Stable isotope tests of the trophic role of estuarine habitats for fish

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Abstract

The role of autotrophic production in different coastal habitats in the production of fish in estuaries is an important consideration in coastal management and conservation. In the estuarine waters of the Australian east coast, many economically important fish species occur over mudflats lacking conspicuous vegetation. I used stable isotope analysis to examine where such fish ultimately derived their nutrition, in the subtropical waters of southern Moreton Bay, Queensland, Australia.

I first tested traditional processing methodologies of autotroph samples, in this case of mangrove leaves, and examined variability in mangrove isotope values at different spatial scales. Mangrove leaves processed using time-consuming grinding showed no significant difference in isotope values than coarsely broken leaf fragments. Isotope values of green leaves were not meaningfully different from yellow or brown leaves that would normally be the leaves that actually dropped on to the sediment. Future analyses therefore can use green leaves, since they are more abundant and therefore more easily collected, and can simply be processed as whole leaf fragments rather than being ground to a powder. Carbon and nitrogen isotope values varied at several spatial scales. The proportion of variability partitioned at different scales varied depending on the species of mangrove and element (C or N) analysed. To properly represent a geographic area, isotope analysis should be done on leaves collected at different locations and, especially, from different trees within locations.

The autotrophic source(s) supporting food webs leading to fish production on mudflats might be either *in situ* microphytobenthos or material transported from adjacent habitats dominated by macrophytes. I tested the importance of these sources by measuring $\delta^{13}C$ values of 22 fish species and six autotroph taxa (microphytobenthos on mudflats, and seagrass, seagrass epiphytic algae, mangroves, saltmarsh succulents and saltmarsh grass in adjacent habitats) in Moreton Bay. I calculated the distribution of feasible contributions of each autotroph to fishes. All fish $\delta^{13}C$ values lay in the enriched half of the range for autotrophs. For over 90% of fishes, the top three contributing autotrophs were seagrass, epiphytes and saltmarsh grass, with median estimates of approximately 60-90% from these sources combined. Seagrass was typically ranked as the main contributor based on medians, while epiphytic algae stood out based on 75th percentile contributions. The other three sources, including MPB, were ranked

in the top three contributors for only a single fish. Organic matter from seagrass meadows is clearly important at the base of food webs for fish on adjacent unvegetated mudflats, either through outwelling of particular organic matter or via a series of predator-prey interactions (trophic relay). Modelling results indicate that saltmarsh grass (*Sporobolus*) also had high contributions for many fish species, but this is probably a spurious result, reflecting the similarity in isotope values of this autotroph to seagrass. Carbon from adjacent habitats and not *in situ* microphytobenthos dominates the nutrition for this suite of 22 fishes caught over mudflats.

The ultimate autotrophic sources supporting production of three commercially important fish species from Moreton Bay were re-examined by further analysing carbon and nitrogen stable isotope data. Mean isotope values over the whole estuary for fish and autotroph sources were again modelled to indicate feasible combinations of sources. Variability in isotope values among nine locations (separated by 3-10 km) was then used as a further test of the likelihood that sources were involved in fish nutrition. A positive spatial correlation between isotope values of a fish species and an autotroph indicates a substantial contribution from the autotroph. Spatial correlations were tested with a newly developed randomisation procedure using differences between fish and autotroph values at each location, based on carbon and nitrogen isotopes combined in two-dimensional space. Both whole estuary modelling and spatial analysis showed that seagrass, epiphytic algae and particulate organic matter in the water column, potentially including phytoplankton, are likely contributors to bream (*Acanthopagrus australis*) nutrition. However, spatial analysis also showed that mangroves were involved (up to 33% contribution), despite a very low contribution based on whole estuary modelling. Spatial analysis for sand whiting (*Sillago ciliata*) demonstrated the importance of two sources, mangroves and microalgae on the mudflats, considered unimportant based on whole estuary modelling. No spatial correlations were found between winter whiting (*Sillago maculata*) and autotrophs, either because fish moved among locations or relied on different autotrophs at different locations. Spatial correlations between consumer and source isotope values provide a useful analytical tool for identifying the role of autotrophs in foodwebs, and were used here to demonstrate that organic matter from adjacent habitats, and in some cases also *in situ* production of microalgae, were important to fish over mudflats.

Whilst recognising that production from several habitats is implicated in the nutrition of fishes over mudflats in Moreton Bay, clearly the major source is from seagrass meadows. Organic matter deriving from seagrass itself and/or algae epiphytic on seagrass is the most important source at the base of fisheries food webs in Moreton Bay. The importance of seagrass and its epiphytic algae to production of fisheries species in Moreton Bay reinforces the need to conserve and protect seagrass meadows from adverse anthropogenic influences.

Declaration

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Andrew Melville

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