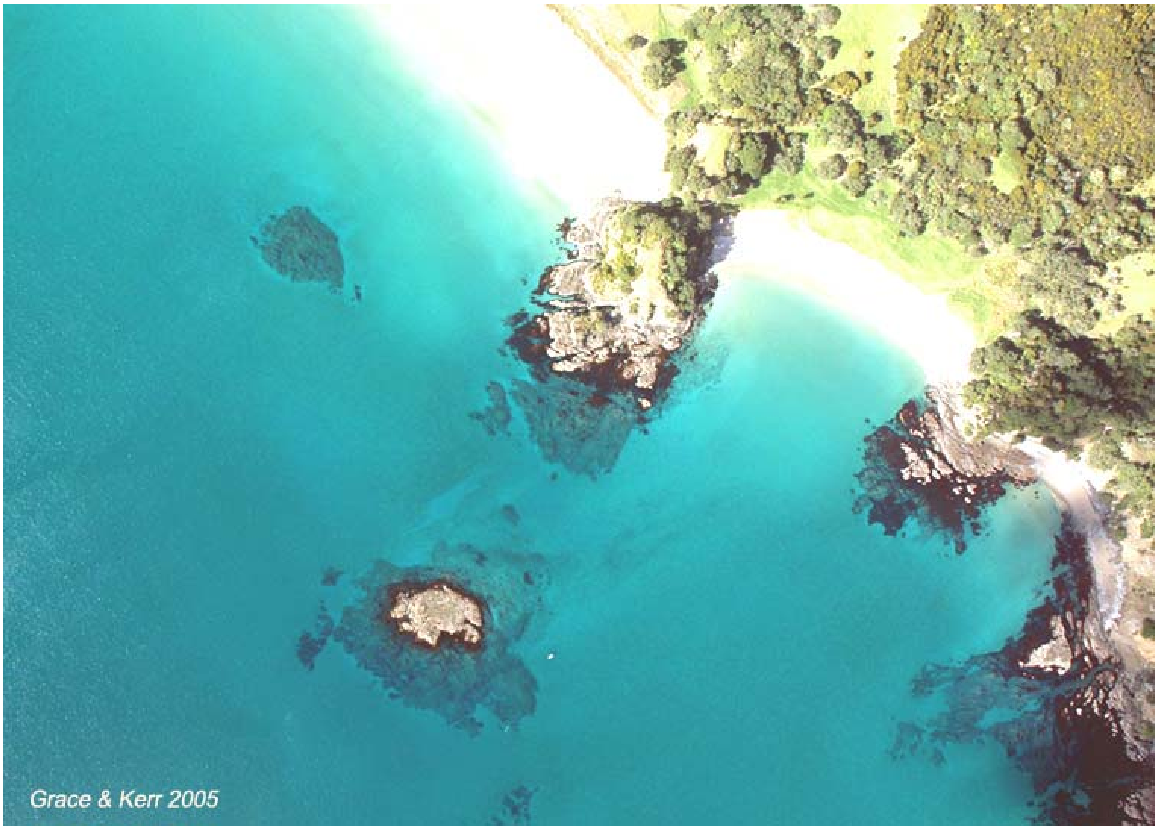
Towards a Strategy for Future Marine Monitoring at Mimiwhangata



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For

Department of Conservation,
Northland.
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Cover picture: Dramatic changes in algal forests, and associated loss of biodiversity, have occurred throughout Northland in the latter decades of last century, mainly as a result of trophic cascade effects from heavy fishing. The pale rock off Pa Point is kina barren, where 30 years ago lush tangle-kelp forest predominated. Restoration of algal forests is expected to be a key response to protection within the future no-take marine reserve. Aerial photo Grace & Kerr, May 2005.

Summary

The Mimiwhangata Marine Monitoring Programme was a pioneering endeavour established in 1976 as an aid to management in the then proposed Marine Park. Emphasis was on species likely to be taken as seafood with a view to ensuring their long-term viability as a recreational resource.

The Mimiwhangata Marine Park was set up in 1984 with special rules for recreational fishers, though commercial fishing continued up to 1993. Monitoring carried on at variable intervals from 1976 to 1986 then lapsed for 15 years, but was resumed in 2001 and continued to 2005.

Details of methods used are presented and their merits and weaknesses discussed. Development of new monitoring techniques and an expectation of statistical rigour, as well as aspirations regarding regional and national consistency in monitoring proceedures, suggests that the historic monitoring programme is due for an overhaul.

The historic data sets contain much valuable information, however, especially in view of the parallel programme which has been running at Tawharanui Marine Park over a similar long time period. Despite the perceived weaknesses of parts of the historic programme, extremely valuable analyses are possible, for example the comparison of effects of different management regimes on crayfish populations at Tawharanui (no-take) and Mimiwhangata (partial protection).

Recommendations are made for future monitoring, incorporating some modern philosophies and priorities to blend with the old, thus not losing the value of the long-term data sets already achieved, but bringing the monitoring programme more in line with modern thinking.

1. Introduction.

Monitoring of marine life at Mimiwhangata commenced in 1976, and continued, regularly in the early years but more intermittently thereafter, up to 1986. There was then a gap of about 15 years with no monitoring. Monitoring recommenced in 2001, and has continued annually up to and including 2005.

There needs to be a rationalisation of the existing monitoring programme in the light of recent experience with monitoring methods, and a new set of objectives and timelines sorted out. There is also the possibility of multi-reserve projects, which have value on a broader regional or national scale.

This document discusses monitoring to date, and investigates options for the future of marine monitoring at Mimiwhangata.

2. Monitoring last century.

The history of marine monitoring at Mimiwhangata goes back to the mid 1970's, when the owners of Mimiwhangata Station, Lion Breweries Ltd., had a vision of a Farm Park and an associated Marine Park, managed sustainably for the enjoyment of all New Zealanders. The Breweries had already commissioned a marine report (Ballantine et al., 1973) in which the marine life of Mimiwhangata was documented and described, and the marine habitats mapped in a pioneering study regarded as a first in New Zealand if not the world.

Lion Breweries, and the Mimiwhangata Charitable Trust they set up in 1975, envisioned a marine park in which commercial fishing would be prohibited, but tightly controlled recreational fishing would be allowed, using "environmentally friendly" methods and for a limited range of "fishing-tolerant" species. It was considered appropriate that all other marine life be totally protected. (The special fisheries regulations established on creation of the Marine Park in 1984 are set out in Appendix I).

Because the land was privately owned, public access to Mimiwhangata was limited to visitors arriving by boat, or walking along the shoreline. Both means of access were difficult and visitors were few. The Breweries and the Trust were aware that opening up the property for easy public access by road had the potential of increasing extractive impacts on the marine life, particularly that on or adjacent to the shore.

