moreton Bay	6	2009	MNP
Flinders Reef—The Nursery	3	Outer Moreton Bay	6	2009	MNP
Hancock's Shoal	1	Sunshine Coast	11	2009	n/a
Hancock's Shoal	2	Sunshine Coast	11	2009	n/a
Hutchinson's Shoal	1	Outer Moreton Bay	11	2007	GU
Inner Gneerings, The Caves*	1	Sunshine Coast	11	2009	n/a
Jew Shoal, The Pin	1	Sunshine Coast	10	2009	n/a
Kings Beach	1	Sunshine Coast	3	2009	HP
Marietta Dal	1	Outer Moreton Bay	10	2009	HP
Mudjimba Island*	1	Sunshine Coast	5	2007	n/a

*These research sites were funded by SEQ Catchments Ltd, all other sites funded by the Australian Government's CoastCare

March 2009 Oil Spill Monitoring

On March 11, 2009 a container ship called the *Pacific Adventurer* spilled 270 tons of fuel oil approximately seven nautical miles off the coast of Cape Moreton. Due to severe storm conditions at the time, much of the oil was dispersed or washed past nearby coral communities (DERM 2009), but latent long-term effects of the event are not known. Major areas of oil accumulation included Moreton Island to Bribie Island and north to Point Arkwright on the Sunshine Coast (Figure 2).

RCA was awarded funds through the SEQ Catchments Moreton Bay Oil Spill Environmental Restoration Program to survey marine ecosystem health at three locations after the event. During the 2009 survey season, RCA monitored fourteen sites within the impacted area, including four established research sites with baseline data prior to the spill. SEQ Catchments also provided RCA with funding to compile a report of marine health data, including statistical analysis of data collected before and after the oil spill to investigate changes in substrate cover, indicator invertebrate abundance and coral health impacts.

Figure 2. Map of coastal areas with oil deposition, image courtesy of SEQ Catchments Ltd

Impacts of Oil on Coral Habitats

Oil has the potential to result lethal or sublethal effects on corals, although impacts are dependent on the length of exposure, oil type, amount of oil and cleanup methods (NOAA 2001, Loya & Rinkevich 1980). Long-term exposure can effect coral reproduction, growth, development and behavior (NOAA 2001, Loya & Rinkevich 1980); but some coral species are more sensitive than others. Different hard coral growth forms also display differing sensitivities to oil exposure; branching corals are more sensitive than massive or plate corals (NOAA 2001). Different life stages are likely to have differing responses as well.

Although reports indicate that most of the monitoring sites would not have been directly exposed to oil, particles of oil or oil components suspended in the water column are a potential pathway of exposure (NOAA 2001). This is a concern, as the oil components most likely to disperse into the water column are also considered the most toxic (NOAA 2001). Almost all field and laboratory studies have found sublethal affects in coral from chronic exposure to low levels of oil, suggesting that this type of exposure may have more drastic long term effects than large, acute doses (NOAA 2001). Oil has been shown to reduce not only photosynthesis productivity in symbiotic zooxanthellae, but also energy transfer to the coral host (NOAA 2001). Oil constituents can also bioaccumulate in the tissues of both zooxanthellae and coral (NOAA 2001).

Broad generalizations about the impacts of oil spill events on marine organisms are challenging due to their extensive diversity. Numerous marine organisms may be exposed to direct oil contact in the water column or at the ocean surface, although many species are mobile and can move away from affected areas. Reef fish tend to be more at risk than pelagic fish, due to small home ranges (NOAA 2001). Numerous invertebrate species, particularly filter feeders such as clams and other bivalves, are likely to accumulate oil in their tissues (NOAA 2001). There is also evidence that oil exposure may reduce reproductive success of numerous marine invertebrates (Loya & Rinkevich 1980). Oil may interfere with chemical stimuli sensitivity, resulting in changes in behavioural patterns and cues for many marine organisms (Loya & Rinkevich 1980). Invertebrate communities may experience alterations in abundance, community structure and reproductive success, potentially enacting larger trophic impacts (Suchanek 1993).

Due to their wide distribution in the water column, larvae and other planktonic organisms are prone to oil exposure. This is problematic due to their broad connections within the food web, creating exposure pathways for other organisms (NOAA 2001, Loya & Rinkevich 1980). Oil can also inhibit photosynthetic abilities of algae and other marine plants, presenting the potential for wide-spread trophic impacts (O'Brien & Dixon 1976). Other lethal and sublethal effects on plant communities may be enough to seriously alter community structure (O'Brien & Dixon 1976).

Statistical Analysis and Trends

Data from each of the established RCA monitoring sites was statistically analysed for differences in substrate composition, invertebrate abundance and frequency of impacts between different sites and different survey years. This analysis is intended to present major statistical differences at sites before and after the spill, but cannot provide conclusive evidence of changes resulting directly from the spill due to the length of time between surveys, limited monitoring locations and possible impacts from other human and environmental factors. Summary data collected at each of the ten new monitoring sites within the spill zone is also presented in this report, creating a baseline for continued monitoring of changes at these locations.

Coral is a sensitive indicator of environmental change. Of the four RCA monitoring sites established prior to the spill event, two sites had slightly increased coral cover and two sites had decreased hard coral cover when surveyed in 2009. Overall, hard coral cover ranged from 15 to 58 percent across all monitoring sites in the impact area, with most sites averaging between 15 and 25 percent cover. The eight Sunshine Coast sites averaged 19 percent hard coral cover, ranging from 14 to 24 percent. The 6 sites offshore from Moreton Bay had an average of 30 percent hard coral cover, with sites as low as 15, but also sites with extensive hard coral cover (58%).

Comparison of Substrate Data Between Sites

Both a Principal Coordinate Analysis (PCO) and an Analysis of Similarity (ANOSIM) of the Bray-Curtis similarity matrix showed significant differences in the patterns of substrate distribution for each of the four monitoring sites. Flinders Reef—The Nursery and Mudjimba Island (fringing reef leeward), Flinders Reef—Aladdin's Cave (Fringing reef seaward) and Hutchinson's Shoal (rocky outcrop) can be viewed as visually distinct groups in a PCO Bray-Curtis Similarity matrix (Figure 3), suggesting differences in substrate composition between the sites. An ANOSIM test was performed on the Bray-Curtis Similarity matrix of substrate composition and showed statistically significant differences among the three habitat types (Global R=0.40, p<0.00).

