Graduate Research School

RP

Research Proposal Coversheet for Candidates in

Research Higher Degrees

EXAMPLE OF RESEARCH PROPOSAL SUBMISSION

RESEARCH AREA: Fish Diversity

DEGREE: PhD

Please note that all identifying information has been removed from this research proposal and replaced with XXX.

Research Proposal for the Degree of Doctor of Philosophy

Name (Student Number)

School

The University of Western Australia

2009

A. Proposed Study

Title

Environmental and Anthropogenic Influences upon Western Australian Marine Fish Functional Diversity and Functional Groups.

Contribution to Scholarship

Background

Biodiversity

Earth's biodiversity, being the range of life forms at a particular hierarchical level (Gaston, 2000, Norse, 1993), is diminishing at an unprecedented rate (Chapin III et al., 1997, Naeem et al., 1994, Stachowicz et al., 2007), due mostly to the direct activities of humans and indirect "spill-ons" such as climate change (Baird, 2009, Chapin III et al., 2000, Diaz et al., 2003, Hooper et al., 2005, Loreau et al., 2001, Naeem, 2006). This loss not only includes the loss of species *per se*, but also of genetic variation, functional groups and interactions among organisms, creating a reduction in the temporal and spatial distribution of biota (Naeem, 2006). Possibly the most pressing aspect of decreased biodiversity for the remaining life on earth is the potential alteration, impairment, or failure of ecosystem functioning (Hooper et al., 2005, Ieno et al., 2006). Ecosystem functioning refers to the total biogeochemical processes occurring within an ecosystem and is essentially, the cycling of nutrients, matter and energy (Naeem, 1998, Virginia & Wall, 2001).

As it has been demonstrated in many studies that biodiversity is strongly associated with the functioning of an ecosystem, this view is now generally accepted (Balvanera et al., 2006, Benedetti-Cecchi, 2006, Bracken et al., 2008, Giller et al., 2004, Hooper et al., 2005, Solan et al., 2006, Somerfield et al., 2008). However, studies investigating the effects of biodiversity loss upon ecosystem functioning are problematical, as losses in genetic, taxonomic and functional diversities are not necessarily independent of one another (Allison, 1999, Naeem, 2006). It has been hypothesised that the amount of relevant biotic traits in a community, or its functional diversity, is the most appropriate "tool" to be used when investigating ecosystem functioning, as this is the biological aspect that directly relates to the functioning of an ecosystem (Bellwood et al., 2002, Hooper et al., 2005, Somerfield et al., 2008, Villeger et al., 2008).

Functional diversity

Functional diversity is a useful tool for ecologists as it is an ecologically relevant means by which the complexity of natural ecosystems can be reduced to a comprehensible level (Dray & Legendre, 2008, Nagelkerken & van der Velde, 2004, Schwartz et al., 2000). One of the most commonly cited definitions of functional diversity is that of Tilman (2001) "…the values and range in the values, for the species present in an ecosystem, of those organismal traits that influence one or more aspects of the functioning of an ecosystem." Therefore, the study of functional diversity is the most appropriate method by which to consider ecosystem processes or functioning, utilising species presence and actions or phenotypic traits as opposed to their taxonomic identity (Bellwood et al., 2002, Hewitt et al., 2008, Petchey & Gaston, 2006, Somerfield et al., 2008); and how these ecosystem processes may differ among regions, along environmental gradients, due to anthropogenic impacts or potential changes due to climate change. Despite this, there remains a multitude of issues associated with the definition and measurement of functional diversity (Somerfield et al., 2008).

Many functional ecology studies have used the terms functional group or functional guild interchangeably and without definition, while the two terms have related, although differing meanings (Blondel, 2003, Hawkins & MacMahon, 1989, Lavorel & Garnier, 2001). Functional guilds refer to groups of species that are similar in their utilisation of resources or response to environmental change, while functional groups consist of species that perform similar tasks concerning the processes of an ecosystem (Blondel, 2003, Elliott et al., 2007, Franco et al., 2008, Hooper et al., 2002, Lavorel & Garnier, 2001, Petchey & Gaston, 2006, Root, 1967). More often than not, studies of flora have concentrated upon functional groups, while faunal studies have utilised functional guilds (Blondel, 2003, Lavorel & Garnier, 2001, Wilson, 1999). Functional guilds have also been referred to as response or alpha groups, while other descriptions of functional groups include effect or beta groups (Mason et al., 2005, Suding et al., 2008, Wilson, 1999).