As an aid to management in the future Marine Park, they engaged Dr Roger Grace to establish a monitoring programme to follow changes in marine life on the shore and in subtidal areas (Grace, 1978). Emphasis was on those species which were likely to be taken by visitors for seafood, although peripheral observations were also to be made to keep an eye on the general well-being of the marine environment.

In 1976 marine monitoring programmes were in their infancy worldwide, so many of the methods had to be "invented" and specially tailored to suit the specific needs of the programme, environmental conditions, and types of marine life present at Mimiwhangata. When the programme was established there was little regard for the need for statistical rigour in monitoring design - an important feature in most modern monitoring regimes.

The historic programme has produced an unusually long-term data set and thus has special value. In addition, a parallel programme was running concurrently at Tawharanui, so monitoring was thus replicated on a large regional scale. This adds unique value to the historic data sets for Mimiwhangata and Tawharanui, particularly as the two areas started out with similar management, but then diverged in the degree of protection offered in the two marine parks.

3. Monitoring programme set up in 1976.

The Mimiwhangata Marine Monitoring Programme was established in winter 1976. The Programme was designed to provide long-term stocktaking information on the marine resources, particularly popular edible species, to facilitate their management and conservation. There was little consideration given to the idea of establishing "control" sample sites outside the proposed marine park area, except that one oyster monitoring site was established at Oakura.

To try to understand seasonal changes, in the first year of monitoring sampling was carried out quarterly, in winter, spring, summer and autumn. After that sampling was carried out in spring and in late summer, to try to see any differences over the summer period as a result of the summer influx of visitors.

Subsequently sampling became more intermittent, with sampling mainly occurring in summer. There were gaps when no sampling occurred in some years, and not all parts of the programme were completed during each sampling session, largely due to budget restraints. The last full monitoring occurred in summer 1986 after which there was a gap of 15 years. A listing of sampling times is given in Appendix 2.

Species targetted.

The species or species groups targetted for monitoring included;

Intertidal: rock oysters, tuatua, kina (in pools), green-lipped mussels

Subtidal: reef fish, crayfish, kina (subtidal), and scallops.

Location of sites.

The approximate locations of each sampling station is shown in Figure 1.

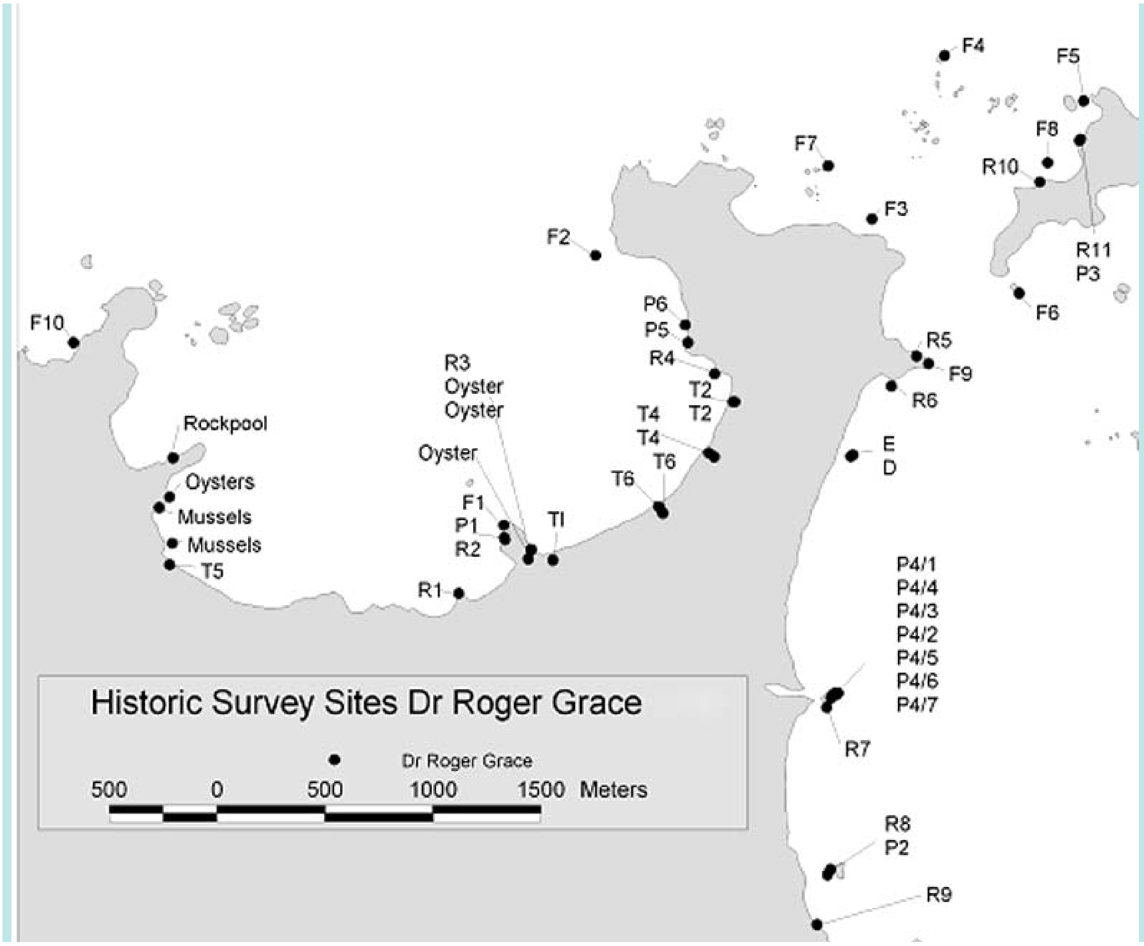

Figure 1. Location of historic monitoring sites established in mid 1970's (Grace 1978). F1 to F10 are fish and crayfish sites. R series are rock oyster sites. P series are intertidal kina pools. "Mussels", D & E are green mussel sites. T series are tuatua transects. (Scallop sites not included on map).

The location of each intertidal sampling station was influenced by the following considerations:

known established beds of popular edible shellfish;
ease of access from land or sea;
likely focal points of activity for visitors to Mimiwhangata.

The locations of the subtidal scallop sites were selected on a haphazard basis, attempting to cover a range of depths and sediment types, and degrees of exposure.

The locations of fish and crayfish sampling sites were decided on a subjective basis with consideration of the following criteria:

1. Approximately 10 sites were wanted to represent the study area, and spread around the area as well as possible, but with consideration also of the ability to dive at those areas reasonably reliably. There seemed little point, for example, in placing sites were it was unlikely we could dive on most occasions because of high swell or poor visibility.

2. As the purpose of the study primarily was to assess human exploitation impacts on the populations, it was decided to locate stations where visiting divers would be likely to dive. There seemed little point in placing sites in what would seem "boring" areas for divers. With this in mind sites were chosen which were fairly prominent within the local area, looked interesting when nearby in a boat and where it was expected a diver new to the area would choose to dive.

