Department of Environment
and Resource Management

Moreton Bay Marine Park Monitoring Program

February 2012

Toward Q
Tomorrow's Queensland

Queensland Government

Prepared by: Water Quality and Aquatic Ecosystem Health, Environment and Resource Sciences

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Moreton Bay Marine Park zoning

Moreton Bay is home to hundreds of fish species and coral, an abundance of dolphins, migratory whales and the world's largest population of dugong next to a capital city. On 1 March 2009, the Moreton Bay Marine Park—which covers a 125 km length of coastline from Caloundra to the southern tip of South Stradbroke Island—was re-zoned to better protect the area's biodiversity and unique habitats and wildlife. As part of the new zoning plan, green zones to protect habitats from extractive uses such as fishing were expanded to cover around 16 per cent of the bay. As well as increasing green zones, a number of other measures were expanded to protect the future of Moreton Bay's marine environment. These measures included go-slow areas to protect dugongs and turtles and no anchoring areas to protect sensitive coral habitats.

Moreton Bay Marine Park monitoring program

Prior to the re-zoning, a monitoring plan was put in place to evaluate the health of the marine park. Over a five-year period, the Department of Environment and Resource Management (DERM) is undertaking a joint $4.6 million monitoring program in a shared funding partnership with Commonwealth Scientific and Industrial Research Organisation (CSIRO), Griffith University, University of Queensland, University of the Sunshine Coast and the Department of Employment, Economic Development and Innovation (DEEDI). The monitoring program includes assessment of the effectiveness of zoning on commercial and recreational fish species, the effectiveness of go-slow areas in reducing impacts on turtles and dugongs, and the socio-economic implications of the revised marine park. This monitoring will enable adaptive management of the park, and the results will be regularly communicated to the public so that they are informed about the zoning progress and the species and ecosystems in Moreton Bay. DERM has also engaged community groups in the monitoring, including Birds Australia and South East Queensland Traditional Owners Alliance. The Port of Brisbane Corporation is one commercial investor who is also involved in a research project.

The program has enabled DERM and its monitoring partners to undertake studies to understand more detail about various animals and habitats in the marine park. Ultimately over the five-year program, participants will know more about the effects of the marine park on various species from fish to birds. Participants will have an understanding of the socio-economic implications of the marine park, and will have a good idea of things we should measure into the future to determine the long-term effectiveness of the park.

This report gives an update on key findings from the project. Discussions in the report include:

- baseline information on the values that different groups of South East Queensland have for the Moreton Bay Marine Park
- how use of the bay has changed as a result of the new zonings
- information on changes to fish communities on offshore reef sites
- changes to fish and invertebrates in Moreton Bay
- a project to assess the effect of stopping trawling in parts of the bay on soft sediment fauna
- some interesting information about key habitats and the role that protected areas can have in helping the bay to deal with large scale events such as the January 2011 floods
- information about non-migratory shorebirds.

What do South East Queenslanders feel about the marine park?

Helen Ross, Sylvie Shaw, Wolfram Dressler and Helen Johnson (University of Queensland)

In 2009, the team conducted a baseline study of the values that South East Queensland held about Moreton Bay Marine Park. The study included a review of media articles about the Bay from the 1940s on, and an analysis of interviews with the key stakeholders involved in discussions about the marine park. Key stakeholder and community groups represented the following sectors:
(i) marine-related businesses such as commercial fishing, aquaculture, and charter boat operations
(ii) recreational activities such as fishing, boating and diving
(iii) environment groups
(iv) tourism operators
(v) local government
(vi) education
(vii) community and island-based residents' groups; and
(viiii) Traditional Owners.

Both sets of information were then analysed according to the values held about Moreton Bay and its environs over time.

The study found that all key user groups display a profound affinity with Moreton Bay, the marine and island environments, its beauty, myriad of habitats and its fauna. However, stakeholder groups tend to have two different ways of viewing their relationship with the bay. The tourism, industry, fishing sectors view the bay as a great asset with strong economic potential. However, this is tempered through their understanding of the need for sustainable development. Environmental, education and community groups also support sustainable development and work to ensure a healthy bay into the future. These groups view the bay through a different set of values—ecological, aesthetic and symbolic, as they call for a greater marine ethic, wider community education about the bay and the marine park, and greater care of mangrove and marine ecosystems. Through their drive to preserve the bay, they encourage others to get involved in volunteer projects from beach clean ups to seagrass watch, water monitoring and bird observing.

Both sectors had the same opinion about the bay—that there needs to be better management and more effective monitoring of, and information about, the bay and the Moreton Bay Marine Park. All key user groups agreed with the need for joint ecosystem management involving both upstream and downstream systems, as pollution from nutrient run-off, sediment, rubbish and sewerage were seen as deleteriously affecting the bay's water quality, seagrass generation, species' health and the system as a whole. They maintain that an integrated water management approach involving both land and marine ecosystems and including the catchments and creeks, the river and coast, and Moreton Bay and the islands, is vital to ensure the bay's continuous health over the long term.

Sizing up the human use of Moreton Bay Marine Park

How has the marine park affected the use of the marine park?

Rob Kenyon (CSIRO)

Research was undertaken to measure trends in human use of the marine park zones in the bay, before and after re-zoning. A range of zones were surveyed, representing diverse ecosystems and habitats, from offshore oceanic and bay ecosystems, to sheltered habitats.

Since August 2008, most zones in Moreton Bay were surveyed on multiple occasions by boat-based teams (Figure 1). Surveys were also taken six months before zoning was implemented, and then bimonthly in the 24 months after zoning. The study included the period of management change (the introduction of the new zoning), seasonal variations in fishing activity, and other uses of the study area.

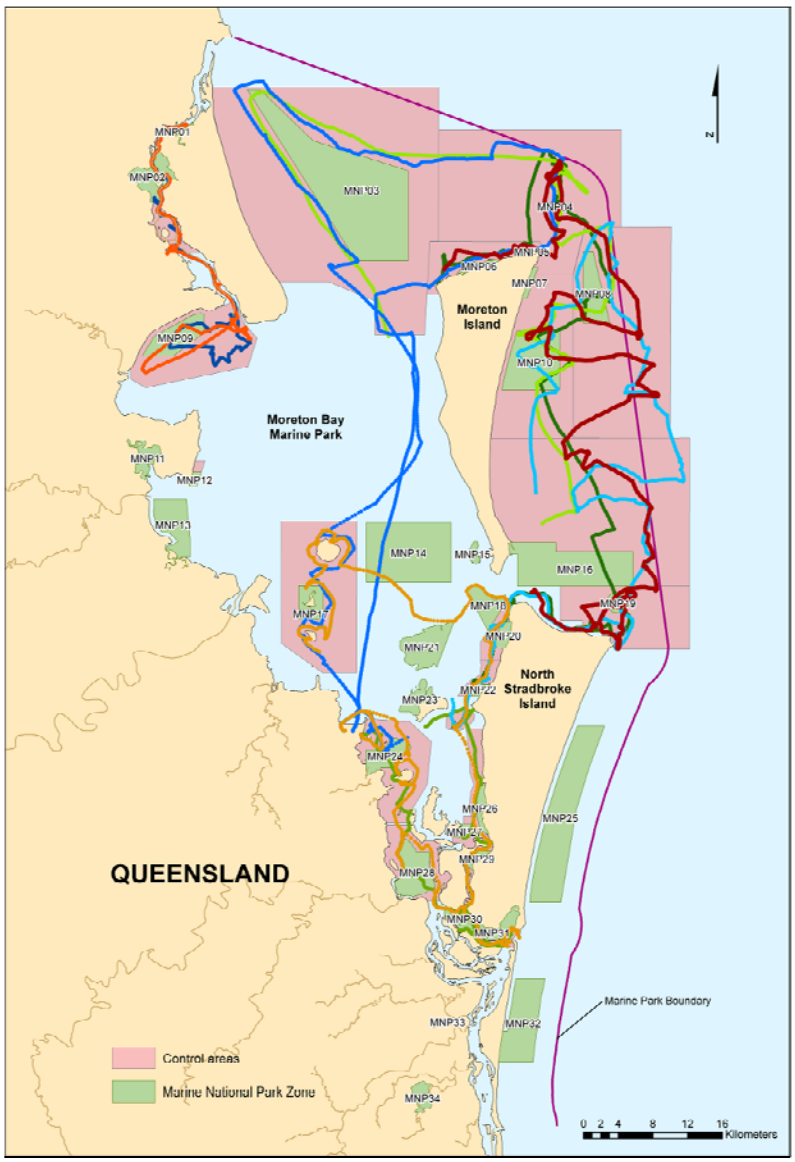

Figure 1. A selection of survey tracks within Moreton Bay Marine Park to indicate the marine national parks (MNPs) accessed during each survey. These tracks are typical of the areas covered during each round of surveys.

