Southern Line Islands - Observations and Marine Survey Report 2008

Vince Kerr[1] and Graham Wragg[2]

Photo: Red snapper, *Lutjanus bohar*, with anthias and trevally in background at Caroline Atoll

[1]Vince Kerr, 176 Dip Rd. RD6,
Whangarei 0176, New Zealand
Phone: 64 9 4351518
Email: vincek@igrin.co.nz

[2]Graham Wragg,
Pacific Expeditions
Rarotonga, Cook Islands
email: info@pacific-expeditions.com

Summary

Marine investigations and monitoring work were carried out as part of a *Pacific Expeditions Ltd* voyage to the Southern Line islands. Marine survey work was carried out by the author on an opportunistic basis. Basic information was also gathered on turtles, marine mammals, seabirds and terrestrial introduced pests where possible. A coral coring team from Georgia Technical Institute was also on the voyage and were able to add substantial observations to support the descriptions and survey work presented in this report. The results of their work on coral coring is presented by them in a separate report. Due to the limited time available at each island and the lack of support divers it was decided to use rapid survey techniques focused on key predator and commercially significant indicator species. In addition, at all sites dived, simple coral health assessments were made. Three of the five Southern Line Islands were visited: Caroline, Malden and Flint.

Results of rapid assessment fish surveys and coral health observations indicated that the coral reefs of the three atolls have significant biodiversity values. Typically there was an abundance of large predator species in the reef fish community. Diversity of fish species was low as would be expected from the isolation of these atolls and their Easterly location in the Pacific Region. Malden and Flint Atolls showed evidence of likely fishing impact. Coral health on the lee shore fringing reefs was moderate to very good for all three atolls. Caroline Atoll stood out as being in pristine condition and having exceptionally healthy and diverse reefs for this region.

Taken as a whole the marine values of the Southern Line Islands are significant on an international scale. There are few oceanic atolls in the world that exist in such a pristine state. Efforts to establish high levels of protection for the coral reefs of these atolls are certainly justified.

Figure 1 Location Map of Southern Line Islands

Introduction

The Southern Line Islands are extremely remote. Existing information consists only of very sketchy and infrequent anecdotal observations. It is possible that there is important marine biodiversity and pristine coral reef communities that remain unknown to science. The ecology of pristine reefs must be understood in order to plan for their future management. It is possible, that due the remoteness of this group of atolls, illegal fishing could be occurring leading to the exploitation and decline of these reef systems before their real biodiversity and ecosystems values are understood fully. Ultimately, if a positive future for these atolls and effective management is to be achieved, basic monitoring and ecological information is required on a regular basis. It is hoped that the observations and information gathered on our voyage create a worthwhile start to this information gathering process.

With the critical threat of coral bleaching affecting these systems it is important that we have regular information on the impacts of climatic events. Whole systems could be lost before the world is informed there is a problem. Similarly, isolated remote atolls are particularly vulnerable to illegal fishing, the effects of which can be detected with rapid survey techniques such as those used in this study. The conservation values of the Line Islands justify making every effort to continue regular monitoring whenever a voyage can be organized.

While traveling from Tahiti to the Southern Line Islands and back we stopped at Caroline, Malden and Flint Atolls and conducted rapid survey dives at various sites on the lee shores. We used similar methodologies to those used previously in the Phoenix Islands (Pierce et al 2007). Due to the limitations of time and anchorages we concentrated on lee shore outer reef edge and slope habitats. Time at each island was extremely limited and the author was the only survey diver. As a result the data collected and the sites surveyed were limited. None the less some important observations and tentative conclusions were made and are reported in this report. We were also able to record observations of marine mammals, turtles, introduced terrestrial pests and seabirds. Tables 1 below detail the dive sites and atolls visited.

The author's data and observations were checked against observations of the three scientists making up the Georgia Tech. Coral coring research team also on this voyage. Part of their work entailed surveying the reef along the shore via a towed snorkel method. This work enabled them to make observations of virtually the entire lee shores of the three islands that were visited. Generally the windward shores were too rough to survey at the time. Observations made by the Georgia Tech. team relevant to this report are included.

Atoll	Site	Latitude (S)	Longitude (W)	Notes
Caroline	Drill Site 1	9 54.599	150 12.740	On lee shore inside (to the south) of Northwest Point
Caroline	Mooring Site 1	9 55.357	150 12.635	Mooring site on lee side of North Islet
Malden	Mooring Site 2	4 00.481	154 58.307	Mooring site off west coast
Flint	Mooring Site 3	11 25.847	151 49.536	Mooring side off W-Sw shore
Flint	Drill Site 2	11 25.190	151 49.655	Coral drilling site off W-Nw shore

Table 1. Survey sites Southern Line Islands

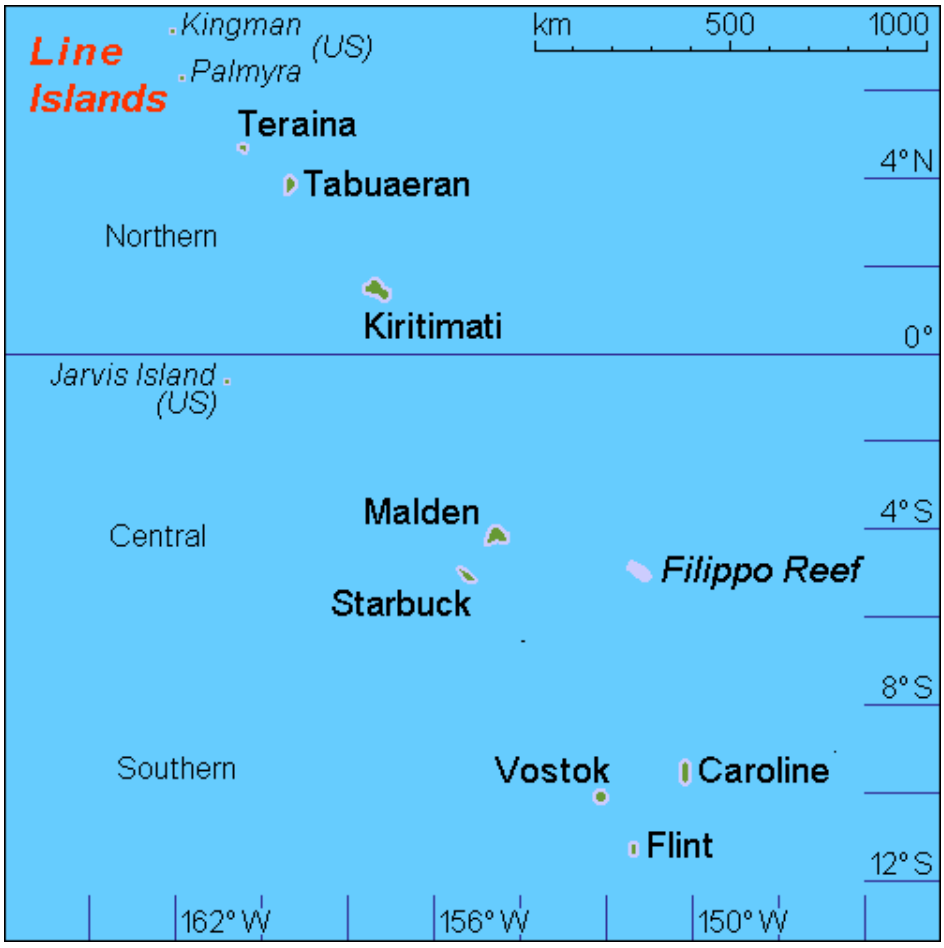


Figure 2. Map of Southern Line Islands

Figure 3. Map of survey sites Caroline Atoll

Figure 4. Map of survey sites Malden Atoll

Figure 5. Map of survey sites Flint Atoll

Methods

The rapid survey methods used are described below and were taken from the methodologies described in (Pierce et al, 2006). All SCUBA dives were carried out by Vince Kerr.

Large Indicator Fish Abundance (30 minute swim)

Twenty-one species of large fish species have been selected as being potential indicators of fishing activity and other impacts on the coral reef ecosystem. This method was a derivation of an internationally standard method referred to as the 'roving diver technique' (Bohnsack 1994 and Hall & Wilkinson 2004). A single SCUBA diver swims for 30 minutes at a consistent depth range between 25m and 8m and records the numbers of fish of the species listed in Table 2 below. For each dive the depth of the survey was recorded to allow for more detailed examination of differences in fish abundance as affected by depth. Considerable care was taken to avoid double counting certain species that have a tendency to follow divers. Estimated sizes of all sharks were recorded to enable further analysis of the shark populations. We also recorded the size of all fish counted to the nearest 10cm measurement. Notes of the visibility of the site and the approximate length of the 30 minute swims were also made to allow for the biomass estimates of each species to be made. Size and biomass analysis has not been done for this report due to the low site and replicate numbers limiting the statistical power of the data in this survey. One advantage this method has over stationary transect based methods is that the diver covers a considerable distance (several hundred meters). As a result large more mobile predator fish, which could easily be missed in standard transect type monitoring, can be observed more consistently. Ideally this method is used in combination with more quantitative stationary fish counts, which wasn't feasible in this study.