3. The area at each site was explored to find the "best" location in which to place the permanent 50 x 10m transect. Given that crayfish and reef fish numbers are dependant to a large degree on the abundance of good habitat, which in turn means high topographical complexity of the reef, with plenty of holes, overhangs, caves and tunnels, sites were chosen which contained the best of these features.

4. In most cases the zero end of the transect was placed at or close to the low water mark on the rocky shore, with the transect running more or less perpendicular to the shore at that point.

There was no attempt to keep the 50 x 10m transect within a particular habitat. In fact the opposite was true - where possible each transect cut across habitat boundaries, to include as much habitat variety as possible within the transect.

There was no precedent to follow with respect to transect length or width. This was simply decided on a common sense basis. Given the topographical complexity of the chosen sites, the sample size had to be sufficient to result in reasonable numbers of fish and crayfish, but also able to be completed comfortably in a single dive. With those factors in mind the 50 x 10 metre sample size was determined.

Marking of sites.

GPS was not available in 1976. Sites were marked on existing maps and on the most detailed aerial photographs available at the time (the 1950 black and white series). The location of the zero end of each transect was recorded as closely as possible on the aerial photograph, and if necessary a series of topside photographs was used to "zoom in" on the exact position. More recently the exact sites have been located and recorded using a hand-held GPS.

Intertidal sites were marked by different methods depending on the physical nature of the habitat.

Oyster transects, for example, were marked by drilling a hole in the rock with a 5mm masonry bit in a hand drill, to a depth of around 40mm. A short length of stiff plastic tubing was hammered into the hole, reaching the bottom but leaving about 10mm protruding. A short piece of 3mm PVC welding rod was then hammered down the inside of the tube, whereupon it tended to bind up upon reaching the bottom and becoming a very sturdy peg. This was then trimmed off with side-cutters to about 10mm above the rock surface. These pegs are small and very inobtrusive, but are relocatable with care, local knowledge, and sometimes with reference to exisiting oyster transect photos. Approximately 30 of these pegs were used at Mimiwhangata and a similar number at Tawharanui. At Mimiwhangata, in the 26 years from 1976 to 2001 approximately four of these pegs were lost through the peg falling out of the hole. At Tawharanui they have not been examined since about 1990 when they were apparently all still present.

Intertidal kina pools were not physically marked, but just described, drawn, and indicated on the aerial photographs. Sometimes measured distances and directions from other more obvious points were used to pinpoint the kina pools. A similar method was used to record areas where green-lipped mussels were counted.

Tuatua transects were initially marked with a labelled wooden fence batten hammered into the dune about five metres back from the dune front. Unfortunately during the severe storm of July 1978 some seven metres was eroded from the dunes, washing out the tuatua transect markers. Since then transects have been marked with reference back to the farm fence posts about 20 metres behind the dune front.

Scallop sampling sites were located with reference to transit marks based on lining up clear landmarks.

Fish and crayfish transects were located either using obvious physical landmarks, or sometimes with steel marker bolts. In these cases, the exact zero point was marked using a stainless steel bolt embedded head down in "expocrete" - a type of underwater cement - in a small hole drilled with a hand-held star-drill. The exposed end of the bolt was raised about 40mm above the rock surface. This formed a convenient peg to which the zero end of the transect line could be attached securely for each survey.

It is worth noting that, after some 29 years, most of the markers placed by this method are still in place and look almost as good as new. A few went missing as the piece of rock into which they were embedded broke away through natural erosion, but none were lost due to failure of the bolt or expocrete cement or the bond between the rock and the cement. At both Mimiwhangata and Tawharanui the rock type where this method was used is greywacke, a hard erosion-resistant rock which contributed to the long-term success of this marking method. The rock is often jointed, resulting in chunks of rock containing the marker bolt sometimes falling out.

Transect alignment.

During oyster monitoring the observer carried a card with transect alignment details on it. The zero end was indicated as the "south" or "east" peg as appropriate, and the transect direction and distance was also indicated on the card. A measuring tape was laid out between the appropriate marker pegs.

Tuatua transects generally ran down the beach perpendicular to the dune front.

Scallop transects ran from the zero point indicated by transit marks, in a particular direction either indicated as a compass direction or towards a defined landmark.

Fish and crayfish transects generally ran from the zero mark (usually close to low tide mark) offshore in a direction determined with reference to local landmarks. This was indicated either by a back-sight from the zero point to a landmark on shore, or a direction from the zero point toward a landmark or feature visible in the distance on the line of the transect. The transect line was usually swum out on the surface in the appropriate direction before the diver took the 50m end of the line to the bottom and secured it temporarily. Thus the transect line was placed in the same spot on the bottom during each survey.

Transect mapping.

Detailed topographic maps of each fish and crayfish transect were drawn, for all sites at Tawharanui, and some sites at Mimiwhangata. The transect line was laid out on the bottom, and using a prepared and gridded underwater writing pad, major features were mapped in 5-metre squares along each side of the line, while swimming a few metres above the bottom.

The maps allowed major crayfish lairs, or specific reef fish holes, to be mapped, as well as the extent and nature of algal forests over the years. Any other features of special interest, such as individual sponges, could also be mapped and their growth or decline recorded over a long time frame. The maps also helped the divers (especially any new to the monitoring programme) to be confident they were sampling in the right place.

4. Sampling methods set up in 1976.

Rock oysters.

Rock oysters were monitored by three methods:

1. Photographic transects

Oyster transects were photographed along a metric measuring tape laid out between the appropriate marker pegs. Each photo covered 0.5m of the tape, with a slight overlap between adjacent photos. The first photo at each site included a card with date and site information within the frame. To eliminate harsh shadows in bright sunlight, an umbrella was held so as to shade the area of the photograph. In the early years black and white film was used, and the photos laid out in sequence on white card. In later years colour print film was used, and commercial prints of postcard size produced and attached to card pages.

Direct comparison of individual oysters between sampling times was possible by this method. The total area covered by each of these transects varied from 1.0 sq.m. for a 3-metre long transect, to 1.7 sq.m. for a 5-metre transect.

Over the years this method has produced interesting results, following the influx of Pacific oysters to the area around 1978, long-term die-off of oysters due to old age and a lack of recruitment, and complete changes from oyster-dominated rocks to barnacle and small black mussel domination. As individual oysters can be followed, it is possible to determine growth rates and ages for individual oysters. One at Waikahoa Bay survived for about 20 years. A lot of interesting scientific study could be carried out on the historic series of photographs.

This method was good for following natural changes in the oyster populations, but the area covered was generally too small to be useful for detecting illegal removal of oysters.

2. Counting transects

In the early few years counts were made of dead oysters in four categories generally related to the time period for which the base shell had been exposed. This was carried out either on the same area as the photographic transects, or on an adjacent area of rock. Counting transects were usually 10 metres long and one metre wide. Note that only dead oysters were counted. Live oysters were at that time so abundant as to be virtually impossible to count on this scale.