Key research facts

- 397 observations were made using boat-based surveys conducted in the marine national park (MNP) and control areas. These surveys were followed up with 200 interviews with Moreton Bay users.
- More than 60 per cent of the vessels in Moreton Bay were engaged in fishing activities, with 'lifestyle-recreation' vessels the second most common activity.
- The proportion of all recreational fishing activity observed in future MNP zones dropped from 6.3 per cent to 2.6 per cent after the new zoning.
- The proportion of commercial fishing activity in future MNP zones dropped from 25 per cent of the observed commercial fishing to just one per cent (based on only six commercial vessels that were seen in the proposed MNP zones prior to the re-zoning).
- 56.5 per cent of those interviewed didn't believe their activities would be, or had been, affected by new MNP zones.
- Over 40 per cent of boaters interviewed said the MNP zones had affected their fishing activity, although the research shows only about six per cent of recreational fishers had actually fished in MNP zones prior to the new zoning being declared.
- There was a disconnect between the relatively high level of perceived impact and the actual observed displacement from their usual fishing spots.
- 64 per cent felt the rezoning would be 'positive for the biology' of Moreton Bay.

Results summary

Fishing was the most common activity for vessels on the bay (60 per cent) and fishing with a rod from a vessel made up over 70 per cent of the fishing activity on the bay. Crabbing with pots or dillies, and trolling also made up a significant part of fishing activities. Searching for a better fishing spot also took up a considerable portion of fishers' time. Lifestyle recreation vessels were the second most common activity on the bay (20 per cent). There was no difference found in the proportions of activities when the data was compared from before and after the re-zoning of the study area.

After the re-zoning there were fewer recreational and commercial fishing vessels in the new MNPs, as would be expected, but this was a relatively small proportion of the fishing activity that was observed. Prior to the re-zoning 6.3 per cent of recreational fishing vessels were active in future MNPs, which dropped to 2.6 per cent after the re-zoning (Figure 2). This shows only 6.3 per cent of the observed fishing vessels were likely to have been directly impacted by the re-zoning, 3.7 per cent were likely to have actually changed their behaviour, and 2.6 per cent may have continued to fish in MNP zones.

The observed impact of the no-take zones on recreational fishers was much lower than the perceived impact by Moreton Bay fishers. Of the recreational users who were interviewed as a part of this study, 43 per cent believed the new no-take MNP zones would have an impact on their use of the bay (mostly displacement from MNP zones); however, it was observed that only 6.3 per cent were actually affected. Restrictions on the number of fishing lines allowed in the conservation park zones (CPZ) had no measureable effect on the number of lines used after zoning.

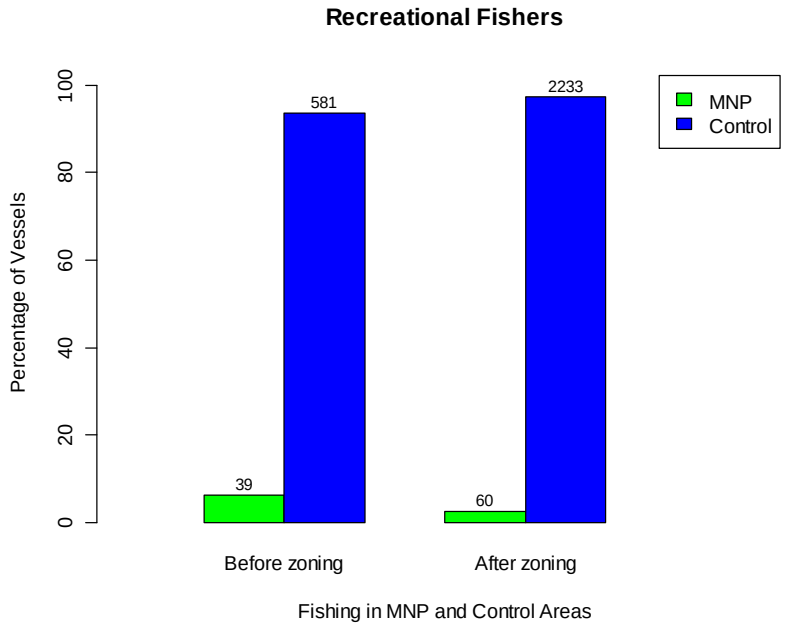

Figure 2. The number of recreational fishing vessels observed within the MNP zones and control areas before and after the zoning changes.

Commercial fishing activity in MNPs dropped from 25 per cent of the observed commercial fishing to just one per cent. However, as only six commercial vessels were seen in the proposed MNP zones prior to the re-zoning, this trend should be interpreted with caution.

There was a highly significant increase in the observations of recreational fishing, and other boat users, in the control areas outside the MNP zones following the re-zoning. Due to the small number of recreational fishers displaced by the new MNP zones, this was probably related to variations between survey years, rather than displacement from the MNP zones.

The study also found:

- There was no general trend for fishers to target their fishing along reserve boundaries in an attempt to capitalise on spill over of fish or other target species from MNPs. The MNP zones that may have high populations of popular target species don't appear to be systematically targeted by recreational fishers, although recreational and commercial crab fishers did seek out certain sanctuary zones e.g. Pannikin Island and Willes Island.

- The trends for the non-fishing users of the bay didn't vary significantly as a result of the MNP or Conservation Park Zone (CPZ) re-zoning. There was no reduction in the number of these vessels observed in MNPs.

As part of the research, on-water or follow-up questionnaires were undertaken. The results from the 200 interviews revealed a majority of respondents (56.5 per cent) didn't believe their activities would be, or had been, affected by new MNP zones. However, over 40 per cent said the MNP zones had affected their fishing activity. This relatively high percentage contrasted with the research that showed only about six per cent of fishers had actually fished in MNP zones prior to the new zoning being declared. Despite perceptions that the 2009 zoning had affected their fishing, a clear majority of respondents (64.7 per cent) felt the re-zoning would be 'positive for the biology' of Moreton Bay.

Fish of offshore reefs

Russ Babcock, Mick Haywood, Richard Pillans (CSIRO)

Baited Underwater Video (BUV) systems were a key part of a study by CSIRO and DERM into marine species recently conducted in the Moreton Bay Marine Park (MBMP). The BUVs were deployed at 175 sites inside green zones, and at similar surrounding areas where fishing was permitted, at Flinders Reef, Henderson's Rock and Flat Rock twice yearly during winter and summer from 2008 to 2010. A total of 63 654 fish comprising 442 species and 77 families, and 52 turtles were identified from 605 hours of BUV footage taken as part of this study.

Photo 1. A typical BUV image in the inshore part of the green zone near Henderson's Rock (MNP10) east of Moreton Island, with a large Maori rock cod *Epinephelus undulatostriatus*, and small groups of brownstripe snapper *Lutjanus vitta* and paradise whiptails *Pentapodus paradiseus*. Various other species of emperor and wrasse are also present. Photo: DERM.

