Feeding Ecology of Fishes at Artificial Reefs in the Northwest Gulf of Mexico

Ecologie Alimentaire des Poissons associés aux Récifs Artificiels du Nord-ouest du Golfe du Mexique

Ecología de la Alimentación de Peces asociados con Arrecifes Artificiales del Noroeste Golfo de México

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EXTENDED ABSTRACT

Introduction

The abundance of several highly exploited reef fish species in the GoM (groupers, snappers, triggerfishes, etc.) are high at artificial reefs (ARs) (Dance et al. 2011), but the functional role of ARs to these and other reef-associated species is not well understood. Studies investigating trophic interactions of fauna associated with ARs can yield valuable information on their function as habitat, in addition to the ecological roles of members within the biological community (Daigle et al. 2013). Gut content analysis has been used to reconstruct the feeding patterns of fauna on ARs, and can be used to discern complex trophic interactions when paired with dietary tracers (stable isotopes) (Wells et al. 2008 and Daigle et al. 2013). Trophic relationships can be determined from gut content analysis over a relatively short-term (hours to days), but has the potential to underestimate soft-bodied prey (due to differential digestion) (Michener and Lajtha 2008, Wells et al. 2008, Tarnecki et al. 2015). Natural stable isotopes of carbon (d^{13}C), nitrogen (d^{15}N), and sulfur (d^{34}S) can be used to track energy flow through trophic pathways, determine an individual's trophic position, and provide a long-term measure of diet (weeks to months) (Post et al. 2002, Michener and Lajtha 2008). Predator d^{13}C ratios are useful for determining the contribution of organic matter from primary producers (fractionating by only 0.5 - 1.5‰) that differ in their d^{13}C ratios (e.g. planktonic vs. benthic carbon), while nitrogen d^{15}N ratios in a consumer (fractionating by 3-4‰ from its prey) can be used with primary producer d^{15}N ratios to estimate trophic position (Michener and Lajtha 2008). Sulfur d^{34}S ratios change little with trophic level, but significant differences in benthic sulfides (depleted d^{34}S) and sulfates in the water column (enriched d^{34}S) can be used to discern benthic vs. pelagic producers (Michener and Lajtha 2008, Wells et al. 2008). In this study, two heavily exploited species on ARs in the northwestern GoM were used as model species to compare the feeding ecology of one midwater (Gray Triggerfish *Balistes capriscus* n = 89) and one demersal (Red Snapper *Lutjanus campechanus* n = 279) predator at nearshore ARs. Objectives were to determine if differences exist between model species use of ARs as foraging habitat, and to examine spatial feeding patterns of Red Snapper across a north to south gradient along the Texas coast, and at inshore (with low relief reefs) and offshore (with high relief reefs) ARs via pairing species-specific stable isotope ratios of carbon (δ^{13}C), nitrogen (δ^{15}N), and sulfur (δ^{34}S) with gut content analysis.

Methods and Materials

Model species were collected via vertical longline and trap surveys from May - August of 2014 and 2015 at seven AR sites in coastal waters off the northern GoM, in addition to collection of particulate organic matter (POM), benthic microalgae (BMA), and zooplankton within the same period. Sites consisted of five inshore (< 20 m depth and < 38 km from the shoreline) sites with low relief (< 5 m) structure and two offshore (> 20 m depth and > 38 km from the shoreline) sites with higher (> 5 m) relief structure. Sites were distributed from north to south, and were grouped by three regions (Sabine (n = 3), Galveston (n = 2), and Freeport (n = 2)) that are approximately 101 km apart. Gut contents were identified to the lowest possible taxon, counted, weighed (both wet and dry), and dried at 60°C for 24 - 48 hours. Nine prey categories (created from the identified contents: fish, decapod shrimp, stomatopods, crabs, bivalves, gastropods, echinoderms, zooplankton, and other inverts) were used to analyze gut content data. Percent composition by dry weight was used for the main gut content analysis, as it can be used to assess the nutritional contribution of each prey type (Wells et al. 2008), and percent index of relative importance % IRI (incorporating % frequency of occurrence, % number, and % weight) was also computed for each prey category. Epaxial muscle tissue was dried at 60°C for 24 hours, lipid-extracted, and homogenized. Benthic microalgae and POM samples were also dried at 60°C for 24 hours. Stable isotope ratios (d^{13}C, d^{15}N, and δ^{34}S) for plant and animal tissue were determined using an elemental analyzer interfaced to a continuous flow isotope ratio mass spectrometer (IRMS) at the University of California-Davis Stable Isotope Facility. Stable isotopes of model species were analyzed using multivariate analysis of covariance (MANCOVA) models, using stable isotope ratios of d^{13}C, d^{15}N, and δ^{34}S as dependent variables and species, inshore/low relief, offshore/high relief, Sabine, Galveston, and Freeport as independent variables (and fork length (FL) as a covariate). Univariate analyses of covariance (ANCOVA) models were then used to test the effect of independent variables on each dependent variable separately (ANOVAs including fork length was used for inshore/low relief and offshore/high relief as well as Sabine, Galveston, and Freeport due to unequal slopes). Potential contributions of POM vs. BMA to Red Snapper and Gray Triggerfish diets were determined using a two source-mixing model (Rooker et al. 2006 and Wells et al. 2008) using the SIAR package in R (Inger, R et al. 2010).