Family	Scientific name	Common name
Scombridae	*Gymnosarda unicolor*	Dogtooth tuna
	Euthynnus affinis	Mackerel tuna
Carangidae	*Scomberoides lysan*	Doublespotted queenfish
	Elegatus bipunnulata	Rainbow runner
	Caranx sexfasciatus	Bigeye trevally
	Caranx malanpygus	Bluefin trevally
	Caranx lugubris	Black trevally
	Caranx ignoblis	Giant trevally
	Chanos chanos	Milkfish
Sphyraenidae	*Sphyraena genie*	Chevron barracuda
	Sphyraena barracuda	Great barracuda
Labridae	*Cheilinus undulatus*	Napoleon/Humphead wrasse
Serranidae	*Epinephelus fuscoguttatus*	Brownmarbled grouper
	Plectropomus laevis	Blacksaddle grouper
Lutjanidae	*Aprion virensis*	Green jobfish
	Lutjanus bohar	Twinspot snapper
	Macolor macularis	Midnight snapper
Carcharhinidae	*Carcharihinus melanopterus*	Blacktip reef shark
	Carcharihinus amblyrhynchos	Grey reef shark
Hemigaleidae	*Triaenodon obesus*	Whitetip reef shark
Mobulidae	*Manta birostris*	Manta ray

Table 2. Species counted in 'Large Indicator Fish Abundance 30 Minute Swim' surveys

Description of Reef Fish Communities

Due to time and diver limitations on this trip it was decided that it was not possible to undertake transect based survey of fish abundance. Instead a reef fish diversity list was compiled if time permitted. The method used was an adaptation of the standard fish diversity survey described by Allen (2002) which has been used in numerous similar studies in the Pacific. In this case notes of rare and/or unusual species were kept during all the dives. On at least one dive at each site the diver divided the time available between the depth and habitat zones: reef slope 30-12m, reef edge (crest) approx 12m, shallow reef platform 12m-5m, and surge zone 5m – 0m depth. The names of all species were recorded with the diver searching the substrate as much as time permitted for cryptic species. Where there was any doubt about identification a photograph was taken to enable post-dive study. Any fish whose identification was not certain was not included in the final list. Common names used in this report are taken from Randall, (2005).

Coral Health Rapid Assessment

Coral descriptive work was done on a time available basis and was the third priority behind the two fish survey methods used. The methods described below take very little time and were done at all sites. At each (SCUBA) dive site, visual estimates of the percentage of the live coral cover were made and recorded. Notes were taken of any sightings of recent coral bleaching, coral disease, crown of thorns starfish *Acanthaster planci* present, and crown of thorns starfish damage. At each site a set of

digital photographs was taken at typical locations in three depth ranges: surge zone 0-5m, reef platform 5-12m, and reef slope 12-30m. For at least one representative location for each site a set of 'landscape' photographs were taken from about 2m above the reef surface, at an oblique angle. The diver rotated 360 degrees taking 5-12 photographs looking out along the reef at different angles.

Photographs for the coral description work were taken with a TZ3 Panasonic 7mb digital camera in a Panasonic underwater housing.

At each site notes were taken of the profile and habitat zonation of the reef and are presented here in the form of a notated drawing.

Turtles and Marine Mammals

All sightings of turtles and marine mammals were recorded and this data is summarized in the results of this report. Where possible turtle nests were counted on beaches. No tagging of turtles was attempted.

Seabirds

A protocol for evening fly-on counts of birds – at anchor' (all species) from the boat at anchor (following methodology of Pierce et al 2006), was conducted on all three atolls.

Observations of rare bird species - from both shore visits and passages at sea - are included in the results section.

Terrestrial Introduced Pest Species

All members of the voyage were briefed on the recognition of rat and cat signs and were asked to take note of any sign of these species. At the end of each atoll stay the author interviewed all crew who went ashore and summarized findings for each atoll. The author was not able to spend time ashore on any of the islands.

Results

The type and number of fish surveys completed and locations are detailed for each atoll and site in Table 3 below.

Atoll	Site	Number of 30 minute swims completed	Number of Dives	Fish Diversity survey	Notes
Caroline	Drill Site 1	0	1	No	On lee shore inside (to the south) of Northwest Point
Caroline	Mooring Site 1	2	1	No	Mooring site on lee side of North Islet
Malden	Mooring Site 2	8	5	Yes	Mooring site off west coast
Flint	Mooring Site 3	6	4	Yes	Mooring side off W-Sw shore
Flint	Drill Site 2	2	1	Yes	Coral drilling site off W-Nw shore

Table 3 Dive sites and surveys completed

Large Indicator Fish Abundance (30 minute swims)

Table 4 below shows the presence and absence of species seen from the list of large indicator fish (see Table 2) across all surveys completed for each atoll.

Family	Scientific name	Common name	Caroline	Malden	Flint
Scombridae	*Gymnosarda unicolor*	Dogtooth tuna	A	P	A
Carangidae	*Scomberoides lysan*	Doublespotted queenfish	P	A	A
	Elegatus bipunnulata	Rainbow runner	A	P	A
	Caranx sexfasciatus	Bigeye trevally	P	P	A
	Caranx malanpygus	Bluefin trevally	P	P	P
	Caranx lugubris	Black trevally	P	P	P
	Caranx ignoblis	Giant trevally	A	P	P
	Chanos chanos	Milkfish	A	A	P
Sphyraenidae	*Sphyraena genie*	Chevron barracuda	A	P	A
Labridae	*Cheilinus undulatus*	Napoleon wrass	P	A	A
Serranidae	*Epinephelus fuscoguttatus*	Brownmarbled grouper	P	A	
Lutjanidae	*Aprion virensis*	Green jobfish	A	A	A
	Lutjanus bohar	Twinspot snapper	P	P	P
	Macolor macularis	Midnight snapper	A	A	A
Carcharhinidae	*Carcharihinus melanopterus*	Blacktip reef shark	P	P	P
	Carcharihinus amblyrhynchos	Grey reef shark	P	P	A
Hemigaleidae	*Triaenodon obesus*	Whitetip reef shark	P	A	P
Mobulidae	*Manta birostris*	Manta ray	A	P	A
Totals			10	11	7

Table 4 Indicator species present on 30 minute swim counts (P = present, A = absent)

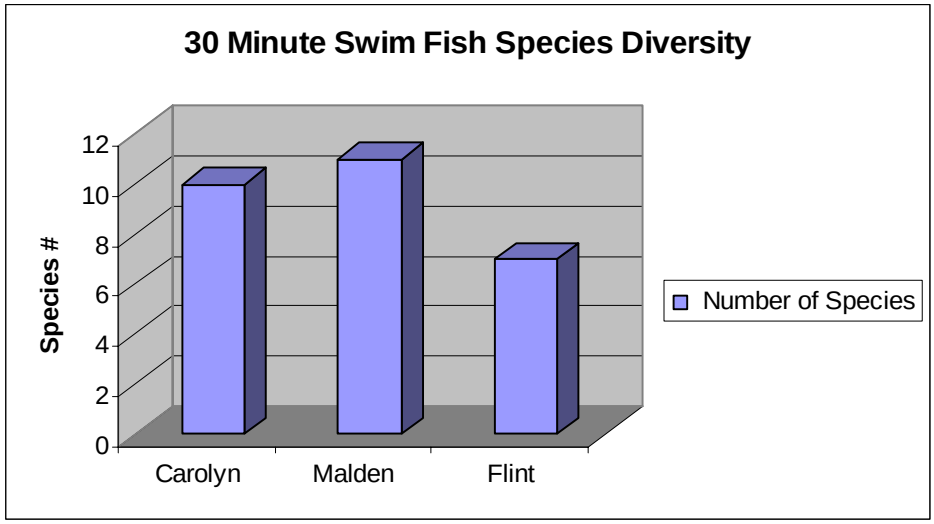


Figure 7. Number of indicator species present in rapid survey counts, 30 minute swims for each island

The diversity of indicator species on the three atolls is high and indicates a healthy reef fish community The Southern Line Islands lie well to the East of the Central Pacific region. As a rule, reef fish biodiversity declines from West to East in the Pacific. Also, due to the sheer scale and diversity of habitats that archipelagos have compared to isolated atolls, remote isolated atolls would be expected to have less diversity than complex groups of islands. With these considerations in mind, the results indicate that Malden and Caroline have relatively high diversity of the indicator species, nearly on a par with the best of the Phoenix atolls. Flint appears to have less diversity, but still scores higher than the fished reference sites of the Tokelau atolls and equal with the lower diversity atolls of the Phoenix group as reported in Pierce, (2006).