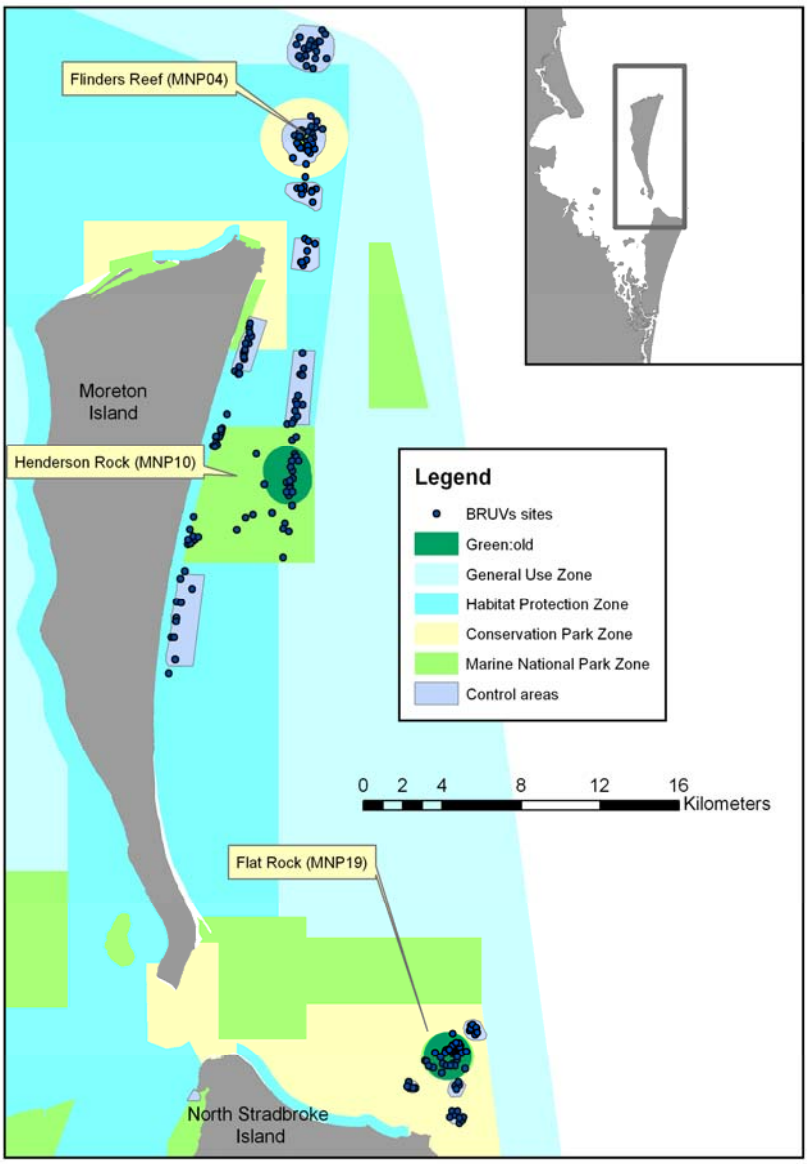

Figure 3. A map of the northern offshore section of the Moreton Bay Marine Park showing the location of the green zones and areas open to fishing surveyed using Baited Underwater Video (BUV) systems.

The sites surveyed as part of the study included:

- old green zones—those that had been closed to bottom fishing for either five years (grey nurse shark protection zones—Henderson's Rock and Flat Rock) or 11 years (1997 Moreton Bay Marine Park green zones—Flinders Reef)
- new green zones—those within the newly established Marine National Park zones that were detailed in the 2009 Moreton Bay Marine Park Zoning Plan
- open zones—those located in areas where fishing was permitted.

Encouraging results

Although the new green zones have only been in place for approximately two years, the study found encouraging results for several fish species targeted by anglers, including:

- the average biomass of snapper, spangled emperor, redthroat emperor, blackspot tuskfish, Maori rock cod and goldspot wrasse all increased in the new green zones, in the offshore areas of the MBMP
- the numbers of venus tuskfish and blackspot tuskfish increased in the new green zones.

While these results are encouraging, it should be noted the changes to the marine park are still new and many of these species are long-lived (e.g. snapper and spangled emperor live for up to 30 years), therefore the responses of populations within the new green zones may take many years to become fully evident. Any responses will also vary among species depending on their range of movement, as well as the size and the types of habitat that are prevalent within each green zone.

The human use study showed that although the numbers of people fishing in green zones has declined, fishing has not stopped completely. This activity has the potential to reduce or nullify any positive results within green zones.

Fishing target species

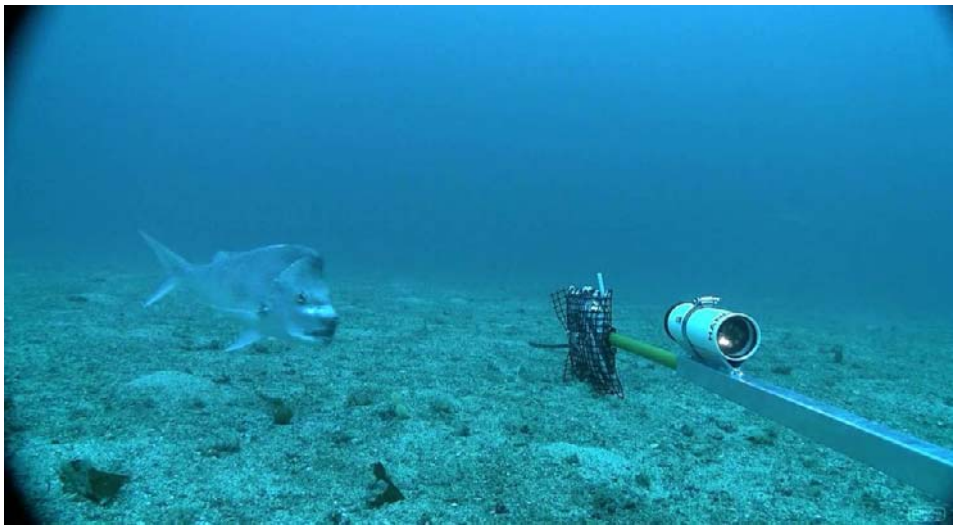

Photo 2. A large snapper at 42 m depth approaching the BUV bait bag at Flat Rock. Photo: DERM.

Snapper

- The numbers of snapper increased during the study in the open (14.8 ± 14.8 [mean ± 95% confidence interval] % per season) and old green (19.7 ± 17.5 % per season) zones, but not in the new green zones.
- The average biomass of snapper increased by 13.6 ± 12.5% per season inside the new green zones, but there was no significant change in average weight in either the old green or open zones.

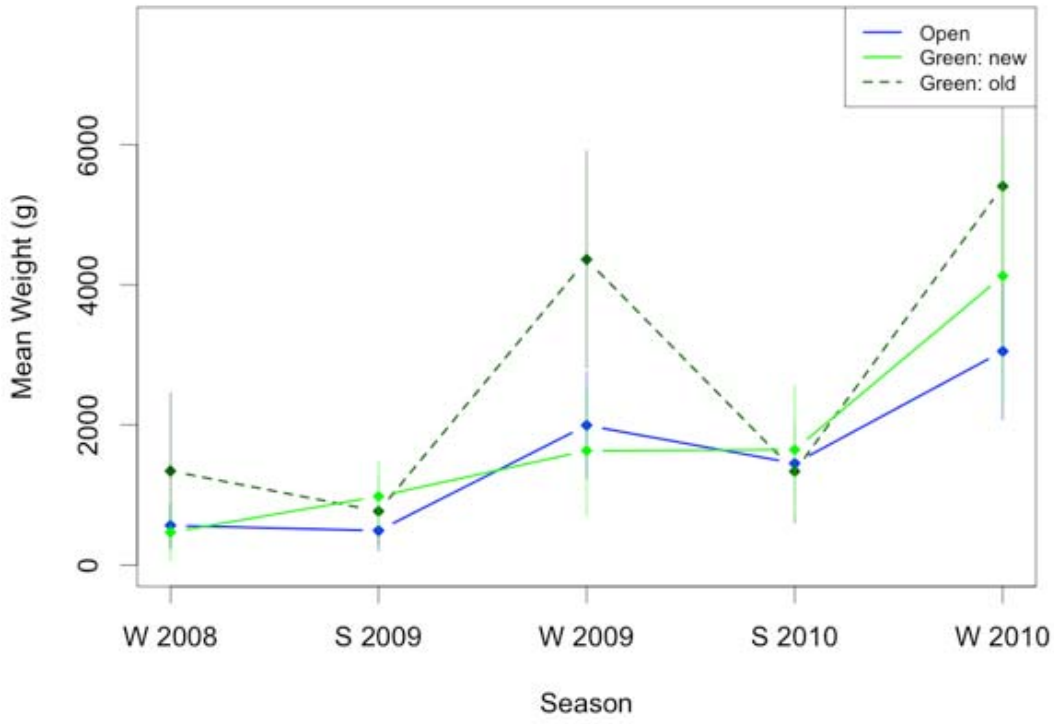

Figure 4. The relative biomass of snapper *Pagrus auratus* at offshore reefs indicates an overall increase in numbers in all zones during the study period. Biomass estimates are based on summed estimated weights of fish per BUV recording. Data are mean biomass per season ± 1 Standard Error. Standard Errors reflect how much the weights of individual fish varied on each sampling occasion.

Spangled emperor

- Numbers of spangled emperor *Lethrinus nebulosus* decreased by an estimated 83 ± 82.5% per season in the old green zones, with no detectable change in numbers in the other zones.
- The average biomass of spangled emperor in the new green zones increased significantly during the study (33.9 ± 34.0%).

Redthroat emperor

- Redthroat emperor *Lethrinus miniatus* were observed throughout the study area, but they were consistently more abundant within the old green zone at Henderson's Rock.
- There was a significant decrease in the numbers of redthroat emperor in both the open (36.1 ± 17.0%) and old green (15.7 ± 12.5%) zones and no change in the numbers in the new green zones.
- The average weight of redthroat emperor increased significantly in all zones over the period of the study (open: 18.0 ± 12.5%; new green: 33.0 ± 17.0%; old green: 17.9 ± 10.0%).