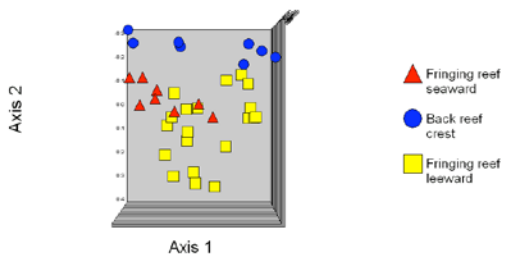

Figure 3. PCO case scores in a Bray-Curtis similarity matrix for RCA substrate composition data shows distinct clusters of samples when grouped by habitat type, indicating differences in substrate composition for each habitat type.

A review of the summary data for each site shows the following broad patterns:

- Mudjimba Island has the highest consistent rock substrate recorded.
- Flinders Reef—The Nursery had diverse types of hard coral present, but varies over the three years of monitoring, it was the only site monitored in 2009 with massive coral colonies present. Flinders Reef the Nursery had more recorded soft coral and "other" category (i.e. ascidians, anemones, zooanthids) than either Hutchinson's Shoal or Mudjimba Island. This site also had more leathery soft coral than other sites.
- Flinders Reef—Aladdin's Cave had the highest hard coral cover of the four sites, made up of mostly encrusting and general HC categories. It also had the highest and most consistent sponge cover, made up mostly of encrusting sponge.
- Hutchinson's Shoal had the highest consistent levels of branching hard coral and more recorded "other" category than Mudjimba Island.
- All sites have rock covered with turf algae as consistent substrate types, only Flinders Reef has consistently recorded rock with coralline algae during the course of monitoring.

Comparison of Substrate Data Between Survey Years

Clustering patterns of the PCO case scores for substrate data grouped by survey year suggests differences in substrate composition over time (Figure 4). For this analysis, all sites were grouped by year (as opposed to direct comparisons between years). An ANOSIM of the Bray-Curtis Similarity matrix support patterns displayed in the PCO ordination, indicating changes in substrate composition over time.

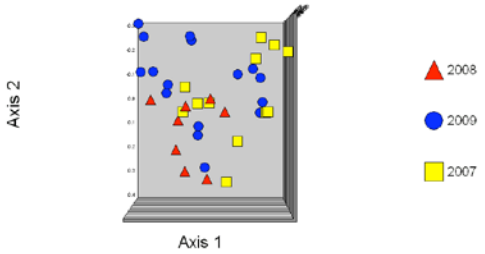

Figure 4. RCA substrate PCO case scores in a Bray-Curtis similarity matrix shows distinct clusters of samples when grouped by survey year, indicating differences in substrate composition over time.

However, pairwise comparisons between survey years only found significant differences in data from 2007 when compared with 2008 & 2009 ($R=0.38$, $p<0.00$). There were no significant differences in substrate composition found between 2008 and 2009 for any site ($R=-0.002$, $p=0.47$). This suggests that both sites at Flinders Reef (the only sites surveyed in 2008) did not experience detectable impacts on substrate from the March 2009 oil spill event.

- Flinders Reef—The Nursery did show very slight declines in hard coral cover, but the Aladdin's Cave site showed increased percent cover of hard coral substrate.
- Hard coral communities at Hutchinson's Shoal also increased in cover since 2008.
- Massive hard coral on both of the leeward sites (Flinders Reef—The Nursery and Mudjimba Island) decreased.

- Mudjimba Island showed decreases in the percent cover of hard coral cover between 2007 and 2009, but there are multiple potential factors impacting hard coral cover, particularly over a two year timeframe. No clear patterns were discernable in general substrate trends regarding percent cover of substrate categories or substrate growth forms.
- Flinders Reef the Nursery had slightly decreased hard coral cover from 2008 surveys, but is still higher than coral cover recorded in 2007. Branching coral cover has decreased since 2009. Leathery soft coral cover has increased from 2007. Coralline algae levels have remained consistent.
- Flinders Reef—Aladdin's Cave had slightly higher levels of hard coral cover since 2008. Soft coral (including zooanthids for the first time) and sponge cover also increased.
- Hutchinson's Shoal showed increased hard coral cover since 2008.

Comparison of Invertebrate Data Between Survey Sites

A PCO Analysis was performed on clean, sorted data for invertebrate abundance at each research site. A Bray-Curtis similarity matrix of PCO case scores revealed obvious patterns of association for invertebrate communities in the three different habitat types (i.e. samples for each habitat type clustered together, Figure 5).

An analysis of similarity was performed on the samples, also indicating significant statistical differences in invertebrate communities between the three habitat types ($R=0.22$, $p<0.03$).

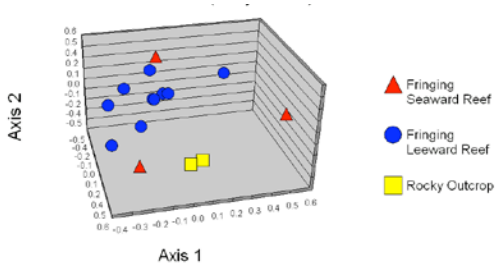

Figure 5. RCA invertebrate PCO case scores in a Bray-Curtis similarity matrix shows distinct clusters of samples when grouped by habitat type, indicating differences in invertebrate communities between sites.

Pairwise comparisons between habitat types showed that samples from the seaward site (Flinders Reef—Aladdin's Cave) were statistically different from the two leeward fringing reefs, Flinders Reef—The Nursery and Mudjimba Island ($R=0.31$, $p<0.02$).

Comparison of Invertebrate Data Between Survey Years

When samples for the research sites are grouped by survey year, then a Bray-Curtis similarity matrix of the PCO case scores shows visually distinct patterns of clustering for samples from 2007 and samples from 2008 and 2009 (Figure 6). This pattern suggests that composition of invertebrate communities has changed over time. An ANOSIM supports this assumption and reveals a significant differences in invertebrate communities between all sample years ($R=0.49$, $p<0.00$).

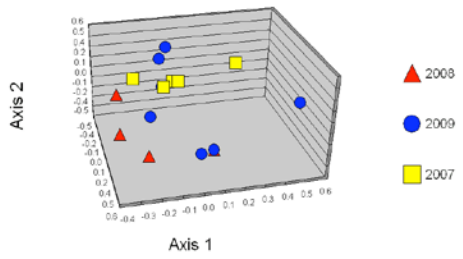

Figure 6. RCA invertebrate PCO case scores in a Bray-Curtis similarity matrix shows distinct clusters of samples when grouped by survey year, indicating differences in invertebrate communities over time.