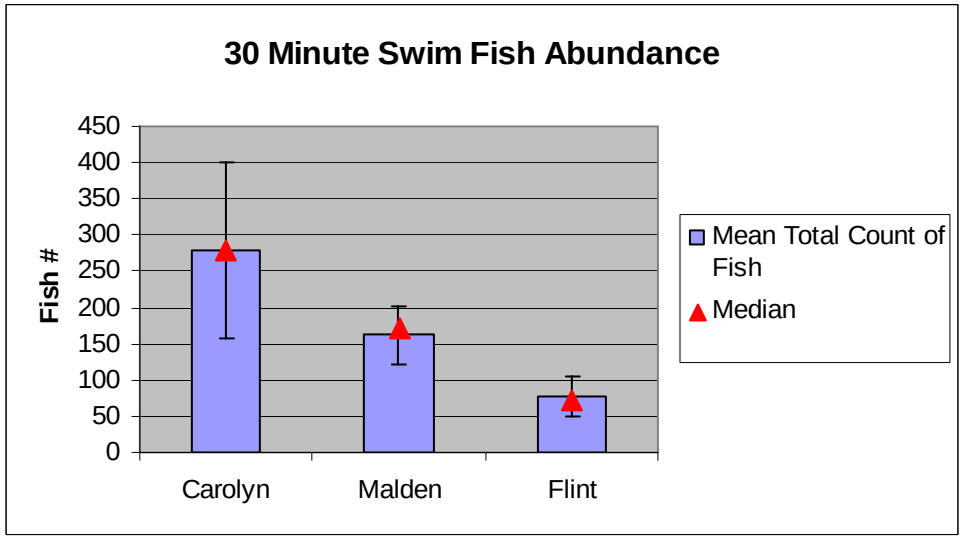


Figure 8 Fish abundance all species 30 minute swim counts, (plus or minus SE)

Figure 8 above shows the result of calculating the mean of all indicator fish counts for each atoll. This result shows a dramatic difference between the three atolls.

Caroline stands out as having outstanding abundance of these species comparable with the best of the Phoenix atolls. It has a fish community profile that is dominated by predators and consists of a substantial number of large and long lived individuals. This profile is consistent with a pristine or near pristine state.
The abundance of fish at Malden atoll was much less than at Caroline but is still substantial when compared to fished reefs of populated atolls and islands.
Flint is lower still; this level of abundance could be compared with a reef that has had some fishing pressure, although many reefs in populated areas would have a much lower abundance value.

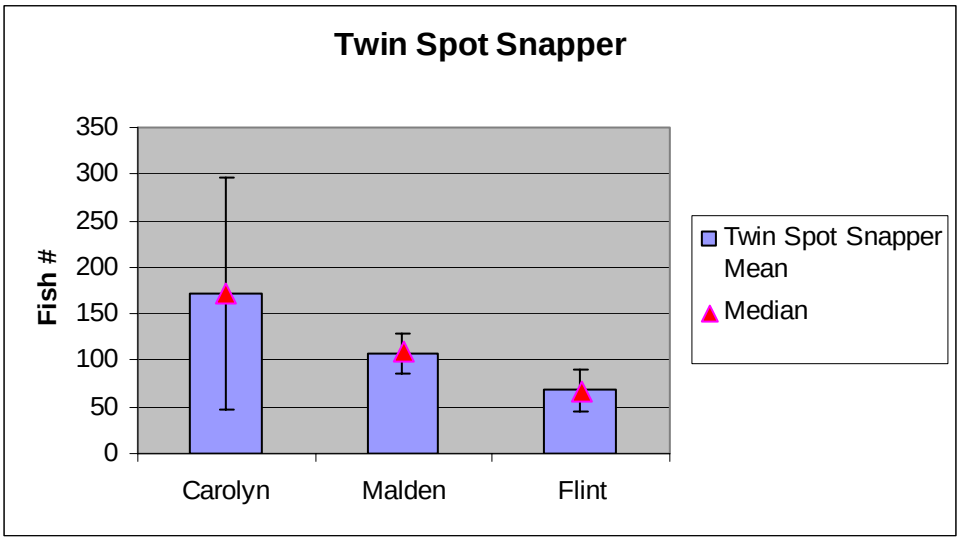


Figure 9 Abundance of twin spot snapper, (plus or minus SE)

Twin spot snapper in the three atolls visited is high in comparison with what is experienced in fished atolls. Twin spot snapper is a preferred specie for harvest and is easily caught via a number of methods. Typically in fished populations there are very few or no large individuals present. By contrast, Caroline, Malden and Flint Atolls had significant numbers of this species; there were large individuals recorded on all transects as well as a spread of sizes making up the population. This pattern is one that would be expected of an atoll in this region in an un-fished state. The abundance figures for the three atolls are very high and indicate that the twin spot snapper occupies a very dominant position as a top predator on these reefs. In comparison with the Phoenix Islands, Caroline Atoll appears to have a very high abundance figure, roughly equivalent to the best of the Phoenix atolls. Again the pattern of Caroline having very high values, with Malden lower and Flint lower still is repeated. From the small data set presented here it is not really possible to determine if this difference is the result of fishing or if other environmental factors are responsible. It is worth noting also that the Caroline data is very limited, resulting in the large standard error shown on the graph, thus any conclusion drawn from this result should be regarded as indicative only.

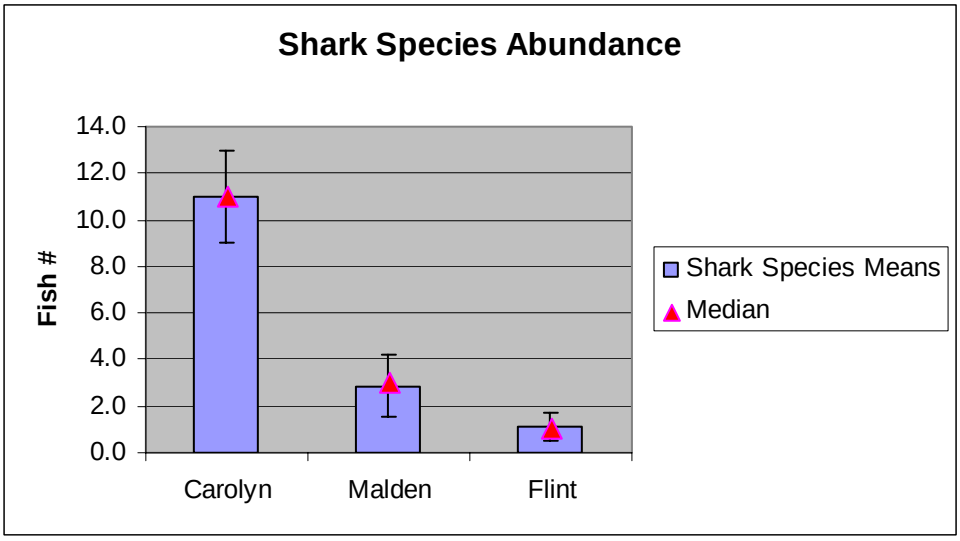


Figure 10. Mean abundance of reef sharks; grey, whitetip and blacktip combined, (plus or minus SE).

Caroline	
Indicator Species	**Mean**
Blacktip reef shark	3.0
Grey reef shark	7.5
Whitetip reef shark	0.5
Total Sharks	11.0
Malden	
Blacktip reef shark	0.5
Grey reef shark	2.4
Whitetip reef shark	0.0
Total Sharks	2.9
Flint	
Blacktip reef shark	1.0
Grey reef shark	0.0
Whitetip reef shark	0.1
Total Sharks	1.1

Table 5. Mean abundance counts of individual reef sharks species for Caroline, Malden and Flint atolls.

For the three reef shark species, Caroline atoll had the highest mean abundance on 30 minute swims with a mean count of 11. This level is exceptional and is indicative of a very healthy shark population possibly unaffected by fishing. All three shark species were present at Caroline Atoll. This level of abundance is comparable to similar counts made in the Phoenix Islands by the author and was only exceeded at two of the Phoenix atolls, Manra and Enderbury. Abundance counts at Malden and Flint were considerably lower and seem to suggest that there has been some harvesting of sharks at these atolls. Flint atoll especially had a combined specie mean count of 1.1 sharks per 30 minute swim count. This is a low figure for a remote atoll and significantly no grey sharks were seen on any of the 30 minute swim counts. The pattern shown in this limited data set was consistent with what was observed by the coral coring team and all observations made in the water which covered much of the

reef of the lee shores of these atolls. It seems highly likely based on these observations that Malden and Flint have been affected by shark fishing, whereas Caroline has had much less impact from harvesting or possibly none.

Estimates of the sizes of all sharks counted were recorded; this data is available from the author for further analysis. Small blacktips were noticeable at Caroline Atoll on the reef and in the lagoon, indicating there is excellent breeding and recruitment happening there for this species. Other than this observation the sizes of the sharks were typical of mature individuals in the 1.4-2.0m range.

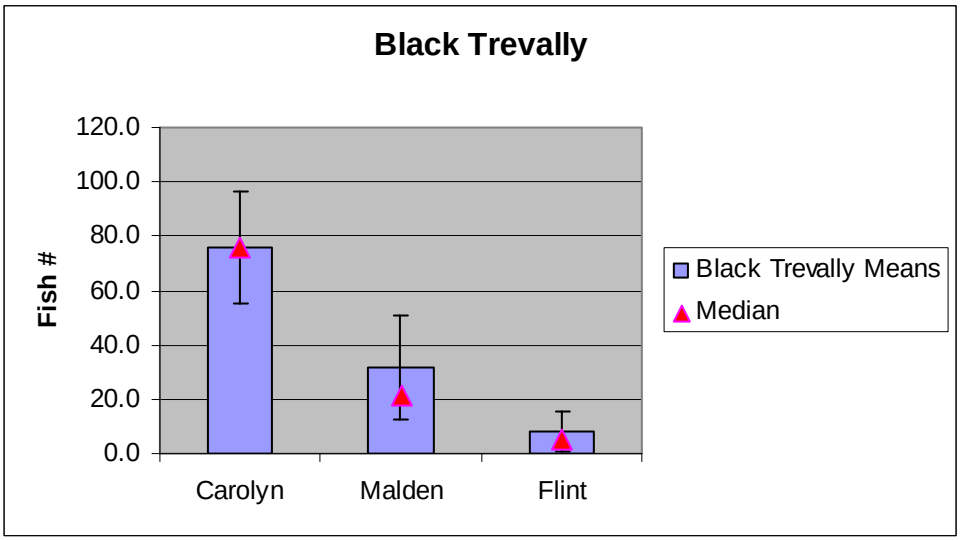


Figure 11. Mean abundance of black trevally (plus or minus SE), counted on Island 30 minute swims.