Overall for the 12 emperor species recorded in the study, the numbers remained steady. Individuals found in old green zones were significantly heavier than those in other zones, and while they did not tend to increase in weight over the study, those in other zones did, with the greatest increase in weight (17± 13% per season) seen in the new green zones.

Venus tuskfish *Choerodon venustus*

- Venus tuskfish were observed almost exclusively at Flat Rock.
- The relative abundance of Venus Tuskfish increased significantly in the new green zones (41.1 ± 28.5% per season) and there was no change in their numbers in the either old green or open zones.
- The average weight of venus tuskfish decreased by an average of 23.5 ± 21.5 % per season only in the new green zones throughout the study period.

Blackspot tuskfish *Choerodon schoenleinii*

- Blackspot tuskfish were more abundant at Flat Rock compared to either Henderson's Rock or Flinders Reef.
- Mean relative abundance of blackspot tuskfish increased over the period of the study—in the new green (42.8 ± 42.5% per season) and less so in the open zones (19.6 ± 20.5 % per season).
- Mean weight of blackspot tuskfish increased over the period of the study in the new green zones (44. 1 ± 44.0 % per season).

Overall, for the seven tuskfish species recorded in the study, numbers increased significantly over time in the old green and new green zones but not in open zones. The overall biomass of tuskfish in old green zones was significantly greater than in other zones.

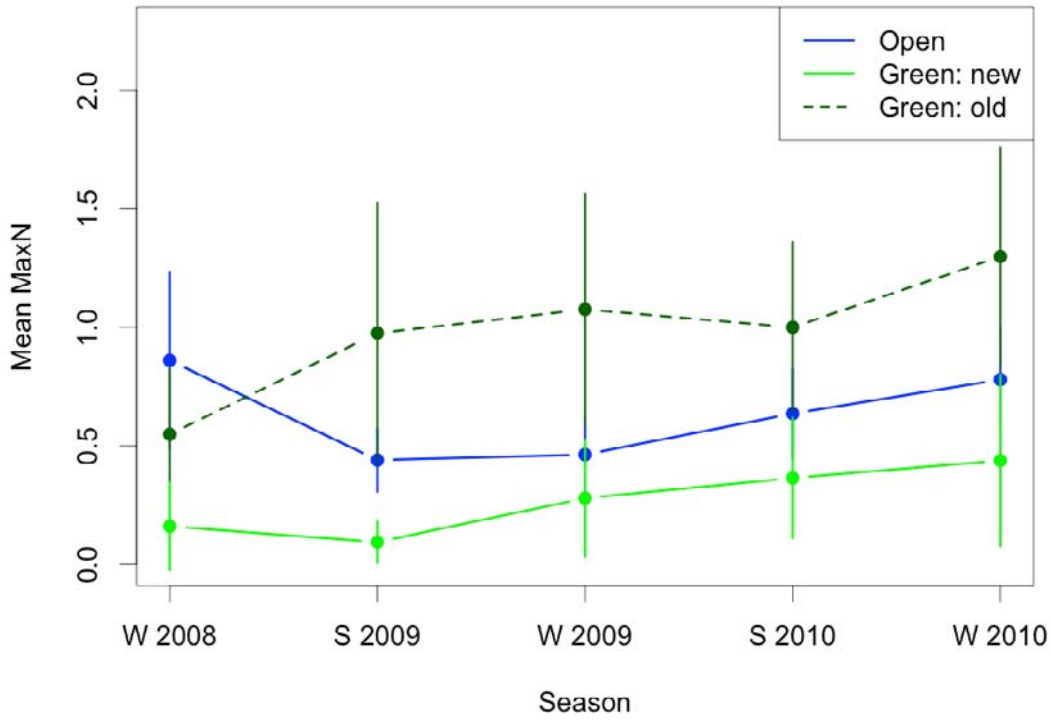

Figure 5. The relative abundance of tuskfish *Choreodon schoenleinii* and *C. venustus* at offshore reefs. In green zones there has been an overall increase in the number during the study period, but no change was measured in the areas open to fishing. MaxN represents the maximum number of fish seen at one time during a BUV deployment. Data are the average MaxN per season ± 1 Standard Error.

Maori rock cod *Epinephelus undulatostriatus*

- Maori rock cod were most common at the new green and open zones in the region around Henderson's Rock and were rarely observed at either Flinders Reef or Flat Rock.
- There was no evidence to suggest there was a change in abundance of Maori rock cod since the introduction of the 2009 Moreton Bay Marine Park Zoning Plan.
- There was however, an indication that the average weight of Maori rock cod in the open and new green zones increased significantly (28.9 ± 34.5% and 30.6 ± 42.0% respectively).

Goldspot wrasse *Bodianus perditio*

- Goldspot wrasse were consistently most abundant in the old green zones at Henderson's Rock.
- The relative abundance of goldspot wrasse did not change significantly in any of the zones but there was a statistically significant increase in average biomass in the open (14.8 ± 13.5%) and marginally statistically significant increase in the new green (22.0 ± 22.0%) zones throughout the period of the study.

Aquarium target species

Six species of fish targeted by the aquarium fish industry were observed on the BUVs in sufficient numbers for analysis:

- pencil surgeonfish *Acanthurus dussumieri*
- keyhole angelfish *Centropyge tibicen*
- Guenther's butterfly fish *Chaetodon guentheri*
- neon damselfish *Pomacentrus coelestis*
- moon wrasse *Thalassoma lunare*
- green moon wrasse *Thalassoma lutescens*.

However, there was no significant change in the relative abundance of these species during the study.

Inshore monitoring of crabs and fish in Moreton Bay Marine Park

Russ Babcock and Richard Pillans (CSIRO)

The purpose of this component of the monitoring program carried out by the CSIRO was to measure the response of populations of crabs and fish targeted by fishers in Moreton Bay, to assess the effectiveness of the zoning in protecting these species within the new no-take areas.

A total of 3522 crab pots were set at 671 sites during this study of inshore areas of Moreton Bay. During the study 1777 mud crabs and 1507 sand crabs were captured and measured and sexed, 136 line fishing sites were surveyed and were sampled 539 times during the study, with over 1570 fish captured and measured.

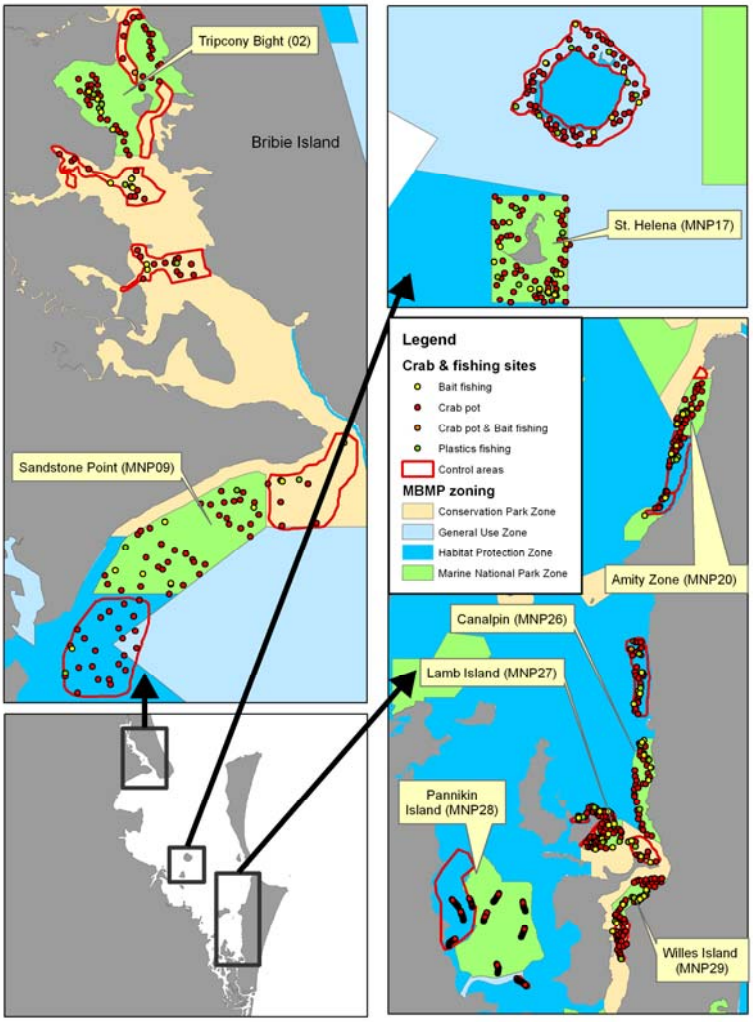

Figure 6. Moreton Bay Marine Park Inshore Study areas included green zones and Open zones (control areas) that were sampled 2008–2011.

