Introduction to marine monitoring

Version 1.0

This specification was prepared by Shane Geange, Debbie Freeman, Vincent Zintzen and Kath Blakemore in 2016.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

This introduction will help you choose the most appropriate marine monitoring method(s) for your study objectives. It focuses on methods that are used frequently in New Zealand rather than being a comprehensive overview of the range of methods available. The methods in this module will be updated from time to time, in line with ongoing international research and development into inventory and monitoring methods for the marine environment.

The principles to consider when you are designing a study are outlined in 'A guideline to monitoring populations' (doccm-870579).[1]

This introduction also contains information about the inventory (or inventorising) and monitoring of marine species and habitats in New Zealand including:

- The difficulties in monitoring marine species and habitats
- What to consider when choosing a method (taking into account project objectives or data requirements)
- Decision tree ('Marine: decision tree'—doccm-2783264)[2]
- Comparative tables ('Marine: comparative tables'—doccm-2783270)[3]
- Issues to consider when planning the details of a project

Inventory and monitoring studies

An inventory is data collected at a single point in time, while a monitoring study involves the same measurements repeated over time.

International and national obligations exist to take inventories and monitor the marine environment. Although studies are local in scope, it is important to note that they can contribute to an assessment of the status and trend of marine environments at regional, national or international levels.

Standardised methods are essential to ensure that different studies are consistent and comparable.

Types of inventory and monitoring

There are five types of biodiversity inventory and monitoring. Each one has a particular purpose, although they may overlap (Lee et al. 2005):

[1] http://www.doc.govt.nz/Documents/science-and-technical/inventory-monitoring/guideline-to-monitoring-populations.pdf

[2] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-decision-tree.pdf

[3] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-comparative-tables.pdf

- Management inventory and/or monitoring to assess the need for, or effectiveness of management intervention
- One-off habitat inventory to fully define a resource
- Status and trend monitoring, with regular recurrence
- Surveillance monitoring, focused on a well-understood problem and immediate threat
- Research monitoring, where the results of long-term monitoring are used to understand fundamental ecological questions

Large- and small-scale monitoring

Marine inventory and monitoring can be undertaken at a wide range of scales, depending on the objectives of the study.

Large-scale or general monitoring can add to knowledge about ecological patterns and processes in an area (e.g. effects of water depth and turbidity on the composition and biomass of seaweed). This knowledge may be critical for interpreting study results (e.g. changes in seaweed biomass following marine protected area (MPA) implementation) by separating natural variation from changes brought about by management measures.

At a smaller, local scale, most marine reserve monitoring aims to assess the effectiveness of the MPA—usually by focusing on particular species.

New monitoring tools

In the past, monitoring and inventory has focused on changes in the abundance of previously harvested species within marine reserves, relative to non-reserve areas. More recently, however, a suite of tools to monitor and report on ecosystem processes, environmental contaminants, exotic species, ecosystem composition and adaptation to climate change has been developed.

Since the development of these new tools is ongoing, this module will be periodically updated as these methodologies are developed, implemented or commonly used.

About inventory and monitoring methods

Choosing a method

We recommend you refer to relevant textbooks, published papers and the sections on statistical concepts and sampling approaches in ‘A guideline to monitoring populations’ (doccm-870579)[4] when planning a project.

[4] http://www.doc.govt.nz/Documents/science-and-technical/inventory-monitoring/guideline-to-monitoring-populations.pdf

The comparative tables ('Marine: comparative tables'—doccm-2783270)[5] and decision tree ('Marine: decision tree'—doccm-2783264)[6] associated with this document are also useful tools for selecting the most suitable and cost-effective method(s) for your project. The comparative tables show that not all methods are suitable for both inventory and monitoring, or for all study objectives.

Choose and define your inventory and monitoring objectives carefully before using the tools. General objectives should be broken down into a series of specific objectives, which then govern the study design and the type of data collected.