Black trevally are important predators and foragers in the coral reef system. They are often targeted and caught by various fishers. The high abundance figure for Caroline atoll suggests that very little fishing for these species has taken place at this atoll. The more modest mean abundance figure for this specie at Malden suggests that either there has been some fishing history or there is an environmental difference between these atolls. Flint Atoll shows a relatively low figure for mean abundance of black trevally. This suggests that there has been a significant fishing impact at Flint Atoll in recent times or it is possible that some other environmental factor is responsible. Numbers for the other trevally species were lower than for black trevally across all three atolls consistently. It is not clear why bluefin trevally and bigeye trevally were in relatively low numbers at these atolls. Also there were no large schools or groups of rainbow runners seen at these atolls.

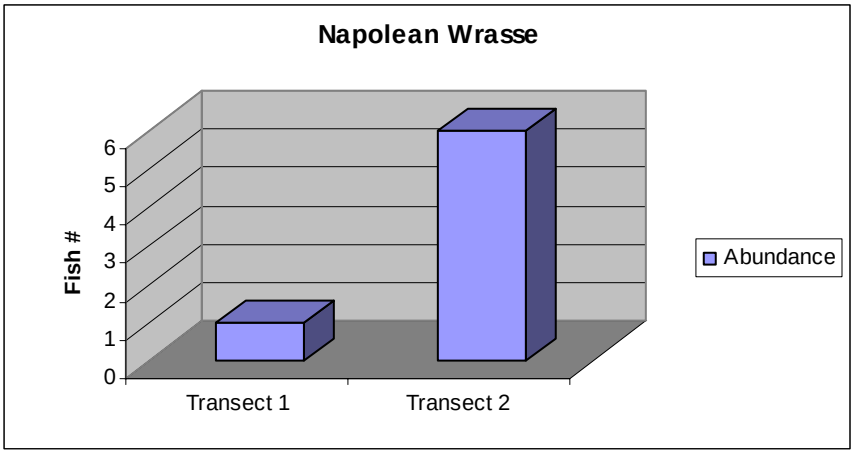


Figure 12. Abundance of Napoleon wrasse counted on the 30 minute swims at Caroline Island. (Note: No Napoleon wrasses were seen at Malden and Flint Atolls.)

Napoleon wrasses are slow growers and are long lived growing to well over a meter in length. They are easily targeted and highly valued by fishers and are reported as being threatened by overfishing in nearly all areas of the Pacific where people live. Napoleon wrasses are therefore an ideal indicator fish for assessing fishing impacts. Figure 11 above shows the actual counts of Napoleon wrasse completed at Caroline Atoll. Unfortunately it is hard to be very certain of abundances of this species based on only two transects. However two transects of 30minute swim corresponds to a distance of ½ km of reef observed. Other observations along the lee shore by the coral coring team described the Napoleon wrasse being commonly seen and a mixture of sizes from young adults to very large individuals over 1m in length. On our transects the size classes were also mixed ranging from 50cm to well over 100cm in length. The abundance at Caroline is clearly in the healthy range for this species and indicates a lack of fishing impact and is comparable to the abundance recorded at the Phoenix Islands.

No Napoleon wrasses were observed at Malden and Flint Islands in this survey. This result is unexpected and is likely a result of fishing impacts. This interpretation must be treated with caution however as there is also a possibility that other environmental factors could be responsible such as differences between the atolls in coral health as discussed below.

Reef Fish Community and Diversity Notes

The very limited diver time available on this survey meant that it was not possible to attempt more detailed quantitative surveys of reef fish abundance and community structure. It was possible to make some observation of overall reef fish diversity. At Malden and Flint Atolls an initial reef fish diversity list was attempted which is included in this report in Appendix 1. A summary of the family makeup in this list is included here in Table 6 below.

Ranking	Family	Malden # Species	Flint # Species
1	LABRIDAE	21	17
2	ACANTHURIDAE	15	17
3	POMACENTRIDAE	13	12
4	SERRANIDAE	11	8
5	CARANGIDAE	8	4
6	BALISTIDAE	6	5
7	CHAETODONTIDAE	4	6
8	LUTJANIDAE	4	3
9	POMACANTHIDAE	4	4
10	LETHRINIDAE	3	3
11	SCARIDAE	3	2
	Total # Species	**120**	**108**

Table 6. Numbers and ranking of reef fish species occurring in key families observed at Malden and Flint Atolls.

At Caroline Island a reef fish diversity list was not attempted, but the overall impression from our divers was that Caroline Atoll would have more species than Malden and Flint Atolls. This would be expected from an atoll that has a very healthy lagoon system and in this case a healthier coral reef overall. Malden and Flint Atolls do not have lagoon systems. Some important species present at Caroline that were not seen at Malden and Flint Atolls were: the parrot fish, blunthead parrotfish, *Scarus microhinos,* and the marbled grouper, *Epinephelus inermis.* In general terms Caroline Atoll was well represented with the Labridae, Serranidae, Pomacentridae, Balistidae, and Cirrihitidae families. Significant families like the Chaedontidae, Pomacantihidae and Scaridae were relatively poorly represented. This overall pattern was consistent with the composition of families at Malden and Flint Atolls.

Locality	Observed # of Reef Fish Species	Est. # of Reef Fish Species	Known Reef Fish Species
French Polynesia		754	730
Society Islands		563	560
Tuamotu Islands		496	389
Hawaiian Islands		398	435
Marquesas Islands		267	331
Malden Atoll, (this survey)	**120**	*	*
Flint Atoll, (this survey)	**108**	*	*

Table 8. Overall reef fish diversity recorded at Malden and Flint Atolls compared to other Eastern Pacific atolls and islands. Source: (Allen, 2006) * *Note: there is no published figure for estimated reef fish diversity for the Line Islands or southern Line Islands – there is only an estimate for all of Kiribati. Given the extent of this area East to West this figure would not be very accurate for the Line Islands. Gilbert and Phoenix Island groups would be expected to have considerably higher diversity.*

The list reported here for Malden and Flint Atolls should be treated as an initial indication only of reef fish diversity, due to the small number of sites surveyed. It would be necessary to make many more observations to be certain of an estimate of the total number of reef fish species present. In comparing the observed numbers of species at Malden and Flint Atolls with estimated diversity at the Marquesas and Tuamotu Islands, it is possible that the Malden and Flint Atolls would have a total diversity approaching that of the Marquesas group. Typically total diversity can be a third larger or twice that what is observed in a very quick snapshot survey such as the one we have done. These quick counts of overall diversity indicate a healthy level of reef fish diversity when it is taken into account that these islands are very isolated oceanic atolls, whereas the Marquesas and the Tuamotus are complex archipelagos with greater habitat diversity.

Coral Health Rapid Assessment

Coral health observations for the three atolls visited are summarized below. Representative photographs are included in Appendix 2.

Atoll	Coral Health & Habitat Descriptions								# COT Obs.	COT Damage
	Wave Zone		Reef Flat		Reef Crest		Reef Slope			
	Depth	Est.% Live Coral	Depth	Est.% Live Coral	Depth	Est.% Live Coral	Depth	Est.% Live Coral		
Caroline	0-5m	<10	5-9m	30-60	9-12m	60-90	12-60m+	60-90	nil	nil
Malden	0-5m	<10	5-9m	20-40	9-12m	30-60	12-60m+	<10	nil	nil
Flint	0-5m	10-40	5-7m	50-80	7-8m	60-90	12-20m 20-60m+	60-90 <10	2	minor

Table 9. Summarized observations of coral health and habitat zonation.

We saw no evidence of recent (<1yr old) coral bleaching events and no conspicuous examples of coral disease. Crown of thorns starfish were seen only at Flint Atoll, with 2 starfish seen on 5 dives. There damage was minor, with just a few isolated coral colonies showing recent crown of thorns predation

The coral health observations from this survey should be interpreted with caution. Our observations were confined to the lee shore outer reef habitats which is just one of the suites of habitats found at these islands. Having said this, lee shore reefs have some of the best coral growth on many atolls.