The continuous changes in invertebrate communities, even before the oil spill event, suggest that the spill is certainly not the only consideration in inferring causation of changes. Other factors such as changes in zoning, weather events, natural variation and seasonality could all be important considerations.

No overarching trends or patterns in invertebrate community composition during the course of monitoring emerge upon review of summary data.

- Flinders Reef—The Nursery shows a consistent presence of long-spine black urchins (*Diadema* spp.and *Echinothrix* sp.) over the three years of monitoring. Giant clams continued to be recorded in both 2008 (n=1) and 2009 (n=2), although sea cucumber abundances declined from 1/100m^2 in 2008 to zero in 2009. The coral eating snail, Drupella, recorded in 2008 (1/100m^2) were not seen in 2009.
- No invertebrates were recorded at Hutchinson's shoal during the 2008 survey and only Drupella were recorded in 2009 (>1/100m^2).
- Flinders Reef—Aladdin's Cave showed an increase in the abundance of recorded anemones (1/100m^2) and giant clams (n=2), not found in 2008. Drupella that were recorded in 2008 (>1/100m^2) were not seen in 2009.
- Mudjimba Island had one sea cucumber and one pencil urchin recorded during the 2008 survey. These were not sighted in 2009, but one anemone was recorded, along with several Drupella (<1/100m^2).

Comparison of Impact Data Between Survey Sites

Many of the impacts recorded on RCA surveys would not result directly from the oil spill event (such as fishing line, anchor damage, marine debris) and will not be discussed in this report. An ANOSIM performed on the Bray-Curtis similarity matrix of case scores from impact type and/or abundance grouped by habitat type did not reveal any statistically significant results (R=0.07, p=0.12).

Comparison of Impact Data Between Survey Years

When samples were grouped by survey year, (R=0.34, p<0.00). Samples from 2007 and 2008 are statistically different to samples from 2009, indicating that there was a change in the type and frequency of recorded impacts between these years. It is important to note that there were noticeable differences in the type and abundance of impacts within replicate transects on a single site. This is likely due to multiple factors, including natural variation and intensity of human

use. All sites showed an increase in recorded scarring from unknown causes and three sites (excluding Flinders Reef—The Nursery) showed an increase in the abundance of Drupella scars. Only two sites reported any coral bleaching, and these were at low levels. One site reported coral disease.

Key Summary Points:

- Two RCA monitoring locations (Flinders Reef—Aladdin's Cave and Hutchinson's Shoal) showed slight increases in hard coral cover, and two locations (Flinders Reef—The Nursery and Mudjimba Island) showed slight decreases in hard coral cover.
- The three habitat types represented by the four RCA monitoring sites within the oil spill zone display statistically significant substrate compositions, indicating natural (and possible anthropogenic) influences on habitat types.
- There have been statistically significant changes in substrate composition at Mudjimba Island, Hutchinson's Shoal and Flinders Reef—Aladdin's Cave between the 2007 surveys and the 2009 surveys.
- There was no statistical difference in substrate composition for surveys completed in 2008 compared with those completed in 2009 for Flinders Reef—Aladdin's Cave or Flinders Reef—The Nursery Site 1. This suggests no detectable impacts from the oil spill event on coral at this location.
- There were statistically significant differences in invertebrate communities within different habitat types. The invertebrates community of the seaward site (Flinders Reef—Aladdin's Cave) was statistically different to both leeward locations (Flinders Reef—The Nursery and Mudjimba Island).
- Analysis of invertebrate data between survey years indicates statistically significant differences in the composition of invertebrate communities between each of the three monitoring years (2007, 2008 and 2009). This pattern suggests that invertebrate communities were in flux prior to the oil spill event and that other factors (weather, seasonality, harvesting etc) may influence invertebrate abundance. It does not provide meaningful conclusions regarding impacts from the oil spill on the invertebrate communities at these sites.
- The type and frequency of impacts recorded in 2007 and 2008 was statistically different from those recorded in 2009. This included and increase in the number of coral scars on all sites and an increase in scars from Drupella snails on three sites. Two sites reported low levels of coral bleaching and one site reported coral disease in 2009.

INCREASING CORAL COVER

Flinders Reef—Aladdin's Cave, Site 1

Flinders Reef is a MNP zone, but is a frequented diving and boating location.

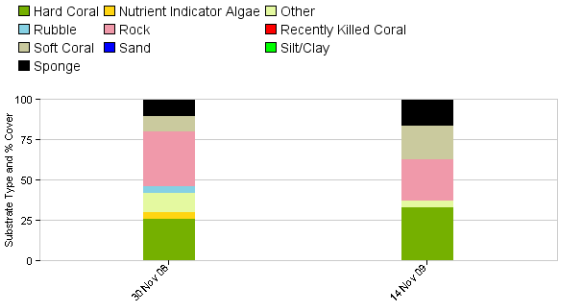

Figure 7: Substrate type and percent cover at Flinders Reef: Aladdin's Cave: medium: Site 1: Fringing reef seaward

The percent cover of hard coral cover increased since the last survey in 2008 (from 23% to 33%). On the same transect, nutrient indicator algae and bare rock decreased while soft coral increased (from 9% to 21%). Almost half of the soft coral category cover consisted of zooanthids, not seen the year prior. Sponge cover also increased (from 10% to 16%) and almost all was encrusting. Rock substrate previously covered with turf algae decreased from 80 percent to 50 percent. Macro algae averaged more than 3/100m^2 (mostly *Asparagopsis*).

Photo 1. RCA surveyor at Flinders Reef, Aladdin's Cave, Site 1

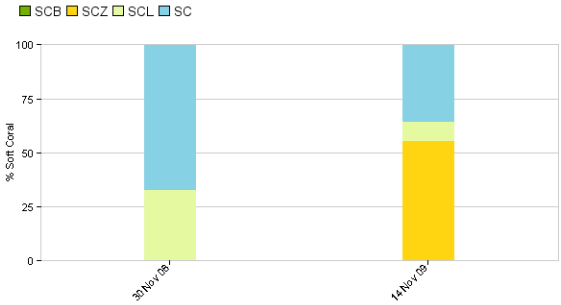

Figure 8: Soft coral type and percent cover at Flinders Reef: Aladdin's Cave: medium: Site 1: Fringing reef seaward

One anemone was seen per 100m^2 and two giant clams were recorded on the transect. There was an increased reporting of coral damage (from n=0 to >2/100 m^2) and unknown scars (from n=1 to >1/100m^2) compared with 2008. Two accounts of coral disease were recorded for the first time on this site.