Questions

These questions may help you choose the most appropriate method(s):

- What is your objective?
- What scale are you working at?
- Are you monitoring all or most species, or selected indicator species, such as previously harvested species?
- Are you monitoring or taking an inventory of community structure, species diversity or species richness?
- Are you monitoring changes in population size and/or abundance?
- Do you need quantitative, semi-quantitative, or qualitative data?
- What parameters are essential to measure?
- What covariate data do you need to help with interpretation?
- What resources do you have?
- What is the distribution of the species or habitat you are interested it?
- What skills do you have available?
- What funding is available?
- What is the longevity of the monitoring programme?

Inventory methods and their uses

Inventory methods are designed to record patterns at a single point in time. Common inventory questions include:

- What species and communities are present and how are they distributed spatially?
- What are the main environmental/site factors associated with changes in species composition?

[5] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-comparative-tables.pdf

[6] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-decision-tree.pdf

- How does the condition of selected indicator species vary over the landscape?

These methods are used to document the habitats, species and communities present, and to describe how they are distributed and what condition they are in. (Note that not all methods are capable of addressing all of these applications—multiple methods may need to be used concurrently.)

Limitations of inventories

Since inventory data is collected at a single point in time, it cannot be used to interpret changes in an area. Statistically significant correlations between composition and spatial or environmental/site factors can be used to suggest causes for the patterns, but measurements at a single point in time may not identify factors that are the immediate causes of the patterns.

Analysing patterns and relationships

The patterns found in an inventory can be examined spatially or in relation to other variables including:

- Environmental factors (e.g. depth, exposure, turbidity)
- Habitat assessments (e.g. distribution of rocky reef or soft sediment substrates)
- Species densities (e.g. distribution of biogenic habitats (species that provide habitats for other species) or keystone species)

An analysis of the relationships between these variables and habitat, species or community patterns using multivariate techniques (such as classification and ordination) provides insight into factors that are driving the patterns. Some examples include a comparison of the mean depth, turbidity or exposure for different communities; determining the main environmental/habitat factors correlated with gradients in individual species abundances and total community composition; and comparing population abundances in areas with different biogenic habitats or predator densities.

Spatial analyses

Spatial analyses show the distribution of species or habitats across the landscape. The use of a geographic information system (GIS), which enables layers of spatial information to be presented, is a powerful modern tool.

Examples of spatial analyses include:

- Mapping habitat types and species distributions
- Comparing the composition of habitats in MPAs
- Comparing patterns between MPA and non-MPA areas

Some examples of common inventory designs

Some common features of inventory designs include:

- Sampling a single area or several areas to define the distribution, abundance and condition of indicator species
- Mapping a single area or several areas to define the main biophysical habitat types and their distribution over the landscape

Monitoring methods

Monitoring methods are designed to detect trends in an area over time, often at selected sites. They aim to determine whether the composition, structure and condition of an environment are changing over time or in response to a management intervention. Monitoring methods repeat the same measurements of sample units such as quadrats or transects over time.

Some methods are designed to monitor all the species present in an area (e.g. ‘Marine: quadrats for invertebrate and macroalgal communities’ (doccm-2595952)[7]; ‘Marine: soft sediment sampling for infaunal communities’ (doccm-1438155)[8]; ‘Marine: underwater transects for fish’[9]), while others target a limited number of species (e.g. ‘Marine: potting for lobster populations’[10]; ‘Marine: baited underwater video surveys for fish’ (doccm-1450395)[11]). ‘Indicator’ species, which signal environmental or ecological conditions for a group of other species, are often chosen for monitoring studies.

Monitoring aims

One simple monitoring aim is the description of a trend over time, along with an assessment of whether it is significant. More complex aims include examining temporal trends in populations in relation to spatial, environmental or habitat factors under different management regimes, such as MPA and non-MPA sites.

Statistical considerations

Temporal trends can be examined using a range of statistical methods, from non-parametric statistics to the analysis of variance and multivariate methods such as ordination.