A metric tape was laid in a straight line in a specified direction from one of the photographic transect markers. In a one-metre wide strip parallel to the tape, counts were made of the following categories of dead oysters:

(i) Dead oyster, but with the upper valve of the shell still attached to the base shell at the hinge. Inferred cause of death is natural.

(ii) Fresh white base shell exposed. Indicates recent death and is typical of artificial removal. Sometimes a chip or scratch on the base shell indicates removal with an instrument.

(iii) Base shell exposed as in (ii) above, but weathering of shell surface indicates that death did not occur very recently.

(iv) Base shell exposed as in (ii) and (iii) above, but heavy weathering indicates that death occurred some time ago, generally more than six months previously.

Once the base shell started to erode to the extent that holes or chunks were missing from the shell, it was no longer monitored.

This method produced some academically interesting results, and occasionally detected incidences of illegal oyster removal, but the transect size was also too small to be of much value for monitoring harvest of oysters and was discontinued.

3. Observations of recent "oyster feasts".

Removal of the top shell and flesh of an oyster leaves a conspicuous white shell attached to the rock, which is clearly visible for a few months before it weathers and dulls. Oyster gatherers frequently work in a small area, leaving an obvious patch of white shells scattered over a few square metres.

One of the most practical and simple methods of assessing human impact on the oysters was to note these patches of white shells while traversing the shores to reach the formal monitoring sites. The location of a patch was noted, and numbers of white shells counted in each area affected. The shells were also examined for any tell-tale marks which would clearly indicate removal with a sharp instrument, usually a knife or a screwdriver.

Over the years this simple method gave the clearest indication of changes in oyster poaching, and documented the upsurge in oyster poaching soon after the Farm Park was opened to the public in 1980.

Tuatuas.

Tuatuas were sampled on transects at Mimiwhangata Beach. A transect line was run down the beach from the marker point (usually a fence post) and specific features measured from the datum point, such as the dune front, high tide mark for the day, and low water for the day. Quadrats were dug and sieved generally at 5 metre intervals between the tide lines, but more closely where a dense bed of tuatuas occurred. Quadrat sizes varied over the years, but were generally between 0.1 sq.m. and 1.0 sq.m. Sieve mesh size was usually 2mm. The most recent sampling (2005) used 0.1 sq.m. quadrats and 5mm wire mesh.

In the early days of monitoring, sampling was continued into the subtidal area off the beach by diving, to a distance of 200 metres from the marker at the top of the transect.

A sample of 100 or more individuals was taken from the densest part of the bed for size-frequency analysis, using a measuring board or simply holding each tuatua against a ruler. Shift in the mode (most frequent length) of tuatuas between sampling times reflected the growth of the tuatua population.

Sometimes absolute numbers of tuatuas in particular beds were crudely estimated by taking several samples for density estimates, noting the area covered by the bed, and making a simple arithmetic calculation.

Kina (sea urchins) - intertidal.

Kina pools were examined at low tide. Usually all kina were removed from the pool and measured across their greatest diameter. Initially this was done with calipers to the nearest millimetre, but later each kina was "eye-balled" against a ruler and the shell diameter estimated in 5mm intervals. Kina were kept out of the sun as much as possible and returned to the pool with time to re-attach properly before the tide came in. In some instances kina were counted only and not measured. Gravelly areas in some pools were carefully examined for juvenile kina, which tend to hide amongst the gravel close to the rock edge. Kina in the size range 5 to 15mm were found by this method. At this size kina are green and difficult to spot.

Mussels.

Green-lipped mussels were counted and usually measured in 5mm size intervals. Individual large rocks were examined on Okupe Beach below the Lodge, and the mussels counted on each of about five specific rocks. At Ngahau a small headland at the northern end of the beach was examined, and all mussels around the fringe of the rock platform counted.

Scallops.

A 100-metre transect line was laid out in a specified direction from the zero point. The seabed was carefully examined in an estimated 2-metre wide strip on each side of the transect line; a total area of 400 square metres. Scallops were collected, and on board the boat were counted and measured across their greatest width. They were then returned to the general area of the transect.

Scallops were only rarely encountered, and this part of the programme was discontinued after several years. Subsequently a "watching brief" was maintained, by either occasional dives on the main historic area for scallops (between Rimariki Island and the mainland), or occasional mantaboard runs through this area.

Kina (subtidal).

Subtidal kina were examined at the sites of the fish and crayfish transects. In a specific area on each transect, a sample of 50 kina were collected in a bag, taking care to collect all the kina from a small area rather than only large conspicuous specimens. They were then taken up to the boat and measured across their greatest shell diameter, then returned to the area they were taken from. No density measurements were made, simply a size-frequency analysis always from the same area. In more recent years kina were measured undisturbed on the bottom by the same method used for intertidal kina. In the past few years no kina measurements have been made pending a more satisfactory sampling programme including density measurements.

Fish and crayfish.

Fish and crayfish were counted concurrently on each transect. Counts were not attempted if underwater visibility was less than 5 metres. A diver ran out a 50m line after securing the zero end, and placed the reel at the 50m end. Generally two divers completed the counts. Starting at the 50m end the two divers headed along one side of the line, counting animals within a 5m wide strip. One diver concentrated on fishes swimming in open water, and stayed about one metre above the bottom, progressing reasonably quickly along the line. Upon reaching the zero end this diver then progressed back toward the 50m end along the other side of the line.

Meanwhile the other diver concentrated on fishes and crayfish more intimately associated with the bottom. This involved swimming a more complex course, making sure that every hole and crevice was examined. This took a lot more time than the first divers counts, particularly if there was good algal cover on the rocks. Counts of semi-stationary animals such as crayfish could be accurately made by this method. There was a danger of multiple counts of mobile fishes, or reef fish such as red moki, but by taking great care and recognising some of the individual fishes, and by comparing the notes of the two divers, in practice there was little error. There were few fishes missed by this method, which could be easy in such complex topography if a more "aerial view" approach was adopted. Counts were recorded on pre-prepared underwater writing pads. Lengths of the more prominent individual reef fish were recorded, though for schooling or more abundant fishes such as sweep or spotty recording lengths of individuals was not attempted.

Crayfish were recorded as legal or sub-legal in size, often with additional notes indicating, for example, if sub-legal specimens were all very small or just sub-legal etc. Large individuals were also noted, with an estimate of their size in terms of weight. No attempt was made to sex crayfish. Because of the complex topography on many transects, sexing individual crayfish would be very difficult or impossible in some holes.

It generally took between 40 minutes and an hour to complete one transect.