For the purposes of this study, functional diversity will encompass both guilds (response groups) and groups (effect groups). A distinction between the two will be attempted, although precise information pertaining to the relationship between traits and environmental factors or ecosystem functioning is rare or unattainable (Bremner, 2008). Despite this obstacle, it has been proposed that life history traits such as dispersal and fecundity can be considered as effect traits and features relating to nutrient cycling (trophic level and growth rate) as response traits (Suding et al., 2008). The allocation of species to effect and response groups is a desirable outcome as this will allow the prediction of potential ecosystem level responses to a set of disturbances or hypothesised climate change scenarios (Hooper et al., 2002, Methratta & Link, 2006).

Possibly the most important step in studies involving functional diversity is the selection of appropriate traits (Fox & Harpole, 2008, Petchey & Gaston, 2006). If traits are selected that are not relevant to the hypothesis being tested, erroneous functional groups will result, and the study will be ecologically irrelevant, or provide incorrect results (Petchey & Gaston, 2006). Identifying how and which traits are important for resource acquisition or ecosystem functioning, and how to measure them is critical to studies of functional diversity (Duffy et al., 2007, Petchey & Gaston, 2006). Constraints arise as information relating to the relevance of traits is limited and financially costly to determine; furthermore, hard traits, being traits directly related to a function, may be difficult to measure (Bremner et al., 2006). In such cases, soft traits, those that are not directly related to a function, but co vary with hard traits, or are directly related to hard traits, may be available to measure and thus used as a proxy for a hard trait (Bremner, 2008, Leps et al., 2006, Violle et al., 2007).

Application of Functional Diversity

Since the functional identities of the species that comprise a particular assemblage are considered, one of the major strengths of utilising functional diversity for ecological studies is that the extent of functional redundancy can be evaluated (Fonseca & Ganade, 2001). Functional redundancy exists with the spatial or temporal occurrence of more than one species able to perform a particular function (Bolger, 2001), and has been regarded as a form of "ecological insurance" (Boström et al., 2006, Duffy, 2006). Therefore, the greater the number of species in a particular functional group, the greater the functional redundancy of the group (assuming the species within the group differ to some extent), be it an effect or response group. It should be noted however, that although species can be "clustered" within a functional group, they are not completely identical to one another in their overall contribution to ecosystem functioning, as their ecological niches will not completely overlap (Chapin III et al., 1997, Muradian, 2001).

Environmental conditions vary temporally and spatially, and thus no ecosystem will remain or be totally ideal or suitable for a given species (Bengtsson, 1998, Duffy, 2006). If unfavourable conditions toward a species involved with a particular function occur, functional redundancy suggests that there will be at least one other species within the group for which the new environmental conditions are still favourable (Resetarits & Chalcraft, 2007). As a result, individual species abundances and/or biomasses may be observed to fluctuate temporally, but that of the associated functional group can remain relatively stable (Hawkins & MacMahon, 1989).

Effect groups are utilised in studies concerned with ecosystem functioning; investigations into the influence of disturbances such as climate change measure response groups, and traits related to a particular effect or response group are not necessarily significant with regards to the other group (Hooper et al., 2005). As a result, species that are found within a particular effect group are not automatically in the same response group. This provides a "buffer" for ecosystem functioning under changing environmental conditions for a particular process to potentially continue unimpaired, because it may be maintained by species allocated to several response groups (Duffy, 2006). As human use of the planet has induced rapid environmental change, at both regional and global scales (Halpern et al., 2008, Holling, 1992), the ability to measure functional redundancy within an ecosystem, region or functional group can provide the means by which "stability" or "vulnerability" of the particular scale of interest can be assessed, allowing preventative or protective measures to be taken if necessary.