Permanently marking a location, such as a transect, makes for faster and more reliable repeated monitoring. Pre- and post-treatment measurements in treated (impact) and non-treated (control) areas can also improve the quality of data from a study (i.e. Before–After–Control–Impact Paired Series designs—see Schmitt & Osenberg 1996).

[7] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-quadrats-for-invertebrate-and-macroalgal-communities.pdf

[8] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-soft-sediment-sampling-for-infaunal-communities.pdf

[9] This method specification is currently under development.

[10] This method specification is currently under development.

[11] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-baited-underwater-video-surveys-for-fish.pdf

A well-designed monitoring programme will help separate out the effects of natural variability from management-induced effects, but may require covariate data to be collected (e.g. an increase in rock lobster numbers may reflect reduced extractive use, increased recruitment or both).

Research questions

The questions in Table 1 may help you choose the most appropriate method(s) for your monitoring study.

Table 1. Research questions and suggested methods

Research question	Suggested method
Have the densities of reef fishes, lobster, pāua and kina increased inside a marine reserve after 10 years of marine protection?	• Marine: underwater transects for fish*, and • Marine: transects for mobile invertebrates (doccm-2780482)†
Has the size of rock lobsters increased inside a marine reserve after 10 years of protection?	• Marine: transects for mobile invertebrates (doccm-2780482)†, or • Marine: potting for lobster populations*
What is the type and flux of beach-cast litter within a marine reserve?	• Marine: transects for beach-cast litter*
What is the relationship between fish assemblage structure and the density of kelp forests, and how does this change through time?	• Marine: underwater transects for fish*
Has the establishment of an MPA increased snapper density and size?	• Marine: baited underwater video surveys for fish (doccm-1450395)‡

* Method specification currently under development.

† http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-transects-for-mobile-invertebrates.pdf

‡ http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-baited-underwater-video-surveys-for-fish.pdf

Designing a monitoring study

The objectives and questions of a monitoring study must guide the design and planning of a study. These may be very specific (e.g. tracking the size distribution of blue cod cohorts) to general (e.g. evaluating if physical changes to a marine environment have changed the diversity of functional traits). There may also be more than one objective per monitoring plan.

Some common study designs are listed below.

Control–Impact (CI)

Although this is strictly an inventory design (as it only involves a single sampling date), the method is commonly used to compare an impact site with a non-impact site (often also termed control or non-treatment site). Multiple samples are taken from each site on a single date and an impact is assessed by statistically comparing various parameters between the impact and non-impact sites.

The CI design does not account for natural spatial variability between control and impact sites, but assumes that the sites are identical. Ecological systems, however, vary considerably, and it is extremely unlikely that the two sites would exhibit the same result in the absence of an impact if sampled sufficiently (Schmitt & Osenberg 1996).

Before–After (BA)

Sampling an ‘impact’ site before and after an activity lessens the problems caused by natural spatial variability outlined above. Here, a change is assessed either by comparing one or several sampling times before and after an activity and using variation through time as evidence of ‘impact’.

The BA design does not separate natural temporal variability from the activity of interest. It also assumes that the factor being measured does not experience natural temporal variability, which is extremely unlikely for many ecological parameters (Schmitt & Osenberg 1996).

Before–After–Control–Impact (BACI)

A control site and an impact site are sampled once before and once after an activity. The test of an impact looks for an interaction between time and location effects, using the variability among samples taken at a single site on a single date as an error term.

This design may confound the effects of the impact with other types of unique fluctuations that occur at one site but not at the other. Unless (in the absence of an impact) the two sites perfectly track one another through time in terms of the factor being measured, the design will yield erroneous indications that an impact has occurred (Schmitt & Osenberg 1996).

Before–After–Control–Impact Paired Series (BACIPS)

The BACIPS design is an extension of the BACI design and is based on a time series of difference between the control and impact sites that can be compared before and after the activity begins. A comparison of the before differences with the after difference indicates impact.