5. The dark ages.

In the 1980's the last full monitoring of all intertidal and subtidal sites at Mimiwhangata occurred in 1986 before the Department of Conservation took over administration duties from the Bay of Islands Maritime Park. There followed a change in priorities, and marine monitoring was discontinued for about 15 years, despite the following recommendations made in 1986:

"RECOMMENDATIONS

1. A secure means of funding for monitoring should be found, so that regular monitoring can be continued in order to understand changes that are occurring in the *marine environment at Mimiwhangata. Large gaps in data sequences, and intermittent sampling, makes analysis of trends very difficult and somewhat unreliable. With the exisiting long-term data base at Mimiwhangata, despite its drawbacks, it would be more valuable to continue monitoring at this site than to start monitoring at new sites if budget restraints forced a choice. Trends monitored at Mimiwhangata would also be applicable in other proposed northern marine protected areas.*

2. Commercial fishing in the Marine Park (crayfishing and long-lining) is due for phasing out 10 years after the establishment of the Marine Park, specifically in October 1993. In fact it was understood at the time of establishing the Marine Park that the commercial fishing arrangement would be reviewed at 2-year intervals. It is likely that recreational fishing controls will also be reviewed in 1993, or sooner. It should be ensured that sufficient monitoring has been carried out at Mimiwhangata in order to make sensible suggestions for this review of fishing activity." Grace (1986), page 14.

The original purpose for monitoring was to provide information on which to base management decisions within the Marine Park. With the lack of monitoring over such a long period, however, there was no feedback on the effects of the fisheries controls within the Park. Hence it was not possible to know whether marine life was improving, staying static, or deteriorating. No review was carried out at the time that commercial fishing ceased in 1993, and so no changes were made to the recreational regulations which had been established at the Park's creation in 1984.

In 1994 the DOC Park Ranger tried to bring a prosecution through MinFish over illegal removal of paua from the Marine Park. This opened up a can of worms. Legal interpretation of the Fishery Regulations (Appendix 1) showed that, although certain species could be taken by certain methods, due to an omission during drafting of the regulations other marine life was NOT protected as intended. This situation created confusion and concerns around the effectiveness of the Marine Park, and its regulations have been commonly considered unenforceable. Effectively what we have now is a Marine Park in which no commercial fishing has occurred since 1994, but recreational fishing continued with limited by unenforceable controls. Thus we have a unique opportunity to test the effects of recreational fishing in the absence of commercial fishing. This has proved to be a useful, though unintentional, experiment.

6. The new Millenium.

Interest in marine aspects of Mimiwhangata was rekindled in 2001, and in the winter of 2001 intertidal monitoring was again completed, with almost all established intertidal monitoring sites being revisited.

Subtidal fish and crayfish monitoring was again picked up in summer 2002, when nine of the ten sites were monitored. In summer 2003 six of the ten sites were monitored, then in summer 2004 and 2005 all ten sites were monitored.

In addition, discussion with DOC and Auckland University scientists led to recognition of two weaknesses of the historic fish and crayfish monitoring at Mimiwhangata in terms of quantitative analysis. These are (1) a lack of control areas outside the current Marine Park, and (2) limitations in spatial replication and the non-random manner in which the permanent transects are sited, which limits calculations of variance and use of other statistical means to test various hypotheses for explaining change in abundance of various species over time.

To partly overcome this problem a comprehensive fish survey was carried out at Mimiwhangata in April 2002 by University of Auckland Leigh Laboratory staff and students, to provide baseline data of fish abundance within and outside the Marine Park. Two survey methods were used: baited underwater video (BUV), and underwater visual census (UVC) carried out by divers with scuba. The survey was described and reported by Denny and Babcock 2002. BUV is a superior method for surveying heavily targeted predatory species such as snapper, while UVC is better at giving a picture of the overall fish assemblage, and is similar to the method used in the historic fish monitoring at Mimiwhangata. The big difference from the historic monitoring, however, was the sampling design. Survey sites were generated randomly, within suitable habitat, both inside and outside the Marine Park (Figure 2), and at each site UVC was replicated three times and BUV generally four times, thus standard statistical analyses could be used on the data.

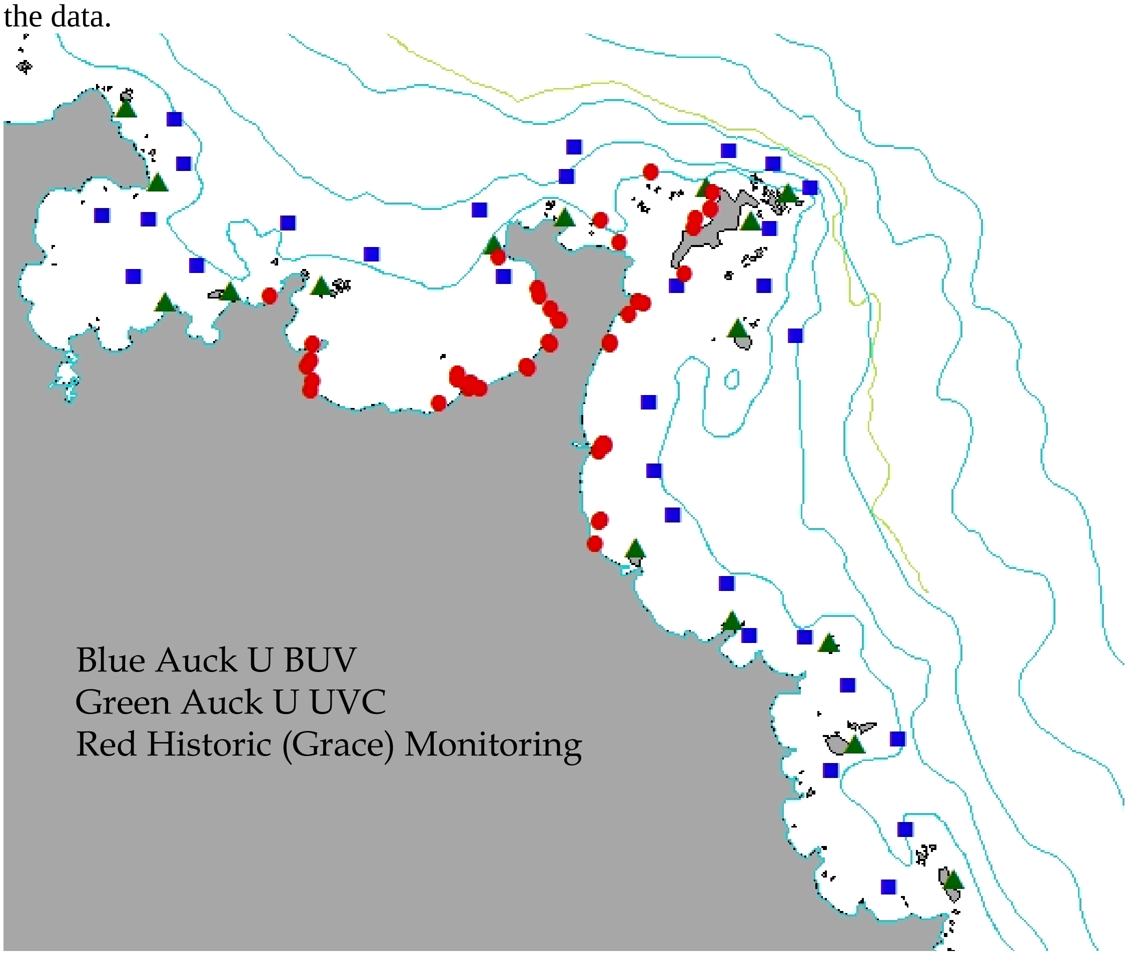

Figure 2. Location of historic monitoring sites (Grace 1978), together with baited underwater video (BUV) and underwater visual counts (UVC) of Denny & Babcock 2002.