The application of functional diversity to studies of ecological assemblages may also be used in a theoretical manner to investigate the potential interactions among species (Farias & Jaksic, 2009). As species within a functional group are assumed to utilise resources in a similar manner, that is, belong to niches which overlap to some extent, it is theorised that competition, and the prospective for complementarity (niche partitioning or facilitation), will occur among these species (Duffy & Stachowicz, 2006, Lavorel & Garnier, 2001, Pianka, 1980). When considering interactions among species from separate functional groups, the potential interactions are those of complementarity, predator/prey interactions and mutualism (Bruno et al., 2006, Chalcraft & Resetarits Jr, 2003, Hawkins & MacMahon, 1989). Thus, functional diversity can also be used as a tool to estimate the ecological interactions occurring in an ecosystem, and the potential changes in these interactions due to changes in assemblage species composition (Farias & Jaksic, 2009).

Extinctions are more likely to occur to species that have small populations with low rates of growth and small geographical ranges, that are rare and with specialised ecological requirements, and species extinctions do not occur randomly (Bracken et al., 2008, Duffy, 2002, Duffy, 2003). Due to species within a response group "sharing" a response to a disturbance, it is theoretically likely that species within the same response groups will become extinct concurrently (Resetarits & Chalcraft, 2007). The ability to allocate species to response groups provides the potential to estimate which species will be most affected by disturbances, while species' allotment to effect groups allows researchers to determine how these extinctions will affect ecosystem properties (Hooper et al., 2005, Wilson, 1999). It should be noted however, in the context of ecosystem functioning the consequences of species additions, such as due to invasive species, have the potential to be as, if not more, disruptive than species deletions (McCann, 2000, Muradian, 2001, Stachowicz & Byrnes, 2006).

A comparison of number of species, or taxonomic richness and evenness among locations may be of interest; however, it conveys no further information relating to the ecological properties of the locations being compared (Bady et al., 2005), and spatially separated locations often do not possess common species. Within a given ecosystem, evolutionary and ecological constraints create the non-random persistence of only those species adapted or suited to that particular environment (Halpern & Floeter, 2008). A major advantage of utilising functional diversity in ecological studies is the ability to compare and contrast geographically separated communities with little or no species in common, as the ecological attributes of functional groups are often comparable (Bellwood et al., 2002, Elliott et al., 2007, Hawkins & MacMahon, 1989).

Measurement of functional diversity

Traditionally, biodiversity studies have used diversity indices such as Richness or Evenness as a proxy for functional diversity (Leps et al., 2006) while other researchers have utilised functional group richness (Villeger et al., 2008). The major issue with taxonomic indices as a measure of functional diversity is that they do not consider the extent of difference among species with respect to effect upon ecosystem functioning (Bady et al., 2005, Bengtsson, 1998, Botta-Dukát, 2005, Leps et al., 2006, Solow & Polasky, 1994). Similarly, the problem with the use of functional group richness is that it considers that species within a group are identical (Villeger et al., 2008). The utilisation of functional diversity needs to take into consideration the species identity, and therefore not consider each species to be identical in their influence upon ecosystem functioning (Bady et al., 2005).

Currently no standard measure of functional diversity has been determined (Somerfield et al., 2008) and despite various statistical methods being proposed in the literature a consensus has not been reached (Ricotta, 2005, Schmera, 2009, Schmera et al., 2009). Generally, two broad methods have been utilised - functional groupings, and a measure of the volume of multivariate trait space occupied by a community

(Mason et al., 2005, Petchey et al., 2004). However, as discussed in the previous paragraph there are issues involved with the use of functional groupings.

The suite of morphological, life-history, physiological and behavioural traits belonging to each species can be considered to represent a combination of a species' various axes in multivariate "trait space". Each trait can be considered to be an axis in multivariate space, with species located along them, in a continuous, non-discrete manner (Diaz & Cabido, 2001, Hooper et al., 2005, Olden et al., 2006, Villeger et al., 2008). As a number of locations along these axes are not viable, due to environmental and/or evolutionary constraints, species will appear to be in loose clusters (niche-spaces) in various regions of this multivariate "trait space" (Hawkins & MacMahon, 1989, Hooper et al., 2002, Stegen & Swenson, 2009). The amount of trait space taken up by a community can be considered one form of measurement of functional diversity, with communities that display a greater range of traits occupying more trait space, and thus possessing greater functional diversity (Petchey et al., 2004, Villeger et al., 2008).