Each difference in the before period is assumed to provide an independent estimate of the underlying spatial variation between the two sites in the absence of an impact. Therefore the mean before difference added to the average state of the control site in the after period yields an estimate of the expected state of the impact site in the absence of an impact during the after period (i.e. the null hypothesis).

If there is no impact, the mean difference in before and after periods should be the ‘same’ (ignoring sampling error). The difference between the before and after differences provides an estimate of the magnitude of the impact. It is still possible that a natural source of Time × Location interaction may operate on the same time scale as the study and confound an interpretation of an impact, but this is less likely than in other designs (Schmitt & Osenberg 1996).

Control-Impact Paired Series (CIPS)

This design samples a time series at a control site and an impact site. Impact is determined by a comparison of the within-site sampling error for each sampling time or the use of within-site variation through time as the measure of variability. The CIPS design assumes that the two sites are identical in the absence of the activity and that the factor being measured experiences similar temporal variability at both sites.

Given the lack of time series data prior to the establishment of MPAs, this is perhaps the most commonly used design for monitoring of MPAs in New Zealand.

Types of data collected

The methods in this module assess the composition, structure, condition and biomass of a marine area using a range of numeric, demographic and trophic measures. Each measure has advantages and disadvantages; several measures are often used in combination in one method.

Qualitative, semi-quantitative and quantitative measures

Measures can be qualitative, semi-quantitative or quantitative. Exact definitions of these terms vary, but they reflect an increasing degree of precision in assessing how much of a species or attribute is actually present (Hill et al. 2005).

Qualitative measurements assess whether a species or attribute is present or absent. They may describe how much is present (e.g. how many or few individuals per m^2) but do not count exactly how many.

Quantitative measurements involve accurate and precise measurement of an amount present (e.g. 12 individuals per m^2). Between these extremes, semi-quantitative measurements are made when an amount is either estimated visually (e.g. cover abundance of 0–25%), or a variable is measured accurately but the value is not expressed as the precise figure (e.g. 10–20 individuals per m^2).

Numeric measures

Numeric measures can be used to monitor individual species, populations or community composition. They include:

- Density: the number of individuals per unit area. Density is a highly quantitative and precise measure.
- Census: the total number of individuals in an area or sample unit. This measure is similar to density but requires that all individuals are detected, which is difficult for large sample areas or cryptic species.
- Relative abundance: a component of diversity that refers to how common or rare a species is, relative to other species in a defined location or community.

- Cover: a quantitative measure of the proportion of an area covered. Cover is time consuming to measure precisely and for this reason is often estimated visually as a semi-quantitative measure.
- Frequency: the proportion of sample units or sub-units occupied. Frequency is a quantitative measure that is easily and accurately obtained. However, values are affected by the size of sample unit and the spatial distribution of the variable being monitored. It is good for detecting temporal change, but comparison between species is difficult or impossible. Frequency is poorly related to cover or biomass unless the sample units or sub-units are very small (approaching a point of zero size).
- Presence/absence: the presence or absence of a species or attribute in a sample unit or sub-unit. This is the most basic, qualitative measure that can be obtained from most of the methods described in the module. Presence/absence can be converted to frequency by calculating the proportion of sample units/sub-units occupied.

Derived measures

Derived measures include:

- Biomass: mass per unit area (e.g. approximated from length–weight relationships for fish, and density and frond length–weight relationships for kelp). Biomass is a good measure of the relative dominance of different species, but can be difficult, destructive and time consuming to measure precisely.
- Richness: the number of different species represented in an ecological community, landscape or region. Species richness is simply a count of species and does not take the abundance of the species or their relative abundance distributions into account.
- Diversity: a measure of the diversity within an ecological community that incorporates species richness (the number of species in a community) and how similar the abundance of each species in a community is. Species diversity is a component of biodiversity.