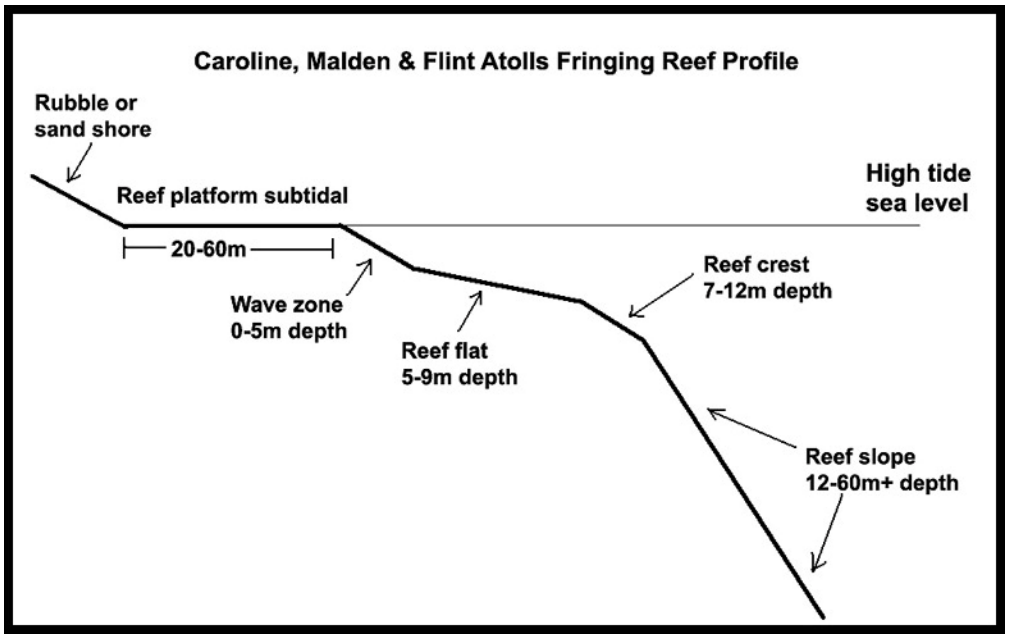


Figure 13. Generalized profile and habitats of the lee shore fringing reef at Caroline, Malden and Flint Atolls.

Caroline Atoll

Of the three atolls we visited Caroline Atoll stood out as having the most diverse and the healthiest coral reef community on its lee shore. In all the habitat zones except for the wave zone there was a thriving coral community. Large plate *Acropora* colonies were a feature. From the reef crest down the reef slope as far as we could observe the corals were thriving and generally in good health. The percentage of live cover often reached 90%. There was no sign of coral disease, recent coral bleaching, crown of thorn damage or elevated nutrient levels. There was some *Halimeda spp.* Algae growing on the reef but no other nutrient indicator algae were observed. The profile of the reef could best be described as very steep. Neither the reef platform nor the reef flat habitat zones extend very far off shore and are typically not very large. From the reef crest the reef plunges off down with very steep slopes to great depths..

Malden Atoll

The coral reef communities at Malden Atoll were characterized by lower live coral percentages across all the habitats than Caroline Atoll. There was an impression that there had been a serious impact on coral health in the past, (approximately 10-20+ year time frame). The reef slope habitat zone was particularly poor in coral cover with most areas dominated by old coral skeletons or rubble areas covered in encrusting red algae. Overall there was much less diversity than at Caroline Atoll. In most areas of live coral the community consisted mainly of small colonies of *Acropora* species apparently re-colonizing areas that were dominated by encrusting algal cover. Old dead coral colonies were largely intact which may suggest that the historic cause of decline on this reef was not storm related. Severe storm damage tends to grind the reef flat or to fine rubble. There was no sign of coral disease, recent coral bleaching, crown of thorn damage or elevated nutrient levels.

Flint Atoll

Overall the coral health was good at Flint Atoll along the lee shore. There were two observations that differed from the other two atolls visited. The wave zone and the reef flat had surprisingly good cover of small to medium sized *Acropora spp*. colonies. In places the coral cover was good right up to as shallow as 1m, which is surprising with an exposed oceanic atoll such as Flint. Another characteristic of the lee shore reef was the very sharp drop off in coral cover and coral health on the reef slope below 20m.There live corals had all but disappeared and rubble and encrusting algal cover were observed. At this stage we can not offer an explanation for this rather sharp boundary of change at 20m depth.

Evidence of Fishing Activity & Sunken Wrecks

Heavy monofilament line was observed in several locations on the reef at approximately 10-15m depth at both Flint and Malden Atolls. There was no fishing related debris observed at Caroline Atoll.

There was one wreck observed at Malden Atoll located at 7m depth approximately 300m South along the fringing reef from ‘Mooring Site 2’ (please refer to Fig.4). This wreck is from a steel ship possibly 20-30m in original length and now consists of

basically a skeleton of keel and ribs with some pieces of debris scattered around the immediate area.

Turtle Sightings

All sightings of turtles and their tracks were recorded and are summarized in Table 9 below. Turtles were present at all three atolls we visited. All three atolls had significant sandy shore areas suitable for turtle breeding. All had significant numbers of turtle tracks coming ashore and up the beaches. At all three atolls turtles were seen moving around the fringing reef during dives and from the boat. At Flint sightings of turtles were frequent with an estimated number of 20 individuals seen in the water along the lee shore. No tagging was attempted due to limitations of time ashore.

Atoll	Location	Number of Turtles Sighted	Est. No of tracks sighted	Common name	Notes
Caroline	West shore of North Islet		70-200	Sp. uncertain	Very suitable sandy beach habitat bordered by shallow reef flat
Caroline	East shore of North Islet		8	Sp. uncertain	estimated count
Caroline	Reef - west shore of North Islet	3		Sp. uncertain	estimated total from fish transects and coral survey
Malden	Reef - NW corner and along West shore	2		green	estimated total from fish transects and coral survey
Malden	Reef - NW corner and along West shore	4		Sp. uncertain	estimated total from fish transects and coral survey
Malden	SW, S, E & N shores		0	Sp. uncertain	entire shoreline was walked at night, N & East shore has some suitable beach areas
Malden	Western shore		50-100	Sp. uncertain	very suitable sandy beach habitat
Flint	Reef - NW &SW shores	20		green	estimated total from fish transects and coral survey

Flint	NW &SW shores		90-150	green	estimated count
Flint	NW shore beach	1		green	seen on beach
Flint	Eastern shore		30-40	green	estimated count

Table 9. Turtle sightings and observations

Marine Mammal Sightings

Table 10 below details marine mammal sightings made over the entire voyage, which traveled in roughly a North to South course from Tahiti to Malden Atoll and return. Just over three weeks in total were spent at sea or at anchor on lee shores of the islands visited. While at sea there was a crew member on watch at all times and in addition there was usually one or more crew on deck. All crew were instructed at the beginning of the voyage to immediately signal the presence of any marine mammals.

The only encounter we had was at anchor on the lee shore of Caroline Atoll where a small group of bottlenose dolphins, *Tursiops truncatus* came around the boat. On Malden Atoll one of our crew came upon a dead spinner dolphin, *Stenella longirostris* washed up on the beach. We did not have any sightings of whales over the entire survey voyage.

Atoll	Location	Number of Animals Sighted	Common Name	Notes
Caroline	Mooring site 1, Western shore of North Islet	4	Bottlenose dolphin	Possibly more animals present
Malden	Middle of North shore	1	Spinner dolphin	Dead washed up on shore

Table 10. Marine mammal sightings

Water Temperature

Water temperature was monitored continuously with a temperature logger attached to the bottom of the hull of our vessel and water samples were taken at regular intervals along the way. This data will be reported in a separate report from the Georgia Tech. research group. Typically surface temperatures were around 27-28 degrees C. We did not encounter any significant thermo clines down to 35m depths.

Seabird Counts and Observations

		Caroline	Malden			Flint
Common name	**Species name**	**4-Nov**	**10-Nov**	**11-Nov**	**12-Nov**	**17-Nov**
Brown booby	*Sula leucogaster*	187	153	43	61	111
Masked booby	*S. dactylatra*	7	5	1	1	
Red footed booby	*S. sula*	6				
Black noddy	*Anous minutus*	50				12
Brown noddy	*A. stolidus*	36				
Frigate birds (greater & lesser spp)	*Fregata* spp.	20	2	4	8	36
Sooty tern	*Sterna fuscata*	123	371	309	199	2
Common white tern	*Gygis alba*					27
Grey-backed tern	*Sterna lunata*	12				
Christmas shearwater		2				18
Totals		443	531	357	269	206

Table 11. Numbers of seabirds counted in 'evening fly-on counts of birds – at anchor'

Results of the evening fly on counts are detailed above in Table 11. This method has limitations as only a portion of the leeward side of the atoll is surveyed, and only species that return before darkness can be observed. Only 5 counts were completed. When considered along with other observations we made this information adds to the knowledge of the seabird species and abundance on these atolls.

Brown booby featured as the most abundant booby species on all three atolls. These islands probably have the largest populations of brown bobbies (presumably breeding) in the central Pacific.

All three atolls also had substantial sooty tern colonies. Caroline atoll stood out as having the highest diversity and abundance of seabirds, with grey-backed terns present. All three booby species, frigatebirds, black and brown noddies and Christmas shearwaters appear in our counts. At Flint Atoll a very large population of common white terns was evident. At all three atolls there were no tropicbirds sighted flying or observed by crew walking along the shoreline. Some storm-petrels (unknown species) were observed at sea, but none where seen while at the islands. No blue noddies where observed during the expedition.

Terrestrial Introduced Pest Species

All crew members (who spent time ashore) were asked to look for signs of rats and cats at all times.

At Caroline Atoll we had two crew members ashore over one night. In the area around North Islet, small rats thought to be Pacific rats (*Rattus exulans*) were commonly seen. No sightings of larger rats or cats or cat sign were made.