<u>Western Australian Marine Fish Assemblages</u>

The Western Australian marine environment ranges from tropical ecosystems in the north to warm temperate ecosystems in the south and covers 23° of latitude, and displays high levels of endemism (Fox & Beckley, 2005, Roberts et al., 2002, Tuya et al., 2008). The ichthyofauna corresponds to this with more than 3000 tropical, sub-tropical and warm temperate species being found in their respective regions, with some distributional overlap (Hutchins, 1994, Hutchins, 2001). These highly diverse assemblages are also characterised by low biomass, due to the presence of the Leeuwin Current providing oligotrophic tropical water and suppressing major upwelling, in addition to low terrigenous nutrient input (Caputi et al., 1996).

The Western Australian marine environment is experiencing increasing stresses through direct and indirect human pressures such as fisheries and climate change. The utilisation of functional diversity to assess changes in the marine fish assemblages due to natural gradients or anthropogenic influences can provide indicators as to the susceptibility of the various bioregions along this coast to these impacts. Although functional diversity, at this point in time, has issues in its definition, measurement and calculation, it shows potential as a more holistic approach to studying ecosystem functioning. The utilisation of a more encompassing technique should lead to a potentially more predictive and accurate method for the management and conservation of ecosystems.

B. Research Direction

Aims

The overall objective of this research will be to investigate changes in the functional diversity of West Australian marine fish assemblages, particularly with respect to the influences of environmental gradients and anthropogenic impacts. Specifically, this study will investigate eight questions –

1) How many and which traits are important for functional groupings?
2) What spatial scale is appropriate to measure functional diversity?
3) How does functional diversity respond to environmental gradients and human impacts?
4) Does functional diversity or groups change with habitat or tropical/temperate ecosystems?
5) Is temporal variability in species' biomass at a location reflected by variation within functional groups?
6) Does functional diversity change with fishing protection?
7) Can functional diversity be utilised as a means to compare geographically separated fish assemblages?
8) Can functional diversity be applied in studies investigating the potential effects of climate change on fish communities?

Methods and Predicted Outcomes

1) Functional traits.

Hypothesis

Statistically significant functional groups of Western Australian fishes can be created both *a priori* and post-hoc, based on relevant functional traits.

Methods

The University of Western Australia Marine Ecology Group databases will be utilised to provide a list of species at various locations along the West Australian coast, from Broome (17° 57' S, 122° 14' E) to the Recherche Archipelago (34° 12' S, 122° 21' E). Multiple relevant traits for the species will be determined through existing literature and statistical testing. The traits will be comprised of general life history, morphology and behavioural aspects of fish ecology and will be applicable to both temperate and tropical ecosystems. If possible, traits used will differ more among than within species and be based on a continuous, non-discrete scale (McGill et al., 2006).

Initially, traits will all be normalised to be comparable across units of measurement and to possess equal weighting. The effect of various trait weighting scenarios will also be investigated. All species, their associated traits and references for the information will be entered into a Microsoft Access database. If the opportunity presents itself, traits will also be categorised as effect or response traits, resulting in the formation of various effect and response groups. The diversity within response groups will be used for investigations into effects such as climate change or fishing impact (nest effect groups within response groups), while studies into the functioning of ecosystems will utilise the diversity within effect groups (response groups nested within effect groups) (Hooper et al., 2002).

Functional groups will be determined through the Similarity Profile procedure (SIMPROF) analysis from the Plymouth Routines In Multivariate Ecological Research (PRIMER) software (Clarke & Gorley, 2006) and based upon a species x traits matrix. The SIMPROF procedure provides a clustering of statistically significant groups, thus removing some of the bias or arbitrary decisions concerning allocation of species to groups and size of groups. Co-variance of traits will also be investigated through the species x traits matrix.