Demographic measures

Demographic measures relate to the structure of populations and changes over time. They include:

- Survival: the proportion of individuals that continue to exist within a defined population over a specified period of time
- Mortality: the proportion of deaths within a defined population over a specified period
- Productivity: the rate of biomass generation in a population, community or ecosystem
- Sex ratios: the proportional distribution of sexes in a population, usually calculated as the number of males per 100 females

Trophic measures

Trophic measures relate to the structure of feeding relationships among organisms in an ecosystem. They include:

- Trophic position: the trophic level that an organism occupies in a food chain
- Trophic niche width: the width of niche space occupied by a population or community
- Trophic structure: the pattern of movement of energy and matter through an ecosystem
- Trophic diversity: the variety of species within or across trophic levels

Planning a successful study

Considering the following points will help ensure your study is successful, robust and useful.

Clear objectives

A successful inventory or monitoring study must be driven by clearly formulated objectives or questions. The objectives drive the study at all levels, including such factors as sampling design, sampling method(s), and number and type of sample units.

Appropriate design and method

Use the 'Standard inventory and monitoring project plan' (doccm-146272)[12] to plan your study and seek approval before proceeding. Once your objectives have been formulated, selecting the appropriate study design and method(s) are key steps in determining whether the study is capable of addressing the objectives. Always seek advice from a statistician or suitably experienced person before collecting any data. This will ensure the data collection is robust and suitable for answering the research question and that you understand the reporting measure you will be using. Refer to 'A guideline to monitoring populations' (doccm-870579)[13] for more information on design and sampling.

Overall science plan

Thinking about how an inventory or monitoring study fits into an overall science plan can be helpful. A single method may not be sufficient for a monitoring programme, and several monitoring methods may need to be used at each site.

For example, biological monitoring of the Te Whanganui-A-Hei Marine Reserve currently includes:

- Sampling of 1 m^2 temporary quadrats for macroalgae
- Encrusting species, urchins and gastropods
- Sampling of 100 m^2 permanent quadrats for invasive species
- Site-scale assessments of physical variables including rock type, wave exposure, depth, percent cover of sand and sediment

[12] http://www.doc.govt.nz/Documents/science-and-technical/inventory-monitoring/im-toolbox-standard-inventory-and-monitoring-project-plan.doc

[13] http://www.doc.govt.nz/Documents/science-and-technical/inventory-monitoring/guideline-to-monitoring-populations.pdf

- Sampling of 50 m × 10 m temporary transects for lobsters
- Baited underwater video sampling for fish abundance and species richness

Long-term commitment

Detecting change can be a slow process—it can take a long time for trends to emerge, even in well-designed and efficiently targeted studies. Monitoring studies often require long-term investment and commitment to data collection. History has shown that many data sets have been invaluable for addressing future questions that were not apparent or urgent at the time the study was initiated, so the temptation to establish 'quick and dirty' data sets should be strongly resisted. It is also important to think about the frequency of measurement relative to expected rates of change.

Inheriting and adapting an existing study

Investigators frequently inherit an ongoing study or need to adapt an existing study for different or additional objectives. Common issues include:

- Will the existing study design adequately address the new objectives or will it limit statistical inference and ecological interpretation?
- The perceived 'ideal' sampling unit, method, or study design may need to be traded off for a less perfect but existing sampling unit, method or design which is adequate but also has the benefit of long-term data that will greatly help data analysis and interpretation of trends.
- Data continuity and comparability must be maintained by ensuring that any changes to the methods are documented and added to the existing methods, and by ensuring that the new methods can still be compared to the original ones. This includes calibrating the two methods to ensure comparability and continuity of the sampling methods over time. Changing methods is not advisable, except if there are considerable advantages to doing so.
- Deciding whether a study should be continued or whether a measurement interval can be extended in the face of changing objectives or diminishing resources.
- Uncertain quality of historical data, such as species identification, counts, or measurements. Most credible studies will have adequately documented methods that allow replication of the study—if they are not well documented, the value of continuing or adapting the study should be questioned.
- Finding the sample units in the field. Finding plots or other sample units has been simplified by the use of GPS units in the last 20 years, but even these methods have limits for relocating specific points underwater, such as the start locations of transects (that need to be conspicuous and permanently marked). Most marine monitoring in New Zealand has not used permanent sampling units, but sampling units placed in a rather haphazard manner within a study site. In these instances, it is important to ensure sampling units are placed using the same criteria (e.g. placed on rocky reef), and covariate data related to the placement of sampling units (e.g. biophysical habitat composition along a transect) is collected to help interpret the results.