Within the MBMP five new green zones (those within the newly established Marine National Park zones that were detailed in the 2009 Moreton Bay Marine Park Zoning Plan) and two old green zones as well adjacent open zones (those open to fishing) were monitored throughout the study, with the same sites sampled each summer and winter.

Inshore sampling was conducted twice a year (in winter and summer), before and after re-zoning between August 2008 and March 2011. Crab pots and fishing lines were set in new green zones and in corresponding adjacent areas open to fishing and with similar habitat; and also in old green zones and adjacent areas open to fishing.

Photo 3. The Queensland National Parks and Wildlife Service (QNPWS) vessel Spoonbill played a major role in supporting the surveys of crabs and fish at inshore areas of the MBMP. The crab pots were baited and left overnight, then the pots were collected and the crabs measured and released. Photo: DERM.

The surveys have shown a number of positive effects as a result of the new green zones, as well as confirming the continued effectiveness of the old green zones. They have also highlighted that different species are likely to respond differently to the creation of no-take zones within the bay depending on the type of habitat in each zone.

Representative results from different inshore habitats in Moreton Bay

Old green zones

In 2009, the old green zone at Tripcony Bight was increased in size. Catch rates of legal size male mud crabs in the old green zone at Tripcony were 4–17 times greater than the catch rates in the open zone, or the new green zone. However, they did vary over time with factors such as the season and the following the floods in January 2011. The catch rates of legal size male mud crabs increased steadily over time in the new green zone and were between two and six times greater than catch rates in the open zone. Catch rates of legal size male mud crabs in the old green zone were 1.6–9 times greater than the new green zone except in the 2011 summer immediately after the Brisbane River floods.

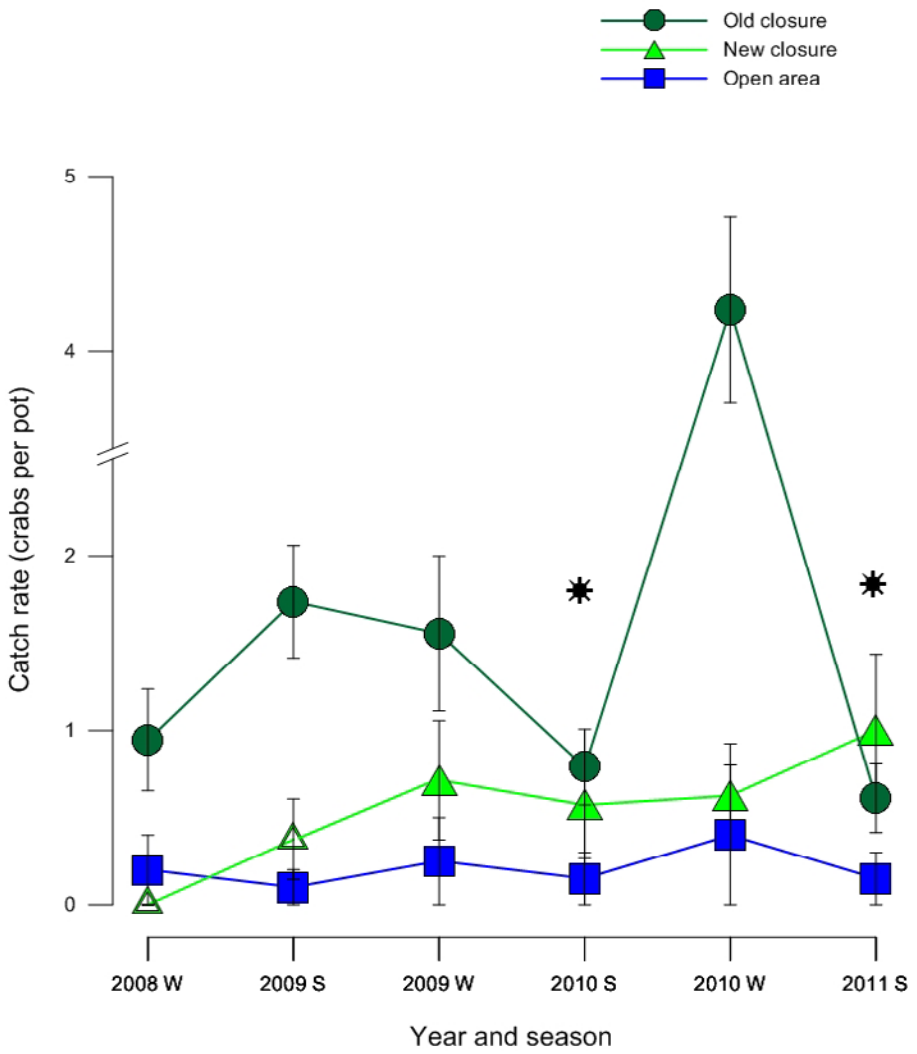

Figure 7. Mean catch rates of legal-sized male mud crabs S. serrata in the Tripcony Bight study area. Empty triangles indicate New Green zone prior to the implementation of the 2009 Moreton Bay Marine Park Zoning Plan. Asterisks indicate years when catches were influenced by floods. Data are means ±SE.

Inside the green zones at Tripcony Bight, mud crab catches were dominated by male crabs above the legal size, while in open zones, females were the dominant catch at sizes greater than the legal limit. Similar trends were seen at the other old green zone at Willes Island.

Both sand crabs and mud crabs are relatively short lived species, reaching sexual maturity between 12–18 months and generally not living more than three years. Any changes to the population structure such as increased abundance, increased size of individuals and changes to the sex ratio as a result of creating no-take zones are likely to be detected within 12–24 months. Therefore, our ability to detect changes in abundance, size and sex ratio of crabs was not restricted by time.

Yellowfin bream catch rates in the old green zone at Tripcony were highly variable but up to seven times greater than in the open zones. The study also showed:

- catch rates of legal size bream (25 cm total length) were 6–9 times higher than the open zones
- the total biomass of bream caught was up to 2.5 times greater in the old green zone than in the open zone but it was also highly variable
- catch rates of bream in the new green zone trended strongly upwards over the period of the study.

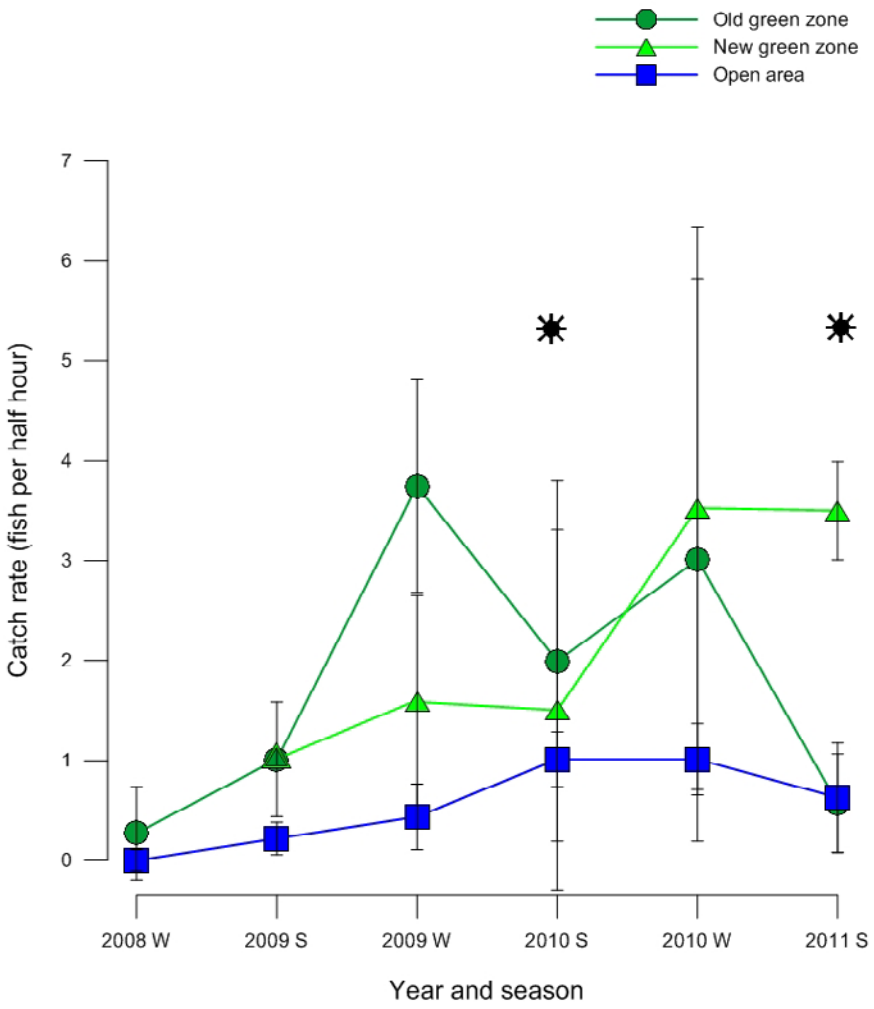

Figure 8. Mean catch rates of yellowfin bream at Tripcony Bight. Empty triangles indicate New Green zones prior to the implementation of the Moreton Bay Marine Park Zoning Plan in autumn 2009. Asterisks indicate years when catches were influence by floods. Data are means ±SE.