Functional diversity of the resulting groups and the overall assemblages will then be analysed through functional richness, functional evenness, functional divergence and functional dispersion as proposed by Laliberté & Legendre (2009). Four indices of functional diversity will be utilised because, as with traditional diversity measures, the full extent of information concerning diversity, at any level, cannot be encapsulated by a single figure (Laliberté & Legendre, 2009, Mouillot et al., 2005, Ricotta, 2004). As such, references to functional diversity in the following methods and outcomes are referring to the above three aspects.

Predicted Outcomes

a) Establish the traits relevant to the measurement of functional diversity.
b) Create functional groups based on similarity of traits shared.
c) Assess the natural existence of functional guilds/groups (Are a posteriori groups formed?)
d) Determine the appropriate scales for various applications of functional diversity.
e) Assess the extent of (potential) redundancy within groups at various scales.
f) Verify the traits that represent/determine the functional groupings.
g) If possible, establish response and effect groups.

2) Changes in functional diversity within and among regions.

Hypothesis

Functional diversity and functional groups of western Australian marine fishes will differ among regions with respect to environmental conditions and anthropogenic impacts.

Methods

This chapter will utilise the UWA Marine Ecology Group data for analyses concerning regional changes in the functional diversity of marine fishes. In particular the effects of environmental gradients (temperature/latitude, depth and disturbance regime), human impacts (fishing intensity, human use) and habitat heterogeneity will be investigated.

Temperature and depth were recorded at time of sampling, and habitat heterogeneity of a site will be estimated from the habitat type recorded at time of footage analysis for each of the stereo Baited remote Underwater Video System (stereo BRUVS) samples. Anthropogenic impacts will be measured and/or estimated according to "log-book" data concerning both recreational and commercial intensity, the proximity to towns/cities and the population size of the town/city and proximity to boat ramps or access points. In addition, abundance-biomass curves (ABC curves) (Warwick, 1986) will be utilised to investigate the overall relative impact sustained by each location. This method plots cumulative percent dominance against species rank for both biomass and abundance. Relatively natural populations will display plots with biomass curves above that of the abundance, while impacted locations will present abundance curves above that of the biomass (Warwick, 1986).

In order to assess the extent of change in functional diversity, a traits x sample matrix will be created through matrix algebra utilising the R software (R Development Core Team, 2009). In this step, the species x sample matrix will use the biomass of each species for each sample, rather than species abundances, as biomass is more relevant being related to resource and energy (Villeger et al., 2008). The relevance or association of traits with various environmental gradients, human uses and habitat type will be investigated through the creation of a traits x environmental/human use/habitat matrix via further matrix algebra. These matrices will allow for the detection of changes in functional diversity among locations, habitats, human uses and along environmental gradients.

Predicted Outcomes

a) Determine the influence of the physical environment upon functional diversity.
b) Determine the influence of habitat (within site) and habitat heterogeneity (among sites) upon functional diversity.
c) Determine the influence of anthropogenic impacts upon functional diversity.
d) Investigate the influence of scale upon functional diversity.
e) Investigate changes in functional redundancy due to environmental and human factors.

f) Compare temperate and tropical regions with respect to functional diversity and functional groups.

3) Temporal variability in functional diversity.

Hypothesis

Temporal variability in fish species biomass will not be observed at the functional group level; instead the relative biomass contributions of species to a functional group will fluctuate.

Methods

A UWA Marine Ecology Group historical data set spanning 5 years from the Capes region (from 33° 31’ S, 115° 00’ E to 34° 22’ S, 115° 08’E) will be utilised for these analyses. Over this time frame in this region, biomass at the species level has shown large temporal variability (J. Meeuwig, pers. comm.). This study will investigate the extent of temporal variability when these assemblages are considered at a functional level.

For the purposes of analysis, the species will be allocated to the groups previously determined. Temporal changes within and among functional groups will be considered, in that the functional diversity, redundancy and total biomass will be compared among groups for each year. Within group analyses will consider temporal changes in the diversity and relative biomass at a species level within a group over years.