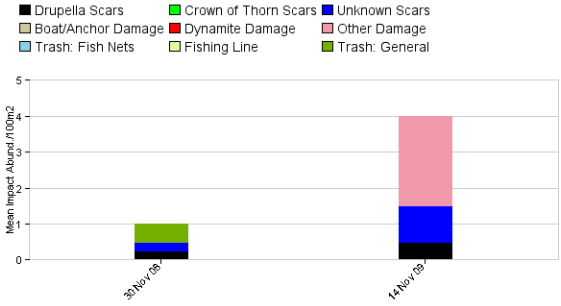

Figure 9: Mean abundance of impacts at Flinders Reef: Aladdin's Cave: medium: Site 1: Fringing reef seaward

Butterfly fish abundance increased from less than one to four individuals per 100m^2. Snappers were not seen this year, but sweetlips were spotted (<1/100m^2). One green turtle was also sighted.

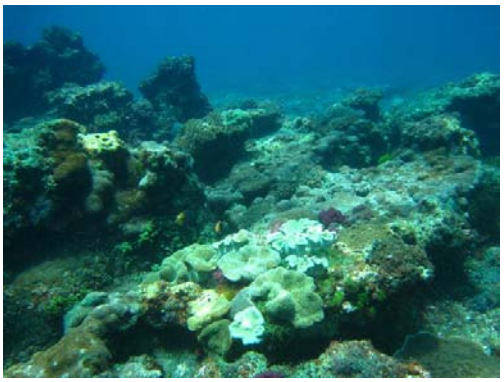

Photo 2. Flinders Reef, Aladdin's Cave, Site 1

Hutchinson's Shoal, Site 1

This is a relatively isolated area located north of Flinders Reef. Due to its exposed location, it is not often visited by divers, boaters or fishers.

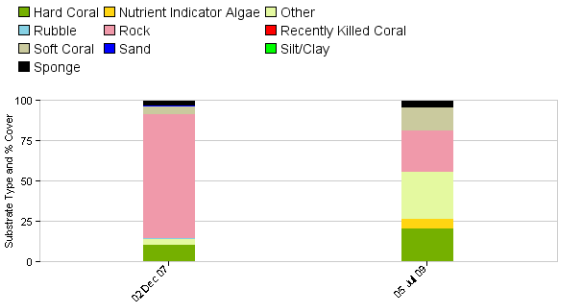

Figure 10: Substrate type and percent cover at Hutchinson's Shoal: Hutchinson's Shoal: medium: Site 1: Rocky outcrop

Hutchinson's Shoal was last surveyed in 2007. Since that time, hard coral coverage has increased on this site in that time from 11 to 19 percent, along with organisms such as zooanthids in the RCA other category, which have increased by almost 25 percent. Soft coral coverage has also increased from five to 13 percent. Nutrient indicator algae was also recorded this year (>2/100m^2). There was a total of >3/100m^{2}macro algae counts across the transect (mostly red algae, Photo 3). This was less than 2007, but this may be a seasonal variation. Rock with turf algae has decreased from 100 percent to 75 percent on rock surfaces.

Photo 3. Crinoid and algae (*Asparagopsis*)

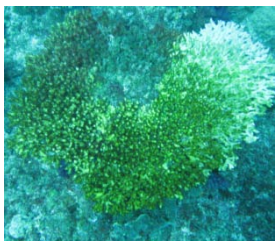

Photo 4. Coral scar

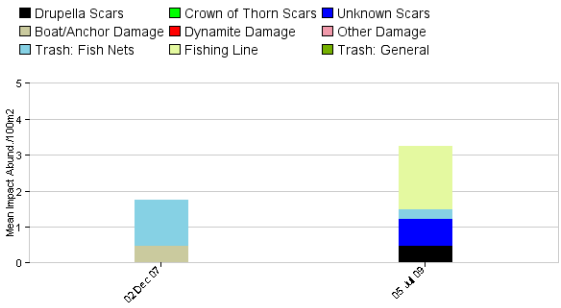

Figure 11: Mean abundance of impacts at Hutchinson's Shoal: Hutchinson's Shoal: medium: Site 1: Rocky outcrop

Less than one scar was found per 100m^2 (Photo 4). Very low levels of coral bleaching (<1% of hard coral population, 70% of colony surface) and disease were recorded (n=1). On average, more than one *Drupella* snail was found per 100m^2. Two *Drupella* scars were recorded.

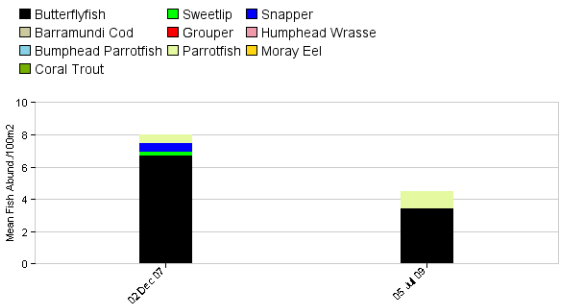

Figure 12: Mean abundance of fish at Hutchinson's Shoal: Hutchinson's Shoal: medium: Site 1: Rocky outcrop

Butterfly fish abundances decreased from almost seven per 100m^2 to less than three per 100m^2 since the last survey in 2007.

Photo 5. Hutchinson's Shoal, Site 1

DECREASING CORAL COVER

Flinders Reef—The Nursery, Site 1

This site has been surveyed annually since 2007. Over this time hard coral cover has fluctuated, this year showing a slight decrease from 2008 levels, down from 23 to 19 percent, but overall showing an increase in coral cover since 2007 (12%). Branching coral forms have shown a decrease since 2007, although foliose and plate growth formations have increased. Sponge cover has increased from two to five percent. Nutrient indicator algae that were recorded in 2008 were not seen this year (possibly a seasonal variation). Most organisms in the RCA "other" category were colonial ascidians (Photo 6). Macro algae levels have fluctuated over time, with this year showing the lowest recordings yet (2/100m^2 down from 9/100m^2 in 2008)—again potentially due to seasonal variation. Rock substrate is generally covered with turf algae.

