The influence of multi-species feeding associations on the foraging behaviour of Australasian gannets (*Morus serrator*) in the Hauraki Gulf, New Zealand

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"It is good to have an end to journey toward; but it is the journey that matters, in the end."

- Ernest Hemingway

Abstract

In order to successfully capture prey in a challenging and physically demanding environment, Australasian gannets (*Morus serrator*) have developed a number of foraging strategies. Foremost among such strategies is the joining in formation of mixed species feeding associations (MSFA's) and the use of specialised plunge diving behaviours. This study sought to determine how gannets vary individual and group plunge diving behaviours in order to maximise the benefits and mitigate the risks associated with feeding in densely packed, highly active MSFA's.

Specifically this study's aims are to examine how variations in gannet dive heights, angles and completion rates are influenced by external stimuli, including weather parameters, oceanographic conditions and MSFA's species composition and behaviour. This study additionally seeks to examine what mixed and/or con-specific cues are associated with the formation of synchronous diving bouts, and determine its role as a form of local enhancement for gannets foraging in MSFA's.

Between March 2013 and June 2014, 45 independent boat based surveys were conducted aboard *Dolphin Explorer*, a 20m tour boat based in New Zealand's Hauraki Gulf. Using a Canon XH A1S high definition video camera, approximately 11.9hrs of MSFA video footage was collected, containing 5565 recorded gannet plunge dives. Variations in these dives, including their height, angle of entry, and synchronous timing were examined in context of environmental variables including wind speeds, sea surface temperatures, and Beaufort sea states as well as against MSFA variables including the abundance of other foraging gannets, the abundance and behaviour of common dolphins (*Delphinus* sp.), and the presence of other species including shearwaters (*Puffinus* spp.), petrels (*Fregetta spp.*), terns (*Sterna* spp.), and Bryde's whales *(Balaenoptera edeni*).

While weather influences were found to have minimal effects on gannet dive behaviours, higher winds were associated with lower altitude dives, and less frequent synchronous diving bouts. This is likely due to the decreased visibility of deeper prey caused by increased surface disturbances as a result of higher wind speeds, coupled with the inherent difficulties of performing highly coordinated aerial manoeuvres in high wind conditions.

Increased gannet flock sizes were found to correlate with more frequent high-altitude 90° dives, and increased rates of dive synchrony. This may be a result of the need to better coordinate dives in denser assemblages of con-specifics to avoid collisions, coupled with the increased foraging success associated with larger foraging groups, and local enhancement.

Increased foraging dolphin pods were also associated with more frequent high-altitude vertical dives. This may result from gannets capitalising on the increased bait-ball density and stability associated with larger foraging pods by taking deeper dives in order to make multiple prey captures with greater ease. Gannet synchrony,

however, was only found to decrease in the smallest dolphin pods, again attributed to the decreased foraging abilities of smaller pods.

Dolphin foraging behaviours most associated with the maintenance of dense stationary bait-balls were most heavily associated with high, vertical gannet dives, and increased gannet synchronous dives. This is likely the result of gannets capitalising on denser prey assemblages by taking deeper dives in pursuit of multiple prey capture.

The presence of Bryde's whales at MSFA's was found to decrease the frequency of both high vertical dives and synchronous dives, as lunge feeding on bait-balls scatters fish and decreases prey density.

The presence of hetero-specific avian species had various effects on gannet dive behaviours. Most notably, the presence of shearwaters and petrels was found to be associated with greater frequencies of low altitude gannet dives, thought to be a result of an increased collision risk in their presence. Terns meanwhile were associated with decreased dive synchrony, possibly as a result of false hetero-specific signalling caused by their white plumage.

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hrs……hours

km/h……kilometres per hour

Kw……kilowatt

L…….. litre

m……..meters

m/s…….. meters per second

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