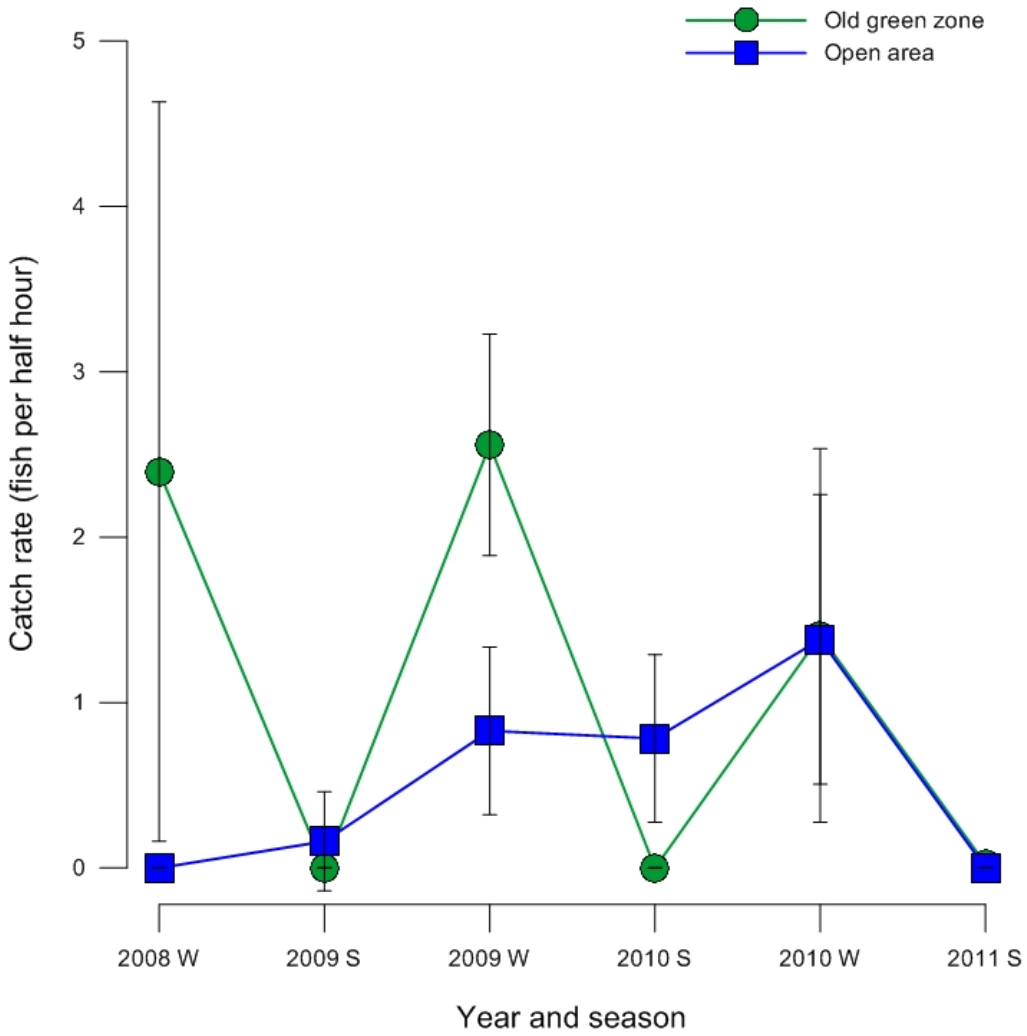

Figure 9. Mean catch rates of dusky flathead at Tripcony Bight. Data are means ±SE.

Flathead catch rates in the old green zone at Tripcony were highest in winter with no seasonal pattern in the open zones. In winter surveys the catch rates of flathead were up to 20 times higher in the old green zone, however in winter 2010 catch rates in the two areas were similar. There were three times more legal flathead captured in the old green zone and the proportion of legal flathead in the old green zone was 1.3 times greater than the open zones.

Photo 4. Six dusky flathead from a standardised 30 minute angling session, at one of the Old Green zones at an inshore area of MBMP. These fish were caught using a standardised lure-based method prior to being measured, tagged and released. Photo: DERM.

Changes in the abundance and size are relatively more difficult to detect for fish species than for crabs due to longevity of many fish species, combined with relatively low catch rates and high variability in catches of fish using the catch and release sampling methods employed in this study.

New green zones

At Canalpin there was a significant increase in the total catch of mud crabs in both the new green and the open zones. However, catch rates in the new green zone were approximately four times greater than the open zone.

The catch rates of legal male crabs in the open zone remained very low throughout the study, in the new green zone there was a significant increase in the catch rates from less than 0.1 crab per pot in winter 2008, to one crab per pot in summer 2011. The study also showed that two years after the area was protected from fishing, the catch rates of legal males were 12 times greater than the catch rates before the reserve was created.

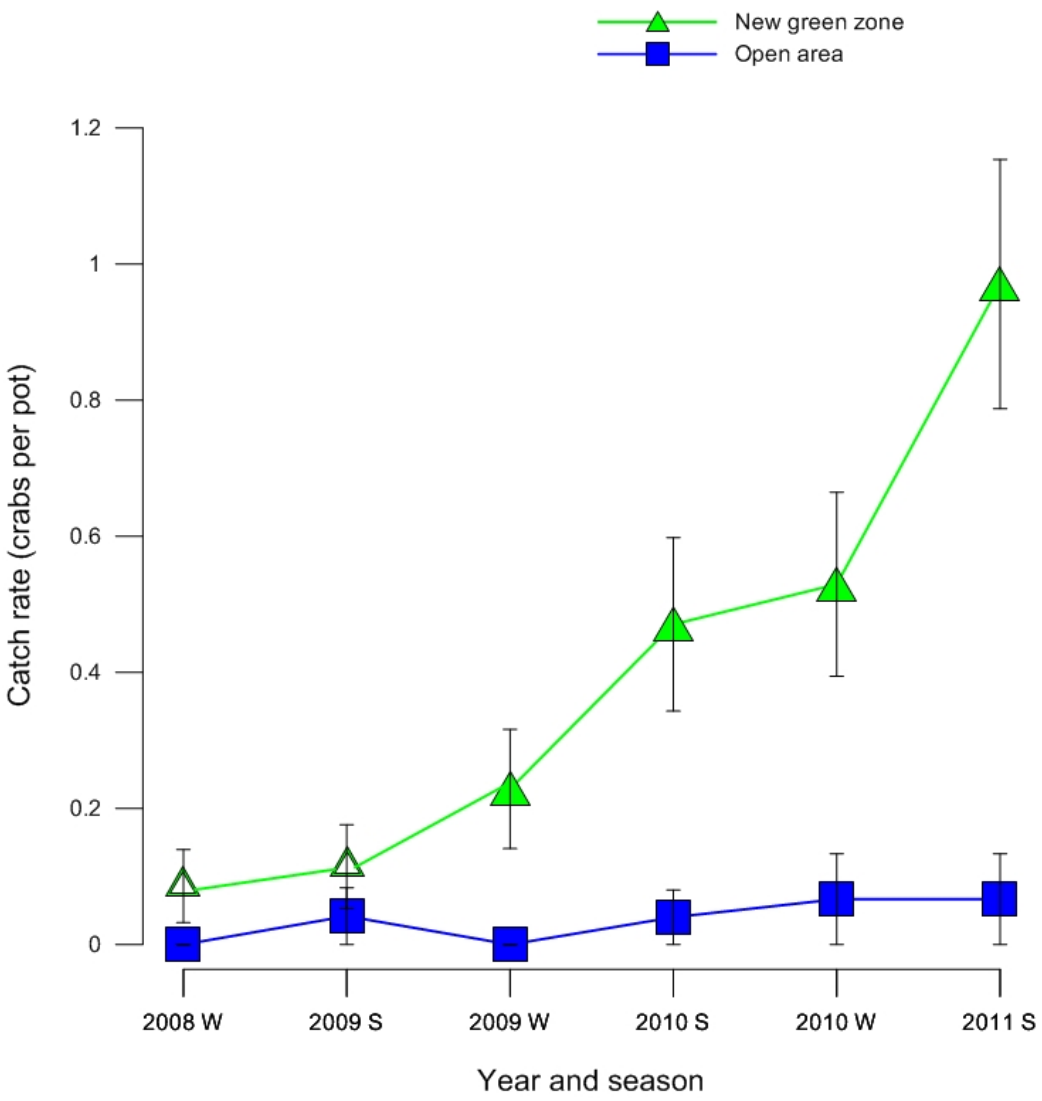

Figure 10. Catch rates of legal-sized male mud crabs in the Canalpin study area. Solid triangles indicate new green zone, empty triangles indicate new green zone prior to the implementation of the 2009 Moreton Bay Marine Park Zoning Plan. Data are means ± SE.