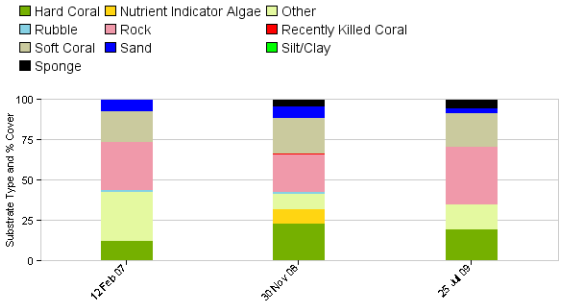

Figure 13: Substrate type and percent cover at Flinders Reef: Nursery: medium: Site 1: Fringing reef leeward

Photo 6. Colonial ascidians

Photo 7. Giant clam

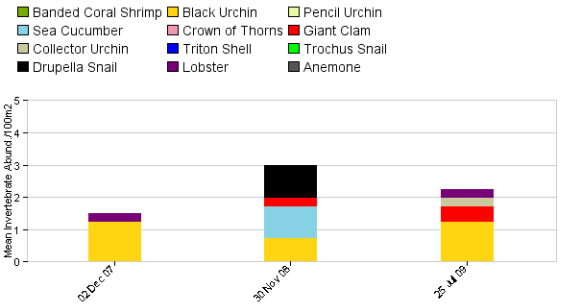

Figure 14: Mean abundance of invertebrates at Flinders Reef: Nursery: medium: Site 1: Fringing reef leeward

Invertebrate abundances have been generally low at the site over the three year monitoring period; *Diadema* urchins (>1/100m^2) and giant clams (n=2) were recorded this year (Photo 7). One lobster was sighted. There were recorded accounts of coral damage (>1/100m^2) and coral scars (>3/100m^2) not seen in 2008.

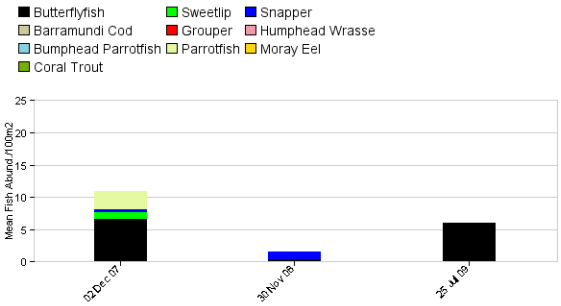

Figure 15: Mean abundance of fish at Flinders Reef: Nursery: medium: Site 1: Fringing reef leeward

Butterfly fish abundance increased since 2008 (from <1/100m^2 to 6/100 m^2). One wobbegong was sighted on the transect.

Photo 8. Wobbegong at Flinders Reef, Site 1

Mudjimba Island, Site 1

The fringing reef around the island is close to the mainland and near the Mooloolah River mouth. The island has been deemed as a conservation zone for cultural reasons, although marine-based activities are not restricted.

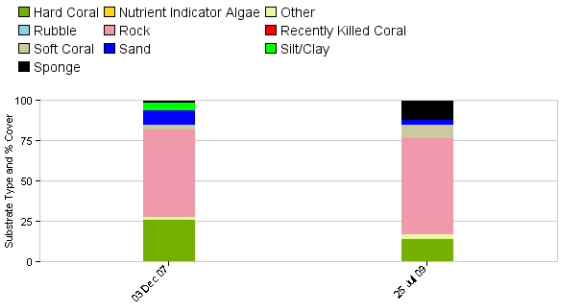

Figure 16: Substrate type and percent cover at Mudjimba Island: Mudjimba Island: medium: Site 1: Fringing reef leeward

Coral cover has decreased on this site since it was last surveyed two years ago in 2007 (from 24% down to 14%). The percentage of branching coral and plate coral increased, while massive growth forms decreased. Increases were seen in the cover of both sponge (up from <1% to 11%) and soft coral (up from 3% to 9%). Macro algae counts were substantially lower than in 2007 (down from a total of 10 counts to 1), but surveys were completed in different seasons. All rock surfaces were covered with turf algae. The first accounts of zooanthids (2%) were recorded at this site during the 2009 survey.

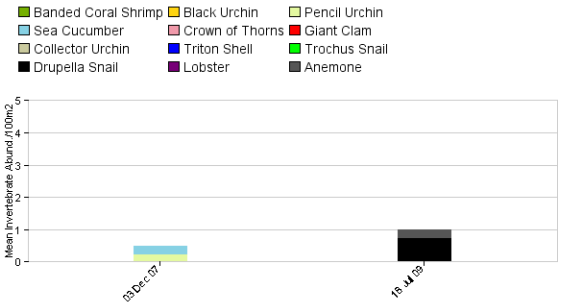

Figure 17: Mean abundance of invertebrates at Mudjimba Island: Mudjimba Island: medium: Site 1: Fringing reef

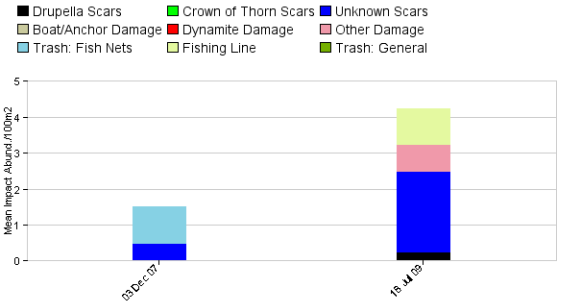

Figure 18: Mean abundance of impacts at Mudjimba Island: Mudjimba Island: medium: Site 1: Fringing reef leeward

Coral scars increased from n=2 in 2007 to >2/100m^2 (Photo 9). Coral damage (n=2) and *Drupella* scars (n=1) were not seen on this site prior to 2009. There was a small amount of coral bleaching seen, affecting less than one percent of all hard corals, averaging 18 percent of the surface of impacted colonies (Photo 10).

Photo 9. Coral scar

Photo 10. Coral bleaching

Few RCA indicator invertebrates were recorded at this site. Less than one *Drupella* per 100m^2 was recorded, along with one anemone. Sea cucumbers (n=2) and pencil urchins (n=1) seen on the 2007 survey were not seen in 2009.

Photo 11. Mudjimba Island, Site 1

NEW SURVEY SITES

Currimundi Reef, Site 1

This is a new research site in the Sunshine Coast region. It is an exposed rocky outcrop that is not frequented by divers, fishers or boaters. Hard coral cover was almost 18 percent (more than three quarters encrusting growth forms), with even higher soft coral coverage (23%), which was mostly leathery growth forms. All recorded sponges were encrusting (8%). Most rock (75%) was covered with turf algae. Siltation levels were low.