At Malden Atoll we had some (non-scientific) crew members ashore over two days and two nights. One person walked the entire atoll perimeter by foot at night by using a flashlight.. No trapping was attempted. No rat sightings or evidence was observed. A single sighting of what was believed to be cat tracks was made but identification of the tracks was not certain. As we did not look at coconuts etc for rat gnaw sign, or check for egg shells broken open etc then our observations need to be considered limited/anecdotal at best

At Flint Atoll we had one crew member ashore for one day and one night. Pacific rats were common and no sightings, or signs of, cats or other rat species were made.

Miscellaneous Notes

Hermit crabs were abundant on all three atolls. Coconut crabs were abundant on Flint and Caroline Atolls but were not observed on Malden Atoll.

Anchoring on the lee shores of all three of these atolls is difficult as the reefs drop off very steeply close to the fringing reef edge. We preferred to make temporary moorings by taking ropes down to attach to a solid coral outcrop on the reef at approx 15m depth. With a long rope and buoy which can be cast away quickly in an emergency this approach is workable and safer than attempting to anchor.

Landings at these three Atolls are also tricky and totally dependent on having minimal swell coming from the West, Southwest or Northwest. Any large swell from the North or South easily wraps around these atolls to make the lee shore difficult for landings. Even swells from the East tend to wrap right around the atoll to a considerable degree. As a result a safe landing can not be counted on. The man-made gut on the lee (NW) shore of Flint Atoll, easily seen from satellite photos is fine in flat sea conditions, however if there is any significant swell from westerly quarters this gut is very dangerous as the gut and the entrance to it is quite shallow causing even medium size waves to break. Malden has a stretch of steep beach which offers a reasonable shore landing if westerly swells are not too big. This is a very steep beach which makes landing with the surf especially tricky. There are no sand beach lee shore landings at Caroline and Flint Atolls. Caroline Atoll also has a blind passage on the southeast corner of the atoll. This passage is navigable by small boats as long as the easterly wind and swell is not too strong.

Discussion

The Southern Line Islands are situated in one of the most remote equatorial regions of the Pacific and are amongst the most Easterly of the Pacific's atoll groups. They are extremely remote and seldom visited with a history of sporadic human settlement. At the present they are uninhabited. All of these factors make these islands of unique ecological and heritage importance. While all the Southern Line Islands deserve consideration for protection because of their unique biodiversity value, Caroline Atoll stands out as having special values as an atoll system in near pristine state. It can not be overstated how important protection of this atoll is, as there are now so few of these systems left anywhere in the world. In its current state Caroline Atoll has tremendous scientific importance and ultimately ecotourism potential. The threat to

this world class atoll is a reality, as it could easily be fished out for small one off gains that would adversely affect it's marine biodiversity for generations.

Our voyage was one of the very few to these islands that has attempted to document the biodiversity values and in particular the marine values of their coral reef systems. Taken as a whole, our data and observations are only an indication of the biodiversity values that exist on these atolls.. Further data collection would be required to validate, support and extend the descriptions made here. Rapid assessments, such as those used on this expedition, made by scientists with experience in remote atoll surveys, can give a practical base of information to enable future planning of more detailed studies. We hope information such as this will assist the Kiribati government to plan and achieve the highest possible protection for the biodiversity these atolls.

Recommendations

1. All possible opportunities to collect further descriptive and monitoring information for these atolls should be encouraged in order to 1) regularly check that illegal exploitations of the atolls' resources is not occurring and 2) further develop and document the understanding of the biodiversity values of these atolls.

2. These coral reef atoll systems should be viewed as connected to the adjacent oceanic marine pelagic/seabird ecosystem. In all management planning a precautionary approach should be practiced, weighted on the side of conservation.

3. All of the Atolls visited are worthy of consideration for protection because of their unique heritage and in particular their coral reef values. Caroline atoll has the highest marine biodiversity values as well as high seabird and terrestrial values. It is likely based on this initial study that Caroline would rank up with a handful of the Pacific's most pristine coral reefs systems, justifying the position that it should be put forward for the highest level of protection achievable.

4. Consideration should be given to ways of achieving some sort of regular presence and surveillance on these atolls. This could be part of a concept to develop the ecotourism potential. Due to the extreme remoteness of these islands and the almost total lack of aerial surveillance opportunities, it would be ideal to create a warden or caretaker role, especially at Caroline Atoll. An example of this approach is the caretaker program at Suwarrow Atoll in the Northern Cook Islands carried out during each yachting season. Failure to establish some sort of regular presence and surveillance leaves a very high risk that future illegal fishing will have dramatic adverse affects on these islands.

Acknowledgements

Special thanks are due to the Department of Conservation who supported me in undertaking this work and granted time to be away from my work in New Zealand. Thanks to the entire Bounty Bay crew and especially the Georgia Tech research group on this voyage for putting in all the extra effort which made it possible to tackle the marine survey work. Thanks to Dr's Ray Pierce and Roger Grace who reviewed this manuscript, also thanks to Diane Kerr for her editing contribution.

References

Alling, A., Doherty, O., Logan, H., Feldman, L., Dustan, P., 2006**.** Catastrophic Coral Mortality in the Remote Central Pacific Ocean: Kiribati Phoenix Islands. Atoll Research Bulletin (in press).

Bohnsack, J.A., 1995. Two Visually Based Methods for Monitoring Coral Reef Fishes. Coral Reef Symposium January 26-27, 1995. Miami Laboratory, Southeast Fisheries Science Center, National Marine Fisheries Service, Miami, Fl.

Hill, J., Wilkinson, C., 2004. Methods for Ecological Monitoring of Coral Reefs, A Resource for Managers, Ver. 1. Australian Institute of Marine Science, PMB No 3, Townsville MC Qld 4810, Australia.

Obura, D., Stone, G., 2003. Summary of Marine and Terrestrial Assessments Conducted in the Republic of Kiribati, June 5-July 10, 2002 (2002). Primal Ocean Technical Report: NEAq-03-02, New England Aquarium, Boston.

Obura, D., G. Stone, G., S. Mangubhai, S. Bailey, A. Yoshinaga, C. Holloway, and R. Barrel, 2006a. Baseline Marine Biological Surveys of the Phoenix Islands, 2000. *Atoll Research Bulletin* (in press).

Obura, D., 2006b. Coral reef structure and zonation of the Phoenix Islands. *Atoll Research Bulletin* (in press).

R.J. Pierce, T. Etei, V. C. Kerr**,** E. Saul, A. Teatata, M. Thorsen, G. Wragg, 2006. Phoenix Islands conservation survey and assessment of restoration feasibility: Kiribati. Funded by Conservation International Samoa and Pacific Islands Initiative. Eco Oceania Ltd, Mt Tiger rd, Rd 1 Onerahi, Whangarei 019

Planetary Coral Reef Foundation, http://www.pcrf.org/phoenix.html P.O. Box 201, Pacific Palisades, CA 90272 Department of Biology, College of Charleston, SC 29424

Randall, J.E., 2005. Reef and shore fishes of the South pacific: New Caledonia to Tahiti and the Pitcairn Islands. University of Hawaii Press.

Rodgers, C.S., et al., 1994. Coral Reef Monitoring Manual for the Caribbean and West Atlantic. Southeast Regional Office, national park Service, Office of International Affairs, National Park Service.

Sluka, R.D., 2004. Humphead wrasse (*Cheilinus undulates*) abundance and size structure among coral reef habitats in Maldives. *Atoll Research bulletin* No. 538.

Stone, G., Obura, D., Bailey, S., Yoshinaga, A., Holloway, C., Barrel, R., Mangubhai, S., 2001. Marine Biological Surveys of the Phoenix Islands: Summary of Expedition Conducted from June 24-July 15, 2000. New England Aquarium Primal Oceans Program Report, New England Aquarium, Boston.

Stone, G. 2004. Phoenix Islands: a coral reef wilderness revealed. *National Geographic Magazine*, 205 (**2**), 48 – 64 (2004).