The BUV and UVC survey was compared with similar surveys at Poor Knights (protected) and Mokohinau and Cape Brett (fished) (Denny and Babcock 2002).

The University of Auckland also carried out UVC of crayfish at randomly selected sites inside and outside the Mimiwhangata Marine Park in April 2003 (Usmar et.al. 2003), using methodology established by MacDiarmid (1991) and used extensively in surveys of other reserves since then (Kelly et al., 2000). Transects were 50m long by 10m wide (the same dimensions as the historic fish and crayfish transects), and replicated three times at each site.

7. The New Age.

Moves are being made to change the status of Mimiwhangata Marine Park, in which recreational fishing is allowed, to a total no-take Marine Reserve (DOC, 2004). It is also envisioned to extend the area covered by the Marine Reserve well beyond the present boundaries of the Marine Park, to include valuable reef areas offshore as well as extensive sediment areas to the north and south of the reefs (Kerr & Grace, 2005). This change will have far-reaching conservation benefits for the marine life in the Reserve.

Clearly a monitoring programme should be continued to document the changes which will occur following establishment of the Marine Reserve. The reality is, however, that there is never enough funding nor long-term security of funding to allow all the monitoring which is desirable for a full understanding of the changes, and to relate what is happening at Mimiwhangata to the dynamics of other protected and non-protected control areas regionally and nationally.

In order to maximise value from future monitoring we need to be clear on the purpose of monitoring. There are at least four objectives for a monitoring programme at Mimiwhangata.

1. To assess the effects of changes in the management regime, for example a change to no-take status, or establishment of customary management in adjacent areas. These effects may include:

Change in crayfish numbers and size;
Change in fish populations and sizes;
Change in biodiversity;
Change in algal forest cover;
Change in kina distribution, abundance and size.

2. To document long-term changes not necessarily associated directly with local marine management. These may include:

Change in tuatua and oyster populations;
Effects of storm events;
Effects of sediment and nutrients from the land;
Invasive species;
Effects of climate change.

3. To form part of a multi-reserve regional study of changes associated with marine protected areas, together with unprotected control areas, and relate this to national goals.

4. To form part of an educational package for the future Mimiwhangata Education and Restoration Centre. Groups could get involved with shore monitoring of tuatuas, mussels, oysters and kina, as well as doing beach profiling associated with storm events or climate change. There is also limited potential for involvement with subtidal projects.

8. Recommendations for moving forward.

There needs to be a rationalisation of what to monitor and why, where, when, how, by whom, and a consideration of costs and funding.

Rock oysters.

The oyster programme has produced interesting results over the years, and the historic photos have considerable research potential if someone is interested in pursuing further analysis. The long-term value of this programme could be maintained by photographing all sites at intervals of approximately three years. This should be sufficient to follow progress of individual oysters, and influx of new recruits, as well as major changes in oyster occupation of the rock surface. These days digital photography should reduce costs considerably.

From a management and compliance point of view, just visiting all rocky shores and looking for incidences of "oyster feasts" at the end of summer each year, counting oyster bases and looking for evidence of illegal removal, should produce clear results with little effort or cost. It may be possible to get volunteers or school groups involved.

Tuatuas.

In the early days of monitoring some useful information on tuatua behaviour was produced, showing seasonal migration from low to high water and return. Growth rates, and overall population change was also documented until the beds finally died out apparently of old age.

There has recently been a good settlement of tuatuas at the northern end of Mimiwhangata Beach (Grace & Kerr, 2005). There are also moderate numbers of edible-size tuatuas further south near the middle of the beach. It would be useful to follow the progress of these beds to see if protection in a marine reserve makes any difference to their long-term progress. This information could be compared to the documented progress of similar beds in the late 1970's and early 1980's, when the beds were lightly harvested.

From time to time tuatuas have been found on Ngahau Beach. If a bed develops there monitoring should include this area as a comparison with Mimiwhangata Beach. Ngahau Beach is likely to fall outside the future marine reserve, whereas Mimiwhangata Beach will be inside. The comparison could be valuable.

Volunteer or school groups could carry out this work with suitable guidance.

Kina (intertidal).

Rock pools in the historic programme could be included in future monitoring of kina, especially if they can be monitored by school groups or volunteers and used as part of an educational package. From a management or compliance point of view this part of the programme has little value, except perhaps at Okupe Island where large numbers of kina were removed immediately following opening of the Farm Park (Grace, 1984). Unfortunately those pools were not included in the programme until after this major removal event. Being close to the carpark, kina in these pools are probably still the most vulnerable to removal by visitors.

Green-lipped mussels.

Numbers of mussels have been sporadically present at a few sites since the beginning of monitoring. A low-key monitoring programme could be maintained probably by volunteers or school groups with suitable guidance.

It would be worth finding out if the mussel populations become more permanent under a no-take regime than with periodic harvesting. I suspect, however, that those below the Lodge at Okupe will be the only mussel rocks ending up within the future marine reserve. Mussels are not likely to ever become large, abundant or permanent in this habitat, even with protection. Those at Ngahau where the best beds are, and probably those toward the southern end of the property south of Komakoraia Island, are likely to fall outside the marine reserve boundaries.

Scallops.

Scallops are not really an issue at Mimiwhangata, and unless they become obvious it is not worth attempting to monitor them. Efforts should be limited to occasionally looking at the channel floor between Rimariki and the mainland. If a bed of scallops develops anywhere around Mimiwhangata it is likely to be noticed by divers and the situation could be reconsidered at that time. It is noted that following a large swell event in March

2004, hundreds of scallops washed up on Mimiwhangata Beach indicating there was a scallop population somewhere in Mimiwhangata Bay (Grace & Kerr 2004).

Reef fish.

After establishment of the marine reserve we would expect reef fish to benefit and to slowly improve in both numbers and sizes. Both underwater visual counts and baited underwater video techniques should be used to monitor the changes, because both are important and do different jobs.