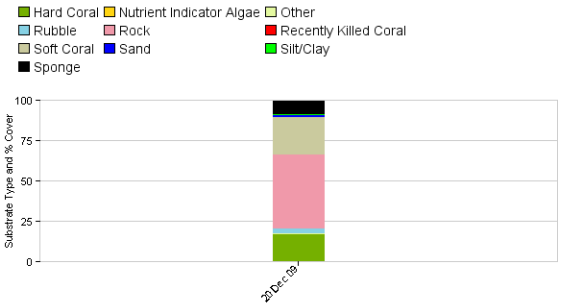

Figure 19: Substrate type and percent cover at Currimundi Reef medium: Site 1: Rocky outcrop

The only recorded invertebrates were three *Drupella* snails and one anemone. Less than one *Drupella* scar was reported per 100m^2. Coral disease was recorded at >1/100m^2. There was one coral scar on the entire transect.

Photo 12. Currimundi Reef, Site 1

Currimundi Reef, Site 2

The second survey site at Currimundi Reef was dominated by mostly rocky substrate with 24 percent hard coral cover. Growth forms were generally encrusting (>75%). Soft coral accounted for 20 percent cover, a quarter of soft corals were leathery growth forms. Most rock was covered with turf algae, although five percent cover was rock covered with calcareous algae. Siltation was low.

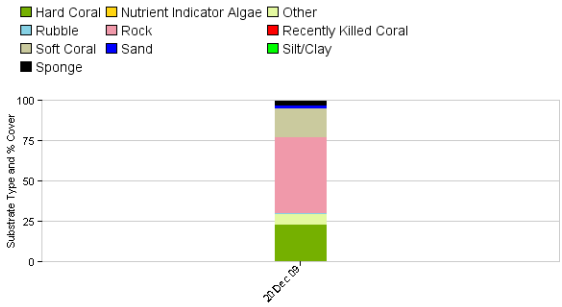

Figure 20: Substrate type and percent cover at Currimundi Reef: Currimundi Reef: deep: Site 2: Rocky outcrop

One *Drupella* was seen per 100m^2, but less than one *Drupella* scar was recorded per 100m^2. Two scars from unknown causes were also recorded on the survey.

Photo 13. Currimundi Reef, Site 2

Flinders Reef—The Nursery, Site 2

This is a new site, which includes a large expanse of branching *Acropora* coral and a green turtle cleaning station. It is a popular dive site and has been declared a MNP zone under the Moreton Bay Marine Park rezoning. The immediate surrounding area is a conservation park, where some fishing activities are allowed.

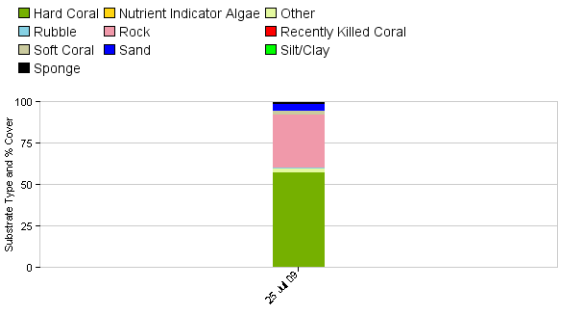

Figure 21: Substrate type and percent cover at Flinders Reef: Nursery: medium: Site 2: Fringing reef leeward

The extensive growth of branching coral at this site make hard coral cover quite high, with 58 percent cover recorded (made up of almost 100% branching coral). The rest of the transect area included mostly rock and sand with very little coverage of soft coral or sponge. There were two counts of macro algae per 100m^2 (assorted red algaes).

Due to time constraints, invertebrate & impact surveys were not completed for this transect.

14. RCA surveyor at Flinders Reef, The Nursery, Site 1

Flinders Reef—The Nursery, Site 3

This site had 36 percent hard coral cover and a small amount of soft coral (5%). Most of the hard coral recorded was branching (>75%). Half of the rocky substrate was covered with turf algae and a small portion was covered with coralline algae (5%).

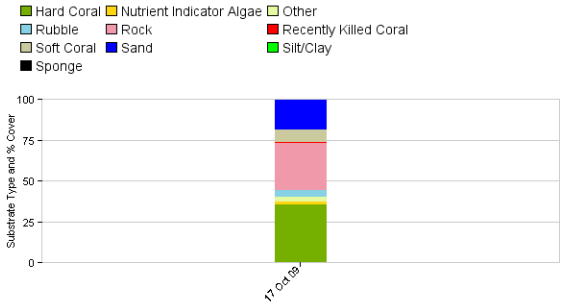

Figure 22: Substrate type and percent cover at Flinders Reef: Nursery: medium: Site 3: Fringing reef leeward

Anemones were found at abundances of less than one per 100m^2. Other invertebrates included one giant clam, one collector urchin and two *Diadema* urchins. One egg cowrie was also recorded (Photo 15).

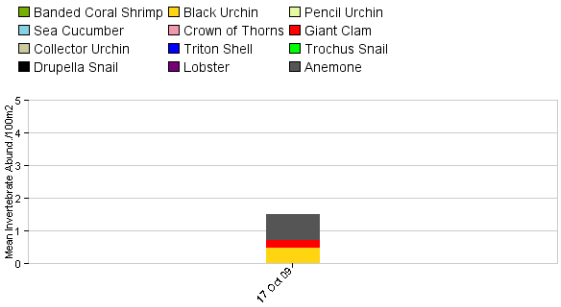

Figure 23: Mean abundance of invertebrates at Flinders Reef: Nursery: medium: Site 3: Fringing reef leeward

Photo 15. Egg cowrie

Almost two scars per 100m^2 were recorded, as well as three incidents of coral damage per 100m^2. Two incidents of coral disease were recorded (Photo 16).

Photo 16. Coral disease on branching coral

A variety of target fish species were seen, including butterfly fish (2/100m^2), snapper (1/100m^2), parrotfish (>2/100m^2), one sweetlips and one coral trout. This was one of the most varied fish assemblages recorded on a SEQ survey. One green turtle was sighted as well.