Predicted Outcomes

a) Establish if biomass changes temporally at a functional group level within a region.
b) Determine the functional groups responsible for changes in biomass (either change at group level if functional groups display temporal variability, or the functional groups that variable species belong to if no change in functional groups).

c) Examine the extent that functional redundancy is influenced by temporal changes in species biomass.
d) Investigate temporal variability in functional richness, evenness and dominance.

4) The influence of fishing upon functional diversity.

Hypothesis

Marine fish functional diversity and the relative biomass contribution of marine fishes to functional groups at the Abrolhos Islands will be altered with respect to fishing intensity.

Methods

To investigate the effect of fishing pressure upon functional diversity of fish assemblages, UWA Marine Ecology Group data collected from the Abrolhos Islands (28° 43’ S, 113° 47’ E) will be utilised. This data consists of temporal fish biomass at sites within and outside of marine reserves and has previously been demonstrated to display changes in assemblage structure due to the impacts of fishing (Watson et al., 2007).

As with the previous data chapter, the species will be allocated into the appropriate functional groups that were previously determined. Analysis of this data will consist of investigations into changes within and between groups with respect to fishing protection. To investigate changes within groups, the overall and relative species contribution to biomass will be considered. Changes among groups will be assessed via comparisons of the functional diversity, redundancy and total and relative biomass of each group.

Predicted Outcomes

a) Investigate the changes in functional diversity due to fishing pressure.
b) Evaluate the extent of change in functional redundancy due to fishing.
c) Determine if functional diversity and redundancy change among islands.

5) **Comparison of geographically isolated marine fish assemblages utilising functional diversity.**

Hypothesis

Functional diversity and functional groups of marine fishes will not differ among geographically separated comparable ecosystems.

Methods

As one of the proposed advantages of utilising functional diversity is the ability to compare geographically separated assemblages or communities. This chapter will explore the potential for this feature to be applied to marine fishes. Fish biomass from comparable regions/ecosystems (Perth (31° 57' S, 115° 51'E) and locations from Victoria/South Australia and/or Ningaloo (22° 17' S, 113° 48' E) and Great Barrier Reef (15° 52' S, 148° 28' E) will be used in these analyses. Species will be designated groups based upon their multiple traits as in the previous chapters. Comparisons will include between temperate and tropical ecosystems and between comparable ecosystems from either side of Australia, further investigations will be performed into any changes found in within group redundancy, biomass and functional diversity.

Predicted Outcomes

a) Determine the usefulness of functional diversity to compare geographically isolated fish assemblages at comparable ecosystems.
b) If changes exist, compare the changes in functional diversity between temperate and tropical ecosystems from either side of Australia.

6) **Predicting the effects of climate change upon fish assemblages through functional diversity.**

Hypothesis

The poleward distribution change of species will be able to be predicted through the use of changes in functional response groups, and the potential regional changes in ecosystem functioning approximated through the resulting changes in functional effect groups.

Methods

This chapter will investigate the capability of functional diversity to predict potential changes in fish assemblages and ecosystem health due to hypothesised climate change scenarios. The proposed advantage of utilising functional diversity in such a study is that the changes in ecosystem functioning may be predicted through the use of effect and response groups. The result of climate change on species will differ across response groups. The changes in a region's species can be predicted from the response group to which they have been allocated, the subsequent changes in ecosystem functioning can be predicted through the synchronous changes in the region's effect groups.

This study will use UWA Marine Ecology Group species and biomass data, the previously determined response and effect groups and hypothesised climate change scenarios to predict the changes in species composition and ecosystem functioning as a result of global warming.

Predicted Outcomes

a) Determine the extent of change in Western Australian marine fish functional diversity due to hypothesised climate change.
b) Propose the potential effect of climate change upon ecosystem functioning through changes in marine fish assemblages of Western Australia.