The size of females in the new green zone and open zones were similar, however the average size of males in the new green zones increased significantly and was equal to or greater than minimum legal size in all surveys after rezoning.

The sex ratio of crabs also changed in the new green zones following the rezoning, with the proportion of males in the large size class (15–18 cm) increasing after zoning, which resulted in fewer larger females. Similar trends in mud crab populations were also recorded in the new green zone at Pannikin Island.

Photo 5. Large male mud crabs such as this individual, dominated the catches at inshore no-take zones within suitable habitats. Photo: DERM.

In the new green zone at St Helena Island snapper responded strongly. Catch rates of snapper on soft plastic lures prior to rezoning were similar in the new green zone and open zones, however after rezoning the catch rates in the new green zone were approximately 10 times greater than open zones. Because of the seasonality of snapper movements in the bay this trend is most pronounced in winter.

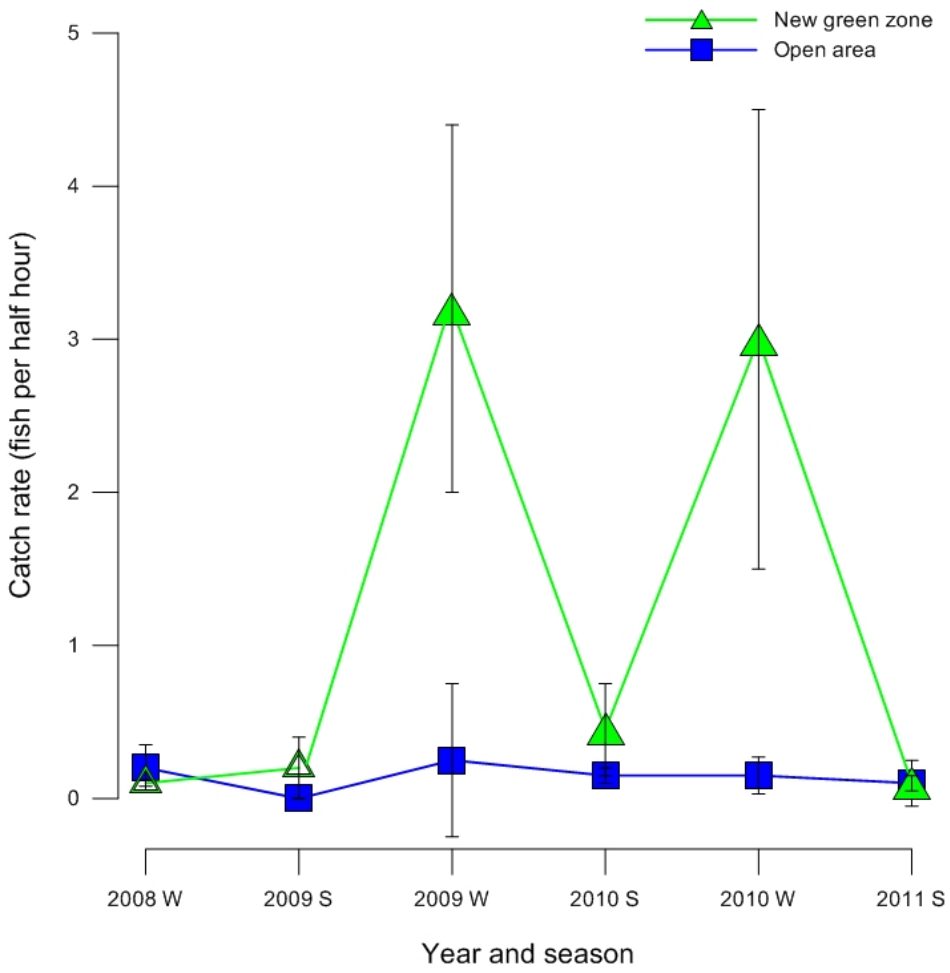

Figure 11. Response of snapper at St Helena Is. Catch per 30 minute standardised fishing session (plastic lures) in a new green zone (St Helena Island) and an open zone (Mud Island) are shown. Empty triangles indicate New Green zone prior to the implementation of the 2009 Moreton Bay Marine Park Zoning Plan. Data are means ±SE.

There was a significant increase in the weight of snapper in the new green zone, with approximately an 18 per cent weight increase per annum. The weight of snapper in the open zone increased by approximately one per cent per annum and was not significant. The number of legal size snapper captured in the new green zone was approximately seven times greater than the open zone with most legal size fish captured 12–18 months after rezoning.

At St Helena there was no response observed in catch rates of other fish, mud crab or sand crab catch rates. The size of male sand crabs increased significantly in the new green zone MNP17 and MNP26, however the reasons for this increase are uncertain given there was no trend. Sand crab numbers didn't show any direct response to zoning at any of the MNP zones surveyed, potentially because of the high rates of movement in this species.

Have trawling closures had any effects on the soft sediment habitats of the bay?

Tim Stevens

A team has begun to study the physical and biological effects of closing areas that have previously been extensively and intensively trawled. The study aims to:

- quantify changes in benthic assemblage structure, after removal of fishing pressures, in comparison to fished and unfished reference sites
- place these changes in the context of longer term (<5 years) changes at pre-established reference sites
- quantify changes in small-scale topography after removal of fishing pressures, in comparison to fished and unfished reference sites.

The study will focus on documenting changes over time within three or four green zones, compared to similar adjacent habitats.

To date the team has worked on developing and testing the equipment they will use in the study. They have selected and resurveyed long term reference sites in three green zones and have also established the exact locations at which they will collected information.

What are some of the other lessons about fish and habitat that we have learned from the monitoring program?

Rod Connolly, Kylie Pitt, Andrew Olds, Paul Maxwell

Habitat connectivity and the performance of marine reserves

Photo 6. Coral reef adjacent to mangroves. Photo DERM.

Coral reefs and mangrove forests provide a range of valuable ecosystem services and are frequently targeted for conservation in marine reserves. The spatial arrangement of these habitats can strongly influence fish populations, the structure of food webs and benthic ecological processes, with many fish species being more abundant in seascapes where both habitats are located close together.

Connectivity can improve the ability of reserves to promote fish abundance

Connectivity between reefs and mangroves can enhance the ability of marine reserves to promote fish abundance. In Moreton Bay, this translates to more harvested fish, particularly yellowfin bream, moses perch and black rabbitfish, in marine reserves where both habitats occur in close proximity.

A role for habitat connectivity in maintaining reef resilience

Despite data collected by CSIRO (discussed above) showing reduced numbers of some species of fish and crabs in certain green zones following significant rainfall and flooding, there is some good news about the role that protected areas contribute to the ability of key habitats to withstand the pressures of flooding and to bounce back to pre-flood conditions sooner than unprotected areas. A separate study by Griffith University researchers found that marine reserves with well connected reefs and mangroves also supported the greatest abundance of herbivorous fish. Their work suggests that connectivity may be important for maintaining ecological processes in reserves. Herbivorous fish play a key role underpinning the resilience of coral reefs. They graze on fleshy algae, which compete with coral for living space, and their efforts can tip this competition in favour of coral. Given the greater abundance of herbivores, there may also be an expectation of increased grazing and a greater resilience of protected reefs near mangroves. With the major flooding of the Brisbane River into Moreton Bay over the 2010–2011 summer, this finding may have important consequences for the persistence and recovery of local coral reefs.

Photo 7. Rabbitfish grazing in Moreton Bay.
Photo: DERM.

Potential cascading effects of higher crab densities on invertebrate macrofauna

The higher densities of harvested species inside reserves, especially of mud crabs (Figure 15), could result in higher predation pressure on potential prey species. Potential predation pressure was measured using tethering experiments. Two species were examined; a small (3cm) burrowing bivalve *Paphies striata* and the barred estuarine shrimp, *Paleamon serrefis*. The two species were selected as they were likely to be preyed on by different types of predators and the use of two species, therefore, would enable us to assess the effects of zoning on a greater range of predators. Tethering of *P. striata* was undertaken on two occasions in 2009: March/April and July/August. Tethering of *Paleamon serrefis* was undertaken once in April 2009.