It is also important that monitoring covers both inside and outside the marine reserve.

Because of the long history of data from the historic fish transects, and the probable inclusion of some of these transects in future crayfish monitoring (see later), future monitoring of fishes on some of the historic sites should be continued, despite the drawbacks of lack of replication and non-random placement. Some reef fish species, such as spotted black grouper and to a lesser extent red moki, are very "non-random" in the way they use and occupy rocky reef space. For these species, as for crayfish, fixed permanent transects in areas of good habitat have high scientific value. Statistical tests have been developed which overcome some of the problems of analysis of the historic data sets (see crayfish later). The existence of the parallel Tawharanui historic data set is also a reason to keep on with some of the historic monitoring sites.

There is a case to be made to perhaps drop 5 of the 10 historic sites and concentrate mainly on those with good crayfish lairs, occupation by spotted black grouper and other resident fish, and important history of algal forest change (suggest keeping Lunch Bay, Taukawau Point, Porae Point, Grey Rock and Pa Point). At the same time new transects could be set up outside the proposed marine reserve. One of these could be the existing Suicide Cove transect at Paparahi, with another one on the west side of the proposed reserve and three more on the Whananaki side.

There is also a good case to continue with the BUV and UVC approach of Denny and Babcock 2002, particularly as this is the method used in most other marine reserve and control studies elsewhere in northern New Zealand and direct comparisons can be made, with good statistical rigour.

Baited underwater video, or a variation of it, may also be developed for use in deeper water off Mimiwhangata, where in future it may be possible to detect re-establishment of hapuku populations, and perhaps terakihi, in the marine reserve. (This would also be an important feature of monitoring in the future Great Barrier Island marine reserve, where excellent hapuku habitat is widespread).

Except in the case of snapper, most reef fish populations are likely to be fairly slow to respond to marine reserve (no-take) status. Thus it may not be necessary to carry out UVC monitoring surveys of reef fish very frequently after reserve establishment.

Snapper populations, however, could develop quickly as at the Poor Knights, so BUV may be desirable frequently in the first few years.

Crayfish.

Data from other marine reserves and Tawharanui Marine Park suggest that crayfish, particularly red crayfish, are likely to increase in numbers and sizes quite rapidly (MacDiarmid and Breen, 1993) in the future Mimiwhangata Marine Reserve. The habitat is excellent for them, with a multitude of suitable lairs scattered throughout the area. Crayfish numbers and sizes should become quite spectacular within five years, and continue to improve over at least another 20 years (Shears et. al. in prep.).

Because of the likely rapid increase in crayfish, monitoring should be carried out frequently in the first few years.

Clearly sampling inside and outside the future marine reserve is desirable.

Crayfish normally aggregate in specific areas or lairs where there is good shelter for them, such as small caves, crevices, overhangs, and lots of gaps amongst broken rock areas. They are thus very "non-random" in the way they occupy rocky seabed habitat. This behaviour leads to high spatial variability. When random sampling techniques are applied there is a need for high replication in order to get sufficient numbers for statistical analysis. This has led to a move away from random sampling techniques in some areas (eg. Taranaki) and instead researchers where crayfish are seriously depleted are tending to target specific lairs and follow numbers over time within those lairs (Duffy et. al. 2003). This technique has parallels to the historic sampling at Mimiwhangata, where permanent transects were set up in areas of high topographical complexity where crayfish numbers are highest.

Although non-random sampling on single fixed transects (or at sites of specific crayfish lairs) provides scant information about spatial variability over a large area, it does give a valid basis for assessing crayfish density over a long time period, especially to follow effects of a change in management. Thus the historic crayfish transects at Mimiwhangata are valuable in that they have produced a long time series both before and after establishment of the marine park with its particular management regime. When this regime is again changed to a no-take marine reserve, the long time series of samples will provide a sound basis for following changes in crayfish at those historic sampling sites.

There is of course the problem of a lack of sampling outside the proposed marine reserve, except for a single site near Paparahi (Suicide Cove) which is inside the current marine park but is likely to be outside the future marine reserve. More sites are needed outside, and it is suggested that four more permanent sites be established, one west of the future marine reserve and three south towards Whananaki.

It is suggested that we concentrate on the five most useful permanent transects inside the proposed marine reserve, which are Lunch Bay, Porae Point, Taukawau Point, Grey Rock and Pa Point, but also provide for five permanent transects outside the proposed reserve. This would bring the scheme into line with the parallel sampling regime at Tawharanui, where five sites are inside and five are outside the no-take zone, and thus facilitate direct comparison with that area.

A report is nearing completion (Shears et al., in preparation) which analyses the historic crayfish data from Tawharanui and Mimiwhangata, and shows some very clear patterns in crayfish numbers between the two locations, illustrating effects on crayfish of total protection, partial protection, and the fully fished state. This report grapples with the statistical difficulties resulting from the non-random nature of the historic sampling, and comes up with valid ways of using the potential of the data and retrieving important results.

There are additional reasons why the continued use of permanent transects is recommended. There is also useful long-term data on fish on the permanent transects, as well as long-term information on algal forest changes.

It is recognised that the random sampling design carried out by University of Auckland Marine Laboratory in April 2003 (Usmar et. al. 2003) provides valuable information on spatial variability inside and outside the Park, and gives a valid basis for direct comparison with other areas researched in the same way. With the current highly fished state both inside and outside the marine park, zero counts were very common on the 48 transects completed, which does cause some difficulties in analysis. After establishment of the marine reserve at Mimiwhangata this situation will rapidly change. As crayfish become more abundant they become less dependent on specific lairs, and become more scattered within their rocky habitat (personal observation at Tawharanui) and the incidence of zero counts with a random sampling regime should reduce substantially. This approach should also be continued at Mimiwhangata, but perhaps be sampled less frequently than the permanent transects.

The sampling regimes discussed above concentrate specifically on crayfish in shallow rocky areas, generally less than 10 metres deep. With full protection in a marine reserve crayfish may also begin to occupy some of the complex deeper reef areas beyond 33 metres depth to the east of Mimiwhangata, as mapped in Kerr & Grace, 2005. If a build-up of crayfish density in deeper water is to be followed, a different technique will be required. At Gisborne the deeper reef areas (and some shallow reefs) are being sampled using crayfish potting techniques (Clinton Duffy, pers. comm.), expressing results as catch per pot lift inside and outside the reserve. This also provides opportunities for tagging studies, as well as accurate measurement of crayfish, and other observations. A commercial crayfisherman is employed for the field work. A similar approach may be useful at Mimiwhangata.

Algal forest change and kina barrens.

This is arguably the most important aspect of future monitoring at Mimiwhangata, as it is a large-scale habitat change of wide significance to the rest of the rocky reef ecology, and relevant to all of the north east coast of New Zealand from North Cape to East Cape.

