Literature review

**Predicting human impacts on costal marine ecosystems**

Subheading: The role of large mobile benthic invertebrates in reef ecosystems

Section1: Significance of the study:

* Humans are effecting costal marine areas
* Why is there a taxonomic sampling bias? (less representation of invertebrates)
* Disruptions known to effect the food web, hence populations
* We want to be able to predict how potential environmental changes will influence food webs

Section 2: Current food web modelling techniques

* How food webs are currently modelled
* How have food web models currently included invertebrate groups?
* Brief intro to size-spectrum modelling

Section 3: Size spectrum modelling

* History of size spectrum models – how they came about
* What are the advantages/disadvantages of this modelling method?
* How have studies incorporated large mobile invertebrates into size spectrum models? What challenges did they come across?
* Theory behind size spectrum models
* How size spectrum models have been used to make predictions

Section 4: Discussion

* Importance of modelling food webs
* Why invertebrates are often excluded
* Advantages and disadvantages of food web modelling techniques
* Benefits to size spectrum modelling
* Areas of potential exploration

**Significance of the study**

1. Human impacts on coastal marine ecosystems

Globally, humans are impacting all reaches of the marine environment (Halpern et al., 2008), through planned or un-planned activity as well as human-induced natural disasters. The extent to this impact on coastal marine ecosystems is vitally important for conservation, economic and moral stand points, as a major source of protein and nutrients, especially in less developed countries (FAO, 2016). The first major problem however is quantifying human impacts, whilst on land this might be quantified as distance from roads, or estimated from satellite data (e.g. deforestation), the marine environment proves a more difficult task (Ban and Alder, 2008). The second problem is quantifying the disturbance to the ecosystem. For this a series of metrics are commonly measures, often these metrics aim to quantify the lack of certain ecosystem characteristics (Mageau, 1995), such as: biodiversity loss, reduced size distribution, dominance of non-native species, and reduced production per unit biomass.

It is well agreed that globally, marine environments have been, and continue to be negatively affected by human activities, such as fishing, transportation, and pollution. Loss of biodiversity however is resulting in reduced ecosystem services, but further a reduced resilience to further disturbances (Worm et al., 2006). Worm et al. (2006) did conclude, however that currently these changes could be reversible with correct restoration management services. It is important however to look at the historical conditions of marine ecosystems, as many of the major activities negatively effecting marine ecosystems predate monitoring programs (Jackson et al., 2001). Although, even shorter-term monitoring have revealed changes in landings of fish from larger-long lived species to lower trophic level species (Pauly et al., 1998). The result of which, is that many more ecosystems may be susceptible to collapse in the near future, than expected without considering historical conditions.

Human impacts in terrestrial ecosystems are much better documented than in marine systems, likely due to the difficulty in sampling or the more conspicuousness of impacts in marine ecosystems (Hoegh-Guldberg and Bruno, 2010). This reduced documentation of human impacts naturally leads to reduced management strategies. Considering the importance of marine ecosystems in food security, we must concentrate efforts in trying to understand how marine ecosystems will respond to ongoing ecosystem damage, and how we might be able to mitigate these impacts for future generations.

1. Taxonomic sampling bias

Simply comparing marine and terrestrial systems, it is clear there is a bias in sampling. Even within the marine realm, there is a taxonomic bias against invertebrate species (Troudet et al., 2017). Invertebrates are functionally important (Wilson, 1992), and form part of the complex interactions between populations in the community. Furthermore, invertebrates dominate coral reef ecosystems in terms of biodiversity (Glynn and Enochs, 2011), and yet they are underrepresented in the literature.

Bias in marine environment is likely due to the focus on economically favourable fish species and charismatic species for conservation purposes. However to understand the population dynamics of these ‘important’ species we must understand the community dynamics, that is the other individuals in the community they interact with. This includes understanding how these species relate to invertebrates in the complex food web, allowing us to estimate how changes in any aspect of the food web will affect their dynamics.

1. Food web

The food web describes the consumption interaction between all individuals in the system. Typically these types of systems are modelled as the interactions between species. If there is a decline in one species, we could expect a decline in their predator abundance, assuming they do not switch to another food source, or an increase in the abundance of a competitor. Often however, the complex interaction between species makes teasing apart the various interacting factors difficult. The complexity of these food webs means we often have to model an entire food web to gain an understanding of how perturbations (natural or human induced) will modify the system. The role of large mobile benthic invertebrates is less understand however. It is therefore important to understand why there is this bias against modelling benthic marine invertebrates and how they can be better included in food web models. Modelling the dynamics of both benthic invertebrates and fish in reef ecosystems will allow us to better predict how climate change, pollution, ocean acidification, or chemical spills will effect entire reef ecosystems.

**Modelling the food web**

1. Current modelling methods

Traditionally food web models such as ECOSYM or ECOPATH identify the interactions between species (Pauly, 2000). These modelling approaches were developed and applied in the 1980s, and provide a robust method to model community dynamics in the face of change. The methods however are only applicable to a specific site in question, and increasing the scale increases the number of species and interactions between those species, and can quickly become very computationally expensive. An alternative approach to ecosystem modelling is size-based (see Blanchard et al., 2017). Size-based food web modelling works on the premise that an individual’s body size is of more important to how it interacts with its environment than what taxonomic group it belong to.

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