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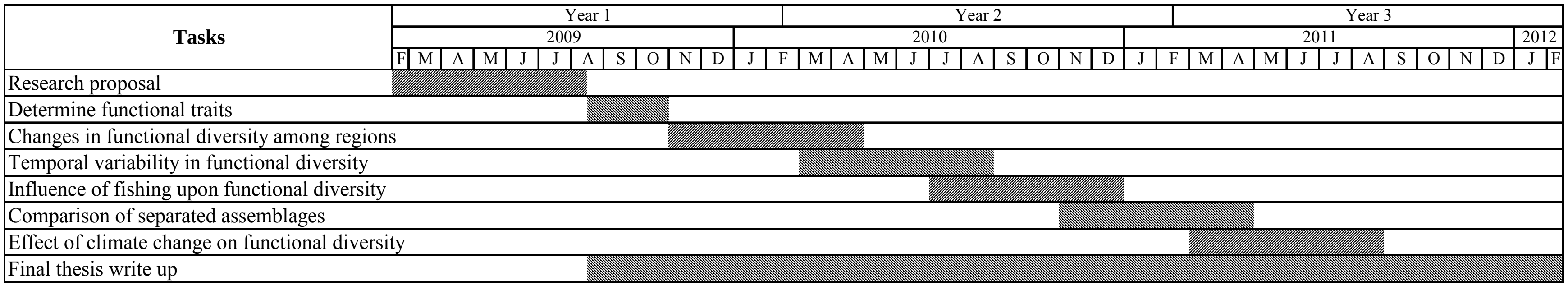
Duplication

To the best of my knowledge, this combination of proposed aims, objectives and methodological approaches has not been applied to achieve these outcomes before.

C. Candidature Plan

Timeline



Agreed Task / Milestone (for the first 12 months of candidature ONLY)	Date to be completed by
Completion of AACE7000	Completed
Research proposal	16/8/09
Determine relevant functional traits	15/10/09
Collect trait value data for each species	15/10/09
Create functional groups based on similarity of traits shared	1/11/09
Assess the natural existence of functional guilds/groups (Are a posteriori groups formed?)	1/11/09
Determine the appropriate scales for various applications of functional diversity	1/11/09
Assess the extent of (potential) redundancy within groups at various scales	1/11/09
Verify the traits that represent/determine the functional groupings	1/11/09
Establish response and effect groups	1/11/09
Determine the influence of the physical environment upon functional diversity	16/2/10
Determine the influence of habitat (within site) and habitat heterogeneity (among sites) upon functional diversity	16/2/10
Investigate the influence of scale upon functional diversity	16/2/10
Compare temperate and tropical regions with respect to functional diversity and functional groups	16/2/10

Skills Audit – I currently possess the generic skills required to use Microsoft Word and Excel and some relevant statistical packages. Throughout the duration of this project, I will participate in statistics courses where required and a Microsoft Access course to gain the skills required to use a database correctly.

D. Facilities

It is not foreseen that this project will require any special equipment or literature.

E. Estimated Costs

Item	**Cost**
Photocopying/printing	$150
Access course	$350
Statistics courses	$70
Design and analysis of experiments course	$100
Scientific writing course	$600
Transport to work with supervisors and collaborators	$6,500
Vehicle costs	$2,000
DVDs/Hard drive	$250
Textbooks	$300
PRIMER licence	$500
Sigmaplot package	$300
Total	**$11,120**

F. Fieldwork

This project will not require fieldwork, although work outside the University will consist of going to New Zealand. While there I will spend time with one of my supervisors and distinguished ecologists to discuss the approach and methodologies of this project.

G. Supervisors

1. Co-ordinating Supervisor

Dr XXX (80%)

XXX Contact details removed

Role - Day to day management and administration; provision of data

2. Additional Supervisors

Prof. XXX (10%)

XXX Contact details removed

Role - Statistical advice and ecological interpretation

Prof. XXX (10%)

XXX Contact details removed

Role - Statistical advice and ecological interpretation

H. Confidentiality & Intellectual Property

There are no confidentiality or intellectual property issues that we are aware of with this project.

I. Approvals

This project will not require the use of animals, participation of human subjects, genetic manipulation, potentially biohazardous procedures or situations, use or disposal of potent teratogens or carcinogens, use of ionising radiation, or other matters of a hazardous nature.