Appendix 1 Reef Fish Observed at Malden and Flint Islands

Appendix 2 Photo Collection from Caroline, Malden and Flint Atolls

Appendix 1 Fish Lists for Malden and Flint Atolls

Family	Species	Common Name	Malden	Flint
CARCHARHINIDAE	*Carcharhinus amblyrhynchos* (Bleeker, 1856)	Grey reef shark	1	1
CARCHARHINIDAE	*Carcharhinus melanopterus* (Quoy & Gaimard, 1824)	Blacktip reef shark	1	1
CARCHARHINIDAE	*Triaenodon obesus (*Rüppell, 1835)	Whitetip reef shark	1	1
MURAENIDAE	*Gymnothorax flavimarginatus* (Bennet, 1832)	Yellow margin moray	1	
MOBULINAE	*Manta biristris* (Walbaum, 1792)	Manta ray	1	
CHANIDAE	*Chanos chanos* (Forsskål, 1775)	Milkfish		1
BELONIDAE	*Tylosurus crocodilus* (Peron & Lesueur, 1821)	Hound needlefish		1
MUGILIDAE	*ID not certain*	Mullet		1
HOLOCENTRIDAE	*Myripristis berndti* (Jordon%Evermann, 1873)	Bigscale soldierfish	1	1
HOLOCENTRIDAE	*Sargocentron spiniferum* (Forsskal, 1775)	Sabre squirrelfish	1	1
SERRANIDAE	*Epinephelus areolatus* (Forsskal, 1775)	Areolate grouper	1	1
SERRANIDAE	*Epinephelus fasciatus* (Forsskal, 1775)	Blacktip grouper	1	1
SERRANIDAE	*Pseudanthias olivaceus* (Randall & McCosker, 1981)	Olive anthia		1
SERRANIDAE	*Epinephelus melanostigma* (Schultz, 1953)	Black spot	1	1
SERRANIDAE	*Cephalopholis miniata* (Forsskal, 1775)	Coral hind	1	
SERRANIDAE	*Cephalopholis urodeta* (Forster, 1801)	Darkfin grouper	1	1
SERRANIDAE	*Epinephelus socialis* (Gunther, 1873)	Surge grouper	1	
SERRANIDAE	*Epinephelus malabaricus* (Bloch & Sneider, 1801)	Malabar grouper	1	1
SERRANIDAE	*Cephalopholis argus (*Bloch & Sneider, 1801)	Peacock hind	1	1
SERRANIDAE	*Pseudanthias pascalus* (Jordan & Tanaka, 1927)	Purple queen	1	
SERRANIDAE	*Anyperodon leucogrammicus* (Valenciennes, 1828)	Slender grouper	1	
SERRANIDAE	*Pseudanthias bartlettorum* (Randall & Lubbock, 1981)	Bartlet's anthia	1	1
CIRRHITIDAE	*Paracirrhites arcatus* (Cuvier, 1829)	Arc-eye hawkfish	1	1
CIRRHITIDAE	*Paracirrhites forsteri* (Schneider, 1801)	Blackside hawkfish	1	1
CIRRHITIDAE	*Paracirrhites bicolor* (Randall, 1963)	Bicolor hawkfish	1	1
CIRRHITIDAE	*Cirrhitichthys oxyycephalis* (Randall1963)	Pixe hawkfish	1	
CIRRHITIDAE	*Paracirrhites hemistictus* (Günther, 1874)	Half-spotted hawkfish	1	1
CIRRHITIDAE	*Paracirrhites xanthus* (Randall, 1963)	Yellow hawkfish	1	
CIRRHITIDAE	*Cirrhitus pinnulatus* (Forsyer, 1801)	Stocky hawkfish		1
CIRRHITIDAE	*Neocirrhites armatus* (Castelnau, 1873)	Flame hawkfish		1

APOGONIDAE	*Ostorhinchus apogonides* (Smith & Radcliffe, 1911)	Striiped cardinalfish	1	
ECHENEIDAE	*Echeneis naucrates* (Linnaeus, 1758)	Sharksuckers		1
CARANGIDAE	*Caranx ignobilis* (Forsskål, 1775)	Giant trevally	1	
CARANGIDAE	*Caranx sexfasciatus* (Qouy & Gaimard, 1825)	Big eye trevally	1	1
CARANGIDAE	*Caranx melampygus* (Cuvier, 1833)	Bluefin trevally	1	1
CARANGIDAE	*Carangoides orthorgrammus* (Jordon & Gilbert 1882)	Island jack	1	1
CARANGIDAE	*Elagatis bipinnulatus* (Qouy & Gaimard, 1825)	Rainbow runner	1	
CARANGIDAE	*Trachinotus baillonii* (Lacepede 1801)	Smallspotted pompano	1	
CARANGIDAE	*Scomberoides lysan* (Forsskål, 1775)	Double-spotted queenfish	1	1
CARANGIDAE	*Decapterus macarellus* (Cuvier, 1833)	Mackeral scad	1	
LUTJANIDAE	*Lutjanus kasmira* (Forsskål, 1775)	Bluestipped	1	
LUTJANIDAE	*Lutjanus monostigma* (Cuvier, 1828)	One-spot snapper	1	1
LUTJANIDAE	*Aphareus furca* (Lacepède, 1802)	Small tooth jobfish	1	1
LUTJANIDAE	*Lutjanus bohar* (Forsskål, 1775)	Twinspot snapper	1	1
LETHRINIDAE	*Lethrinus xanthochilus* (Klunzinger, 1870)	Yellow lip	1	1
LETHRINIDAE	*Gnathodentex aurolineatus* (Lacepède, 1802)	Goldlined	1	1
LETHRINIDAE	*Monotaxis heterpdon* (Bleeker, 1854)	Redfin emperor	1	1
MULLIDAE	*Parupeneus multifasciatus* (Quoy & Gaimard, 1825)	Multibar goatfish		1
MULLIDAE	*Parupeneus crassilabrus* (Valenciennes, 1831)	Thicklipped goatfish	1	1
KYPHOSIDAE	*Kyphosus pacificus* (Lacepede, 1801)	Pacific chub	1	
KYPHOSIDAE	*Kyphosus sydneyanus* (Gunther, 1886)	Blackfin chub	1	
CHAETODONTIDAE	*Chaetodon pelewensis* (Kner, 1868)	Dot-dash butterflyfish		1
CHAETODONTIDAE	*Forcipiger flavissimus* (Jordan & McGregor, 1898)	Forcepsfish	1	1
CHAETODONTIDAE	*Chaetodon ou natissimus* (Cuvier, 1831)	Ornate butterflyfish	1	1
CHAETODONTIDAE	*Hemitaurichthys thompsoni* (Fowler, 1923)	Thompson's	1	
CHAETODONTIDAE	*Chaetodon lunula* (Lacepède, 1802)	Racoon butterfish	1	1
CHAETODONTIDAE	*Chaetodon reticulatus* (Cuvier, 1831)	Reticulated butterfish		1
CHAETODONTIDAE	*Chaetodon unimaculatus* (Bloch, 1787)	Teardrop butterflyfish		1
POMACANTHIDAE	*Pomacanthus imperator* (Bloch, 1787)	Emperor angelfish	1	1
POMACANTHIDAE	*Centropyge flavissimus* (Cuvier, 1831)	Lemonpeel angelfish	1	1
POMACANTHIDAE	*Paracentropyge multifasciata* (Carlson & Taylor, 1981)	Griffth's angelfish	1	1
POMACANTHIDAE	*Centropyge loriculus (*Gunther, 1874)	Flame	1	1
POMACENTRIDAE	*Chromis agilis* (Smith, 1960)	Agile chromis	1	1

POMACENTRIDAE	*Chromis margaritifer* (Fowler, 1946)	Bicolor chromis	1	1
POMACENTRIDAE	*Plectroglyphidodon johnstonianus* (Fowler & Ball, 1924)	Blue-eye damselfish	1	1
POMACENTRIDAE	*Plectropglyphidodon dicki* (Lièнard, 1839)	Dick's damselfish	1	1
POMACENTRIDAE	*Stegastes nigricans* (Lacepède, 1802)	Dusky gregory	1	1
POMACENTRIDAE	*Abudefduf sordidus* (Forsskal, 1775)	Blackspot sergeant	1	1
POMACENTRIDAE	*Plectroglyphidodon phoenixensis* (Schultz, 1943)	Pinkbarred Damselfish	1	1
POMACENTRIDAE	*Abudefduf septemfasciatus* (Cuvier, 1830)	Seven bar sergeant	1	1
POMACENTRIDAE	*Plectroglyehiedon imparipennis* (Vaillant & Sauvage, 1875)	Brighteyed damselfish	1	1
POMACENTRIDAE	*Dascyllus trimaculatus* (Rüppell, 1828)	Threespot dascyllus	1	
POMACENTRIDAE	*Chromis vanderbilti* (Fowler, 1941)	Vanderbilt's chromis	1	1
POMACENTRIDAE	*Stegastes aueus* (Fowler, 1927)	Golden gregory	1	1
POMACENTRIDAE	*Chromis xanthura* (Bleeker, 1854)	Variable chromis	1	1
SPHYRAENIDAE	*Sphyraena genie* (Klunzinger, 1870)	Blackmargin barracuda	1	1
LABRIDAE	*Hemigymnus fasciatus* (Bloch, 1792)	Barred thicklip wrasse	1	1
LABRIDAE	*Labroides bicolor* (Fowler & Bean, 1928)	Bicolor cleaner wrasse	1	1
LABRIDAE	*Gomphosus varius* (Lacepède, 1801)	Bird wrasse	1	1
LABRIDAE	*Bodianus loxozonus* (Snyder, 1908)	Blackfin hogfish	1	1
LABRIDAE	*Labroides dimidiatus* (Valenciennes, 1839)	Stripped cleaner wrasse	1	1
LABRIDAE	*Thalassoma amblycephalum* (Bleeker, 1856)	Bluntheaded wrasse	1	1
LABRIDAE	*Coris centralis* (Randall, 1999)	Central pacific coris	1	1
LABRIDAE	*Halichoeres hortulanus* (Lacepède, 1801)	Checkerboard wrasse	1	1
LABRIDAE	*Coris aygula* (Lacepède, 1801)	Clown coris	1	1
LABRIDAE	*Thalassoma quinquevittatum* (Lay & Bennett, 1839)	Fivestripe wrasse	1	1
LABRIDAE	*Bodianus prognathus,* (Lobel, 1981)	Long-nosed hogfish	1	
LABRIDAE	*Bodianus diana* (Lacepède, 1801)	Redfin hogfish	1	
LABRIDAE	*Labroides rubrolabians* (Randall, 1958)	Redlipped cleaner	1	1
LABRIDAE	*Stethojulis bandanensis* (Bleeker, 1851)	Redshoulder wrasse	1	1
LABRIDAE	*Pseudocheilinus hexataenia* (Bleeker, 1857)	Sixstripe wrasse	1	1
LABRIDAE	*Epibulus insidiator* (Pallas, 1770)	Slingjaw wrasse	1	
LABRIDAE	*Bodianus mesothorax* (Bloch & Schneider, 1801)	Split-level hogfish	1	
LABRIDAE	*Thalassoma lutescens* (Lay & Bennett, 1839)	Sunset wrasse	1	1