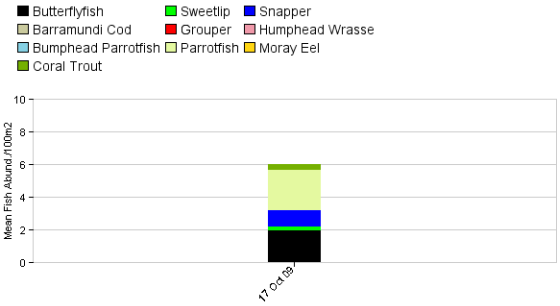

Figure 24: Mean abundance of fish at Flinders Reef: Nursery: medium: Site 3: Fringing reef leeward

Photo 17. Flinders Reef, The Nursery, Site 3

Hancock's Shoal, Site 1

This is a new site in the Sunshine Coast area. It is an exposed rocky outcrop with relatively low use by divers, fishers and boaters. Hard coral makes up 20 percent of surveyed substrate (75% encrusting, 25% foliose), while very little soft coral or sponge is found at this location. Rock with turf algae makes up more than half of recorded substrate. Macro algae counts across the transect totalled two. Silt loading levels were mid-range.

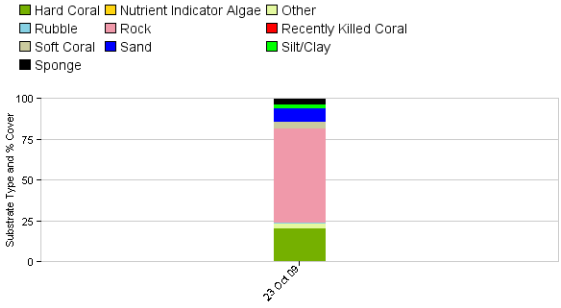

Figure 25: Substrate type and percent cover at Hancock's Shoal: Hancock's Shoal: medium: Site 1: Rocky outcrop

Very few invertebrates were found at this location, with only one *Diadema* urchin recorded. Scarring was recorded at slightly more than once per 100m^2 and less than one incident of other damage was found over 100m^2 on average. Bleaching was only recorded on five percent of one coral colony.

One octopus and one moray eel were recorded. This site had low recorded target fish abundance, with less than one parrotfish seen per 100m^2.

Photo 18. Hancock's Shoal, Site 1

Hancock's Shoal, Site 2

The second site at Hancock's Shoal had 23 percent hard coral cover (almost all encrusting) and another fifty percent was rock (95% percent with turf algae). Only two counts of macro algae were recorded on the transect.

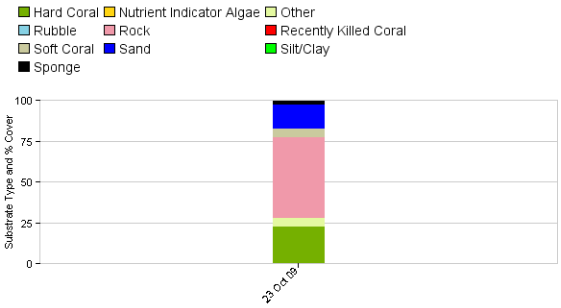

Figure 26: Substrate type and percent cover at Hancock's Shoal: Hancock's Shoal: medium: Site 2: Rocky outcrop

This site showed low invertebrate abundance, with only one *Drupella* snail sighted. Coral scars were reported almost three times per 100m^2 and less than one incident of other damage was recorded per 100m^2. A small amount of coral bleaching was recorded, affecting less than one percent of hard corals overall, with colony surfaces bleached an average of twenty four percent.

Photo 19. Hancock's Shoal, Site 2

Inner Gneerings, The Caves, Site 1

This reef is located just off shore from Mooloolaba and covers an extensive area ranging in depths from 10 to 25m. The area is heavily used for boating and some recreational fishing and diving.

The substrate survey showed 19 percent hard coral cover and 14 percent soft coral cover. Most hard coral was encrusting (75%) and all rock surfaces were covered with turf algae. No macro algae were recorded.

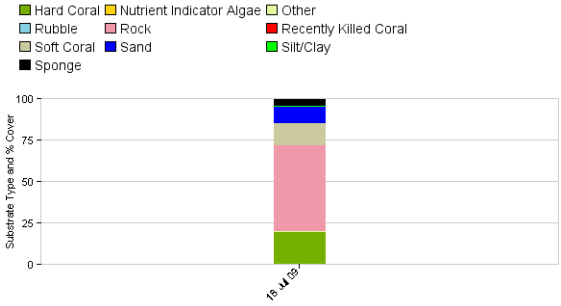

Figure 27: Substrate type and percent cover at Inner Gneerings: The Caves: medium: Site 1: Rocky outcrop

Several key invertebrates were recorded on this site. Two *Diadema* were found on the transect. *Drupella* snails averaged less than one per 100m^2. One giant clam was sighted. One unknown scar was seen per 100m^2, less than one instance of coral damage was reported per 100m^2.

Photo 20. Inner Gneerings, The Caves, Site 1

Jew Shoal, Pinnacles, Site 1

This is a new site on the Sunshine Coast. Close to the Noosa River, the site consists of a large pinnacle with a wall along one edge. This is a major fishing site and a relatively popular boating location.

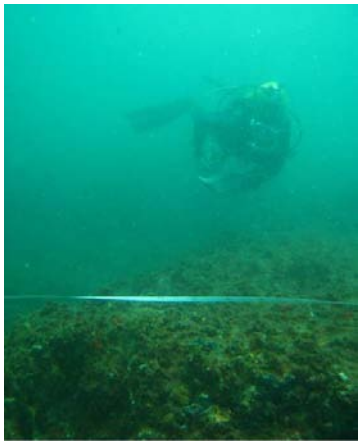

Photo 21. RCA surveyor at Jew Shoal, Site 1

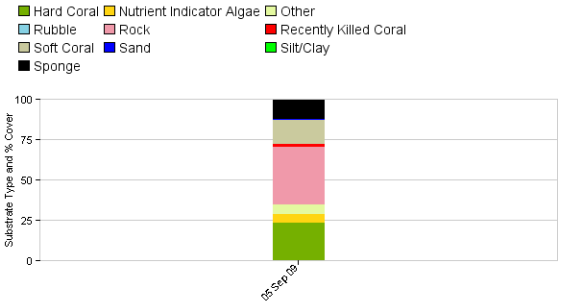

Figure 28: Substrate type and percent cover at Jew Shoal: The Pinnacles (The Pin): medium: Site 1: Rocky outcrop

The site had 24 percent hard coral cover, made up of 75 percent encrusting coral and 15 percent foliose. There was fifteen percent soft coral cover (65 percent leathery) and ten percent sponge, mostly encrusting. Almost all of the 35 percent rock substrate was covered with turf algae. No macro algae were recorded.