- Poorly documented study designs and objectives may restrict the study's usefulness. This does not necessarily mean the study is of little value, as long as the data are accurate and can be used to address the objectives. Always seek advice from a statistician.

Value of existing data

When initiating a study, it is important to find out whether there are any existing data that can be used—for example, a legacy of sample units established by other (or former) agencies, or abiotic time-series data (e.g. sea-surface temperature, significant wave height, turbidity) for a study site that can act as covariate data and aid in the interpretation of results.

Value of 'covariate data'

Interpretation of inventory and monitoring studies is considerably enhanced by collecting interpretative (covariate) data on abiotic and biotic factors considered likely to have direct or indirect effect on the measures being undertaken—these are termed 'optional attributes' in the Inventory & Monitoring Toolbox. Examples include biophysical habitat composition, depth, turbidity, temperature and exposure. Covariates are variables that could be predictive of the measures being undertaken, and may be of direct interest. Alternatively, they may be confounding or interacting variables. Consequently, covariate data can be essential for interpretation.

Permanent and temporary sampling units

Permanent sampling units enable the repeat monitoring of discrete patches to assess population attributes, such as recruitment, mortality, reproductive state and life stage, to help interpret trends in population abundance. For monitoring, the choice between permanent and temporary plots involves a trade-off between the precision and power of permanent plots to detect change (temporary plots typically require more samples to ultimately determine whether a real change is occurring due to artefacts of natural spatial variation) and their higher establishment costs.

Stratified random sampling

Stratification is the process of dividing the target population or community into subpopulations or strata. Stratifying can improve the precision of estimates and inform management.

Improving the precision of estimates

Populations are often stratified to improve the precision of an estimate. This is accomplished by delineating strata so that they are as homogeneous as possible, but differences among strata are as large as possible. For example, in the case of sampling reef fish communities, it might be necessary to subdivide the survey area into depth strata to account for species-specific depth preferences, or into habitat strata to account for species-specific habitat preferences.

The extent of homogeneity within each stratum with respect to the parameter being measured determines the potential effectiveness of the stratification (i.e. the increase in precision per unit sampled). For a survey in which a single parameter is being measured, suitable strata can probably be found. However, several parameters may be of interest, some of which may not be related, such as fish diversity, pāua density and seaweed composition. In these cases, one effective stratification for estimating all parameters may be difficult to find because a set of strata that is appropriate for one parameter may not be for another.

After stratification, the sample size within each stratum is determined. This process is called sample allocation. Often samples of the same size are chosen within each stratum.

Informing management

In many instances, information is required for particular geographic subdivisions, such as bioregions or management areas. If a certain precision is required for each subdivision, regardless of its size, then a sufficient sample size must be obtained within each. This will require different sampling intensities (sample allocation) within each subdivision that can only be obtained through stratification. In this case, the principal objective is to obtain estimates of a required precision for each stratum, at the possible expense of some loss of precision at the aggregate level.

Other considerations

Preventing the spread of marine pests

The introduction of unwanted marine pest species to new environments has the potential to cause irreparable harm to biodiversity and the beauty of New Zealand's marine environment. After diving in an area, remember to clean all the equipment that has been used in the marine environment, including equipment that has no visible marine organisms present—microscopic life stages of organisms can be on equipment, in seawater trapped inside equipment, or within ropes, nets or dive equipment.