LABRIDAE	*Halichoeres margaritaceus* (Valenciennes, 1839)	Weedy surge wrasse	1	1
LABRIDAE	*Anampses twistii* (Bleeker, 1856)	yellow breasted wrasse	1	1
LABRIDAE	*Coris gaimard* (Quoy & Gaimard, 1824)	Yellowtail coris	1	1
SCARIDAE	*Chlororus sordidus* (Forsskål, 1775)	Bullethead parrotfish	1	
SCARIDAE	*Scarus rubroviolaceus* (Bleeker, 1847)	Ember parrotfish	1	1
SCARIDAE	*Scarus festivus* (Valenciennes, 1840)	Festive parrot fish	1	
SCARIDAE	*Scarus spinus* (Kner, 1868)	Greencap parrotfish		1
BLENNIIDAE	*Cirripectus alboapicalis* (Ogilby, 1899)	whitedotted blenny		1
BLENNIIDAE	*Exalis brevis* (Kner, 1868)	Shortbodied blenny	1	1
ACANTHURIDAE	*Naso vlamingi* (Valenciennes, 1835)	Bignose (vallings)		1
ACANTHURIDAE	*Acanthurus nigoris* (Valenciennes, 1835)	Bluelined surgeonfish	1	1
ACANTHURIDAE	*Naso unicornis* (Forsskål, 1775)	Bluespine unicornfish		1
ACANTHURIDAE	*Ctenochaetus marginatus* (Valenciennes, 1835)	Bluespotted bristletooth	1	1
ACANTHURIDAE	*Acanthurus achilles* (Shaw, 1803)	Archilles tang	1	1
ACANTHURIDAE	*Zebrasoma scopas* (Cuvier, 1829)	Brushtail tang	1	1
ACANTHURIDAE	*Acanthurus triostegus* (Linnaeus, 1758)	Convict surgeonfish	1	1
ACANTHURIDAE	*Acanthurus dussumieri* (Valenciennes, 1835)	Eyestripe surgeonfish	1	1
ACANTHURIDAE	*Acanthurus nigricans* (Linnaeus, 1758)	Goldrim surgeonfish	1	1
ACANTHURIDAE	*Naso caesius* (Randall & Bell, 1992)	Gray unicornfish	1	1
ACANTHURIDAE	*Acanthurus lineatus* (Linnaeus, 1758)	Lined surgeonfish	1	1
ACANTHURIDAE	*Acanthurus guttatus* (Forster, 1801)	Whitespotted surgeonfish	1	1
ACANTHURIDAE	*Naso lituratus* (Forster, 1801)	Orangespine unicornfish	1	1
ACANTHURIDAE	*Zebrasoma veliferum* (Bloch, 1797)	Sailfin tang	1	1
ACANTHURIDAE	*Naso hexacanthus* (Bleeker, 1855)	Sleek unicornfish	1	1
ACANTHURIDAE	*Acanthurus thompsoni* (Fowler, 1923)	Thompson's	1	1
ACANTHURIDAE	*Ctenochaetus flavicauda* (Fowler, 1938)	Whitetailed bristletooth	1	1
ZANCLIDAE	*Zanclus cornutus* (Linnaeus, 1758)	Moorish idol	1	1
SCOMBRIDAE	*Gymnosarda unicolor* (Rüppell, 1838)	Dogtoothed tuna	1	1
BALISTIDAE	*Balistapus undulatus* (Park, 1797)	Orangelined triggerfish	1	1
BALISTIDAE	*Balistoides viridescens* (Bloch & Schneider, 1801)	Titan triggerfish	1	1
BALISTIDAE	*Melichthys vidua* (Solander, 1844)	Pink tailed	1	1
BALISTIDAE	*Rhinecanthus rectangulus* (Bloch & Schneider, 1801)	Wedge triggerfish	1	
BALISTIDAE	*Melichthys niger* (Bloch, 1786)	Black duragen triggerfish	1	1
BALISTIDAE	*Sufflamen bursa* (Bloch & Schneider, 1801)	Scimitar triggerfish	1	1

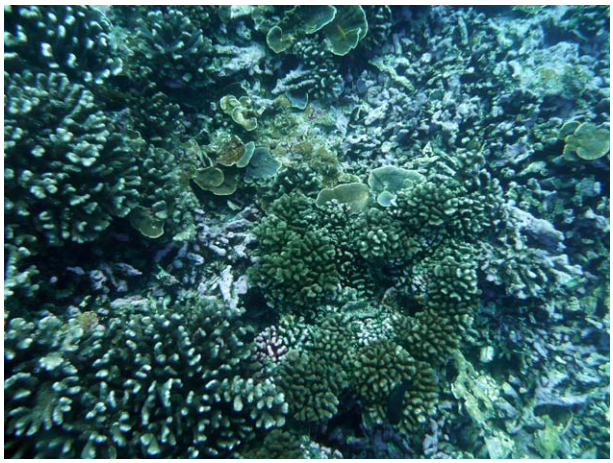
MONOCANTHIDAE	*Aluterus scriptus* (Osbeck, 1765)	Scrawled scribled ? filefish	1	1
MONOCANTHIDAE	*Amanses scopa (*Cuvier 1829)	Broom filefish	1	1
MONOCANTHIDAE	*Cantherines dunerilii* (Hollard, 1854)	Barred file fish	1	1
OSTRACIIDAE	*Ostracion cubicus* (Linnaeus, 1758)	Yellow boxfish	1	
OSTRACIIDAE	*Ostracion meleagris* (Shaw, 1796)	Spotted boxfish	1	
TETRAODONTIDAE	*Arothron meleagris* (Lacepede, 1798)	Guineafowl puffer	1	1
Diodontidae	*Diodon hystrix* (Linnaeus, 1758)	Porcupine fishes	1	1
Total # of Species Both Atolls = 132		**Total # of Species for each Atoll**	**120**	**108**
Note: Coomon names are from Randall, (2005)				

Appendix 2 Representative Photos

Pic1 Caroline Atoll reef slope

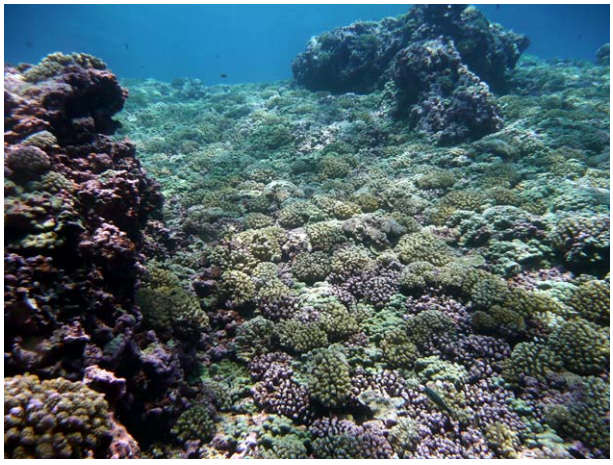
Pic2 Caroline Atoll reef flat looking up to surf zone

Pic 3 Malden Atoll reef crest



Pic 4 Malden Atoll reef flat

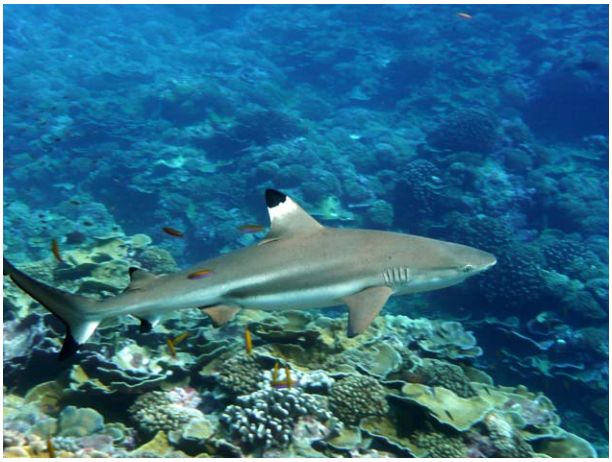
Pic 5 Flint Atoll reef slope



Pic 6 Flint Atoll reef flat

Pic 7 Steephead parrotfish, *Scarus microrhinos* At Caroline Atoll

Pic 8 Napoleon wrasse at Caroline atoll



Pic 9 Blacktip shark at Caroline Atoll

Pic 10 Trevally, surgeon fish and anthias in abundance at Caroline Atoll

Pic 11 Shipwreck on reef flat, Malden Atoll

Pic 12 Yellow hawkfish, Malden Atoll

Pic 13 school of surgeon fish Malden Atoll

Pic 14 Puffer fish Malden Atoll

Pic 15 Green turtle, Flint Atoll

Pic 16 Red snapper, Flint atoll

Pic 17 Reef flat and school of trigger fish

Pic 18 Fishing line entangled in the reef at Flint atoll