The only indicator invertebrates discovered on the site were *Drupella*, averaging slightly more than one per 100m^2. An egg cowrie was also recorded.

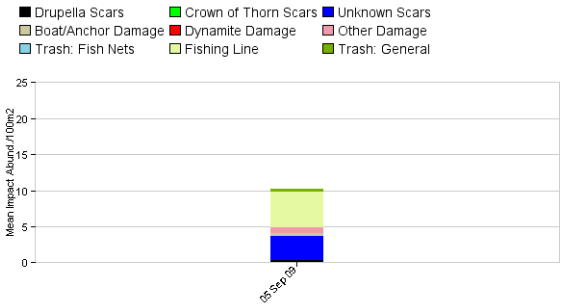

Figure 29: Mean abundance of impacts at Jew Shoal: The Pinnacles (The Pin): medium: Site 1: Rocky outcrop

The site had an average of three incidents of scarring per 100m^2 (Photo 22). There were also recorded incidents of *Drupella* scars (n=2). Other coral damage was seen less than once per 100m^2. Coral bleaching was seen on less than one percent of colonies, impacting around thirty percent of each colony surface. Two accounts of coral disease were reported (Photo 23).

Photo 22. Unknown coral scars

Photo 23. Coral disease

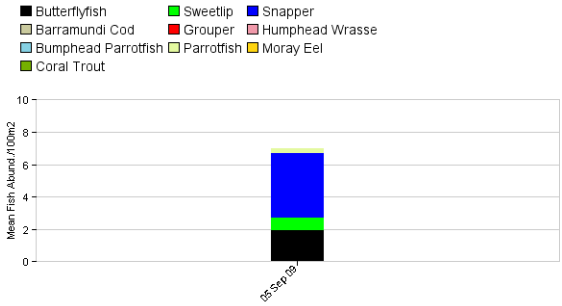

Figure 30: Mean abundance of fish at Jew Shoal: The Pinnacles (The Pin): medium: Site 1: Rocky outcrop

The site had snapper (>3/100m^2), sweetlips (<1/100m^2) and butterfly fish (2/100m^2). A wobbegong, three eagle rays and a flathead fish were also seen.

Kings Beach, Site 1

This is a new site on the Sunshine Coast that was chosen due to its heavy use and proximity to the coast. The site is located just a few hundred meters offshore, adjacent to a boat ramp.

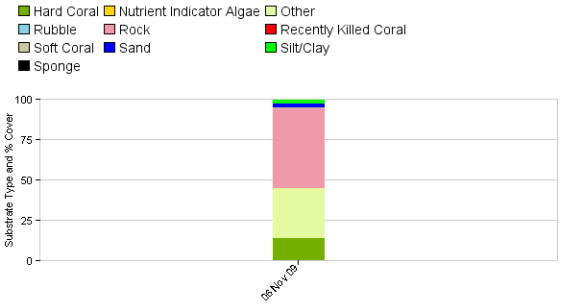

Figure 31: Substrate type and percent cover at Kings Beach: Kings Beach Reef: shallow: Site 1: Fringing reef seaward

Hard coral was recorded on fifteen percent of the transect. More than 50 percent of this was digitate growth forms in the general hard coral (HC) category (Photo 24) and thirty percent was encrusting. More than 25 percent of the transect was made up of the RCA "other" substrate category (the vast majority of this being colonial ascidians, Photo 24). Almost fifty percent of the transect recorded rock, more than 95 percent covered with turf algae. Total macro algae count was slightly more than one count per 100m^2 (assorted green algae).

Photo 24. Hard coral and ascidians

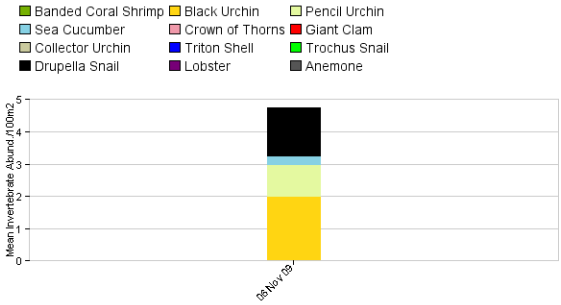

Figure 32: Mean abundance of invertebrates at Kings Beach: Kings Beach Reef: shallow: Site 1: Fringing reef seaward

Invertebrates included an average of three *Drupella* snails, two *Diadema* urchins and one pencil urchin over each 100m^2. One incident of coral damage was seen on average over each 100m^2.

Photo 25. Kings Beach, Site 1

Marietta Dal, Site 1

This site is on the natural coral community adjacent to the wreck of the Marietta Dal, located just outside of Moreton Bay. This is one of the closest sites to the March 2009 oil spill. Due to its exposed nature, the site is not regularly visited by boats or divers.

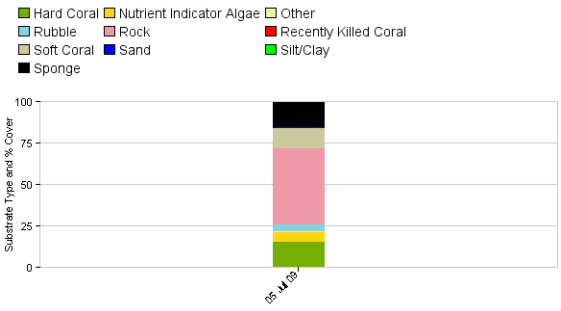

Figure 33: Substrate type and percent cover at Marietta Dal: Marietta Dal Reef: medium: Site 1: Fringing reef

The site had 15 percent hard coral cover, more than half of this was branching coral. Fifteen percent of substrate cover was sponge, 75 percent was encrusting growth. Soft coral accounted for ten percent cover, half of this made up of zooanthids. Average macro algae counts were 18/100m^2 (made up of both crustose and assorted red algae). Almost fifty percent of substrate was rock and nearly all rock was covered with turf algae.

The only recorded invertebrate was one collector urchin. One coral scar and one account of coral damage were recorded per 100m^2. Coral disease was recorded less than once per 100m^2. Two butterfly fish were seen per 100m^2 and two sweetlips and one parrotfish were also seen.

Photo 26. Marietta Dal, Site 1

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