Predation rates varied among locations but neither prey species showed consistent, statistically significant differences among zones (existing green zones versus new green versus outside reserves). The new green zones were only just being implemented as these predation surveys were being carried out, and so cascading trophic effects in these reserves would not necessarily have been expected to show up. However, the existing reserves should have had different predation rates if the higher densities of predators had strong effects, and this could not be detected. It was concluded that for the prey species used, other factors that vary among locations but are not driven by reserve performance have a stronger influence on predation rates than the effects of reserves.

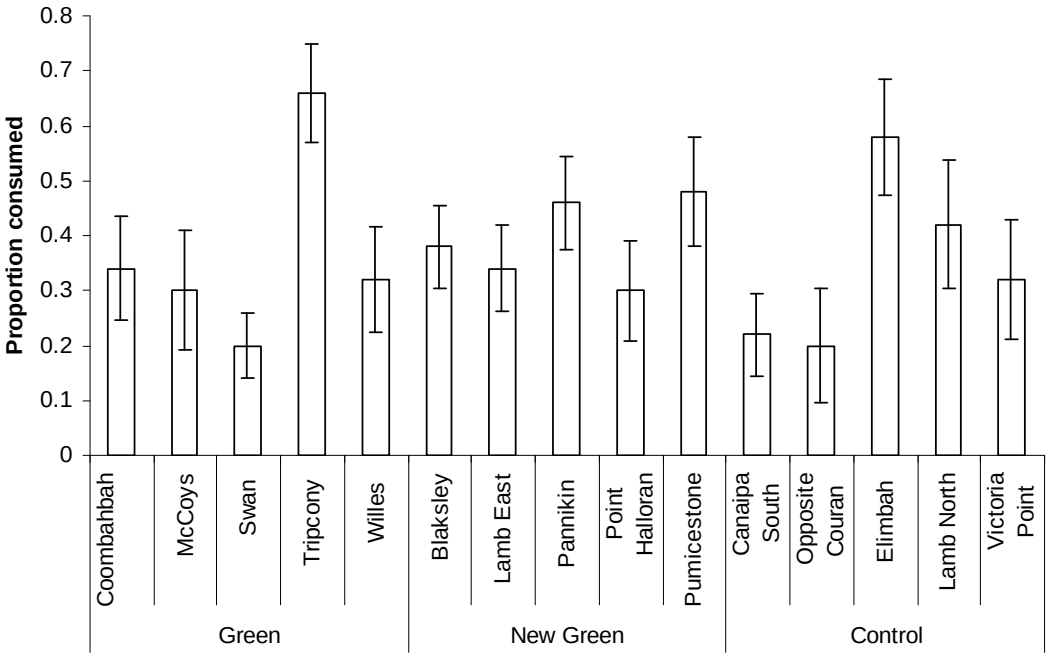

Figure 12. Variation in the average (±SE) proportion of barred estuarine shrimp ***P. serrefis*** consumed among locations. Rates differed among locations but not consistently among the three categories of reserves.

Shorebirds on ocean-exposed beaches of the Moreton Bay Marine Park

Thomas Schlacher, Justin Meager and Tara Nielsen (University of the Sunshine Coast)

Beaches and dunes deliver important ecosystem services (e.g. nesting habitats for turtles and birds, foraging areas for shorebirds and fishes), but the attractiveness of beaches for human use and recreation makes them also ecologically vulnerable.

Photo 8. Example of pressure from vehicle-based recreation: flock of crested terns disturbed by a 4WD on North Stradbroke Island and a dead tern killed by a vehicle. Photo: DERM.

A sizeable number of bird species forage and nest on beaches and coastal dunes, making these critical habitats for vertebrates of the Moreton Marine Park. Yet, habitat quality may be compromised by recreational activities:
(i) birds may be directly impacted by beach users (e.g. cars)
(ii) food availability for birds may be lowered (e.g. clam collecting); or
(iii) invasive species and dogs may reduce nesting success of birds in the dunes.

A basic building block to develop effective conservation and management strategies for beach-dune habitats, and the birds that depend on these habitats, is to document the spatial distribution of birds. Essentially, an understanding is needed to determine how birds utilize the marine-terrestrial interface region and what features of the habitat are important in selecting habitats. To this end, intensive mapping of birds was undertaken and predictive habitat selection models were developed. It was also determined how variation in food availability affects how birds use beaches and measured the rates of egg loss from nests using a large-scale experiment and camera traps.

The team mapped 24 742 birds and 7676 human activities in 135 surveys: 11 surveys along Moreton Island's Eastern Beach (34 km of shoreline), 63 surveys along North Stradbroke Island's Flinders Beach (8 km) and 61 surveys along North Stradbroke Island's Main Beach (34 km). Bird diversity was patchily distributed along the beaches, with diverse areas found along much of the southern part of Moreton Island, the central part of Flinders Beach and several stretches along Main Beach on North Stradbroke Island. Diversity hotspots can coincide with areas of intense beach use, indicating significant pressures on shorebirds. Human activities occurred mostly in the mid to lower intertidal zone of the beach, overlapping closely with the preferred habitats of silver gulls, pied oystercatchers, red-capped plovers and endangered little terns. Predictive habitat selection functions showed that at the local and landscape scales, dune dimensions, the extent and type of vegetation structure, and the frequency of human activity were important predictors of bird density.

Animals routinely select habitats based on the availability and quality of food. For birds feeding regularly on exposed sandy beaches, these food items are small invertebrates buried in the sand, including clams (pipis) harvested by humans. To better predict the habitat requirements of pied oystercatchers, their distribution was compared in relation to the abundance of invertebrates on the lower part of the beach where oystercatchers forage. Food availability clearly is important for how oystercatchers use beach habitats, but selection of areas depends on the spatial scales (extent) at

which the birds feed. Small-scale (hundreds of metres) variations in food availability appear much less important than differences in invertebrate abundance over distances of kilometres. These findings have implications for conservation planning, suggesting that large parts of beach systems need to be conserved to capture this 'landscape effect'.

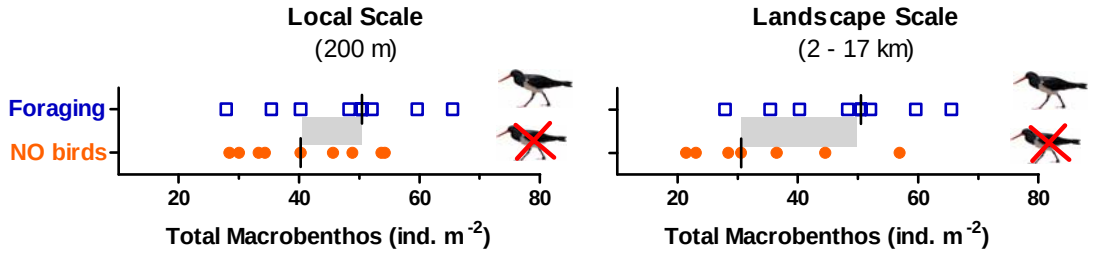

Figure 13. Habitat selection by pied oystercatchers on North Stradbroke Island at two spatial scales based on differences in the abundance of invertebrate prey items buried in the sand macrobenthos.

Coastal dunes are important nesting areas for birds such as red-capped plovers and pied oystercatchers. A large-scale experiment where dozens of nests were created in the dunes using quail eggs (unfertilised) demonstrated that foxes can be a significant threat to nesting success of birds. Foxes repeatedly raid nests, consumer eggs and can cover large tracts of beaches and dunes in a single night. Eggs were also lost from nests in the foredunes seawards of camping areas.

Photo 9. Fox raiding shorebird nest in the dunes of North Stradbroke Island. Photo: DERM.

Importance of monitoring

Results above indicate the importance of monitoring and associated research into the effectiveness of the marine park. Although the new zoning plan has only been implemented for a relatively short period, there have already been some significant and important effects on some key biota. The work on the ability of protected areas to return to a normal condition following the floods is also important and is an additional positive effect of protecting critical habitat.

It is important to continue monitoring key no-take zones in order to understand their long-term effectiveness and to detect any unforseen changes that may arise from the greater level of protection afforded to marine national park zones in Moreton Bay. Furthermore the full value of these no-take zones as benchmarks for ongoing evidence-based management of the broader marine park can only be realised by regular monitoring and assessment, such as the water quality monitoring programs in Moreton Bay.

The socio-ecological focus of the Moreton Bay monitoring program means that people's values and feelings about the marine park will be assessed as well as the biological aspects. This is critical as it provides decision makers with a range of information to consider.

The next steps in the program are to continue to collect and analyse data and to pull together the information gathered by our diverse group and assess how the information can be put together to enable managers and decision makers to assess their actions.