

# Quantitative Marine Science



Abstract

## Improving the representation of large pelagic predators in ecosystem models

**Dr Jay Willis**

November 2007

School of Zoology, University of Tasmania

CSIRO-UTAS Joint PhD Program in Quantitative Marine Science

This thesis explores representation of large pelagic predators in marine ecosystem models. I extend work in theoretical models in ecology and combine these with field experiments to develop new insights into pelagic predator behaviour. There are two threads, 1) Spatial organisation of large pelagic predators is largely unknown and crucial to accurate modelling, and 2) Compensatory dynamics, explicitly assumed in ecosystem models, can be wrong for real ecosystems.

The modelling method involves building on examples from the scientific literature. Three examples are; 1) I extended a dynamic optimization model of the life history of krill to explain the paradoxical decline of krill abundance after their predominant predator was removed. 2) I extended a mathematical model, as an individual based model, demonstrating that root causes of the universal law of school size distribution explain spatial distribution of tuna, and 3) I extended theoretical models as an individual based model of long range navigation.

The field work components are two designed experiments and the reanalysis of two data sets, all focused on southern bluefin tuna (SBT) in the Great Australian Bight (GAB). In the first experiment, I deployed acoustic tags and tethered receivers. In the second, I tested bioelectrical impedance (BIA) for measuring condition during tagging operations. The first data set I reanalyzed was from 10 years of aerial surveying for tuna schools. I used this to test the universal law of school size distribution. The second data set was from archival tags and I used this to explore spike diving and its navigational purpose. I used the Bluelink re-analysis (BRAN) ocean model for currents in the navigation model, a mathematical model of the Earth's magnetic field, and several remote sensed data sets in modelling and analysis.

The thesis is a set of standalone chapters bound by common threads. The individual based models, using correlated random walks, first used with the universal law are extended during analysis of the acoustic tagging, and to model navigation. The paradoxical decline in krill of the first chapter is revisited in the last in relation to pilchards and tuna. The thesis supports recommendations, for instance, for BIA use during tagging, and provides practical tools such as an equation for the spatial distribution of SBT in the GAB. The thesis would be of interest to those interested in large pelagic predators and how to model their behaviour and ecosystem impact.