If you know that a particular marine pest or disease is present in the area that you are diving in, ensure diving equipment is treated with the most appropriate treatment for that contaminant at the completion of diving activities. Otherwise do one of the following:

- Soak equipment in freshwater for 72 hours, replacing water after 12 hours
- Soak equipment in warm water (40–45°C) for 20 min
- Soak equipment in 5% dishwashing detergent/freshwater solution for 1 hour
- Soak equipment in 1% Trigene/freshwater solution for 1 hour
- Spray with 1% Dettol antiseptic/freshwater solution and leave for 1 hour
- Spray with 100% Trigene and leave for 1 hour

If chemical/freshwater treatment is not feasible, remove equipment from the water and thoroughly air dry it for 1 month. Prolonged air exposure is also an ideal follow-up treatment for any items that have been soaked or sprayed.

To report suspected exotic land, freshwater and marine pests, or exotic diseases in plants or animals, call the Ministry for Primary Industries pest and disease hotline: 0800 80 9966.

Health and safety

The method specifications make some suggestions for health and safety but these are not a comprehensive review and do not replace DOC's health and safety requirements or requirements under the Health and Safety at Work Act 2015.

DOC employees and volunteers must follow the following standard operating procedures (SOPs):

- 'Scientific diving: one page SOP' (doccm-743136)[14]
- 'Snorkelling: one page SOP' (doccm-750303)[15]
- 'Scientific diving and snorkelling: technical document' (doccm-237640)[16]
- 'Boat operator certification SOP' (docdm-346005)

Data collection and storage

DOC is currently developing a national database to hold and provide access to data collected from marine reserve monitoring in New Zealand. The aims of the database are to:

- Support consistent standards in national marine reserve monitoring programmes for marine environmental quality
- Coordinate and optimise marine reserve monitoring in New Zealand
- Provide a high quality monitoring dataset for New Zealand's marine reserves

Once operational, descriptions of how to lodge data within the national database will be developed. In the interim, data should be recorded within the spreadsheets associated with each methodology. It is essential that all raw data sheets are completed, digitised and backed up on external hard drives. Raw data and associated metadata should be entered into databases/spreadsheets in a standardised format. This should include metadata stored in a separate sheet, and a sheet containing sampling data collected during the monitoring programme stored in one 'brick' of data that can be continually updated as more surveys in that monitoring programme are carried out.

Each method specification gives guidance on how to collect and store data within DOC's national databases.

---

[14] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-scientific-diving-one-page-sop.pdf

[15] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-snorkelling-one-page-sop.pdf

[16] http://www.doc.govt.nz/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-scientific-diving-and-snorkelling-technical-document.pdf

References and further reading

Hill, D.; Fasham, M.; Tucker, G.; Shrewry, M.; Shaw, P. 2005: Handbook of biodiversity methods: survey, evaluation and monitoring. Cambridge University Press, Cambridge.

Kingsford, M.; Battershill, C. 1998: Studying temperate marine environments: A handbook for ecologists. Canterbury University Press, Christchurch.

Lee, W.G.; McGlone, M.; Wright, E. (Comps). 2005: Biodiversity inventory and monitoring: a review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation. Landcare Research Contract Report LC0405/122 (unpublished).

Quinn, G.P.; Keough, M.J. 2002: Experimental design and data analysis for biologists. Cambridge University Press, Cambridge.

Schmitt, R.; Osenberg, C. 1996: Detecting ecological impacts: concepts and applications in coastal habitats. Academic Press, San Diego.

Appendix A

The following Department of Conservation documents are referred to in this method:

doccm-346005	Boat operator certification SOP
doccm-870579	A guideline to monitoring populations
doccm-1450395	Marine: baited underwater video surveys for fish
doccm-2783270	Marine: comparative tables
doccm-2783264	Marine: decision tree
doccm-2595952	Marine: quadrats for invertebrate and macroalgal communities
doccm-1438155	Marine: soft sediment sampling for infaunal communities
doccm-2780482	Marine: transects for mobile invertebrates
doccm-237640	Scientific diving and snorkelling: technical document
doccm-743136	Scientific diving: one page SOP
doccm-750303	Snorkelling: one page SOP
doccm-146272	Standard inventory and monitoring project plan