The habitat mapping work (Kerr & Grace, 2005) has shown that Mimiwhangata is a dramatic example of the trophic cascade effect of fishing, where depletion of crayfish and snapper, both predators on kina, has led to a population increase in the prey species. In turn kina graze on algae, with the consequence that algal forests have retreated as kina have expanded. The resulting urchin-dominated areas, devoid of large algae, are called "kina barrens" and are depauperate in terms of biodiversity compared to the original algal forest.

Kina barrens slowly revert to algal forests again in no-take marine reserves (Shears & Babcock, 2003), as predator numbers build up, reduce kina numbers, and allow kelp forests to re-establish, thus improving biodiversity and restoring the reef area to a more "natural" state.

Reference sites inside and outside the proposed Mimiwhangata Marine Reserve should be established and mapped at a suitable scale, with kina density monitoring sites associated with them.

A very useful tool will be a full aerial photo coverage of the shores and visible reefs around Mimiwhangata, as well as control areas north and south of the proposed marine reserve. Successful aerial photography for this purpose requires a low tide between 1000 and 1400 hrs, no wind, no swell, cloudless skies, and good water clarity. This combination of suitable factors usually occurs only a few times a year. We should put a system in place which can take advantage of when these conditions occur and be ready to do the flight as a top priority. Full aerial coverage repeated at intervals of three to five years would be extremely useful for following changes in algal forests, as well as for many other purposes (see cover picture).

Other algal forest mapping techniques include diver transect surveys, mantaboard tows (we are currently developing mantaboard video techniques), and low level aerial surveys (we are investigating using a video camera on a helium balloon or a kite above the boat). A helicopter would be nice but likely to be prohibitive due to cost.

Kina density measurements can be done by divers with quadrats, drop-video, manta tows (using a 5-point density scale), and possibly low level aerial surveys.

Existing historic permanent transects can be used as sites for some of this work. Pa Point, for example, has been a kina barrens for about 20 years (cover picture), whereas in the 1970's it was a lush forest of tangle weed *Carpophyllum flexuosum* (Ballantine et.al., 1973; Kerr & Grace, 2005).

Direct underwater observations should also be made of the health of kina, as in some years microscopic toxic algae have appeared in summer and have been known to debilitate and sometimes kill kina. In places near Leigh kina have been so depleted from this cause in recent years that algal forests have again returned, despite the continuing low numbers of snapper and crayfish. In the absence of large numbers of snapper and crayfish, however, it is expected the return of algal forests may be a temporary phenomenon, and in some areas urchins have become abundant again and are attacking the new algal forests (Grace, personal observations).

Establishing a system for study of algal forest change will be very valuable in the future in terms of being a reference site for Northland's east coast, plus it will allow study of the impacts of establishing a Marine Reserve in comparison to the existing Marine Park, and allow for multi-reserve analysis with other Marine Reserves. There is a possibility of DOC Science and Research funding for this project as it lines up with national science priority criteria. Northland Regional Council may also be interested as it falls within their area of concern for the coastal marine area.

9. Summary of Recommendations.

What	Why	Where	When	How	By	Funding
Oysters	Research. Compliance. Education.	Historic sites	c.3 - yearly	Photo transects. Observations of oyster bases.	Volunteers. Schools. DOC.	Trust Schools DOC
Tuatuas	Research. Compliance? Education.	Historic sites. Ngahau	Annually when present	Quadrats on transects. Grid for population.	Volunteers. Schools. DOC.	Trust Schools DOC
Kina - intertidal	Research. Compliance. Education.	Historic sites	c.3 - yearly	Counts and measurements	Volunteers. Schools. DOC.	Trust Schools DOC
Mussels	Research. Compliance. Education.	Historic sites	c.3 - yearly	Counts and measurements	Volunteers. Schools. DOC.	Trust Schools DOC
Reef fish	Research. Monitoring. Regional comparison. MR advocacy.	Some historic sites. New sites outside. Random sites in & out	UVC 2yrs on, 3yrs off. BUV annually	UVC on historic & new. UVC on random sites. BUV on random sites.	DOC. University.	DOC MFish University
Crayfish	Research. Monitoring. Regional comparison. MR advocacy. Compliance?	Some historic sites. New sites outside. Random sites in & out. Random deep.	Annual on historic & new. 3-yearly random & deep.	UVC on historic & new. UVC on random sites. Pots at deep random sites.	DOC. University. Commercial crayfisher with pots.	DOC MFish University
Algal forest	Research. Monitoring. Regional comparison. MR advocacy.	Historic sites. New sites outside. Ref sites in & out. Whole coast Mokau to Whananaki.	Annual historic & new. 3 - yearly ref sites in & out. 3-5yrs full aerials.	Transect data on some historic & new sites. Video drop, manta tow, balloon cam on reference sites. Vertical aerials from aircraft.	DOC. Regional council for aerials?	DOC. Regional council. DOC Science & Research
Kina - subtidal	Research. Monitoring. Regional comparison. MR advocacy.	Some historic sites. New sites outside. Reference sites in & out.	Annual historic & new. 3 - yearly ref sites in & out	Quadrats on some historic & new. Quadrats, video drop, manta tow, balloon cam on reference sites.	DOC. Volunteer dive groups?	DOC. DOC Science & Research Regional council.

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Appendix 1. Summary of special Fisheries Regulations for Mimiwhangata Marine Park.

COMMERCIAL FISHING:

All commercial fishing is prohibited except that potting for rock lobster and longlining shall be permitted until 1st October 1993.

RECREATIONAL FISHING:

Amateur fishermen may use only the methods of unweighted single hooked lines, trolling, spearing and handpicking to take those species of fish and shellfish specified in the list below. Potting for rock lobsters is also permitted providing that only one pot per person, or party, or boat is used.

Permitted list:

Fin fish

Barracouta	Mackerel (all types)
Billfish (all types)	Piper (garfish)
Blue maomao	Shark (all types)
Flounder (all types)	Snapper
Grey mullet	Sole
Yellow eye mullet	Tarakihi
Gurnard	Trevally
Kahawai	Tuna (all types)
Kingfish	

Shellfish

Common kina	Scallop
Green-lipped mussel	Tuatua
Rock lobster	

[NOTE: The following clause was intended to be included with the regulations but was left out during final drafting, with serious consequences for the viability of the Marine Park:

"Other species: All other species of finfish, shellfish, and other marine life are totally protected."]

Appendix 2. List of years and seasons in which some aspects of monitoring were carried out (not all sites or parts of the programme were included each time).

Year	Season
1976	winter
1976	spring
1977	summer
1977	autumn
1977	winter
1977	spring
1978	summer
1978	spring
1979	summer
1981	summer
1981	winter
1981	spring
1982	summer
1982	autumn
1983	spring
1984	summer
1984	spring
1985	summer
1986	summer
2001	winter
2002	summer
2003	summer
2004	summer
2005	