Results and Discussion

Differences in $d^{13}C$, $d^{15}N$, and $\delta^{34}S$ ratios for Red Snapper ($\delta^{13}C$ $\bar{x}$ = -17.13‰, Δ15n $\bar{x}$ = 16.31‰, $\delta^{34}S$ $\bar{x}$= 18.72‰) and Gray Triggerfish ($\delta^{13}C$ $\bar{x}$= -17.61‰, $\delta^{15}N$ $\bar{x}$= 14.12‰, $\delta^{34}S$ $\bar{x}$ = 18.93‰) were significant (ANCOVA, $p < .0.05$), with Red Snapper having higher values for $d^{13}C$ and $d^{15}N$, and lower values for $\delta^{34}S$. Model species gut contents were also significantly different (ANOSIM, $p < 0.05$), with crabs, fish, bivalves, and other invertebrates contributing the most to the dissimilarity between species (using SIMPER analysis). Red Snapper and Gray Triggerfish had mean percent contributions of over 99% for BMA from the two-source mixing model. While both model species derive most of their diet from the benthic source, lower $\delta^{13}C$ and higher $\delta^{34}S$ ratios in Gray Triggerfish may be due to a feeding preference for filter feeding benthic invertebrates compared to the more piscivorous diet of Red Snapper, as is suggested by the %IRI from the gut content analysis (Figure 1). The rate of the relationship of FL with the ratios of $d^{13}C$, $d^{15}N$, and $d^{34}S$ were significantly different between inshore/low relief and offshore/high relief sites, as well as among regions (Sabine, Galveston, and Freeport) (ANOVA, $p < 0.05$). Gut contents for all Red Snapper spatial analysis were non-significant (ANOSIM, $p > 0.05$). Red Snapper at inshore/low relief sites increased in $d^{13}C$ and $d^{15}N$ more rapidly than at offshore sites/high relief sites, while $d^{34}S$ decreased with FL slightly (compared to no discernable trend for offshore/high relief fish). Red Snapper from the southern region (Freeport) increased in $d^{13}C$ and $d^{15}N$ and decreased with $\delta^{34}S$ more rapidly than at the more northern regions (Galveston and Sabine). Lower $d^{15}N$ ratios for offshore/high relief fish may be indicative of feeding at a slightly lower trophic level at offshore sites compared to inshore/low relief sites, but overall feeding patterns were similar across both spatial scales.

KEY WORDS: Artificial reefs, red snapper, gray trigger-fish, feeding

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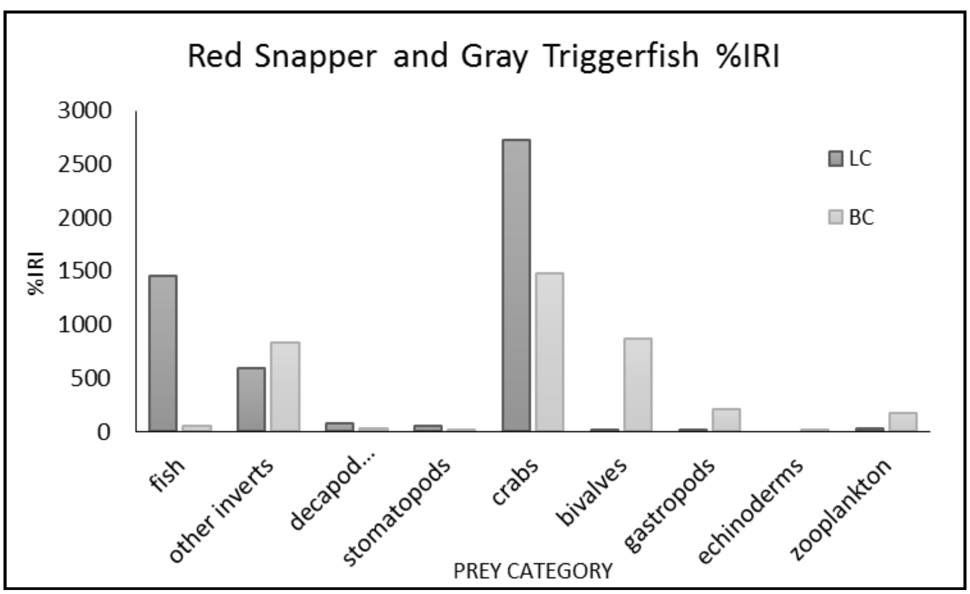

Figure 1. Percent IRIs for each species using dominate prey categories.